SPIMES: A MULTIDIMENSIONAL LENS FOR DESIGNING FUTURE SUSTAINABLE INTERNET CONNECTED DEVICES

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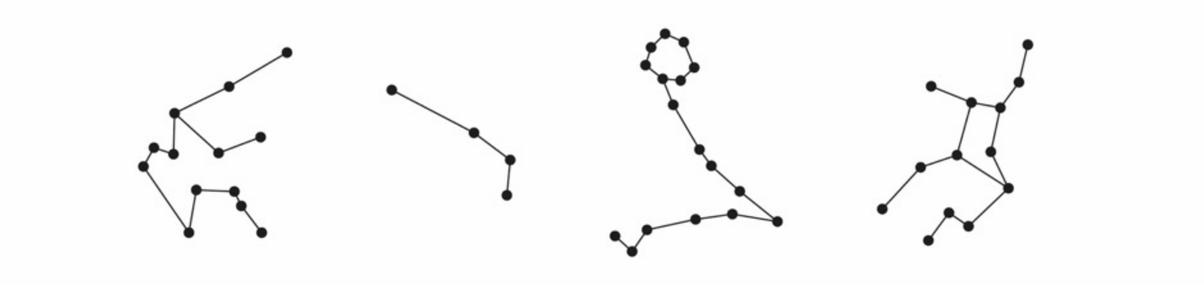
For Sam, Rudy, Indigo, Luna, ABC and the one that is yet to come. Always.



Declaration

This thesis has not been submitted in support of an application for another degree at this or any other University. It is the result of my own work and includes nothing that is the outcome of work done in collaboration except where specifically indicated. Many of the ideas in this thesis were the product of discussion with my supervisor Professor Paul Coulton.

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Stead, M., Coulton, P., and Lindley, J. (2019). 'Spimes Not Things: A Design Manifesto for A Sustainable Internet of Things', PhD contribution. Available at: http://www.research.lancs.ac.uk/portal/files/265954537/Spimes_Not_Things_Design_Manifesto.pdf

Stead, M., Coulton, P., and Lindley, J. (2018). 'Do-It-Yourself Medical Devices: Exploring Their Potential Futures Through Design Fiction', in *Proceedings of DRS 2018 Design Research Society Conference.* Limerick, Ireland. Available at: https://www.scribd.com/document/382347614/DRS2018-Vol-6

Stead, M., and Coulton, P. (2017). 'Old, Sick And No Health Insurance: Will You Need A Permit To Use Your Homemade Health Wearable?', in *DIS 2017 Companion - Proceedings of the 2017 ACM Conference on Designing Interactive Systems.* Edinburgh, UK. DOI: 10.1145/3064857.307917

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Stead, M. (2016). 'A Toaster for Life: Using Design Fiction To Facilitate Discussion On The Creation Of A Sustainable Internet Of Things', in *Proceedings of DRS 2016, Design Research Society 50th Anniversary Conference.* Brighton, UK. Available at: http://www.drs2016.org/455

Abstract

There are numerous loud and powerful voices promoting the Internet of Things (IoT) as a catalyst for changing many aspects of our lives for the better. Healthcare, energy, transport, finance, entertainment and in the home – billions of everyday objects across all sorts of sectors are being connected to the Internet to generate data so that we can make quicker and more efficient decisions about many facets of our lives. But is this technological development completely benign? I argue that, despite all their positive potential, IoT devices are still being designed, manufactured and disposed of in the same manner that most other 'non-connected' consumer products have been for decades – *unsustainably*. Further, while much fanfare is made of the IoT's potential utility for reducing energy usage through pervasive monitoring, little discourse recognises the intrinsically unsustainable nature of the IoT devices themselves.

In response to this growing unsustainable product culture, my thesis centres on the role that sustainability can potentially play in the design of future IoT devices. I propose the re-characterisation of IoT devices as *spimes* in order to provide an alternative approach for facilitating sustainable Internet-connected product design practice. The concept of spimes was first introduced in 2004 by the futurist Bruce Sterling and then outlined further a year later in his book *Shaping Things*. When viewed simply, a spime would be a type of near future, internet-connected device which marries physical and digital elements with innate sustainable characteristics. Whereas the majority of sustainable design theory and practice has focused on the development of sustainable *non-connected* devices, a credible strategy for the design of environmentally friendly *Internet-connected* physical objects has yet to be put forward. In light of this, I argue that now is the right time to develop the spimes concept in greater depth so that it may begin to serve as a viable counterpoint to the increasing unsustainability of the IoT. To make this case, my thesis explores the following three key questions:

- What are spimes?
- Can we begin to design spimes?
- What does spime-orientated research mean for unsustainable Internet-connected design practice?

I outline how, in order to explore these important questions, I utilised a *Research through Design* approach to unpack and augment the notion of spimes through three *Design Fiction* case studies. Each case study concretises different key design criteria for spime devices, while also probing the broader implications that could arise as a result of adopting such spime designs in the near future. I discuss the significance of reflecting upon my *Spime-based Design Fiction Practice* and how this enabled me to develop the spimes concept into a *multidimensional lens*, which I contend, other designers can potentially harness as a means to reframe their IoT praxis with sustainability *baked-in*. The key aspects of my process and its outputs are also summarised in form of a *design manifesto* with the aim of inspiring prospective designers and technologists to create future sustainable Internet-connected devices.

Acknowledgements

I dedicate this thesis to my wife Samantha Ward. It's an understatement to say that the past year has been the toughest of our lives together. The strength and dignity with which you have faced our loss has been truly inspirational and has kept me going throughout the many low moments of recent months. Your unwavering love and support for me over the past 5 years is also immeasurable. You've had to deal with my stress, frustrations, anger and self-indulgence when you shouldn't have had to. You've had to entertain Rudy on your own when you shouldn't have had to. The most profound love and gratitude Babs xXx

A message to you Rudy Constance Ollie Bird Stead – you, along with your Mummy, are quite simply the best thing that ever happened to me. Love you so so much my Baby Goo xXx

To Indigo, Luna and ABC – I think about you all every day and dearly wish that you were here in mine and your Mummy's arms. Be good for Nana Pauline in the sky. Love all of you always and evermore xXx

Mum, Dad, Matt, Jordan, Ben, Gloria, John, James, Bill, Linda, Jamal and Ewen – humongous love and thanks for everything you've all done for me. Thank you, each of you, for always being there.

I would like to say an enormous thank you to Professor Paul Coulton for taking me on as a PhD student, for his encouragement, input and guidance throughout the weird and wonderful process that is a PhD, and for giving me the space and time to navigate, understand and shape my body of doctoral research just how I have wanted to. Cheers Paul.

Thank you, Professor Gordon Blair, for accepting me onto the HighWire Doctoral Training programme and Tish Brown for your continued support throughout my doctoral studies.

Thanks to Joseph Lindley, Adrian Gradinar, Daniel Burnett, Claire Coulton, Rachael Hill, Rebecca Taylor, Ege Sezen and everyone else at HighWire CDT, ImaginationLancaster, LICA and SCC that I've had the pleasure of collaborating with and/or come into contact with during the PhD process. You have, in your own way, each positively contributed to my doctoral journey.

Finally, I would like to say thank you to Tim Shorten, Belinda Hochland, David Spendlove, Mik Pieniazek and Chris Rivlin – each of you have, at various points in my life, helped shape my ongoing creative endeavours, the culmination of which, I believe, led me to undertake this PhD. For this, I am incredibly grateful.

Mike

Contents

List of Figures

1 Introduction

1.1 Setting The Scene For This Research

This thesis centres on the role that environmental sustainability can potentially play in the design of future Internet-connected manufactured devices. To do this, I chose to explore the concept of *spimes* which the futurist and science fiction author Bruce Sterling first introduced in 2004 and then outlined further a year later in his book *Shaping Things*. When viewed simply, a spime would be a type of near future, internet-connected device which marries physical and digital elements with innate sustainable characteristics. The objective of my doctoral research is to unpack the nature of spimes in greater depth and subsequently develop it into a *multidimensional lens* and a *design manifesto* as a means to facilitate future sustainable Internet connected device design. My research encapsulates my interest in the relationship between sustainability, industrial product design and emerging digital technologies. This interest was first piqued while I completed my Master of Arts (MA) in Product Design at the University of Salford, UK in 2009/10. For my final major project, I designed a range of home energy monitoring products which incorporated radio-frequency identification (RFID) and Wi-Fi technologies. It was also through MA course modules such as 'Research Methods' that I started to become aware of the significance, albeit rather crudely, of the interdependence between *design praxis* and *design theory*. Upon joining the *HighWire Centre for Doctoral Training* at Lancaster University, UK in October 2013, I felt quite sure that I wanted to continue to pursue the foci of my MA major project as my PhD topic. Funded by the *Engineering & Physical Sciences Research Council* (EPSRC), HighWire's research remit is *digital innovation* and, as such, the centre is orientated around three core disciplines – design, computer science and management. HighWire characterises the output of this confluence of disciplines as 'post-disciplinary' research. Its doctoral programme is '1 + 3' meaning students must pass a 1-year taught Master of Research (MRes) before commencing their PhD studies. It has been customary for students to arrive 'pre-schooled' in one of the principal disciplines, in my case *design*. The MRes year is subsequently considered to be a 'period of training' where students 'learn' to traverse two or even all three of the core disciplines with the aim of evolving into a *post-disciplinary researcher* by the beginning of their PhD.

Purposely disruptive with the intention of being 'transformative', I found HighWire's post-disciplinary culture difficult to navigate at first and the MRes was quite a demanding year for me. Looking back, I now see that the course was successful in as much as it helped me to gain a greater understanding of what I did, *and did not*, want to research for my PhD and the possible approach I might take. My MRes major project involved collaborating closely with my HighWire colleague, Becca Taylor, and revolved around the design of public green spaces in Manchester, UK. The work had a strong environmental focus, yet, despite both Becca and I having backgrounds in design praxis, the project incorporated very little 'design' on our part. It focussed more on design management techniques and the curation of artefacts created by citizens who live and work in and around the city centre of Manchester. Our analysis also took a mostly positivist stance which was a consequence of the quantitative data we collated from participants and the way in which we chose to analyse it. I enjoyed the collaborative nature of the project and felt our approach suited its subject matter and themes. I was also satisfied with its outcomes which included a trip to the *Urban Interaction Design Symposium 2014* in Venice to present an academic poster. Nevertheless, upon the project's completion, I was resolved to place design praxis at the heart of my PhD as opposed to observing and interpreting other people 'carrying out design'. In short, the MRes major project provided confirmation that to personally express my thinking and ideas through design practice, in some form or other, needed be a core constituent of my PhD methodology.

Thus, as my MRes came to an end and my PhD journey commenced, I returned to the theme of sustainable design practice. I was also particularly intrigued by both the hyperbole and possibilities surrounding the so-called *Internet of Things* (IoT) and how this evolving paradigm could act as a catalyst for new, innovative forms of product design. The first 8 or so months of the PhD were quite challenging, not in regards work ethic or discipline, but because upon reading a wider variety of literature, my assumptions of what I thought sustainable design *was* or *is* began to be contested. Finding it difficult to situate my ideological stance in line with the dominant rhetoric of sustainable design literature, I also kept returning the question of *how I can design physical products when said products are a significant cause of environmental unsustainability?* Whilst in hindsight I view this as a profoundly positive process that helped shape the trajectory of my PhD, at the time such *ideological versus pragmatic* tension proved incredibly trying and to a degree *petrifying*, in the sense that I felt, for want of a better word, 'paralysed'. I did not know how to move my thinking on nor my intended practice forwards. Other MRes projects had touched upon topics including *design values* and *Design for Behaviour Change*. In a bid to get things moving, I considered the latter seriously with the view to focussing on *direct action* behaviour change methods framed around the design and implementation of 'interventionist' persuasive connected devices. Ultimately, I decided this would be too similar in scope to my MA final project work.

Through discussions with my supervisor Professor Paul Coulton, I began to better manage my internal tensions and see opportunities for a more creative type of design research. With Paul's encouragement, I connected with the notion of *spimes*. As the thesis will make clear, Sterling's spimes concept is one of few to make definite links between sustainability, product design and digital technologies. Given growing IoT device electronic-waste and material scarcity issues, the thesis argues that using spimes as a lens is an extremely effective approach to addressing the current lack of consideration of sustainability in the IoT. With this renewed focus, my confidence was bolstered, and I started writing and, perhaps most importantly for me, *started to design to serve as the basis for my writing*. I soon discovered that this practice-led[1] approach – or should I say interdependence between *design praxis* and *design theory* – is consistent with *Research through Design* (RtD) methodology. Speculative Design methods had also been much discussed throughout the MRes year, particularly in reference to *Critical Design* and that field's progenitors Anthony Dunne and Fiona Raby. Paul and various colleagues including Joe Lindley at ImaginationLancaster, Lancaster University's design research lab, were beginning to explore an alternate, emerging corollary of Speculative Design called *Design Fiction*. Future orientated and technology focussed, the origins of Design Fiction (although fine-drawn) can be traced to the same text from which spimes originate, Sterling's *Shaping Things*. I see it as fitting then that I chose to conduct research into the spimes concept using Design Fiction methods.

[1] The term *practice-led* design research is often used interchangeably with other terminology such as *practice-based*, *practice-centred* (Saikaly, 2005) and *constructive design research* (Koskinen et al, 2011). Rust, Mottram & Till (2007), in their review of design research for the UK Art and Humanities Research Council (AHRC), use the term *practice-led* to denote integrative research approaches that incorporate design practice as an instrumental element of the research inquiry. Accordingly, to ensure consistency, I will use the term *practice-led* throughout my thesis when refering to my doctoral research.

Could the body of research contained in this thesis be described as 'post-disciplinary' as is the creedo of the HighWire doctoral training centre? In respect to disciplinary lines, my research is very much rooted in design. However, whilst my background *is* design, I would argue that this ambit was not a conscious decision but an organic process. Despite the difficulties I experienced acquiescing to HighWire's ethos during the MRes programme, I was very much open to the idea of pursuing a PhD that would sinuously traverse both design and computing. While I might not have achieved this fluidity (and for this *I do not* apologise), the IoT and digital technologies are prominent components of my research on spimes. Accordingly, my thesis frames my work in relation computing literature, most notably through engagements with *Ubiquitous Computing* and *Human-Computer Interaction* (HCI) research.

1.2 Thesis Structure

To provide the reader with an overview of how my research explored and developed the concept of spimes into both a *multidimensional lens* and a *design manifesto* with the aim of facilitating future sustainable Internet connected device design, in this section I present short summaries of each chapter of my thesis.

1.2.1 Chapter 2: Literature Review

The main objective of my literature review is to situate and contextualise the thesis's contribution – generalisable knowledge regards the design implications of spimes – in relation to pre-existing design theory and praxis. My review explores three core 'domains' – *Sustainable Product Design*, the *Internet of Things* (IoT) and *Design Futures*. To provide additional rigour, each domain is composed of four specific sub-domains. In essence, the literature review provides the 'knowledge base' upon which I am able to begin to conduct my research into the spimes concept.

1.2.2 Chapter 3: Synthesis

Through synthesis of my literature review, I am able to identify six gaps regards contemporary unsustainable internet-connected device design that I argue require further research. In order to explore these gaps, I contend that taking a 'bottom up' approach and specifically focusing on the sustainability of Internet-connected devices is more effective than attempting research the dense and complex issue of sustainability from a 'top down' perspective. As such, I identify Bruce Sterling's concept of spimes as a provocative counter to the prevailing utopian-like rhetoric of the IoT and thus designate it to be the prime focus of my ensuing practice-led design research.

1.2.3 Chapter 4: Spimes: An Introduction

I introduce Sterling's spimes concept in detail, discussing its origins and contextualising its early discourse in relation to the unsustainability of the IoT and sustainable design practice. To move the discussion forward, I formulate and conceptualise three key questions which I intend to explore through my spime-orientated practice-led design research.

1.2.4 Chapter 5: Research Methodology

The methodology I chose to employ is *Research through Design* (RtD). Despite increasing numbers of RtD based research being produced in recent years, there remains no definitive stance on how to pursue it in a methodological capacity. As a result, I present various viewpoints on the methodological aims of RtD, beginning with Frayling's original definition. From this, I put forth my own interpretation of RtD which is characterised by a generative and exploratory reciprocal relationship between practice and reflection. Through this approach, I aim to produce design outputs that embody theory and meaning regards spimes. I explain how this process is underpinned by my *Interpretivist* ontological and epistemic position, whereby I construct knowledge (*Constructivism/Constructionism*) through *reflective making*.

I identify *Design Fiction* as my principal research method, and accordingly discuss its pragmatics and strong relationship to RtD methodology, particularly in terms of its ontological and epistemological intent. Because *Design Fiction* is an emergent method, it is still evolving. I therefore discuss the commonalities and differences that currently exist across the field. I define which particular tenets of the method I have applied within my doctoral research, namely *diegetic prototyping* and *Design Fiction as World Building*, as well as how these approaches are advantageous to my exploration of the spimes concept.

1.2.5 Chapter 6: Unpacking the Spimes Concept

To root my practice-led spime design work, I decided to first unpack the spimes concept in greater depth in relation to sustainable and technological discourse. Through this analysis, I was able to elicit *six classifying design criteria for spime objects*. Having outlined each criteria, I argue that they provide a theoretical base from which I was able begin to designing spime objects specifically using *Design Fiction* as a means to explore the concept's potential sustainable, societal and technological implications.

1.2.6 Chapter 7: Spime Design Fiction Case Studies

This section is what might traditionally be termed the 'data chapters' of my thesis. Here I discuss in detail my practice-led design research, which takes the form of three spime *Design Fiction* case studies. To give credence to my argument that the design culture of the IoT is inherently unsustainable, each study explores different *key classifying design criteria* for spime objects as identified in the preceding chapter, whilst also highlighting the possible broader implications of adopting such designs:

- The *Toaster for Life* study explores the *sustainability*, *technology* and *temporality* criteria as a means to examine how spimes could affect connected product business models and user behaviour.

- *HealthBand* explores the *synchronicity* and *wrangling* criteria as a means to examine how spimes might impact product design policy through the democratisation of design-innovation practices.

- *The Future Is Metahistory* explores the *metahistory* criteria as a means to examine what the implications of spimes are for digital ethics and data ownership.

1.2.7 Chapter 8: Contributions

In this chapter, I present the main contributions that my doctoral research makes to academic knowledge and praxis. I conceptualise these contributions as generalisable theory in the following three forms:

- *Spime-based Design Fiction Practice Space* – I demonstrate how a near future spime object's design would be defined by three core parameters – the physical (atoms), digital (bits) and sustainability (natural environment) – all three parameters being of equal importance within the spime design process. The confluence of these design parameters results in what I term the *Spime-based Design Fiction Practice Space*.

- *Spimes As A Multidimensional Lens* – By reflecting upon the three practice-led case studies, I outline how I was also able to elicit three research lenses for exploring sustainable connected device design. Collectively, these sub-lenses generate the macro *Spimes As A Multidimensional Lens*. I explain how design researchers and practitioners can harness the multidimensional lens as means through which to begin to consider new ways to reframe their connected product design practice with environmental sustainability firmly in mind.

- *Spimes Not things: A Design Manifesto for A Sustainable Internet of Things* – I outline why manifestos are an effective way to convey design theory and praxis, particularly in technological contexts. I discuss how I created my spimes manifesto and how it differs from other efforts, principally because it includes examples of design practice. Crucially, I argue that the manifesto compliments the multidimensional lens as it conveys the complex themes and ideas that characterise my doctoral research in a manner that broader, non-academic audiences might more easily engage with should the manifesto be presented to them post-thesis.

1.2.8 Chapter 9: Conclusions

I return to the three key questions that I formulated through the synthesis of my literature review. Reflecting upon my body of practice-led research, I conclude how my work has, as practically is possible, 'answered' these questions.

1.2.9 Chapter 10: Future Work

I view my doctoral research as only the first step within a larger body of work which explores the potential advantages, and indeed disadvantages, of designing the necessary transition from today's unsustainable IoT design culture into a future sustainable connected product paradigm. Thus, in this final chapter, I outline how my spime-orientated research might be built upon and developed further in the future, namely through additional *case studies* and *discursive workshops*, as well as the possible impact and value of my thesis' contributions for *design policy and legislation*.

2 Literature Review

2.1 Introduction

The term *spime* was originally coined by Bruce Sterling in 2004. Sterling first outlined the concept at the SIGGRAPH conference during a presentation entitled ‘When Blobjects Rule The Earth’ (Sterling, 2004a) and then in a short opinion piece for the technology magazine *Wired* entitled *Dumbing Down Smart Objects*. In the article, Sterling argued that ‘modern products are advanced, but nowhere near advanced enough to sustain civilised life in the long run’ (Sterling, 2004b). He viewed digital technologies as having the potential to lay bare ‘the reality that underlies all manufactured objects. [This would lead to a paradigm where] manufactured items will be more practical, efficient, and user- and environment-friendly’ (Sterling, 2004b). Sterling (2005) augmented the spimes concept further the following year in his book *Shaping Things* where he describes spimes as potentially being ‘material instantiations of an immaterial system… they are designed on screens, fabricated by digital means and precisely tracked through space and time throughout their earthly sojourn. *Spime* is a contraction of the words *space* and *time*. In *Shaping Things*, Sterling also more explicitly outlined spimes’ inherent environmental credentials, envisioning them to be ‘sustainable, enhanceable, uniquely identifiable, and made of substances that can and will be folded back into the production of future spimes.’ To aid understanding and contextualise the concept in relation to my literature review, I have developed a ‘working definition’ of the term spimes:

> *‘Spimes’ denotes a class of near future, sustainable, Internet-connected manufactured objects, which, unlike the disposable IoT products which permeate our society today, would be designed so that they can be managed sustainably throughout their entire lifecycle. This would have the goal of making the implicit consequences of product obsolescence and unsustainable disposal explicit to potential users.*

Although the above serves as a useful, initial definition, I will discuss Sterling’s original vision in greater depth in Chapter 4 and then begin to unpack, augment and redefine the meaning of spimes from Chapter 6 onwards. As such, my thesis will develop the concept into a more robust and meaningful counterpoint to today’s unsustainable IoT paradigm. The main objective of my literature review is to situate and contextualise my practice-led spimes research in relation to pre-existing design theory and praxis. To this end, my literature review serves as a prelude to my own work, providing a platform of scholarly opinion which I have sought to both interrogate, and build upon, in order to develop my original line of doctoral enquiry regarding spimes.

An issue which is no doubt commonly experienced by all those writing a doctoral thesis is the conundrum of just what to cover within the literature review and what not to include within it. *Design*, *technology*, *sustainability* and *futures* are each, in themselves, vast and diverse fields of study and thus provide a broad canvas upon which to conduct research. To avoid an exhaustive, laborious and sprawling review which entails a plethora of potentially interesting yet tangential topics, I have proactively sought to keep this chapter readable, meaningful and succinct. My review therefore only surveys ideas and knowledge that I believe are specifically relevant to my main line of enquiry – developing the concept of spimes into a *multidimensional lens* and a *design manifesto* with the aim of facilitating future sustainable Internet connected device design. For example, I do not take great lengths to explain terminology or areas of study such as 'climate change', 'global warning' or 'carbon emissions', for while these are the intrinsic to the broader sustainability debate, they are somewhat peripheral to the primary aim of my thesis.

I have chosen to structure my review thematically into three principal domains: *Sustainable Product Design*, *the Internet of Things* and *Design Futures*. Each of one these is composed of four sub-domains which help to provide a thorough grounding for the principal domain. Crucially, the domains should not be viewed as wholly disparate and distinct, rather, they are synergetic. To illustrate the fluidity of this relationship, I have produced Figure 1 which shows how the three domains 'build' my literature review, which, in turn, provides what I term a *knowledge base* upon which I was able to begin to conduct my doctoral research into sustainability, spimes and the IoT.

As outlined in my Introduction, the interdependence of design theory and design praxis is fundamental to my thesis and as a result, both are discussed concurrently in relation to the subject at hand throughout my literature review. Crouch and Pearce (2013) make explicit links between *thinking* and *doing* in design research. They contend that designer-researchers should embrace this duality and acknowledge that design is more than merely a 'material practice' and involves engaging with philosophical arguments as well as considering its sociological implications, as much as it is concerned with practicable outputs. In recognising this, designer-researchers can begin to gain better understanding of the best methodologies and methods through which to plan and carry out their research. This duality of theory and praxis means that I have not only referenced 'conventional' academic secondary texts but also a wider range of sources including some from across the commercial design sector as well as from public agencies and initiatives. I believe this broader analysis reinforces the socio-technical scope of my thesis.

Theoretical perspectives relating to methodologies and methods are only briefly touched upon in my review where and when I consider them to be purposeful and relevant. Moreover, those that specifically pertain to my thesis contribution and epistemic stance with regards to spimes – principally *Research through Design* (RtD) and *Design Fiction* – are more robustly defined, dissected and developed upon in succeeding chapters. As I will explain in greater detail in said later chapters, the *exploratory*, *generative* and *reflexive* nature of RtD methodology means critical insights and knowledge construction in relation to spimes were revealed throughout my practice-led design research process, that is, specifically while I carried out my three spime Design Fiction case studies. Thus, I consider it good sense to introduce both RtD and Design Fiction in standalone chapters. Further to this, I provide additional germane discussion in regard to literature, context and reflection throughout my spime case studies as and when I consider it meaningful.

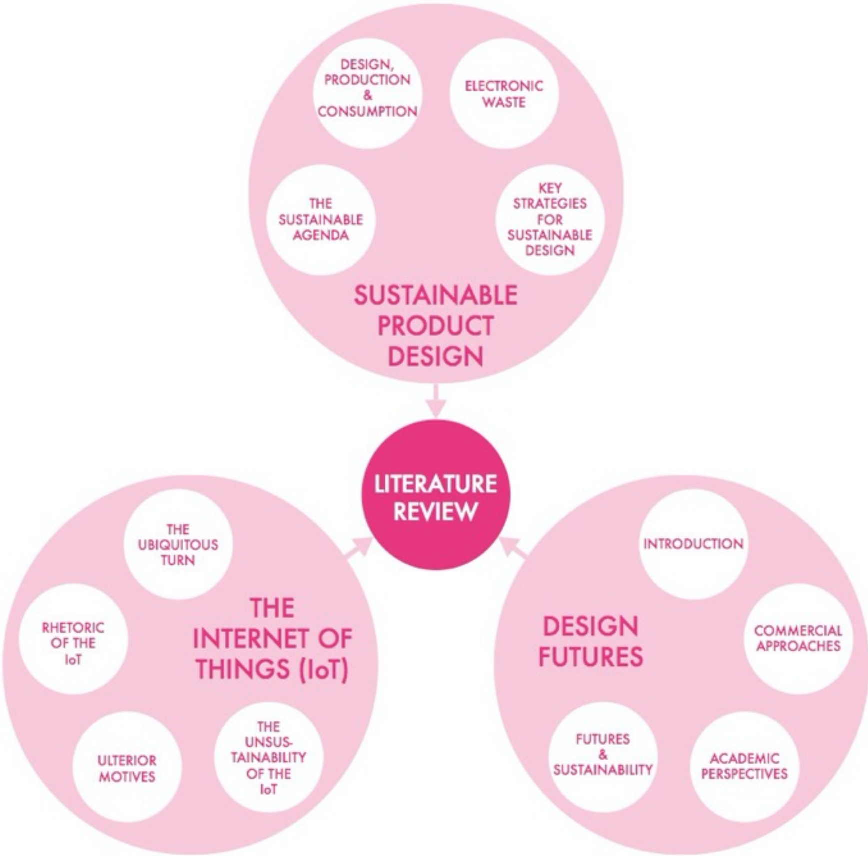


Figure 1: Three principal domains of theory and praxis are discussed in my literature review. Each is composed of four sub-domains. The principal domains 'build' my review, providing the *knowledge base* from which I was able to begin to conduct my doctoral research into sustainability, spimes and the IoT. Source: Author.

2.2 Sustainable Product Design

2.2.1 The Sustainable Agenda

The notion that environmental sustainability is inextricably linked to economic prosperity is often said to have originated within the *Our Common Future* report, also commonly referred to as the *Brundtland Report*, which was published in 1987 by the *World Commission on Environment & Development (*WCED). Indeed, when making the case that environmental, social and economic processes are fundamentally interconnected, the report contains a lasting definition of the term 'sustainability'. It describes *sustainable development* as meaning more than merely environmental protection; it argues that it is in fact the goal of reducing environmental and resource consumption while maintaining economic efficiency and social cohesion. This approach to 'sustainability' concludes the report, is the best method for satisfying future societal material and immaterial needs. That 'environment', 'society' and 'economy' should not be considered in isolation but collectively, was further popularised at the *1992 Earth Summit* in Rio de Janeiro (UN Department of Economic & Social Affairs: Division for Sustainable Development, 1992) and later by Elkington (1997) through his *Triple Bottom Line* (TBL) model. The latter in particular helped cement an accepted view of sustainability within the business sector and commercial industries. Elkington contended that while firms normally try to balance one bottom line – the economics of profit and loss – they should actually be pursuing three simultaneously – *economic prosperity*, *social equity* and *environmental* quality. He argues that only companies which adopt TBL thinking are taking the true cost of their business operations into account. Furthermore, organisations that fail to embrace TBL values are in danger of being usurped by more dynamic and ecologically minded competitors.

Even before the *Brundtland Report*, others were deeply concerned about the long-term impacts of economic and population growth upon the environment. In 1972, Meadows et al published *The Limits To Growth* in which they documented their use of computer simulations to extrapolate economic, population and productivity data. The purpose of the report was not to make specific predictions but to posit potential near-futures and provoke debate around wanton growth and finite resource depletion. The report was highly contentious at the time, as two of the three simulations suggested almost dystopian environmental repercussions, and, as such, challenged the mainstream consensus that economic growth equates to a better world. More recently, Jackson (2009) has been highly critical of western societies obsequiousness to capital logic driven by the use of limited resources to maintain unlimited consumption. He argues that a future without exponential growth '*is no longer a utopian dream* [but] *an ecological necessity*.'

The lack of consensus on the effectiveness of the relationship between economic growth and environmental sustainability in many ways continues to dominate sustainability discourse (Ayres, 2014). That said, it is widely recognized that, in the 30 or more years since the *Brundtland Report* was published, the threat to Earth's sustainability has profoundly intensified (Burns & Witozek, 2012). Overpopulation, mass consumption, material scarcity and unprecedented waste; the sustainable dilemma today is vast, incredibly complex and oftentimes intangible (Ehrenfeld & Hoffman, 2013). Tellingly, the task of returning Earth to a sustainable equilibrium is now regularly characterised as a 'wicked problem' (Rittel & Webber, 1973) meaning that environmentally unsustainable infrastructures, systems and lifestyles have now become so entrenched throughout modern societies that they are yet to be countered (Howes et al, 2017). In the same vein, the phrase 'wicked problem' has also been used to describe both the eradication of world poverty and infectious disease. These two issues alongside environmental sustainability were all decreed *Millennium Development Goals* by UNESCO. With a target 'elimination date' of 2015, other goals included universal education and gender equality. As of August 2019, none of the goals have been achieved (UNESCO, 2019).

As my brief synopsis attests, the discourse surrounding environmental sustainability is vital but also dense and multi-layered. Framing sustainability as a research topic can therefore easily become protracted and extraneous. To ensure my review remains relevant to my thesis contribution, in the following section, I will begin to outline how design – specifically *industrial product design* – has been one of environmental sustainability's leading antagonists for many decades.

2.2.2 Design, Production and Consumption

Environmental problems like energy wastage, rising carbon emissions and expanding landfills have been shown to be a direct consequence of the excessive and consumeristic lifestyles within modern societies (Fry, 2009). In the decades following the *Industrial Revolution* (1760-

1840), the socio-economist Thorstein Veblen (1899) coined the term *conspicuous consumption* to describe the way people purchase materialistic goods as a means to experience superficial gratification and/or amplify their social status. Walker (2011) argues that the rise of this frivolous, individualistic culture coincided with the emergence of the philosophical movement *modernity* during the *Age of Enlightenment* (1715-1789). Such intellectual shifts saw *scientific pragmatism* and new ideals including *liberty*, *constitutional government* and *technological progress* begin to usurp ancient traditions like *absolute monarchy*, *religious orthodoxy* and *heritage crafts*. In Western societies in particular, the implications of *modernity* are said to have truly took hold after the end of the Second World War (1939-1945). This is primarily because, in the years following the war, the industries of design, technology and manufacturing pioneered *mass production*, *planned obsolescence* and *product iteration strategies* as means to persistently increase profits and market share. When coupled with population growth, aging societies and *conspicuous consumption*, these ruinous factors have had a profoundly negative effect on environmental sustainability for the best part of 75 years (Chapman, 2005; Shedroff, 2009).

Packard (1967) was one of the first to attribute peoples' growing propensity to over-consume to designers' use of *planned obsolescence*. *Obsolescence of function* is where a product is designed to purposely fail to significantly shorten its lifespan, while *obsolescence of desirability* is how advertising and fashion trends are used to 'psychologically outmode' existing products. Packard reasoned that whilst obsolescence profits industry, it nurtures excess, waste and dissatisfaction amongst consumers who feel pressured to continually have more and better. Papanek (1971) was another key early thinker who urged product designers to take greater moral responsibility for their work. He advocated practical solutions to societal problems as opposed to a focus on product aesthetics and the creation of superfluous gadgetry which help cause ecological degradation. Designers have thus been a driving force in the development of modern unsustainable material cultures. Yet, in spite of prominent voices like Papanek calling for them evolve their practices, 20th century models of industrial product design, production and consumption continue to endure into the 21st century. With regard to altering perceptions and values across the field of industrial product design and innovation, Fuad-Luke (2009) questions just how effective approaches to tackling unsustainability across design practice have really been. He insists that the impact has been minimal, with the ongoing pursuit of economic growth alongside increasing populations negating any real environmental gains made by designers and the adoption of their products.

Whereas the materialistic tenets of *modernity* are considered to have held firm throughout its tenure from the 1700s into the 1990s, it is envisaged that *postmodernity* will be a 'state of flux', likely characterised by periods of uncertainty and change (Lyotard, 1984). As we move forward into this new era, issues like the environment, ethical consumption and social equity are said to be becoming important parts of the contemporary *collective consciousness* (Durkheim, 1984; Ethical Consumer, 2018). Yet, many argue that the harmful and unsustainable traits of *modernity* still dominate today. As Thackara (1988) stresses, materialism, capitalism and environmental destruction remain the political, economic and technological status quo across Western societies. The latter concern is of key interest to my design research. It has been shown that the march of technological progress has helped industrial product design become an increasingly unsustainable practice. Advances in computing and electronics means that most modern consumer products are inherently 'technological' in nature. And because technology advances at such a high rate, many of these products are outmoded and deemed 'redundant' after only a few short years of life (Slade 2007). This technological dependence, in collusion with mass production, has led to what are termed 'throwaway societies' (Cooper, 2010), where, for the majority of people, product obsolescence and conspicuous consumption are an accepted and normalised aspect of everyday contemporary life. Accordingly, I will next outline the deleterious design attributes of such technological devices as well as the environmental and social consequences of this unsustainable, disposable electronic product culture.

2.2.3 Electronic Waste

Technological progress is resulting in more and more manufactured products reaching consumer markets that have electronics incorporated into their design at an elemental level. The term *electronic waste*, or *e-waste*, is used to describe such products at the point which they are no longer wanted, cease to operate correctly or are obsolete due to the availability of newer iterations which are considered to possess 'better' functionality. Many contend e-waste has become a global epidemic, albeit an overlooked one (Slade, 2007; Ogunseitan et al, 2009). To provide a sense of scale of the issue, in the UK alone, over 2 million tonnes of e-waste was generated by households and companies in 2018. Moreover, an average UK citizen buys three new electronic products every year – equating to 170 million devices nationally – and, as such, is estimated to personally create 3.3 tonnes of waste electronics during their lifetime (GOV.UK, 2018b; HSE, 2019; RecycleNow, 2019).

The ecological implications of the mass disposal of electronic devices is profound. E-waste devices are composed of a complex mix of parts and materials, many of which are valuable such as ferrous, non-ferrous and precious metals including iron, steel, gold, platinum and palladium. Such metals could potentially be used in the design and manufacture of new devices and for other applications. However, in the UK, only 35% of e-waste items are currently recycled, with the remaining 65% sent to landfill sites, either domestically or abroad (RecycleNow, 2019). To compound this, a 2011 study found that 23% of electronics that reach landfill could be actually re-used with a small amount of repair (WRAP, 2011). These statistics do much to highlight that the majority of products classed as e-waste are not yet designed to be disposed of in an environmentally sustainable manner. Their useful components are currently very difficult to harvest, recycle and repurpose. Moreover, e-waste contains copious amounts of potentially hazardous materials such as lead, arsenic, cadmium, mercury, beryllium and bromine. These devices are also manufactured from a wide variety of non-reusable polymer-based substances including epoxy resins, fiberglass, PVC and thermosetting plastics (Greenpeace, 2014). Once at landfill, this raft of toxic materials can potentially contaminate soil, water and air supplies endangering wildlife and destroying flora in the process (McLellan, 2013; HSE, 2019; RecycleNow, 2019).

The detrimental effects of e-waste upon human health should also be not be underestimated. Exponential increases in this type of waste is having an adverse impact on citizens in developing countries in particular. Unsafe exposure to hazardous materials through environmental contamination, and 'informal e-waste processing' operations at landfills, in countries such as Hong Kong, Pakistan, India, Bangladesh and Vietnam (Lane, 2016; Cashin, 2017), has been shown to pose significant health risks to local workers and their broader communities (Noel-Brune et al, 2013). Critically, as Perkins et al (2014) state, people in Western societies are able to benefit from electronic products during their 'use phase', yet more often than not, it is people of distant lands and their communities who must suffer the damaging, long-term consequences once said devices are unceremoniously discarded. E-waste is therefore a direct and growing consequence of affluent societies' increasingly materialistic and technologically dependent lifestyles (Chapman, 2005; 2008).

The exploitation of precious metals and minerals for the manufacturing of electronic devices has resulted in an adjoining crisis – *material scarcity* (Graedel et al, 2013). That the majority of e-waste cannot be recycled or re-purposed only exacerbates this issue. Unsustainable product design practices are leading to shortages of critical raw materials (CRMs) (European Comission, 2017a). Seeking to combat the coactive problems of e-waste and material scarcity, the UK Government introduced their Waste Electrical and Electronic Equipment (WEEE) directive in 2007 (GOV.UK, 2018b; HSE, 2019),). The directive was drawn up with the aim of significantly reducing the amount of e-waste reaching landfill, improving recovery of recyclable materials and componentry, and increasing rates of product repair and reuse (GOV.UK, 2018b; HSE, 2019). Successful implementation was always reliant on proactive adoption and cooperation between product designers, manufacturers and retailers, as well as greater awareness amongst consumers (WRAP, 2019). Thus, while seen as a positive initiative, the efficacy and impact of the directive has long been called into question (Mayers et al, 2011; Cole et al, 2019). In the decade since WEEE was established, levels of e-waste have continued to increase substantially, while material scarcity has become an ever more pressing concern (Cole et al, 2019). This is despite the UK Government extending their directive in both 2013 and 2019 to account for new, previously uncategorized electronic devices (HSE, 2019), and regulations similar to WEEE being adopted by all other EU member states (EC.EUROPA.EU, 2019).

Next I will discuss some of the key sustainable approaches that if adopted by designers and manufacturers are deemed to have the potential to minimise the harmful environmental effects of industrial product design practices.

2.2.4 Key Strategies for Sustainable Product Design

As I cannot practicably and justly outline each and every approach to sustainable product design, in the following paragraphs I provide an overview of the principal sustainable design thinkers and strategies that have underpinned my ensuing research into the relationship between sustainability, spimes and the IoT.

When describing the concept of *Green Design*, Mackenzie (1991) argues it is designers who have the greatest impact on product sustainability as they have the power to make the critical decisions from '*choice of materials* [to] *how effectively it uses energy.*' Fuad-Luke (2007) concurs that while is it designers and innovators who are able to make real sustainable impact, they must strive to create new outcomes, embue artefacts with fresh affordances and encourage user behavioural change. Lofthouse and Bharma (2001a; 2001b) believe that *Eco-design* practice is an effective approach that designers can harness to consider the sustainability of a product's entire lifecycle. Birkeland (2002) similarly seeks to incorporate a more holistic environmental ethos into design activity, proposing a framework which she terms *Design for Sustainability*. It consists of nine benchmarks, ranging from the efficiency of materials and energy use, to the importance of synergic and systemic thinking.

Design for Disassembly (Chiodo, 2005), *Design for Recycling* (Gaustad, Olivetti & Kirchain, 2010) and *Design for Remanufacture* (Hatcher, Ijomah & Windmill, 2011) are related strategies which centre on product *modularisation*. Mass manufactured consumer products commonly make use of glues, screws, hidden seals and irreplaceable parts. Resultantly, they are difficult to disassemble and recycle efficiently when they reach the end of their useful life.

Currently, 90% of consumer products reach landfill in their whole form (Parliament.UK, 2019). In contrast, a *modular product* would be designed with flexible assemblies, accessible parts and easy component separation in a bid to afford more effective product repair and recycling. Greenpeace (2014) argue that, as well as extending a product's use phase and increasing recycling behaviour, design methods like this can also reduce use of materials, energy, packaging and distribution emissions. Nevertheless, strategies such as *Design for Disassembly* are still rarely embraced by industry and there are few examples in practice. While ethical manufacturer *Fairphone* (2015) brought two modular smart phones to market, highly publicised projects like the *Google Ara* phone (2015) and *PhoneBloks* (2015) have never moved past the prototyping stage.

Life-cycle Assessment (LCA) is a technique that designers can use to holistically evaluate the environmental impacts of a product's existence (Shedroff, 2009). During an LCA, input and output metrics are generated for each stage of a device's lifespan – from material extraction, manufacture and use, through to repair and disposal. This data is used by designers and manufacturers to inform sustainable decision making, improve design processes, and to support and revise product standards and policy (UNEP, 2009). LCAs traditionally take two forms – an *Attributional LCA* is where the assessment is made *before* a product is put into production, while a *Consequential LCA*, as the name suggests, is carried out *after* a device has reached the end of its life (Weidema et al, 2018).

Braungart & McDonough (2008) assert that traditional notions of 'reduce, reuse & recycle' are fundamentally ineffective. For them, cutting-edge material science is the key to sufficient management of manufactured product waste. They argue that a device should be designed so that it can easily be separated at the end of its life into *biological nutrients* – natural, biodegradable components – and *technical nutrients* – materials that retain their quality and capabilities. This *Cradle to Cradle* model limits valuable materials becoming degraded, contaminated or lost to landfill.

Whereas the above methods and practices primarily focus on either the product or the relationships that the product affords, the notion of a *circular economy* seeks to emphasise the wider implications of sustainable production and consumption. The term *circular economy* describes a socio-technical system which seeks to minimise the use of key inputs like materials and energy, as well as reduce core outputs including harmful waste and carbon emissions. Proponents contend that this can be achieved through 'closed loops' – where inputted resources are continually preserved and re-appropriated within the production cycle. Such thinking, it is argued, would manifest in longer-lasting products which afford better means for repair, reuse and recycling (Webster, 2015). The systemic nature of the *circular economy* approach contrasts with a *linear economy* which promotes highly unsustainable 'take, make and dispose' modes of production and consumption. Most contemporary societies currently adhere to the latter. Those in favour of adopting a *circular economy* believe that it would not impact peoples' quality of life, nor would it lead to a major loss of revenues for industry. It would however require a substantial reframing of design practices, production processes and business models. Advocates believe that new business opportunities and environmental resilience can both be achieved by improving material security prior to product manufacture and increasing component recycling and reuse upon product disposal (Weetman, 2016).

As has been demonstrated, manufactured devices that are environmentally sympathetic has been a core objective within product design theory and praxis for many decades. Crucially however, recent years have witnessed great advancements in computing and digital technology.

As I will discuss, this has begun to challenge the notions of what products are and what they are used for, as well as the implications for designing them, particularly with regards to sustainability.

2.3 The Internet of Things

2.3.1 The Ubiquitous Turn

Widespread adoption of digital technologies and the Internet over the last 20 or so years has resulted in a fundamental shift. Societies have moved from primarily designing, manufacturing and consuming 'purely' physical objects to embracing a dense network of *physical-digital* product-services (Anderson, 2012). Whereas 'traditional' manufactured electronic products of the pre-digital age were, for the most part, 'inanimate' and 'self-contained', today's consumer devices are increasingly becoming *computerised* and *networked*. The term the *Internet of Things* (IoT) was first coined by Kevin Ashton (2009) in 1999 to describe the idea that any, and potentially every material artefact, could be connected to the Internet. Figure 2 shows examples of Internet-connected physical devices that typically characterise the IoT. Most have garnered widespread adoption amongst consumers. The bottom right image depicts a Google 'driverless car'. Although research and development of connected transport is still ongoing and such products are yet to reach end-users through mainstream markets, 'autonomous vehicles' operated remotely via computer algorithms are considered a bastion of the IoT vision, that is, this type of potential connected product is seen an archetype of what the IoT could be in the future, in other words, what the paradigm *represents* in terms of technological innovation and progress (Hedge, 2017; Saribardak, 2018).

Figure 2: Above are examples of devices that typically characterise the IoT. Most have garnered mainstream adoption amongst consumers. Source: clockwise from top left - www.amazon.com, www.fitbit.com, www.philips.com, www.amazon.com, www.dji.com, www.google.com. Image is unavailable due to copyright restrictions.

The IoT concept is seen as a corollary of Mark Weiser's notion of *Ubiquitous Computing* (Madakam, Ramaswamy & Tripathi, 2015). This vision is outlined succinctly by Weiser in his landmark paper *The Computer for the 21st Century*:

> *Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives* (Weiser, 1991).

Weiser (1996) put forward a set of principles for *Ubiquitous Computing*, among them, 'the best computer is a quiet, invisible servant' and that 'technology should be calm.' In expanding the latter principle, Weiser & Seely Brown (1995), envisioned a future world where widely dispersed computation *informs users but does not demand their complete attention*. In their mind, a paradigm characterised by such ubiquitous *calm technology* would be built on three basic classes of devices: *Tabs* (wearable centimetre sized devices); *Pads* (hand-held decimetre-sized devices); and *Boards* (metre sized interactive display devices). Weiser posits that users would likely interact with these devices via visual output displays (Weiser, 1991).

In 1965, Gordon Moore, the co-founder of the technology giant *Intel*, 'predicted' that, for the foreseeable future, the number of transistors on a microchip would continue to double every 1-2 years, while at the same time, the cost of computers (and latterly, devices with embedded computation) would consistently be halved (Moore, 1965; 1975). Deference to this so-called *Moore's Law* throughout the technology industries, and also across academia, has indeed led to regular improvements to the processing power of computer software and hardware. Since the 1960s, the cost and scale of components like resistors and semiconductors have significantly reduced, with global wireless networks and infrastructures becoming almost *ubiquitous*. In light of this profound technological advancement, Dourish & Bell (2011) argue that the rhetoric of *Moore's Law* and *Ubiquitous Computing* have in many ways consolidated to become the dominant ideological stance throughout computing research and industry. In essence, these concepts were a *self-fulfilling prophecy*. Consequently, over the past 30 years, Weiser's vision of a world marked by pervasive computing has steadfastly become a reality (Turkle, 2011; Greenfield, 2017).

Yet, whilst Weiser posited that users, for the most part, would continue to interact with embedded computation via visual displays, the emergence of IoT has put paid to this orthodoxy. The types of objects with innate computational capabilities has in fact evolved beyond conventional screen-based devices such as desktop computers and laptops, through phones and tablets, into a wide variety of 'things' including fridges, vacuum cleaners, wearable fitness trackers, cars and lighting (McEwen & Cassimally, 2013). With their material elements augmented by small, inexpensive componentry, increasing numbers of mundane, everyday objects now exist as robust networked processing devices, or *nodes*. Commonplace products like kettles, televisions and locks, not only perform their traditional 'non-connected' function but they also sense, collect and exchange data (Rowland et al, 2015). Innate Internet connectivity enables such objects to be locatable, readable, addressable, and/or controllable via other computerized devices and digital systems. The visible elements of the IoT – the physical products – work in conjunction with the invisible aspects – expansive digital infrastructures which share peoples' personal data through a plethora of algorithms, 3rd party platforms, data concentrators and server networks (Coulton et al, 2018).

With seemingly innumerable opportunities for new product development, business growth and research, there is much support amongst technological, design and academic circles for continued development of the IoT. Reports state that, globally, there are currently around 27 billion devices with the capability to connect to the IoT. As Figure 3 shows, it is estimated that this number will likely increase to around 75.5 billion by 2025 (Statista, 2018). With this in mind, I will next explore the key narratives that are helping to shape the ongoing expansion of the IoT.

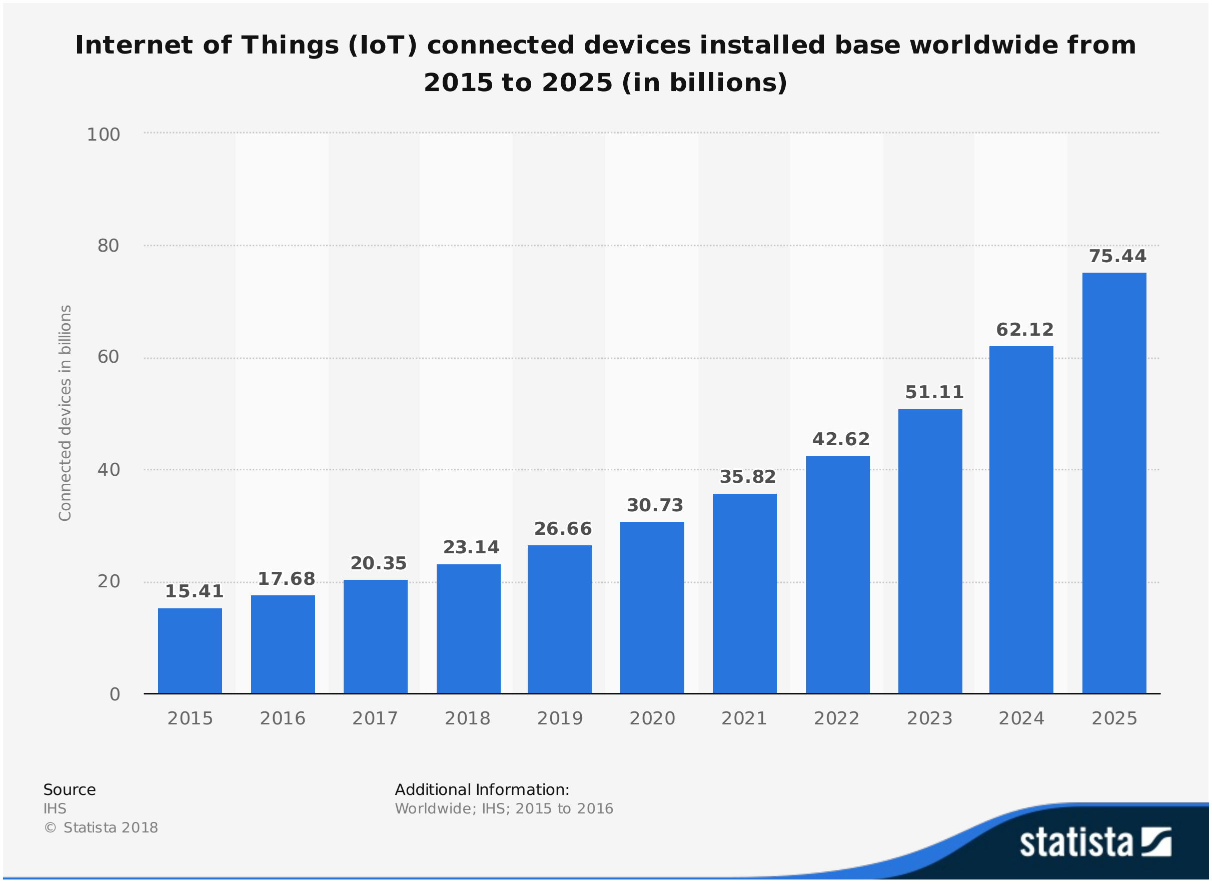


Figure 3: The graph shows that there are around 27 billion IoT connected devices in 2019. This number is estimated to triple to over 75 billion by 2025. Source: https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/

2.3.2 Rhetoric of the IoT

Fritsch, Shklovski & Douglas-Jones (2018) argue that the rhetoric that surrounds the IoT is both persuasive and turgid. Many commentators across industry and academia proclaim that, through its expanding array of networked artefacts, sensors and AI capabilities, the IoT is bringing about an almost utopian change to all sectors of society, from healthcare and energy, through transport and finance, to within the home and entertainment (Manyika et al, 2015; Holler et al, 2014; World Economic Forum, 2019). Branding and advertising play a significant role in perpetuating this idyllic perception of the IoT. Technology corporations such as Intel (2019), Cisco (2019) and Microsoft (2019) sit at the forefront of commercial IoT development. Their websites outline and visualise their respective visions for how the IoT will positively to transform customers' lives over the next 10 - 15 years. As Greenfield (2017) notes, this quixotic framing does much to help the ongoing investment into the design and development of IoT product-services and its broader operational infrastructure. It can also be seen to be echoed in the *Blackett Review* (Government Office for Science, 2014), a prominent report by the UK Government which eulogises the IoT as 'a transformative development [with] the potential to have a greater impact on society than the first digital revolution'. In the year following the report, the government invested £45 million into British IoT infrastructure (BBC, 2014; GOV.UK, 2015; Ofcom.org, 2017).

The notion that digital technologies are resolutely a 'tool for good' that can profoundly improve our world has its roots in a school of thought known as *technological determinism* (Winner, 1977). In simple terms, this is the belief that technologies shape society rather than being a product of it. Resultantly, technologies are considered to be the driving force of culture in a society, and ultimately, determine its course of history (Ellul, 1964). In critiquing the 'dotcom boom' of the early 1990s, Barbrook & Cameron (1995) argue that the rapid expansion and subsequent social hegemony of Internet technologies has its origins in a particular brand of *technological determinism* which was forged in the 1960s amidst a somewhat paradoxical hybridization of left wing counter-culture politics and right wing neo-liberal economics. They term this unified thinking the *Californian Ideology* because the rise of such technologies was primarily orientated in and around the so-called Silicon Valley in California, USA. Like *Ubiquitous Computing* before it, the rhetoric which is used to promote the IoT can in many ways be viewed as a further extension of a type of what Morozov (2013) calls *cyber-evangelism*.

The growing techno-social hegemony of the Internet initially led some to envision a sustainable 'dematerialisation' of many physical products, in other words, a paradigm shift from the production and consumption of material artifacts to predominately digital online services. Appropriating Fuller's (1973) maxim, the Internet's ability to 'do more with less' was celebrated, in that it was envisaged that the use of physical artefacts (and thus material resources) would gradually decline and in effect be 'offset' by the take up of apparent 'immaterial' digital products and services (Thackara, 2005, EPOSS, 2008, Anderson & Rainie, 2014). This theory was in many ways discounted, first by the growth of mobile computing in the form of physical smart phones, and more recently through the emergence of the IoT devices (Barnatt, 2012). Such thinking also neglected to consider that ever greater Internet usage would require major expansion of the digital network, particularly key infrastructure like server farms which are incredibly resource intensive, plus generate huge amounts of heat and carbon emissions (Tarnoff, 2019). Nevertheless, the notion of 'dematerialisation' continues to manifest in resource reduction strategies like 'go paperless' campaigns, the adoption of *e-readers* such as the popular *Amazon Kindle*, and the shift away from 'hard' architecture to 'soft' alternatives like online banking. Despite the realities, Finley (2014) notes how the IoT continues to be framed in a 'green' and environmentally favourable light. To substantiate this, he cites language such as 'environmental sensors can detect pollution … smart thermostats can help us save money on our electric bills [and a] new breed of agriculture tech can save water by giving crops exactly the amount they need and no more.'

The 'smart agenda' is the perhaps most significant narrative to emerge out of IoT discourse. Smart cities, smart homes, smart objects; such tropes pervade connective technology debates (Hill, 2013; Bridle, 2018). A key driver of the 'agenda' is the focus on the notion that *connectivity* can *and will* improve *efficiency*, which in turn, will lead to the creation of new forms of *value* such as saving energy. *Intel* (2019) for example, are keen to stress that they provide ‘proven solutions built for IoT’, while their networked infrastructure will likely ‘increase efficiency and value’. With specific regard to smart objects, Porter & Heppelmann (2014) argue that in order to cultivate new value, one must first view IoT products as being comprised of three primary elements – *physical parts* (e.g. material, electrical and mechanical specifications); *smart components* (e.g. sensors, microprocessors, embedded software and user interface); and *connectivity* (wired and wireless (connections). They contend that the latter serves two purposes: it allows data to be exchanged to and from such products and it enables their novel functionality to exist in a digital capacity and thus separately from the physical manifestation of the device. Assigning value to each of the primary elements leads to what Porter & Heppelmann term a ‘virtuous cycle of value improvement’. In their view, each element amplifies the value of one another, that is, the smart components amplify the value of the physical parts, while connectivity amplifies the value of the smart components. In citing *optimisation of product operations using device performance data* as a prime example of ‘value improvement’, Porter & Heppelmann’s model centres on increasing efficiency and thus, strongly reflects the ‘smart agenda’.

A key corollary of the *efficiency and value* rhetoric which pervades the IoT is the focus on the practice of smart energy monitoring. As Strengers (2013) notes, much fanfare has been made of the IoT’s potential utility for reducing both individuals’ and households’ energy usage through connected monitoring devices. She determines that such hyperbole has helped to build and maintain the perception that smart energy monitoring is a robust technological ‘solution’ to the unsustainable management of energy and carbon emissions across modern society. Strengers characterizes this narrative as a *smart utopia*. Such rhetoric is evidenced in the ‘solutionist’ tone with which commercial IoT energy monitor product-services like the *Google* owned *Nest* smart thermostat and *British Gas’ Hive* connected heating platform are marketed to public audiences (Nest, 2019; British Gas, 2019). The same can be said to also manifest in the UK Government‘s mandate to supply a smart meter to each and every British home by 2020 (GOV.UK, 2018a). Connected domestic energy monitors are designed to visualise their user’s energy consumption and provide estimates of greenhouse gas and carbon emissions. They also by display the monetary costs of consumed energy to their users (smartenergygb.org, 2019). Studies have shown a reduction in home energy use of 5-10% through the deployment of domestic energy monitors and such devices are expected to contribute to a 25% CO_2 saving by 2035 (from 2015 levels) (Delta-ee, 2019). Nevertheless, for Strengers (2013) and Knowles (2013), the almost utopian rhetoric which surrounds smart energy monitoring technologies is, in actuality, a façade that the design and technology industry has created as means for them to be able to increase their *profits*, as opposed to helping make energy and resource management more sustainably efficient. For example, as Figure 4 depicts, the advertising for *Nest*’s connected thermostat boldly promotes its energy saving credentials, while the device itself features a green leaf motif as part of its user interface (Google Nest, 2019). Despite this distinct environmental framing, Knowles (2013) asserts that the genuine focus of these types of technological devices is twofold: firstly, they are designed to save their users’ money and consequently, users adopt such products chiefly for this reason rather than with environmental values in mind. Secondly, increased adoption of these technological products results in greater profits for both the device manufacturers and service providers, which, in the IoT era are fast becoming one and the same. Moreover, not only do the producers profit from sales of the devices and user subscriptions to related digital services but they also make money from capturing and *mining* the data generated when the devices are in operation by users (Srnicek, 2016). Focussed entirely on the monetary advantages of smart metering, Figure 5 provides a clear demonstration of Knowles’ argument. The image is taken from the *Department for Business, Energy & Industrial Strategy’s* (2018) latest progress report for Smart Metering

Implementation. The words ‘sustainability’, ‘sustainable’ and ‘environment’ are not stated or referred to once in the document.

Figure 4: The advertising for *Nest*’s connected thermostat promotes its energy saving competencies, while the device itself features a green leaf motif as part of its user interface to denote its supposed environmental credentials. Source: www.nest.com. Image is unavailable due to copyright restrictions.

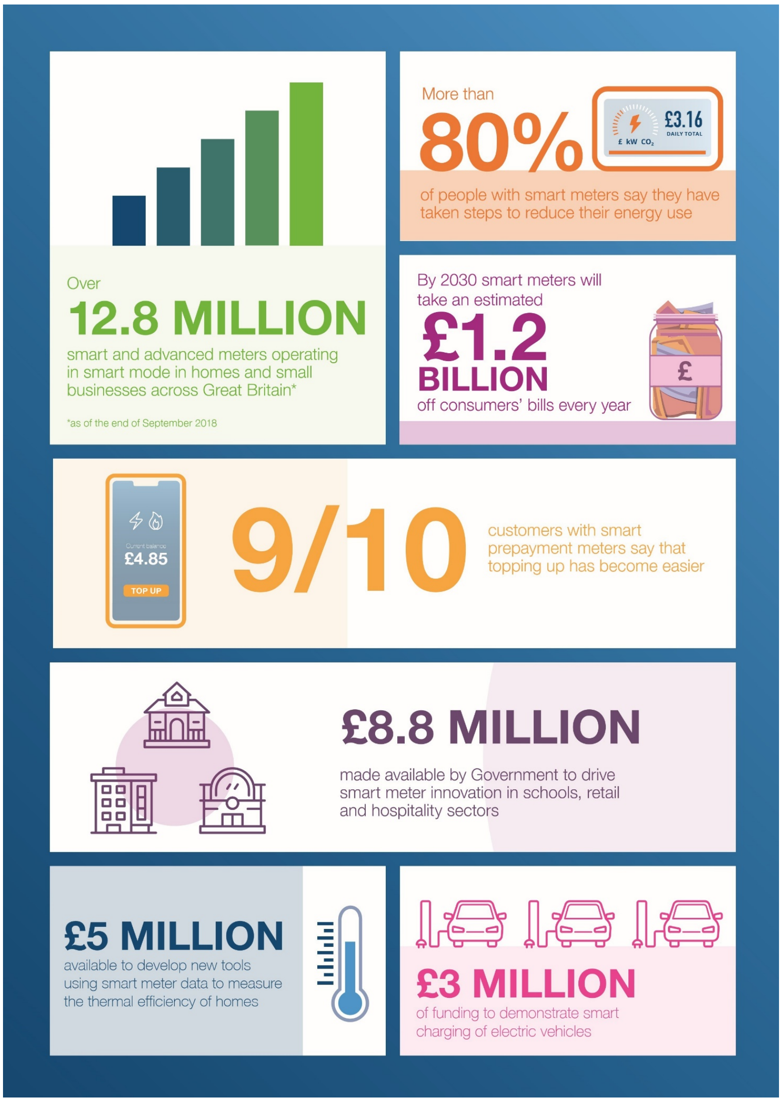


Figure 5: An image from the *Department for Business, Energy & Industrial Strategy's* (2018) latest progress report for Smart Metering Implementation. It is illustrative of how the 'smart agenda' focusses on the economic advantages as opposed to environmental benefits. Source: www.assets.publishing.service.gov.uk

The latter motivation – using the efficiency of environmental resources as a pretense for increasing profits through the monitisation of user data – has now become a fundamental mechanism that underpins the unremitting growth of the IoT (Chen et al, 2015). I will next outline the rationale for this ongoing duplicity in greater detail.

2.3.3 Ulterior Motives

There is an accepted view that the IoT is a 'hotbed' for *disruptive innovation* (Christensen, 1997) which resultantly gives rise to products and services which are efficacious 'tools for good.' Designers, technologists and manufacturers have indeed been quick to explore the creative potential of the IoT, yet the notion that this technological development is a benign and positive endeavour is increasingly being challenged. As Srnicek (2016) argues, corporate entities principally perceive the IoT to be a profit-making enterprise and companies seek to achieve IoT commercialisation by two methods. The first is via *market colonisation*. The decrease in cost and size of computational componentry like sensors and actuators, alongside the immediacy of contemporary software development, means that physical, manufactured devices with Internet connectivity and digital functionality can be brought to consumer markets quickly, cheaply and on a ubiquitous scale (Mattern & Floekermeier, 2010; Kuniavsky, 2010). Secondly, as I briefly outlined in the previous section, IoT firms cultivate profits through *data acquisition*. The personal digital data that is generated by users when they operate their devices is surreptitiously harvested, mined and monetised (Sadowski, 2016). Zuboff (2014) calls this clandestine practice 'surveillance capitalism'.

This 'two-pronged' business model has led firms that were once solely online platforms such as *Google* to start manufacturing physical connected products (e.g. the *Pixel* phone and *Home* smart speaker), while more established consumer hardware companies like *Apple*, also operate connected digital services like *iTunes* and *iCloud* (Sen, 2017). Furthermore, through this approach, technology firms can build and maintain a *competitive advantage* (Porter, 1985) because users often become 'tied' to a particular company's physical-digital *ecosystem*. In other words, after being purchased, a physical IoT device, and, by extension its user, remains linked to a bigger, evolving ecosystem of digital services, processes and support. For example, through the use of Apple devices like the *Watch* and *HomePod*, users can access Apple's online digital services including *iTunes*, *Apple TV* and *iCloud*. Such platforms, and the user data/content that they 'house', can usually only be accessed through Apple branded products. Like most consumer technology firms, over time Apple will release new iterations of their physical devices as well as conduct upgrades to their to digital services. In order to continue to access their personal content, users are often forced to upgrade their devices in line with these changes. As such they become tied (often unintentionally) to a particular brand's product ecosystem (Williams & Chamorro-Koc, 2016).

In short, the connectivity of the IoT is radically changing the relationship between product producers and customers (Anderson, 2012). And whilst societies have long established value cultures in regard to 'purely' physical items, the different types of value propositions Internet-connected devices facilitate are yet to be fully considered (Nissen et al, 2017). Moreover, as Coulton et al (2018) have shown, the often simple and user-friendly nature of IoT devices' interfaces is, in reality, a frontage for extremely complex constellations of virtual processes and interactions. The combined lack of understanding regards IoT devices' real value and the complexity of the technologies involved is helping providers such as *Amazon* and *Facebook* to carry out their data acquisition activities with limited just social, political and legislative resistance (Lanier, 2013). Meanwhile, the fruits of widespread IoT *market colonisation* and *data acquisition* is resulting in a paradigm characterised by networked physical-digital products including smart thermostats, consumer appliances and wearables, distributed at all scales throughout everyday life and generally turned to distinctly common-place ends (Chui, Löffler & Roberts, 2010; Hammersmith Group, 2010). Simon (2011) contends that this socio-technical paradigm is the result of the interminable reach, popularity and power of four high performance technology companies or 'technology giants', namely *Google*, *Apple*, *Facebook* and *Amazon*. Sterling (2014) also includes *Microsoft* amongst this grouping, which he refers to as *The Big Five*. He argues that the omnipotent nature of these five mass computation firms is the result of a series of shared attributes:

All have important central features that previous companies never possessed: an operating system, some dedicated way to sell cultural material (music, movies, books, software, tools for productivity, an advertising business, some means of accessing the internet that they themselves more or less (tablets, smartphones, phablets), a search engine capability, a social network, a 'payment solution' or some similar private bank, a cloud capability and very soon, some dedicated, elite high-speed access that used to be the democratic internet (Sterling, 2014).

Sterling equates *The Big Five* to early industrial pioneers like the US railroad tycoons of the early 19th century, as well as present day oil 'supermajors' such as *Shell*, *BP* and *ExxonMobil*. In doing so, he laments that the economic might and almost governmental-like power of *The Big Five* is *non-democratic* in its influence and has resulted in what he terms *digital-feudalism*. Through *market colonisation* and *data acquisition*, these firms are using the IoT as a means to unceremoniously 'land grab' technological infrastructure, commodities and resources on a global scale. And by consequence, their strategy is leading to the mass production, mass consumption and, as the next section will discuss, *mass disposal* of connected physical-digital IoT devices.

2.3.4 The Unsustainability of the IoT

Feenberg (2002) stresses that 'we are more than ever aware of both the promise and the threat of technological advance, [yet] we still lack the intellectual means and political tools for managing [technological] progress' While the IoT devices that now permeate society are considered to help people to make quicker and more efficient decisions about many aspects of their lives, the nefarious activities that connected products also facilitate (such as *data monetisation*) calls into question the objectives and values that lie at the root of IoT development (Guinard, 2015). The ongoing sustainability of the IoT is another critical issue. The forecast (Figure 3 – page 16) that the number of connected products will likely triple to over 75million devices in the next 6 years (Statista, 2018) begins to raise pertinent questions regarding the long-term environmental impact of the IoT. Bego (2018) asserts that rapid adoption of IoT products emphasises the highly iterative nature of digital technology. She describes its unrelenting expansion as 'the dark side of Moore's Law: the exponential growth in processing power has made it incredibly cheap to connect even the most disposable of items to the internet.' Finley (2014) concurs and argues that the 'smart' rhetoric which precedes the IoT neglects the inherent unsustainability of its 'things', their production and operational infrastructure. In short, technological progress has led to omnipresent computing which itself is leading to increasing amounts of e-waste. This is evidenced, Finley contends, in the way finite, potentially hazardous and non-recyclable raw materials such as conflict minerals, are heavily exploited to manufacture IoT products which currently cannot be disposed of in an environmentally safe manner.

Frick (2016) takes a similar stance and identifies a range of pressing environmental concerns with regards the adoption of the IoT. He highlights the difficulty in gauging the carbon and energy footprints of connected products, not least as a result of their complex manufacturing and distribution processes but also because their many components are produced in numerous disparate locations. Frick is also critical of the disposable nature of most IoT products, which, in his view, is primarily due to developers'/producers' focus on *planned obsolescence*, iterative design/production cycles and their conscious decision not to design their devices with reusable or repurposing strategies in mind. *Obsolescence of function* can also significantly shorten the lifespan of IoT devices. Frick cites regular software upgrades as accelerating the redundancy of connected products as the hardware of older iterations of many devices cannot run new, more complex and powerful operating systems and programs. Moreover, although it is still considered to be a relatively young paradigm, many IoT manufacturers and platforms have already gone out of business. Now defunct products which reached global markets included *Jawbone* fitness trackers, the *Berg Little Printer*, *Violet's Nabaztag Rabbit* and the *Pebble Watch* (Figure 6). All of the data, support services and digital infrastructure which helped these connected devices function effectively is consequently no longer available to their users rendering said devices effectively useless (Graham, 2017; Fairs, 2014).

Figure 6: Above are examples of IoT devices which are no longer available. As a result, the digital support services and data provision that accompanied these devices is also no longer available to their users. Source: www.jawbone.com, www.gadgetreview.com, www.berglondon.com, www.amazon.co.uk. Image is unavailable due to copyright restrictions.

A further repercussion of IoT adoption is that connected products will replace or retire older 'breeds' of devices, which, while 'non-connected', are themselves very difficult to dispose of sustainably (Frick, 2016). Grebler (2017a; 2017b) divides the short lifespans of IoT devices into three main categories. First is the *Duty cycle* which he states is the length of time before a connected product breaks or malfunctions due to regular usage. He sees this as the simplest issue to address and it is the developer's/producer's responsibility to make sure that their devices are resilient as opposed to building in obsolescence strategies. Secondly is the *Utility cycle* which is the length of time before the product is usurped by a seemingly better technology or device. Grebler argues that this cycle can be hard to predict and control but developers/producers could purposely choose to introduce new iterations of their own products with less frequency. Thirdly, is the *Interest cycle* which Grebler describes as the length of time before an IoT product no longer remains what Forty (1986) has termed an *object of desire* in the eyes and minds of their users. Broader factors such as social mores and fashion habits play an important role in this cycle and it is therefore the most difficult to combat effectively from a sustainability standpoint.

Cook (cited in Finley, 2014) argues that while IoT energy monitoring can allow people to gain a better understanding of where their energy originates from, the trend for imbuing multitudes of physical objects with Internet connectivity will likely drive greater consumption of both energy and materials. He notes that billions of IoT devices will each transmit and receive information to a server in a data centre. To cope with this demand, said data centres will need to be powered perpetually. Cook stresses that few of these data centres are currently powered by renewable energy sources. He estimates that, at present, 80% of the electricity used in the world's data centres is still drawn from fossil fuels, with only 20% thus far derived from renewables. Further to this, Andrae (2017) predicts that the technology industry and related *digital economy*, will use 20% of global electricity and emit up to 5.5% of the world's carbon emissions by 2025.

The unsustainability of the IoT is also seen to be a symptom of its decadent design culture. Kobie (2015) laments that the kinds of physical items being given computational and connective capabilities are highly superfluous in nature, and, as a result, only possess limited 'novelty' value. Accordingly, she categorises most IoT devices as unnecessary, useless 'gadgets.' Einstein (2014) argues that designers and producers are so preoccupied with commercialisation and bringing connected objects to market in all forms, that many of these devices do not serve a meaningful function. Watson (2017) cites the *Hidrate Spark* water bottle, *i-Con* condom and the *Quirky* egg box as prominant examples of this disposable connected product design culture (Figure 7). Resultantly, such discourse has led to some commentators to describe the IoT in highly derogatory terms, for example, as the *Internet of Crap* (Lee, 2017), the *Internet of Useless Things* (rehabstudio, 2019) or the *Internet of Shit* (@internetofshit, 2019). The latter interpretation is supported by the *Shitdex*, a database built to aid consumers to 'keep track of smart things and what's worth buying [and] help [them] make better decisions about the Internet of Things devices in [their] home' (https://internetofshit.net, 2019). These negative portrayals share a common theme, that connective technology is being harnessed to make the functionality of consumer devices overcomplicated, inconvenient and disposable, rather than easier to use, meaningful and durable. In essence, many contend that the IoT is, for all intents and purposes, rendering physical objects 'dumb' as opposed to 'smart' (Thackara, 2005; Kobie 2015). In effect, as significant majority of today's IoT products and services embody a design culture built on what Morozov (2013) terms *solutionism*. Though promoted as solving real-world issues, with perverse effect, these devices merely 'solve problems that do not really exist.'

As we move further into an era where billions of everyday physical artefacts with embedded computers, sense and send data across an all-pervasive digital infrastructure, it can be easy to forget that this reality once only 'existed' as an idea or theoretical proposition. Next, I will outline how the notion of *futures* have played and continue to play an extremely important role across technological and design discourse.

Figure 7: Examples of so-called 'novelty' and superfluous IoT products. Source: www.hidratespark.com, www.britishcondoms.uk, www.quirky.com, www.skiin.com. Image is unavailable due to copyright restrictions.

2.4 Design Futures

2.4.1 Introduction

By describing a potential world in which innovative devices like *pads* and *tabs* are commonplace, Weiser used his seminal paper as a means to not simply explain the *current* state of computing but envision to what computing *could become* (Dourish and Bell, 2011; 2014). Ashton, in his 1999 article discussing the possible value and impact of creating and adopting an *Internet of Things* could likewise be said to have done the same. Tellingly, Weiser published his treatise outlining the concept of *Ubiquitous Computing* in 1991 yet titled his paper *The Computer for the 21st Century*. Postulating on the future implications of products and technologies did not begin with Weiser and Ashton, however. Kozubaev (2018) asserts that using such an approach to formalise theory, 'originates in a field known as *futures studies* (also referred to as *futures, strategic foresight*, or the more archaic *futurology*).' Kozubaev traces the evolution of *futurology* from early Chinese writings in 1st century B.C. to what he describes as its modern 'Western-centric incarnation' after the Second World War. Evans (2003) affirms that it was around this time that commercial organisations began to use futurology as part of their strategy and planning activities, citing in particular its application by the *Rand Corporation* in the 1940s and later by the oil and gas firm *Royal Dutch Shell* in the 1960s and 70s.

The notion of *futurology* or *futures* similarly has a long history within the field of design. In his 1969 book *The Sciences of the Artificial*, the psychologist and sociologist Herbert Simon, argued that everything which is 'designed' should be considered as *artificial*, as opposed to *natural*. Stating that designers are 'concerned with how things ought to be', Simon goes on to describe the act of 'designing' as 'changing existing situations into preferred ones'. The latter excerpt has become, certainly in recent years, a useful and popular way for many design researchers to classify to *all* design activity as an innately forward-looking, future-orientated practice (Lindley, 2015; Candy, 2018; Lockton, Harrison & Stanton, 2013). This interpretation is perhaps clearer when Simon's precept is read as part of its original passage:

> *Everyone designs who devise courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state* (Simon, 1969).

Highly influential, Simon's text can now be seen to sit at the forefront of a critical shift that has reclassified the fundamental nature of design over the last 50 or years. In this time, design has evolved beyond established disciplinary boundaries (for example, product/industrial, architecture, fashion/textiles, graphics, interiors and packaging) into its contemporary form – a post-disciplinary and dynamic field of metaphysical enquiry (Manzini, 1986). Through his research into the societal contexts in which 'design' operates, specifically how designers think and make decisions when compared to other professions, Cross (1982) drew similar conclusions to Simon, stating that 'everyone can – and does – design… so design thinking is something inherent within human cognition; it is a key part of what makes us human.' The then radical reframing of design as an 'intellectual activity' – now commonly termed *design thinking* - continued with Schön (1983) who determined that design is not simply concerned with the production of artefacts, craftsmanship or aesthetics, but rather that it can, and should, be understood as a *reflective practice*, specifically one where *self-reflection* is crucial to any successful design process. Echoing Simon's precept, Schön states that a designer is someone who 'carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation.' More recently, with specific regards to how as a discipline it is crucial to shaping futures, Taylor, Peralta & Kermik (2013) conclude design to be 'a way of reasoning and making sense of things that is ultimately involved in the creation of meaning, as much as it is an analytical tool or practical method for solving problems.'

To further establish the ontological and epistemic perspectives that characterise contemporary design discourse, in the following sections I will discuss in greater detail how, as a concept, *design futures* has been, and continues to be, approached by commercial entities and academia.

2.4.2 Commercial Approaches

As Simon (1969) argues, *'the intellectual activity that produces material artifacts is no different fundamentally from… the one that devises a new sales plan for a company*'. It is perhaps unsurprising then that designerly, future-orientated approaches began to be actively adopted by the corporate sector in the years after World War Two. Kozubaev (2018) cites *Royal Dutch Shell* as the key example of how *design thinking* and *futurology* were systematically embraced by a commercial entity. Wilkinson and Kupers (2013) describe how in the mid 1960s, *Shell* formed a 'Long-Term Studies' team whose purpose it was to conduct ‘scenario planning’ and posit ‘alternative futures’ in a bid to help prepare the firm for *unexpected* threats or risks with regards to their oil and gas operations. In 1967, the team delivered the first of many annual *futures reports* to the company’s leaders. Projecting over 30 years ahead, the first report was titled ‘Year 2000’. Their ‘scenario planning’ techniques could be said to resemble Gordon Moore’s much vaunted forecast for *Intel* which, as I outlined earlier, ‘predicted’ regular increases in processing power and decreases in cost for computing components over coming decades (Moore, 1965; 1975). Yet, while *Moore's Law* has been a driving force of technological change for half a century, as has previously been shown, it should be considered a *self-fulfilling prophecy*. Intel, and indeed the computing industry at large, used *Moore’s Law* as a benchmarking exercise, in other words, it was used to set attainable targets for chip development, production and improvement (Dourish & Bell, 2011; Simonite, 2016). In this sense, Moore’s rhetoric differs markedly from *Shell’s* scenario planning activities, which were, as Wilkinson and Kupers (2013) keenly stress, never intended to be *predictions* but more a way for the firm to try and avoid *optimism bias* (Sharot, 2011), in other words, the tendency for people to look for the best in a current situation. *Shell* were concerned with how *optimism bias* could lead their staff to only see familiar patterns and carry on with ‘business as usual’, essentially making them ‘blind’ to the unexpected and less likely to innovate in times of change.

Following *Royal Dutch Shell*’s early explorations, the notion of futures and designing for them, has continued to be a point of focus for corporate entities. The need to consider potential change and/or risks, facilitate short-term and long-term innovation and maintain competitive advantage, has led to a profusion of different methods utilised across business cultures. Such techniques are seen as a *strategic tool*; a successful convergence of futurology and design practice (Brown, 2009). While it is not possible to outline each and every technique here, I will discuss some of the most relevant for my research. Evans (2003) asserts that *trend forecasting* is one of the most popular ‘futures’ techniques employed by modern companies. He describes two facets common across the application of this method. Firstly, the ‘forecasts’ are often presented to audiences in the form of *stories* or as narrative elements rather than through determinable facts or figures. As trend forecasting draws upon a wide variety of insights and perspectives, stories are considered to be the most effective medium for conveying such a diverse body of information. Secondly, though often supported by background or factual information, these narratives communicate ‘alternative futures’ primarily in a visual format as it is deemed to help understanding.

For Conway & Voros (2003), *foresight* is the most appropriate method for exploring ideas about, or images of, potential futures. Providing a more formal definition for business use, Slaughter (1999) describes *foresight* as the ability to create and maintain ‘a high-quality, coherent and functional forward view, and to use the insights arising in useful organisational ways.’ Voros (2001; 2003) identifies *foresight* as the second of three main stages that can lead to the creation of a new strategy and/or policy. He states that the first should be *inputs* which can include activities like data collection and literature reviews. *Foresight* is the second stage which he separates into three distinct phases – *analysis*, *interpretation* and *prospection*. Thirdly, is the *outputs* stage which is characterised by reports, presentations and workshops based on the results of the *foresight* activities. Just as *foresight* has grown as a practice in the corporate arena, its use has also expanded into the public sector, specifically for policy generation within governments and non-profit organisations (Harper et al, 2008). Slaughter (2004) uses the term *social foresight* to denote this type of application. A further adjunct of *foresight* is the *Delphi method*, which places additional emphasis on the importance of expert opinion. The method is characterised by several ‘rounds’ of *foresight* activity with a panel of experts being consulted after each round. The aim is to gain a wider consensus of critical thinking regards the future scenarios or forecasts in question (Linstone & Turoff, 1975). Due to its reach, recent permutations of the *Delphi method* have included using the Internet to crowdsource a broader cache of opinion. Surowiecki (2004) terms this approach as the 'wisdom of the crowd'. He argues that better decisions and courses of action are made by groups as opposed to by individuals – as succinctly expressed in the proverb 'more heads are better than one'.

The links between *foresight* and technological innovation, particularly with regard to emerging technologies and products, have also continued to deepen. This has led to a series of related practices including *technology forecasting* (Martino, 1983) and *technology road-mapping* (Phaal, Farrukh & Probert, 2004). First outlined by Robinson (1982), *backcasting* is another technique, however, where *forecasting* and *foresight* can be used to extrapolate the development of present day technologies as a means to envision their potential futures implications, *backcasting* can be used to approach this challenge from the opposite direction (Holmberg & Robert, 2000). *Backcasting* entails the defining of a specific desirable future goal and then moving backwards step-by-step from that goal to the present point in time, as a way to identify the strategic measures that would be needed to be put in place to attain the desired goal (Robinson, 1990). Tinker (1996) argues that *backcasting* is a method that enables us to pose the question, 'if we want to attain a certain goal, what actions must be taken to get there?' With regards to technological development, Jansen (1994) stresses that *backcasting* can help to form 'an interconnecting picture of demands technology must meet in the future [and] direct and determine the process that technology development must take and possibly also the pace at which this development process must take effect.'

With the path from inception, through adoption to social integration being one of acute uncertainty, new technologies are often launched amidst a large amount of hyperbole. Developers do this with the intent of attracting investors to fund further design, development and implementation of their technology (Posner, 2009; Lanier, 2017). Such practices can however lead to what is termed a *speculative bubble*, which, in simple terms, is where an asset (e.g. an emerging technology) is traded at a price that strongly exceeds the said asset's (technology's) *intrinsic value*. At some point, the 'bubble' will eventually burst leading to a 'crash' in the value and slowdown of the wider market dealing in this technology (Schiller, 2000). *Railway mania* in Great Britain in the 1840s and the USA's *dot-com boom* of the mid to late 1990s are both considered to be examples of a *speculative bubble*. In each case, the inflated pricing and subsequent crash in value of railway and Internet technologies are said to be based on inconsistent views about the how these technologies would evolve and be embraced by societies in the future (Ayres, 2014). Despite the crash of the *dot-com boom*, Internet-based technologies, platforms and services have of course since become a fundamental part of everyday life. In a similar vein, when *artificial intelligence* (AI) technologies first gained prominence in the 1950s, they were accompanied by much hyperbole. While the inflated value of AI did not ultimately culminate in a *speculative bubble*, these technologies suffered what is termed the *AI winter* between the late 1970s through to the late 1980s when the expected tangible applications for them had not yet come to fruition. Despite this slowdown, in the last two or so decades, AI has experienced a resurgence, mainly due to it being integral to a slew of applications related to the expansion of the Internet and *Ubiquitous Computing*. As Kurzweil (2005) states 'today many thousands of AI applications are deeply embedded in the infrastructure of every industry.' The Internet's and AI's turbulent journeys are seen as an example of what Ridley (2017) terms *Amara's Law*:

We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run (Amara, n.d.).

Roy Amara was an engineer and futurist at the *Institute for the Future* think tank. While it has not been confirmed when he coined his maxim – Ridley (2017) surmises that it was likely in the 1970s or 80s – use of it has gained traction over the last 20 years, primarily due to it being seen as the basis for the *Gartner Hype Cycle*. The *Hype Cycle* is a futures analysis graph which has been produced by the technology research company *Gartner* since the year 2000. The firm describe the *Hype Cycle* as providing 'a graphic representation of the maturity and adoption of technologies and applications, and how they are potentially relevant to solving real business problems and exploiting new opportunities' (Gartner, 2019).

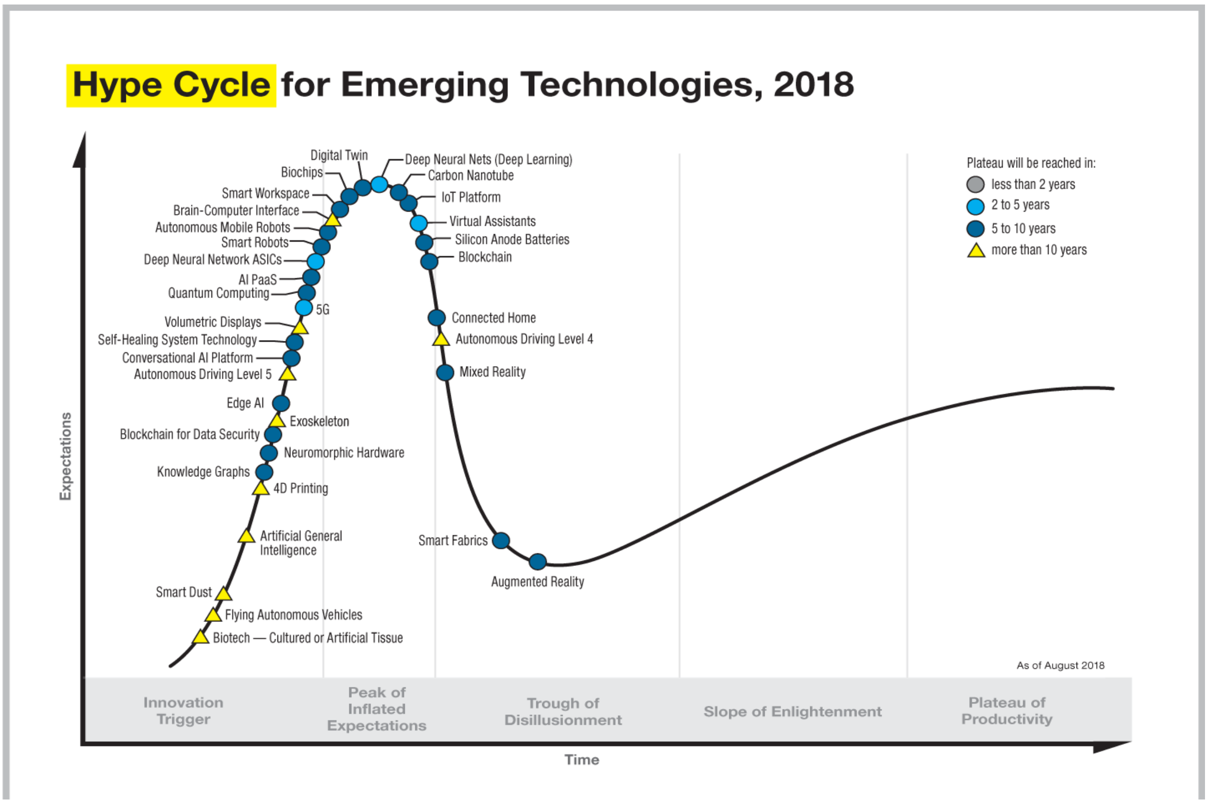


Figure 8: *Gartner* contend that their *Hype Cycle* illustrates the likely five key phases of an emerging technology's lifecycle. Source: www.gartner.com (2019).

As Figure 8 shows, the graph's y axis represents *expectations*, while the x axis divides a technology's lifecycle into five distinct phases:

- *Innovation Trigger* – A technological breakthrough and early proof-of-concept initiates much hyperbole but often no practicable applications of the technology exist, and its commercial viability is, as yet, unproven.
- *Peak of Inflated Expectations* – Increasing hyperbole results in an overestimation of the short-term effects (value/benefits) of the technology. Some companies will decide to invest in and develop said technology but most will not.

- *Trough of Disillusionment* – Low-point as interest in the technology fades amid implementation failure. Developers/producers of the technology either fall into administration or are bought out by competition. Investments continue only if the surviving developers/producers can improve the first generation of the technology to the satisfaction of early adopters.
- *Slope of Enlightenment* – The value and advantages of the technology gradually become more widely understood and embedded in society. Develops/providers continue to produce second, third and fourth generations of the technology. Momentum builds as more and more enterprises invest.
- *Plateau of Productivity* – In the long run, the attainment of what design firm IDEO (2009) deem the trifecta of economic viability, production feasibility and customer desirability result in widespread adoption of the technology (Gartner, 2019).

While there is no empirical evidence that proves the *Hype Cycle* represents the reality of a new technology's lifespan, it has itself become a rhetorical tool within technological discourse, one that is often used to 'promise' that all technologies will ultimately become profitable. The IoT (as *IoT platform*) is currently situated on the *Hype Cycle* within the second phase – *Peak of Inflated Expectations*. This differs from prior iterations of the graph which placed it earlier on the upward curve out of the first phase – *Innovation Trigger* (Gartner, 2015). Further, as per the graph's legend, Gartner's analysts posit that the IoT will likely enter the final phase of *Plateau of Productivity* in 5-10 years from now. Interestingly, Bhatnagar (2019) asserts that the practicability, value and impact of the IoT should be assessed differently when comparing *emerging markets* like India against its *developed* counterparts such as Western nations. He believes the IoT is now firmly established in India and has, to a large extent, already reached the *Plateau of Productivity* due to mainstream adoption and solid investment. He stresses that this is not the case in *developed markets*. Nevertheless, Bhatnagar asserts that Western firms should be able 'skip' the *Trough of Disillusionment* and reach the final phase by avoiding 'the mistakes that others have made in their journeys [and learning] from the emerging markets' success stories, including how to create the right sized opportunities and how to build a strong IoT ecosystem.' This lack of consensus highlights the inherent difficulty commercial entities have when it comes to trying to design and manage the futures of emerging technologies. Although speaking about *futures* more broadly, I feel this issue are keenly observed by Conway & Voros (2003) who note how the future is not predetermined, inevitable or predictable which means that there are always alternatives available or choices to be made, here and now *in the present*. In essence, future outcomes can be influenced by action or inaction taken *today*. This type of mindset in many ways provides the basis for many of the academic approaches to *designing futures* that I will discuss in the next section.

2.4.3 Academic Perspectives

Kozubaev (2018) argues that the intersection of two key trajectories 'has made the use of design to investigate the future even more productive, opening possibilities for new design practices.' I have already outlined some of the approaches that characterise one of these trajectories – *futures studies* or *futurology* – and their commercial applications. Kozubaev affirms that the second trajectory has found particular traction within academic circles and is a movement known as *Critical Design* and/or *Speculative Design*. Both of these terms are often used interchangeably to describe a type of design practice that researchers can utilise to speculate about the values and meanings of potential future products and technologies - designs that will, at the very same time, also reflect and critique the world that we currently live in today (Dunne and Raby, 2013; Mitrović, 2015). Anthony Dunne and Fiona Raby are considered to be the main progenitors of *Critical Design*. The term was first coined by Dunne and applied to the design work featured in his book *Hertzian Tales* (1999). He further developed the approach in a second text – *Design Noir: The Secret Life of Electronic Objects* (2001). Dunne & Raby (2007) further describe the method as a way to generate design proposals which 'challenge narrow assumptions, preconceptions and givens about the role products play in everyday life… its opposite is affirmative design: design that reinforces the status quo'. They define 'affirmative design' as normative commercial design practice, one which is principally driven by market forces and caters for mass consumption. They argue that the *Critical Design* process begins with a 'what-if question' and the finished prototypes serve as *provocations* to open up spaces of debate regards potential social, ethical, cultural and political implications of designed objects and design praxis in way 'affirmative design' simply does not, and perhaps cannot, do (Dunne & Raby, 2013). Figure 9 shows the 'Needy Robot' or 'Robot 4' which is one of several robot designs Dunne and Raby developed for their *Technological Dreams series* (2007). Serving as a commentary on technological advancement and increasing robotic research, each of Dunne and Raby's robot prototypes is an 'individual' with its own distinct personality and idiosyncrasies.

Fundamentally, as an approach, *Critical Design* affords designers a way to shift from 'designing applications to designing implications by creating imaginary products and services that situate these new developments within everyday material culture' (Dunne & Raby, 2013). This sits in contrast to much of the design praxis carried out in the last 100 or so years. As Taylor, Peralta & Kermik (2013) attest, design as a discipline and its ensuing material culture, certainly within Western societies at the very least, has been predicated on ideals emanating from the *Bauhaus* and *New Bauhaus* design schools. Taylor, Peralta & Kermik (2013) characterise this as 'extensive materialism intended to make better physical things.' Conversely, Critical Design subverts this thinking and uses design expertise to 'materialise' ideas and arguments about both what the future may hold and the current order of things (Dunne & Raby, 2013; Kozubaev, 2018).

Other early approaches with related methodology to *Critical Design* include *mock-ups* (Ehn & Kyng, 1991) and *Cultural Probes* (Gaver, Dunne & Pacenti, 1999) – the latter of which Dunne also helped develop albeit only in its initial stages. Bowen (2009) has made note of the links between *Critical Theory* and *Critical Design*. The former, in simplistic terms, is the notion that certain political, cultural, economic, ethical and technological values maintain the status quo in society. In turn, the status quo 'oppresses' the very same values that define it and, as such, make it difficult for people to challenge the current order of things and go about changing society for the better (Horkheimer, 1972). *Critical Design* is consequently seen as a method that designers can harness to try and 'emancipate' prevailing societal values and change the status quo by offering alternate visions of how things might be in the future as well as critiquing current practices (Bowen, 2009, Bardzell et al, 2012).

Figure 9: Needy Robot (2007) is an example of a Critical Design proposal by the field's progenitors Dunne and Raby. Source: www.dunneandraby.co.uk

Conversely, Malpass (2015) suggests that the beginnings of *Critical Design* can be traced to mid 20th century *Conceptual Art* practice, as pioneered by the likes of Marcel Duchamps, Joseph Kosuth and Sol LeWitt. Describing this movement, LeWitt (1967) argued that 'in conceptual art the idea or concept is the most important aspect of the work… it means that all of the planning and decisions are made beforehand and the execution is a perfunctory affair.' This 'art of ideas' allowed practitioners to move beyond conventional artistic paradigms such as 'representation' and begin to explore and critique new frames of reference including alternate social, cultural and political models. Further, they were also 'free' to embrace different materials and ways of creating through media like photography, text and found objects, as opposed to being restricted to established mediums like painting or sculpture. This approach allowed *Conceptual Art* to begin to critique *the very nature of art itself*, essentially proposing the question *what is art?* (Godfrey, 1997). However, where LeWitt stresses that 'execution is a perfunctory affair' and the craft inherent to the finished work is deemed not important in *Conceptual Art*, Malpass (2015) notes how critical design prototypes frequently exhibit a reasonable standard of designerly craftsmanship, in other words, give the impression that they have been properly 'designed'. He argues that this display of technique is not to afford the prototype a level of usability or utilitarian capability. Through *Critical Design*, designers can re-orientate their skills as a means to 'focus on design work that functions symbolically, culturally, existentially, and discursively' (Malpass, 2015). Others argue that *Critical Design's* origins reside in *Radical Design*, a movement which primarily found prominence in Italy in the 1960s and 70s. Such practice used design as a form of critique to eschew and comment upon the dominant values, ideologies and rhetoric found within design discourse and praxis at that time, in particular its facilitation of mass production and consumer culture (Didero & Snyderman, 2017; Mitrović, 2018).

Design Fiction is a method which is often characterised as a corollary of *Critical Design*, in as much as, practitioners similarly use design as a tool to create fictional artefacts in order to facilitate a greater understanding of the future implications inherent to a new product or emerging technology. In doing so, such practice is also a means to question contemporary societal narratives and values (Hales, 2013). Bruce Sterling (2005) is credited with coining the term, with Julian Bleecker (2009) providing a bona fide theoretical underpinning for the approach a few years later. Like critical designs, design fictions are free of commercially driven constraints such as usability, aesthetics and cost, and seek to explore new social interactions and behaviours (Tanenbaum, Tanenbaum & Wakkary, 2012). Bleecker (2009) states that *Design Fiction* prototypes are forward looking, go beyond standard cycles of product iteration and aim both to provoke and offer possibilities for innovation. Whereas *Critical Design* is determined to have a predominantly artistic heritage, it is acknowledged that *Design Fiction* has its roots in science fiction literature and film. This is due in part to Bleecker making discernible links between two important, yet at first glance, seemingly disparate concepts put forward by Dourish and Bell and Kirby respectively. As I have previously noted, Dourish and Bell (2011; 2014) concluded that *Ubiquitous Computing* research has consistently displayed a propensity for envisioning the future applications and implications of widespread computation as opposed to merely outlining its present and practicable technical specifications. From this, Dourish and Bell deduced that science fiction should be seen as a significant 'reading companion' of such research. Kirby (2010) meanwhile posited that the fictional technologies and products seen in Hollywood film, particularly in those of the science fiction genre, can often help lead to the development and implementation of real-world technologies and products. In his view, this is the result of academic research being used as the foundation for the realistic design and application of onscreen fictional technologies. He cites how MIT researchers supported filmmakers during the production of the science fiction film *Minority Report* (2001) as a prime example of this type of symbiotic relationship. Kirby subsequently proposes the concept of *diegetic prototyping* – the notion that fictional technologies and products can be rendered 'material' or operational within *diegesis*, which put simply, means within a story or narrative. Appropriating Kirby's terminology, Sterling (cited in Bosch, 2012) has since described *Design Fiction* as 'the deliberate use of diegetic prototypes to suspend disbelief about change.' Figure 10 depicts a page of diegetic prototypes as featured in the *To Be Designed (TBD) Catalog* (2014), a collection of *Design Fiction* exemplars produced by Bleecker and colleagues at the *Near Future Laboratory*.

Figure 10: A page of *Design Fiction* prototypes as featured in the Near-Future Laboratory's 2014 *TBD Catalog*. Source: The Near Future Laboratory's TBD Catalog (2014).

In the decade since Bleecker's paper, *Design Fiction* has grown as a practice and, like *Critical Design*, has been adopted as a method for designing futures across various fields of academic research. Seeing confusion arising from the use of varied terminology, James Auger suggests that *Speculative Design* be adopted as the broad, inclusive descriptor for the above practices. He feels the differences between each field 'are subtle and based primarily on geographical or contextual usage: all remove the constraints from the commercial sector that define normative design processes; use models and prototypes at the heart of the enquiry; and use fiction to present alternative products, systems or worlds' (Auger, 2013). Moreover, he argues that the use of *speculative* as the modifier enhances the 'plausibility' of the design proposals. This is because, in his view, 'the word 'fiction'… immediately informs the viewer that the object is not real… and 'critical' [reveals] the intentions of the object as an instigator of debate or philosophical analysis.' Thus, for Auger (2013), such 'terms act to dislocate the object from everyday life, exposing their fictional or academic status.'

Auger, with his creative partner Jimmy Loizeau, were, like Dunne & Rady, early pioneers of *Speculative Design* practice. Their design proposal *Audio Tooth Implant* (Figure 11) received much media attention when first exhibited in 2001. Auger & Loizeau state that the implant 'is a radical new concept in personal communication. A miniature audio output device and receiver are implanted into the tooth during routine dental surgery. These offer a form of electronic telepathy as the sound information resonates directly into the consciousness' (Auger & Loizeau, n.d.). The prototype pictured in Figure 11 is non-functional and thus, the description provided above is entirely fictional. Nevertheless, to help make it appear as if the implant is a real emerging technology, they also created a press release outlining the device's *context of use* and a short promotional film, in addition to the physical prototype. Of its fictitious nature, the designers state ‘the Audio Tooth Implant was pitched at a level where its desirability and believability would be acceptable in terms of the contemporary attitude in society’ (Auger & Loizeau, n.d.). The proposal was convincing enough that it featured on the cover of the November 2002 edition of Time Magazine as ‘one of the coolest inventions of 2002’ (Auger, 2013), despite the device not actually existing in a performative capacity. This ‘deception’ was facilitated by Auger & Loizeau also maintaining to journalists that the *Audio Tooth* was in fact a ‘real’ product (Coulton, Lindley & Akmal, 2016).

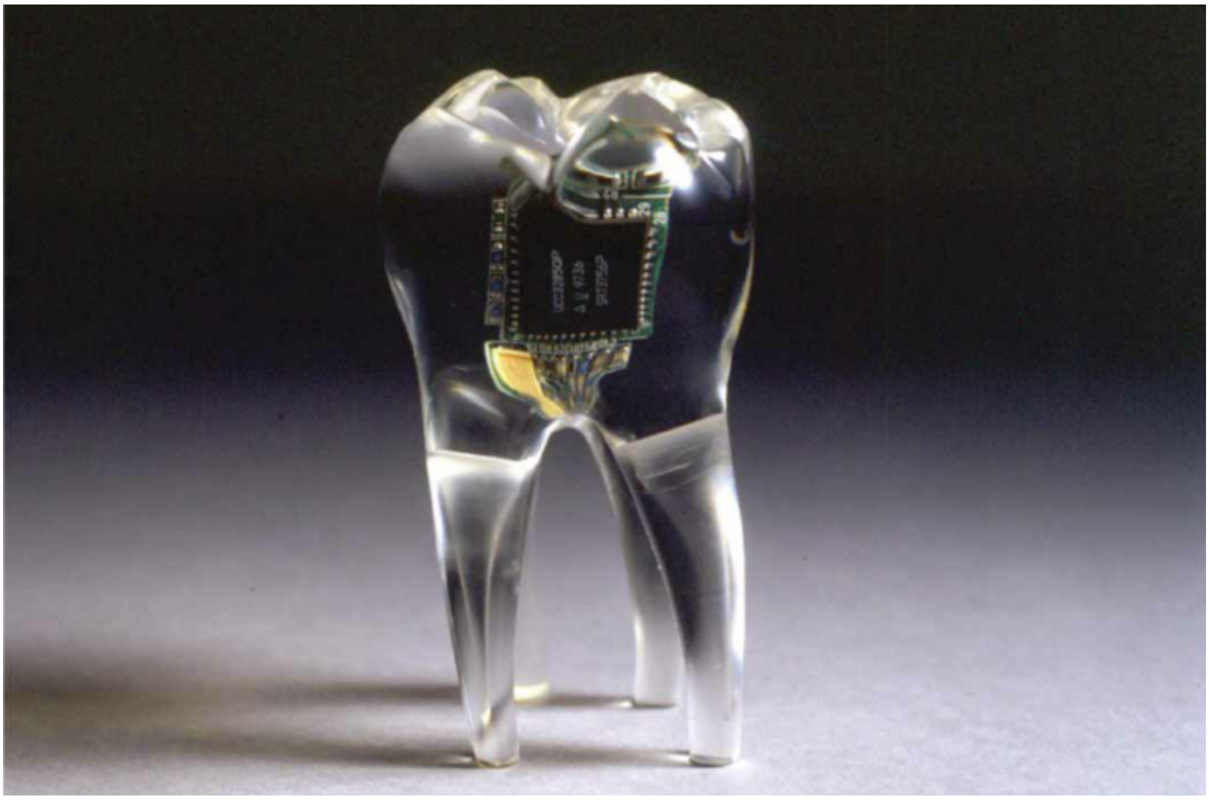


Figure 11: The *Audio Tooth Implant* (2001) - an early but influential example of *Speculative Design* practice by James Auger and Jimmy Loizeau. Source: www.auger-loizeau .com.

The academic pedigree of the aforementioned design practices has led some to question their validity and usefulness in helping facilitate discourse regards alternative futures. Prado & Oliveira (2014) in particular have criticised the elitism, ignorance and superficiality that is demonstrated by many *Speculative Design* and *Critical Design* proposals. They cite Michael Burton and Michiko Nitta’s *Republic of Salivation* (2011) as a prime example of this. Burton and Nissa’s project (Figure 12) explores possible future food shortages and famine in Western contexts. As such, the designers posit that ‘governments will be forced to ration food through restricted food policies to ensure that everyone is fed and to control social unrest. It creates a future where inhabitants of the city are allocated a quota of food according to their employment’ (Burton & Nissa, n.d.).

Figure 12: A photograph from Michael Burton and Michiko Nitta's *Republic of Salivation* (2011) project cited by Prado & Oliveira (2014) as an example of ignorant and privileged *Speculative Design* practice. Source: www.burtonnitta.co.uk.

Prado & Oliveira argue that the work is naïve and comes from a position of privilege, asserting that the potential future it presents 'might be dystopian to some, but in some other parts of the world it has been the reality for decades.' Mitrović (2018) has also used the term *Western melancholy* to describe the 'superiority complex' and 'pity' that 'Euro-centric' speculative proposals display towards other cultural contexts. Perhaps seeking to counter the 'top-down' and dislocated nature of these types of projects, Stuart Candy has proposed the notion of a more inclusive and collaborative *Speculative Design* practice which he terms *Experiential Futures*. This method aims to bring potential futures to life by placing collaborators in 'immersive situations' in which they then co-create 'tangible artefacts.' Candy argues that this process affords participants a better understanding of how alternate futures may come about as those taking part, in essence, *experience the future in the present* (Haldenby and Candy, 2014). Candy and Watson (2015) developed a card game entitled *The Thing From The Future* as a means to help facilitate this communal creative process. Figure 13 shows the *Futurematic Vending Machine* (www.futurematic.cc, 2014) which is filled with a range of artefacts 'from the future'. These fictional items were produced by participants during an *Experiential Futures* workshop at OCAD University in which Candy and Watson's card game was utilised as the point of departure. Candy (2015) states that the game 'takes a certain kind of intellectual and creative operation (viz. quickly moving from vague notions about alternative futures, to ideas and stories revolving around specific artifacts) that has so far been relatively specialised and unusual, and renders it accessible and fun, thereby in a modest way helping to demystify and democratise futures.' As I will outline in the final section of my literature review, the 'demystification' and 'democratisation' of *sustainable futures* has been an important and persistent concern within both commercial and academic design practice.

Figure 13: The *Futurematic Vending Machine* (2014) is filled with 'future' artefacts as produced by participants during an *Experiential Futures* workshop at OCAD University. Source: www.robhopkins.net.

2.4.4 Futures and Sustainability

In the first section of my literature review, I discussed how Meadows et al (1972) used data simulations to posit near-future scenarios as a means to provoke debate with regard to untampered economic growth and resource depletion. Their report, *The Limits To Growth*, can considered to be significant piece of research for three reasons. Firstly, it is an early exemplar of envisioning *sustainable futures*. Secondly, its conclusions challenged the prevailing economic, political and ecological narratives that characterised Western societies at the time. Thirdly, it demonstrates that the notion of *futures* have been a contentious issue within sustainability discourse for many decades. As I also noted earlier, the purpose of the report was not to make specific *predictions* but to speculate upon *potential* future scenarios.

The notion of *sustainable futures* has also been a point of considerable focus for commercial entities for many years. As previously outlined, *Royal Dutch Shell's* 'scenario planning' activities in the 1960s and 70s played a central role in initiating *futurology* based practices within the corporate sphere. Between 1998 and 2011, the company also produced annual *Sustainability Reports* as a means to 'road map' their future contributions to global *sustainable development*. The consumer electronics giant *Philips* is another Dutch firm that has also carried out notable design futures research. Their *Visions of the Future* project was conducted in 1996 with the purpose of 'exploring ideas for products and services, which could be part of our future in the year 2005' (Lambourne, Feiz & Rigot, 1997). The project team was global in its reach and consisted of not only designers but also futurologists, strategists, engineers, sociologists and technologists (Marzano, 1996). Design workshops generated more than 300 scenarios that manifested as short stories with each outlining a product concept and its context of use. As these scenarios were considered to be too broad in scope, they were subsequently restructured and simplified into four manageable 'domains' – *personal*; *domestic*; *public and work*; and *mobile* (Marzano, 1996). As Evans (2003) states, the aim of the project was to 'focus on people rather than technological categories [and the domains were] used to represent all aspects of everyday life.' The concepts were presented to audiences in the form of high-quality three-dimensional prototypes and simulations of potential digital interfaces. In addition, short films were created to help contextualise how the future products and services would be used (Lambourne, Feiz & Rigot, 1997; Marzano, 1999).

Philips' next design futures research program *Design Probes* built upon their earlier work and ran for around five years (2006-2011). Like *Visions of the Future*, *Design Probes*' activities were focussed around the collaboration of diverse multidisciplinary teams which, at different points, produced a range of concepts in the form of 'usability narratives' and 'future scenarios.' The best of these outputs were then translated into high grade physical product prototypes which *Philips* (cited in Anastasiadi, 2010) stresses were 'not predictions' but, were intended to be a 'provocation designed to spark discussion and debate around new ideas and lifestyle concepts.' Sustainability appears to have been a main focus of exploration throughout the course of the *Probes* project, as *Philips* (cited in Etherington, 2011) confirm, stating that 'the mission… [was] to create solutions that satisfy people's needs, empower them and make them happier, all of this without destroying the world in which we live.' Sustainability orientated probes included 'diagnostic kitchen' tools designed to help users determine the provenance and nutrition of various foodstuffs and 'home farming' incubators which would allow users to personally grow plants and rear fish domestically for sustenance. The notion of 'self-sufficiency' was pursued further and formed the basis of one of the program's final probes, *The Microbial Home*. Cédric Bernard, one of its designers, deems *The Microbial Home* to be 'a domestic ecosystem that challenges conventional design solutions to energy, cleaning, food preservation, lighting and human waste' (Bernard, n.d.). As Figure 14 shows, a high-quality prototype of the proposal was produced. *Philips Design* (cited in Etherington, 2011) contends that the probe serves to highlight how 'each function's output is another's input… the home has been viewed as a biological machine to filter, process and recycle what we conventionally think of as waste – sewage, effluent, garbage, waste water.' Perhaps most importantly, Senior Director at *Philips Design*, Clive van Heerden (cited in Etherington, 2011) argues that it is designers who have a fundamental 'obligation to explore solutions which are by nature less energy-consuming and non-polluting… we need to push ourselves to rethink domestic appliances entirely.'

Figure 14: *Philips Design's The Microbial Home* (2011) – a concept for a future 'integrated cyclical ecosystem' which would enable waste from food preparation and consumption to be perpetually recycled thus reducing the environmental impact of those practices. Source: www.dezeen.com. Image is unavailable due to copyright restrictions.

The future in which *Philips*' design team seeks to 'situate' concepts like the *Microbial Home* appears to have shifted during their *Probes* project. For example, in 2010, the firm stated that they established the program to 'explore *far-future* lifestyle scenarios based on rigorous research in a wide range of areas' (Philips Design, cited in Anastasiadi, 2010). The following year however, they contended that the purpose of their *Probes* project was to be a means 'to understand future socio-cultural and technological shifts with a view to developing *nearer-term* scenarios' (Philips Design, cited in Etherington, 2011). As Auger (2013) emphasises, designing for *near*- and long-term *futures* might, at first glance, appear trivial, or at the very least, a nuanced concern, but it is in fact an important issue within design futures research. He points to his and Loizeau's *Afterlife Project* (2001-2009) as an example of a *Speculative Design* proposal which was perhaps 'too futured or 'too uncanny' – in other words, one that was too far removed from audiences present, lived experiences. Like *Philips'* probe, Auger & Loizeau's 'afterlife' coffin and fuel cell concept (Figure 15) explores the possibilities that might arise from applications of *microbial* technology. But whereas the *Philips* prototype is built around the recycling of food waste, Auger & Loizeau's proposal centres on the reuse of human corpses through 'post-death processing'. Their design proposes that the decomposition process of a body could charge a dry-cell battery and thus provide an alternate source of energy for society.

Figure 15: The 'afterlife' coffin and fuel cell – two speculative designs from Auger and Loizeau's *Afterlife Project* (2001-2009) which, like *Philips'* probe, explored the use of microbial technology. Source: www.auger-loizeau.com.

However, as Auger (2013) outlines, audiences were repulsed by the dislocated and 'uncanny' nature of the design:

> *Unfortunately the viewers… chose mostly to ignore the intellectual aspect of the project to focus on the more unsavoury aspects, namely tampering with the process of death, the passing of a loved one and the material activity of the human body during the operation of the fuel cell. This resulted in simple revulsion as the benefits of the concept were overlooked.*

Auger resultantly concludes that when designing any speculation, 'careful management of the uncanny is imperative.' Despite extrapolating a similar form of technology, the contrast between *Philips'* and Auger & Loizeau product concepts rises an important issue with regard the notion of sustainable *utopias* and *dystopias*. A concern for commentators such as Mitrović (2018) is that commercial futures practice like *Philips'* probes more often than not present positive and 'technologically solutionist' outcomes, meaning that a technology can be used to easily and efficiently 'solve' a problem. This is principally due to the affirmative and business-related intent that underscores such activities, as *Philips Design* (cited in Etherington, 2009) make clear – 'the outcomes of this 'far-future' research are used to identify systemic shifts that could affect business in years to come and that could lead to new areas in which to develop intellectual property.' Malpass (2015) contends that academic design futures practice, namely *Speculative* and *Critical Design*, are more likely to envision an assortment of positive and negative futures. Dunne and Raby (2013) argue that a common trait amongst affirmative speculations like *Philips'* probes is that they frequently envision *preferable* futures. They note that the idea of positing *preferable* futures presents difficulties as 'what does preferable mean, for whom, and who decides?'. To make more sense of *preferable* futures, Dunne and Raby appropriated a diagram – the *Futures Cone* – which was first put forward by Voros in 2001. In their interpretation (Figure 16 - left), which they title the *PPPP* diagram, is separated into four 'design futures cones' – *probable*, *plausible*, *possible* and *preferable*. Each cone represents a 'space' for design development. The preferable cone (purple) intersects both the probable and plausible. Johannessen (n.d.) asserts that the purpose of Speculative Design proposals is fundamentally 'to create debate on the position of the 'preferable'. He has also made his own interpretation of the *PPPP* diagram – an adaptation of both Dunne and Raby's (2013) and Mitrović's (2015) interpretations. Like the latter, his version (Figure 16 - right), includes a scatter of speculative proposals/scenarios mapped onto the cones for demonstrative purposes. In addition, to illustrate the breadth of the field, each of these proposals is positioned to be, to a varying degree, either *utopian* or *dystopian*.

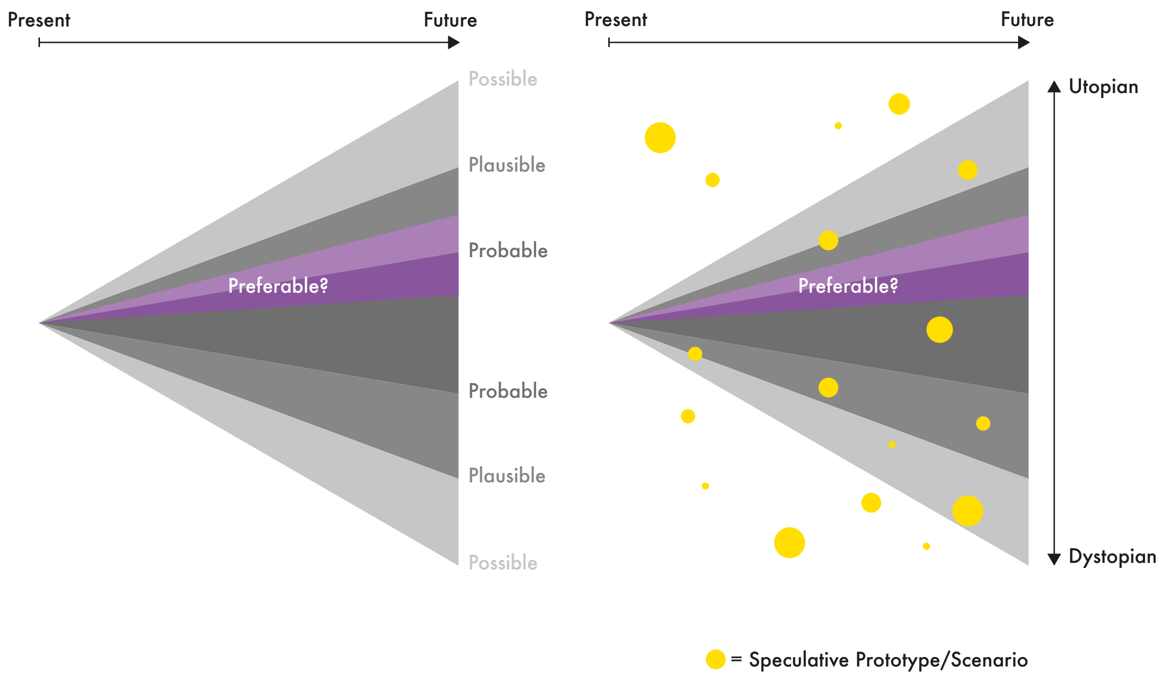


Figure 16: Left: Dunne & Raby's (2013) version of the *PPPP* diagram. Right: Mitrović (2015) and Johannessen's (n.d.) interpretation of *PPPP* which also infers how speculative design futures can be utopian or dystopian in nature. Source: Author – left: facsimile of Dunne & Raby; right: adapted from both Mitrović and Johannessen.

Notions of *utopias* and *dystopias* can similarly be found throughout sustainable design discourse. Papanek (1971) argued that '*all men are designers…* [as] *the planning and patterning of any act towards a desired, foreseeable end constitutes the design process*.' Echoing Simon's (1969) maxim, Papanek saw design as a *futures orientated activity*, particularly one which is intrinsic to combatting unsustainable lifestyles and infrastructures through credible sustainable development. Johannessen (n.d.) suggests that Papanek's view of design was in many ways contradictory, in that he deftly illustrated how it can be, *and is*, harnessed for *both* utopian and dystopian ends. Indeed, Papanek envisioned that design *could and should be* applied as a creative and strategic tool which would help modern societies achieve positive environmental, cultural and ethical change, yet, because of its established role as an agent of capitalism and consumption, he asserted design is also a fervent facilitator of environmental degradation and social dissonance.

Contemporary design theorists continue to take positions similar to Papanek. Thackara (1988; 2005) and Walker (2011) for example, subscribe to the view that mass technological product production continues to lead society towards an unsustainable nadir. For them, capitalism, materialism, globalisation, human exploitation and environmental destruction are all fruits of *modernity* which has led Western societies into an era of post-enlightenment characterised by unsustainable socio-cultural norms and practices. In response, Walker (2006; 2011) contends that societies should adopt a type of 'personally meaningful design' in order to counter the onslaught of profit-driven technological progress. His design praxis takes the form of what he terms *Propositional Design* which shares much of the same fine art lineage as Dunne and Raby's *Critical Design*. The *Ad Hoc Flashlight* (Figure 17) is an example of his work which focusses on critiquing modern unsustainable design cultures using archaic materials and visual language. Walker's synthesis of theory and praxis frames *sustainable futures* in an *image of the past*. Essentially, he *looks back* as a means to *look forward* and strives to root post-modernity in a pre-industrial green idyll where peoples' sense of place, sacred tradition and 'inner' spiritual identity have, in his view, not yet been eroded by technological homogeneity, progress and secularization. Inspired in part by John Ruskin's[2] thinking, Walker's bucolic stance places significance on material objects as embodiments of the hand of the artisanal craftsperson, in opposition of the *simulacra*[3] of *Late Capitalism* (Baudrillard, 1981). Walker (cited in Crocker & Lehmann, 2013) contends that eschewing the utility and efficiency of modernity, will give rise to people-product relationships that afford profound personal reflection, allowing people to transcend their '*physical, mundane realm*' to a '*metaphysical, spiritual realm*.'

Like Walker and Papanek, Fry (1999, 2009) asserts that design is the key expediter of the harmful material cultures that permeate modern life as well as facilitating Western societies subservience to technological progress. He notes how 'technology arrives by design, is applied by design and, in its form and use, technology itself designs' (Fry, 1999). Fry contends that these problems have resulted in an *unsustainable present* which he believes provides the blueprint for a destructive, *unsustainable future*. He uses the term *defuturing* to describe this dystopian trajectory – the idea that unsustainable design practice is 'defuturing the future' and driving the planet towards an environmental and humanitarian catastrophe. Fry argues that in order to change course, it is imperative that societies make a radical shift away from its current paradigm of production and consumption which simply 'sustains the unsustainable'. This shift

[2] John Ruskin (1819–1900) was a Victorian artist, art critic, political commentator, philanthropist and environmentalist. Through his writings on nature and *natural law*, he is seen by some as an early pioneer of sustainable thinking, particularly with regards to environmental awareness, ethical consumption, craft production and personal responsibility towards ecology. Ruskin himself was influenced by medieval and pre-enlightenment schools of thought (MacDonald, 2018).

[3] The French sociologist and cultural critic Jean Baudrillard used the Latin term *simulacrum* to denote an artefact, object or image which is a 'copy' of an original artefact, object or image. Baudrillard outlined his notion of *simulacra* in his text *Simulacra and Simulation* (1981). The terminology has since been used to describe the manufactured products of 20th century *Late Capitalism*, which due to their mass-produced nature, are deemed to be commodified 'imitations' of original artefacts. For Baudrillard, simulacra sits in stark contrast to 'one-off' works of art and artisanal handcrafted objects which, in his view, possess an 'authority' and a greater cultural and societal value. Baudrillard posited that as it continues to usurp 'originality', simulacra will eventually threaten reality itself because people will be left living in a world where everything around them is 'simulated'.

can be achieved through what Fry describes as *redirective practice*, a transformative process where design itself is ‘redesigned’. He asserts that *redirective practice* should be at the very core of design education and, as such, burgeoning designers would be taught to design for an alternative sustainable agenda, one that sits contrary to the design industry’s established pursuit of commercialisation and profit. Fry stresses that *redirective practice* would not reject the pragmatics of design, that is, designed outputs would continue to have practical use and designers would still be trained to apply their expertise and contribute to the economy. Crucially, however, his approach would introduce designers to a wider, more worldly frame of reference, imbuing them with a profound sense of social, cultural, economic, political and environmental responsibility. Fry’s approach to design education would help prospective designers ‘see’ beyond the *anthropocentric* view of design that reverberates across today’s design industry and education. In Fry’s view, acknowledging their responsibility in helping ‘form futures' would allow designers to fully understand the systemic implications of what they design and how they go about it. Through adoption of *redirective practice*, designers would become ‘pathfinders’ and begin to restore the ‘futuring’ potential of design. Thus, like both Walker and Papanek, Fry also sees design as the initiator of a better, more sustainable future world, and accordingly, emphasises that ‘the future will not happen by accident… it can only happen by design’ (Fry, 1999).

Figure 17: The *Ad Hoc Flashlight* – an example of Stuart Walker’s *Propositional Design* practice, a variant of *Critical Design* which specifically focusses on critiquing modern unsustainable material cultures. Source: www.stuartwalker.org.uk.

3 Synthesis

3.1 Introduction

Having outlined the state of the art in relation to the fields of *Sustainable Product Design*, the *Internet of Things* and *Design Futures*, in the following passages I will put forward what I conclude to be several 'gaps' that I have found in the said literature. These 'gaps' provide impetus for my doctoral research. Further to this, I will discuss how the confluence of these insufficiencies in knowledge enabled me to define the central focus for this thesis, that being design-led research into the meaning and value of the *spimes* concept.

3.2 Gaps for My Doctoral Research

3.2.1 Broad & Unfocussed Terminology

Through my discussions of the *sustainable agenda* and industrial product design's pivotal role in both fostering consumption culture and generating unrecyclable e-waste, credence is given to the argument that manufactured consumer products should be always be designed with environmental sustainability firmly in mind. As I have demonstrated in my literature review, this is by no means a new school of thought. With numerous different strategies proposed, product design practice that is innately ecologically conscious has been a major objective for decades. Despite these constructive efforts, the literature and statistics I have presented provide evidence that past and current approaches to sustainable product design have not been effective enough and deleterious impacts such as e-waste continue unabated. In their recent call for article submissions for a special issue of the academic journal *Sustainability*, Bharma and Wilson (2019) corroborate this perspective. Seeking submissions 'that push the frontier of what *Design for Sustainability* could be – and possibly *should* be' they state that '*Design for Sustainability* is not the panacea we hoped it would be when it was first introduced in the latter part of the 20th century.' And, while they note that awareness of environmental degradation and the need for sustainable modes of living have grown, they opine that, as a strategy, '*Design for Sustainability* is not providing the solutions necessary to manifest the level of change required.'

I argue that the inefficacy of *Design for Sustainability* is due in part to it being too broad a terminology which can be applied loosely to any kind of design theory and/or practice that exhibits an environmentally positive intent. Further, the term is often not accompanied by a definable framework that practitioners can readily grasp and subsequently take forward and embed into their praxis. Therefore, as an approach, *Design for Sustainability* can become diluted and lose much of its cogency. I contend that the same can be said of other overly inclusive terminologies like *Eco-design* and *Green Design*, and, can perhaps even be levelled at more seemingly defined strategies such as *Circular Economy* and *Cradle to Cradle* thinking. I maintain that the lack of coherency across sustainable design discourse is also hindered by the extensive of use of sweeping generalisations such as 'climate change', 'global warming' and 'carbon emissions' to commonly describe the problems affecting environmental sustainability. Such terms are not always helpful in bringing about a deeper understanding of the substantial issues facing the planet. Ultimately, sustainability is a vast, complex issue and this makes tackling environmental problems, whether it be from an individual, collective, *designerly* or technological standpoint, a difficult and unwieldy task. The inherent broadness of established approaches to sustainable product design reflect this.

In light of the issues outlined above, new, alternate ways of exploring sustainability, and designing for it, are urgently necessitated. Further, as it is difficult to meet all of the challenges posed by the *sustainable agenda*, I argue that, for my doctoral research, it is more conducive to focus on a specific design space, as opposed to a pursuing a wide, 'catch-all' area of study as epitomised by previous sustainable design theories.

3.2.2 No Sustainable Strategy for the IoT Era

As my literature review outlines, computation and connectivity are being made omnipotent and available anywhere, at any-time, using any physical device. As such, the IoT is fundamentally changing the ways new products are originated, sold and interacted with. Yet the social, cultural, ethical and environmental implications of this shift are less understood. The IoT is beginning to have advantages *and disadvantages* for society. Most IoT discourse focuses on the opportunities for the creation of new products and services and the economic markets that these will bring. Some commentators have however, also looked at the negative impacts of this expanding paradigm. Through his notion of *everyware*, Adam Greenfield (2006) provided a seminal critique on the impacts of widespread, embedded computation on peoples' privacy and social liberty. Despite this, there is a discernible 'gap' specifically with regards to sustainable product design in the age of *Ubiquitous Computing* and the IoT. While much discourse documents the significance of designing sustainable 'non-connected' physical objects, there is little material which discusses how or why designing environmentally friendly IoT devices *should be* a critical objective. Thus, in response to growing e-waste and material scarcity issues, I argue that a credible strategy for designing sustainable Internet-connected products is of imperative importance and a valid concern for my doctoral research.

3.2.3 Ignoring the Unsustainability of the 'Things' Themselves

With it still being an emerging paradigm, one might see the absence of a sustainable design strategy for Internet-connected devices as a prodrome of the IoT's relative youth. I argue that this deficiency is in fact a symptom of the hyperbole that besets much IoT discourse. As outlined in my literature review, there are numerous loud and powerful voices across government, industry and academia promoting the IoT as a catalyst for changing many aspects of our lives for the better. Yet, this rhetoric neglects the inherent unsustainability of the IoT's devices, their manufacture and operational infrastructure. Billions of connected products are being designed, manufactured and disposed of in the same manner that most other 'non-connected' consumer products have been for decades – *unsustainably*. Adapted from Weetman (2016), Figure 18 shows that the lifespan of both a 'non-connected' device and an IoT device are one and the same – *limited, disposable and unsustainable*. The iterative nature of digital technology also plays a significant role in IoT product obsolescence. Adherence to the bombast of Moore's Law has led to us into the era of omnipresent and omnipotent computing. However, there is a limit to which connected products can incorporate perpetual updates to both their hardware and software. As Adams (cited in Frick, 2016) stresses, the IoT is 'a double-edged sword [because] computing is now cheap to the point that chips are disposable, so we need to provide other reasons to make them last beyond them just being expensive to deploy'. The disposability of IoT hardware means that many connected devices, like their 'non-connected' antecedents, will eventually be lost to landfill as e-waste.

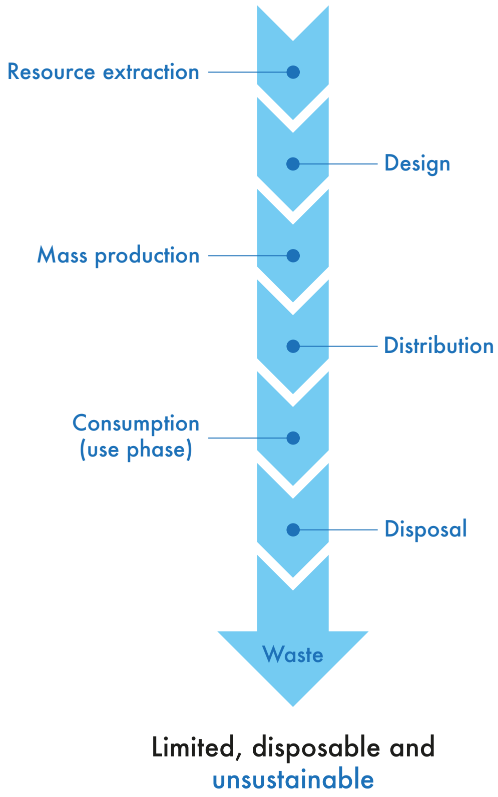


Figure 18: The lifespan of a typical 'non-connected' device and a typical connected IoT device is one and the same – it is limited, disposable and unsustainable. Source: Author, after Weetman (2016).

Despite these clear and pressing issues, little discourse appears to recognise the unsustainable nature of IoT devices themselves. As outlined in my literature review, most IoT rhetoric focusses on *efficiency metrics* such as energy usage and carbon emissions and how these can be monitored and improved by connecting numerous products to the Internet. I contend that this hyperbole obscures the 'material' concerns that I have outlined above. As a consequence, limited praxis has explored the environmental impact of IoT devices' materiality. Resultantly, how to apply design theory and praxis in order to highlight the inherent unsustainability of IoT products provides a third distinct gap that I investigate as part of this thesis.

3.2.4 Data is Money Not Sustainability

To reiterate, it is estimated that around 75 billion everyday objects will be connected to the Internet by 2025 (Statista, 2018). The data spawned as a result of this connectivity may well help people to make quicker and more efficient decisions about different facets of their lives. Despite this positive potential, I argue that *avarice* sits at the heart of this *big data* movement. Whilst the *smart agenda* keenly promotes the sustainable credentials of IoT data generation – which, as noted, is principally through energy monitoring – my literature review shows how the ‘value’ to be obtained from users’ connected product data, is, in fact, economical and not ecological, in nature. The IoT is, in effect, a ‘channel’ through which developers and platforms can harvest, mine and monitise increasing sums of users’ personal data. Within academia, *Speculative Design* proposals like Magee et al’s (2015) and Speed et al’s (2014) *Internet of Second Hand Things* (Figure 19) and Pschetz et al’s (2017) *Bitbarista* (Figure 20) have both, to a certain extent, considered sustainable parameters while exploring alternate value propositions that connected objects might potentially yield. The former deployed a fictional ‘second hand connected product’ called the *Haggle ‘O’ Tron* into charity shop settings in order to ascertain whether connectivity may facilitate new value cultures, namely more durable user-product relationships. The *Bitbarista* prototype meanwhile sought to emphasise the complexity and often unseen impacts of supply chains by displaying production, distribution and purchase data protocols as part of the connected coffee machine’s interface.

Their sustainable connotations notwithstanding, both of these projects do not explore the underlying nefarious implications of IoT connectivity. Accordingly, through my research I will seek to illustrate how the ‘value of connectivity’ can be redirected away from economic gains and towards more explicit environmental concerns.

Figure 19: The *Haggle-O-Tron* is a speculative ‘second hand connected product’ which was deployed in charity shop settings in order to ascertain whether connectivity may facilitate new value cultures, namely more sustainable consumptive behaviours. Source: www.chrisspeed.net.

Figure 20: During its use, the *Bitbarista* prototype displays its data protocols to users as a means to emphasise the complexity and often unseen impacts of coffee supply chains. Source: www.entretags.de.

3.2.5 A Breeding Ground for Novelty and the Superfluous

The economic value of IoT user data in conjunction with the growing availability of disposable IoT hardware has resulted in a further issue. IoT product design cultures display a real penchant for designing and commercialising superfluous, novelty ‘enchanted objects’ – to use Rose’s trite term (2014). This means that more and more of the products that people use as a part of their everyday lives are being connected to the Internet, irrespective of whether these devices actually need to be. The reason for this trend appears to be once again *data acquisition*. Under a façade of innovation, developers seek to colonise consumer markets with their connected products as a means to monitise evermore amounts of user generated data. Greater numbers of physical connected products also result in increased sums of material waste, however. Despite this, it appears most IoT designers and technologists do not stop to consider the lasting environmental damage resulting from the unsustainable production and disposal of their unnecessary devices. Self-driving baby strollers connected underwear and smart dental floss (Smartbe.co, 2019; Skiin.com, 2019; SmilePronto.com, 2019) provide evidence of this ignorance. I therefore aim to throw shade on this superficial aspect of IoT design culture as part of a sustainable design methodology for connected products.

3.2.6 Futures That Look Backwards

In my discussion of design futures, I noted how 'temporality' has always been a key aspect of design theory and praxis. This is encapsulated in Simon's (1969) view of design, where he outlines how those carrying out 'design' are, in effect, seeking to depart from an existing condition with the purpose of arriving at a *preferred* one. In this way, *all design* is a future-orientated activity. As my literature review attests, the notion of designing *preferable* futures has been intrinsic to sustainable design discourse throughout the last 50 years. Key exponent Victor Papanek (1971) concurred with Simon's maxim, while Meadows et al's 1972 report, *The Limits To Growth*, was one of the first to explore the possible future implications of unbridled economic growth, resource depletion and technological progress. The latter posited dystopian repercussions due to unsustainable practices as a means to emphasise the need to shift to more sustainable ways of life. Interestingly, such dystopic thinking has become a tenet of sustainable design discourse in recent years. Thus, in contrast to the persuasive yet turgid *smart utopia* rhetoric that currently surrounds the IoT across academia and industry (Government Office for Science, 2014; Fritsch, Shklovski & Douglas-Jones, 2018), recent sustainable design narratives often amplify dystopian tropes drawn from classical *philosophy of technology* literature by the likes of Mumford (1934), Ellul (1964) and Borgmann (1984).[4] Accordingly, some theorists put forth apocalyptic visions such as human extinction, while others look backwards with hagiography to 'rose tinted' idylls for the answers to the unsustainable quandary we now find ourselves in (Thackara, 2005; Walker, 2014).

While such dystopian hyperbole is provocative, I believe that it can also be unhelpful for those attempting to envision more plausible implications arising from technological progression, particularly in regard to the design and profusion of the IoT. Further, in my opinion, 'looking back to look forward' is somewhat reductive, and, by its very nature, stymies creativity and obstructs innovation – often when it is most warranted. I consider the following excerpt by the media theorist and postmodern philosopher Marshall McLuhan[5] to be a convincing repost to the pessimistic tone we see in much sustainable design literature today:

> *When faced with a totally new situation, we tend always to attach ourselves to the objects, to the flavour of the most recent past. We look at the present through a rear-view mirror. We march backwards into the future* (McLuhan, 1967).

By scouring the past, Walker's ontological and epistemological approach to sustainable design favours a kind of *natural fundamentalism* steeped in olden craft as opposed to *pragmatism* built on innovation. Fry (1999; 2009) also seeks to 'redirect' the fundamental nature of design away from capital logic, yet he still argues for 'design pragmatics' to be at the heart of future sustainable praxis – otherwise, in his view, change will not come. Chapman (2005) agrees and argues that 'we can't halt progress'. Alongside Gant, he stresses how creation and consumption

[4] Lewis Mumford's *Technics & Civilisation* (1934), Jacque Ellul's *The Technological Society* (1964) and Albert Borgmann's *Technology and the Character of Contemporary Life: A Philosophical Inquiry* (1984) are some of the key texts in the field of *philosophy of technology*. All are highly critical of technology's growing hegemony across society and take particular umbrage at how, in their view, technology has come to dominate everyday life, fracturing social cohesion and relationships in the process, as well as erasing traditional, often sacral practices.

[5] In his 1964 book *Understanding Media: The Extensions of Man,* Marshall McLuhan originated the phrase 'the medium is the message'. He also coined the term *global village* (1962; 1964) to describe the phenomenon of how, through technological advancement, the world was becoming increasingly interconnected via the propagation of *new media* like television and digital networks. Resultantly, McLuhan's precept is considered as being prophetic of the later expansion, adoption and dominance of Internet technologies.

are deeply ingrained within the human psyche and people are inclined to and will continue to do both activities (Chapman and Gant, 2007). With this in mind, I accept that the IoT will continue to develop and further ingratiate itself into our everyday lives. However, I argue that as it does so, it is essential that we start to find new more sustainable ways of creating, consuming and disposing of future IoT devices *today*. For as the environmental economist E.F. Schumacher (1973) declared 'to talk about the future is useful only if it leads to action *now*.'

3.3 Chosen Approach

Buckminster Fuller, the 20th century designer, architect, futurist and *environmentalist*, used the metaphor of earth as a huge spaceship travelling through space to emphasise how the planet has a finite amount of resources and needs continual maintenance in order to function properly and stay on course (Fuller, 1967; 1981). I share this view, that due to its complex nature, planetary sustainability should be seen as more of a process to be *effectively managed* as opposed to being a problem to be *outright solved*. This perspective provides the foundation for the practice-led design research that I will discuss for the continuation of this thesis. In addition, my research will focus explicitly on the role that sustainability can potentially play in the design of future Internet-connected devices. Thus, from now on, when I refer to 'sustainability', I do so in the context of the design of manufactured Internet connected consumer products, specifically, what effect the lifespan of such devices – including the design, production, consumption and disposal stages – has on the natural environment. Figure 21 illustrates the difference between managing sustainability from a 'top down' planetary viewpoint, and the way my research will explore the subject from a 'bottom up' perspective – in relation to the unsustainability of manufactured IoT devices and how this 'feeds' the wider issues of manufactured product waste, carbon emissions, and, ultimately, climate change. I contend that taking this approach will enable my research to remain centred on the development of a *multidimensional* research lens to facilitate future sustainable Internet connected device design as opposed to attempting to navigate the issue of 'sustainability' in its all complexity.

When outlining his tenets of *redirective practice*, Fry (1999) appropriates the concept of *phronesis*, a school of thought originated by Aristotle, the ancient Greek philosopher. Fry uses the term to represent a type of 'practical wisdom', wherein theory and praxis function together with *foresight*, to bring about positive action through design. One might also describe this in simpler terms, as *thinking about the consequences of an action before one carries out that action*. Thus, Fry infers that designers have a moral duty to *think* about the environmental implications of their designed outputs, *before* they go about putting them into production and use. Based on Fry's analysis, I have developed my own interpretation of this relationship – Figure 22. The diagram seeks to illustrate that there is a causal link between *thinking*, *doing* and the *future* impact of these activities. Accordingly, my ensuing design-led research into the sustainability of Internet-connected devices is rooted upon this understanding.

At this juncture, I feel it is pertinent to return to Feenberg's (2002) dictum that technological progression brings with it both opportunities and challenges. Thus far, I have primarily outlined the latter, that is, the problems posed by the proliferation of the IoT – namely the inherent unsustainability of its devices. But might there also be sustainable advantages to be gained from widespread computation? What if the value of connectivity was 'redirected' and harnessed as a tool for *sustainable change*? Through the concept of *spimes*, Bruce Sterling began to contemplate both the environmental *harms* and potential *benefits* that might arise from the wanton pursuit of *Ubiquitous Computing* by the design industry, product manufacturers and technology firms. In light of the unsustainability of IoT design cultures, I consider the spimes concept to be highly provocative and ripe to be developed as a new approach for sustainable design in the connected product era. Thusly, in the next chapter, I will introduce the notion of spimes in greater depth, detail how it represents a compelling convergence of my literature review's three principal domains, and explain how it led me to form the three key questions that my thesis seeks to explore through practice-led design research.

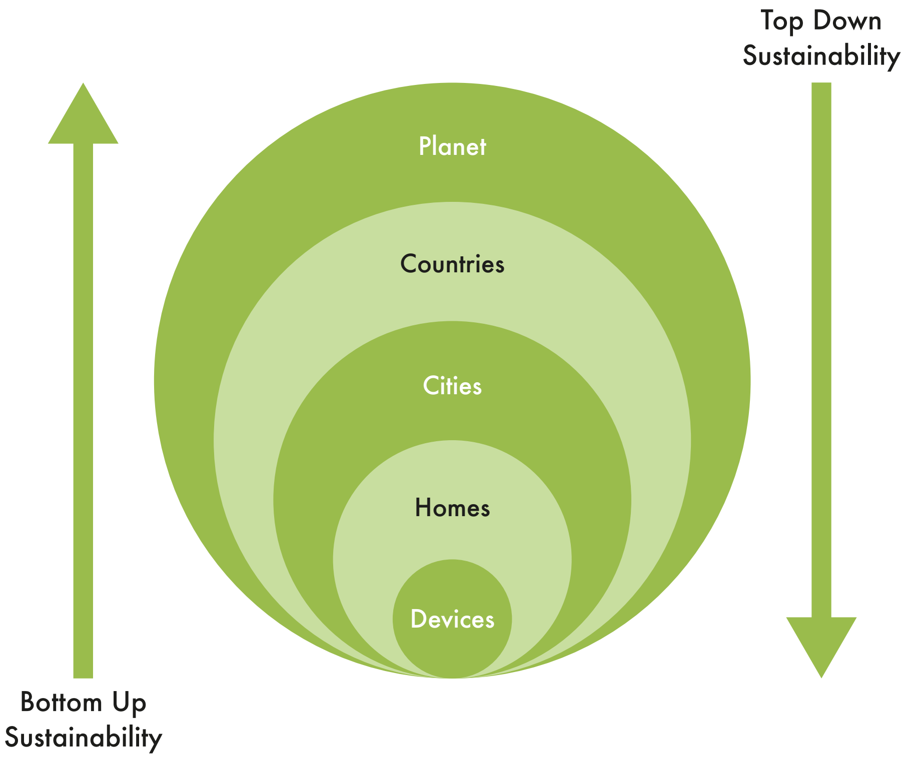


Figure 21: My research will explore sustainability from a 'bottom up' perspective – with specific regard to the design of IoT devices – as opposed to a 'top down' holistic planetary viewpoint. Source: Author, after Hamedani & Huber (2012).

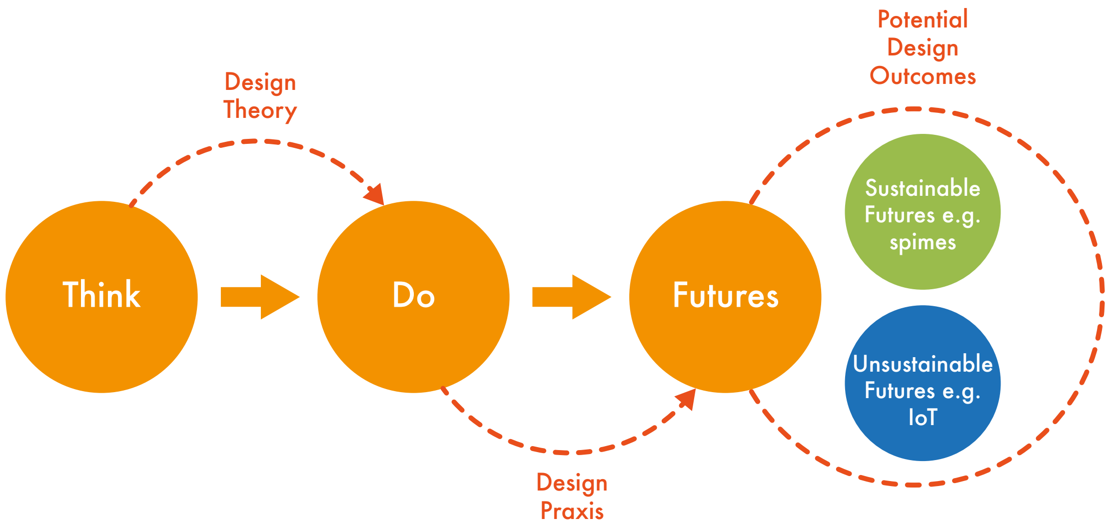


Figure 22: Building upon Fry's (1999) interpretation of Aristotle's term *phronesis*, I have illustrated the *causal link* between *thinking*, *doing* and the potential impact of this relationship upon *future* Internet-connected devices. Source: Author, after Fry (1999).

4 Spimes: An Introduction

4.1 Introduction

Before I begin to properly introduce the concept of spimes, I wish to provide a brief prelude by restating the key environmental issues that arise as a result of contemporary consumer device design cultures. As populations have continued to grow in size and affluence, so too has the consumption of material goods and services. Allied to the linear production model of 'take, make and dispose' that defines much of our global manufacturing industry, such profligate consumption has been shown to be highly detrimental to environmental sustainability (Weetman, 2016). Electronic devices have been exposed as a distinctly unsustainable product sector, with *e-waste* said to be the fastest growing waste stream in the world today, while the material resources needed to manufacture such devices are becoming ever scarcer (Chapman, 2008, Greenpeace, 2014). Product manufacturers' penchant for planned obsolescence drives this culture. By using cheap, subpar materials and purposely failing to incorporate effective means for repair, upgrade and recycling, the lifecycles of most electronic products are designed to be brief. They are further curtailed by routine changes to functionality, aesthetics and software, resulting in older devices becoming quickly outmoded by newer designs (Slade, 2007). I posit that the unsustainability of today's electronic product culture presages an even greater environmental challenge. The emergence over the last decade of widespread, embedded computation in the form of Internet-connected physical devices – the IoT – has only served to accelerate unsustainable design cultures (Gardiner, 2014). Though the *smart utopia* narrative permeates IoT development, this rhetoric neglects the inherent materiality of its devices, their manufacture and operational infrastructure. In addition, the industries of design, technology and manufacturing have long relied upon mass production, product iteration and obsolescence to perpetuate business. These models are being carried forward into the IoT era and is resulting in redundant and discarded connected products feeding the electronic waste stream – a stream that, at present, is complex, mismanaged and rapidly expanding (Mayers et al, 2011; Cole et al, 2019). Such problems thus give rise to an important question:

> *How can we sustainably manage the rapidly increasing amount of physical product waste being created when generations of devices are quickly made redundant because they can no longer support updated digital functionality and/or do not conform to the latest aesthetic/cultural trends?*

In response to this pressing issue, for my doctoral research I have chosen to unpack and develop the concept of *spimes* as a counterpoint to the unsustainability of the IoT. With spimes, futurist and science fiction author, Bruce Sterling put forward a provocative treatise for evolving the relationship between people and material things, specifically one where the core value to be gained from connecting physical artefacts with digital data processes is *sustainable change.*

4.2 What Do We Already Know About Spimes?

At the beginning of my literature review, I briefly outlined the origins of the *spimes* concept. To reiterate, the term was originally coined by Sterling in 2004 and is a contraction of the words *space* and *time*. Sterling argues that 'modern products are advanced, but nowhere near advanced enough to sustain civilised life in the long run' (Sterling, 2004b). He views digital technologies as having the potential to lay bare 'the reality that underlies all manufactured objects. [This would lead to a paradigm where] manufactured items will be more practical, efficient, and user- and environment-friendly' (Sterling, 2004b). In his book *Shaping Things*, Sterling further describes spimes as potentially being 'material instantiations of an immaterial system… they are designed on screens, fabricated by digital means and precisely tracked through space and time throughout their earthly sojourn' (Sterling, 2005). He also more explicitly outlined spimes' inherent environmental credentials, envisioning them to be 'sustainable, enhanceable, uniquely identifiable, and made of substances that can and will be folded back into the production of future spimes' (Sterling, 2005).

To help illustrate his concept, in *Shaping Things*, Sterling describes how a bottle of wine would manifest in a world where spimes are commonplace. To aid my initial unpacking of the term, the following is an adapted form of Sterling's exemplar:

> **Stage 1:** You first encounter the spime bottle of wine as a digital image while searching on a website. The image is deep-linked to the genuine, three-dimensional computer-designed specifications of the object including engineering tolerances and material data as well as its drinkable ingredients. At this time, the spime bottle of wine has no material existence beyond this "digital instantiation".
>
> **Stage 2:** You purchase one bottle. The transaction results in the manufacture of its physical, "material instantiation". Details of your purchase are automatically integrated into your personal spime management inventory system. This enables you to manage your spime throughout its lifespan giving you access to information such as your bottle's unique ID code and its history of manufacture plus a variety of material and energy flow data.
>
> **Stage 3:** Your bottle is delivered to your address. It is location-aware, environment sensing, self-documenting and geographically trackable – a material object that is "information rich" and which continually stores and transmits digital data about its environment and its lifecycle.
>
> **Stage 4:** You finish the bottle. This iteration of your spime has now reached the end of its useful, material life. When you dispose of the bottle, it is deactivated, disassembled and, being made from recyclable substances, is folded back into the manufacturing stream for future spimes. The data it generated during its lifespan is saved and remains available online for historical analysis by you and any other interested parties (Sterling, 2005).

Sterling contends that the practices inherent to contemporary industrial product design and technological evolution cannot continue in their current form because of their lamentable impacts on environmental sustainability. He asserts that modern societies are using energy and materials which are finite, toxic, lead to climate change, social inequity and 'cause resource wars. They have no future' (Sterling, 2005). To make his case, Sterling traces the evolution of the dominant *techno-cultures* that have prevailed throughout societies for the previous 2 million years. Based upon this outline, I define will the meaning of the term *techno-culture* as appropriated within the context of my research:

- **Techno-culture:** this denotes the type of relationship that humans have with the tools that are created, either by themselves, by fellow humans, and/or with fellow humans. As such, the tern *techno-culture* embodies the notion that the development of new technologies not only influences design and technology cultures but also has profound implications for individuals as well as societies at large. Techno-cultures change over time and are characterised by a 'continuing interplay between objects and people' (Sterling, 2005).

Sterling's analysis consequently moves through what he perceives to be the five dominant techno-cultures: from *artefacts*, through *machines*, *products* and *gizmos*, to beyond, to what he considers a *preferable future*, a future defined by *spimes*. In Figure 23, I have depicted these five shifts in *techno-culture*:

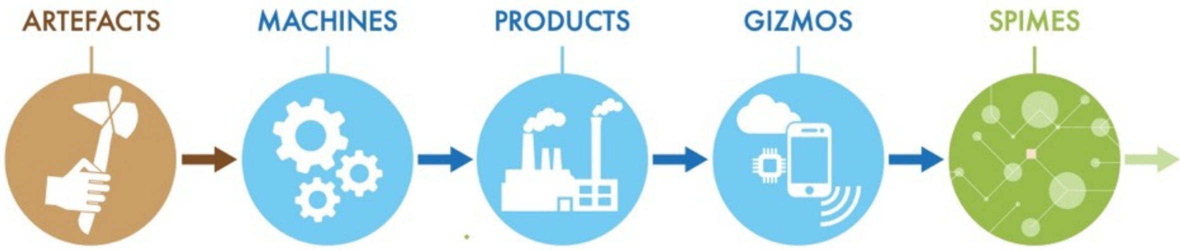


Figure 23: Sterling determines that there have been five dominant techno-cultures in human history – *artefacts, machines, products, gizmos* and *spimes*. Source: Author.

Building on Sterling's (2005) outline, the first four *techno-cultures* can be described as thus:

- **Artefacts** are simple objects, made by hand, used by hand and powered by muscle. The people who design and use *artefacts* are *hunters* and *farmers*.

- **Machines** are complex objects with integral moving parts and with a non-human/non-animal power source. The people within a *machines* techno-culture are called *customers*.

- **Products** are non-artisanal, anonymously mass-produced objects, widely distributed and supported by large and rapid labour, transport, finance and informational infrastructures. The people within a *products* techno-culture are called *consumers*.

- **Gizmos** are highly unstable, user alterable and programmable multi-functional objects commonly linked to network service providers. They have a brief lifespan. People within a *gizmos* techno-culture are called *end-users*.

As a means to start to move beyond *gizmos*, the wine bottle exemplar is useful as helps us to begin to envision a techno-culture in which spimes might exist. It also serves to highlight how a future spime-like product would always have a lineage to the four previously dominant techno-cultures. This is because a succeeding techno-culture does not abolish any of their predecessors outright, but merely – to use Sterling's ecologically oriented phrase – *composts* *them*, with him stressing that 'the future composts the past.' A spime wine bottle would, afterall, continue to be a wine bottle and similar to those drunk that have been from for millennia. In essence, the transition to a spime-based techno-culture would not instantly replace the *artefacts*, *machines*, *products* and *gizmos* that we have today but would alter the forms new objects take and most significantly, change the relationships people have with them. This is because, as Sterling (2005) states, a spime 'is a set of relationships first and always, and an object now and then.' In a spime-based future, material products, objects and things are *materialised nodes*, physical anchors to an expansive, networked digital domain. As Taylor and Harrison (2008) note, 'the importance of a spime is not so much the physical material object. It is the provenance, history and support system that it creates.' Thus, the informational support afforded by a spime would change the relationship between people and the object and not the object per se.

When compared to *gizmos*, Sterling asserts that the first three techno-cultures – *artefacts-machines-products* – had simpler, more linear sets of relationships between humans and objects. People were closer – in terms of both of their understanding and locale – to the industrial processes that were involved in manufacturing their material goods. The *artefacts* techno-culture, for example, included early technologies like bespoke farmers hand tools which used natural materials that could eventually be repurposed or returned to the local ecosystem. The environmental effects caused by the production, consumption and disposal of these early things was therefore miniscule and more transparent than our experience with today's man-made objects. The transparency between humans and tool production eventually became extremely muddied in the transition to *gizmos*. This was due to an overreliance on increasingly complex and unsustainable material extraction, manufacturing, supply chain and consumption infrastructures.

Conversely, the informational support granted by spimes could potentially make implicit industrial, distribution and consumption processes once again explicit – visible, obvious, and potentially, more sustainable. This sits in stark contrast to our present behaviour where a bottle of wine would arrive in one's 'possession seemingly stripped of consequences, but those consequences exist [and] the mythic moment… of throwing it "away", is supposed to be the sudden and total end of [your] mutual narrative as human and object. But that is by no means any end of any object' (Sterling, 2005). In a spime techno-culture then, one would know *where a bottle of wine has come from*, *where it is* and *where it will go*. This transparency would alter the way new products are designed and how people will ultimately use, value and *dispose* of them. As Figure 24 illustrates, the transition through the four techno-cultures prior to spimes has only served to generate increasing sums of unsustainable object waste. Further, we can see that Sterling contends that the *gizmos* techno-culture commenced around 1984, while he views the transition to spimes as beginning in 2004, the year before he published *Shaping Things*.

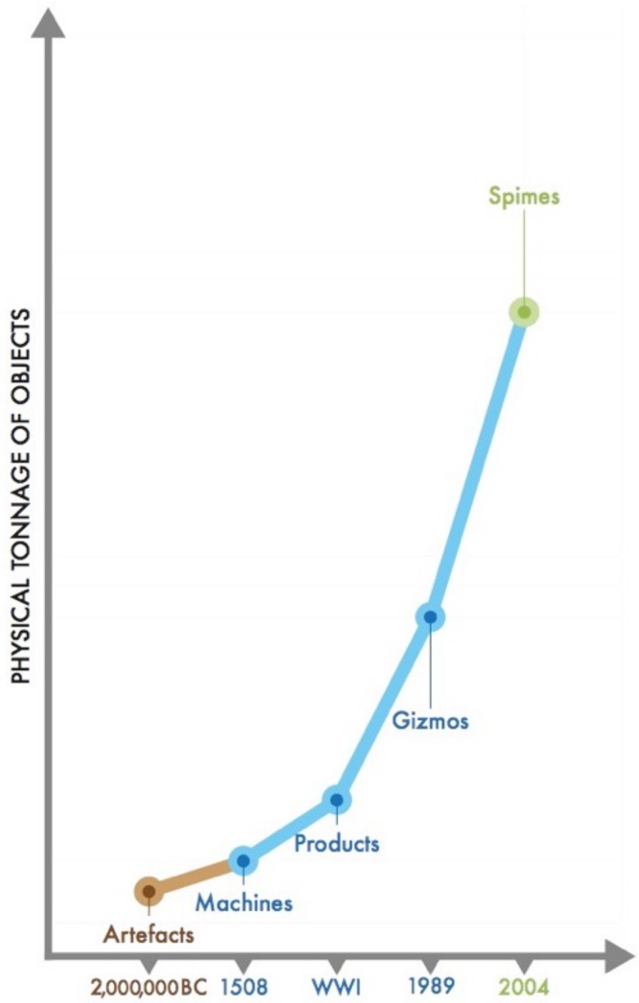


Figure 24: Sterling argues that object waste has increased exponentially through each techno-culture. In addition, he contends that the *gizmos* paradigm began around 1984 and the transition to *spimes* in 2004. Source: Author, after Sterling (2005).

4.3 Spimes & The Known Present

It might be argued that in the years since *Shaping Things* was published, spimes have in fact, come into existence. *Stages 1* and *2* of the wine bottle exemplar certainly share similarities with our *known present*. Today, you can search through millions of digital product images on Internet commerce sites such as *Amazon* and *eBay*. Purchase a particular product and details of the transaction are automatically added to your personal account. You are then able to track the delivery journey of your product's material incarnation – from when it is packaged to when it arrives at your personal address. Sterling was originally inspired by the U.S Department of Defence's adoption of radio-frequency identification (RFID) technology to 'tag' and track its weapons throughout its supply networks (Sterling, 2004a; Violino, 2003). The rapid growth of *e-commerce* in the late 1990s/early 2000s was no doubt also an influence, particularly *Amazon's* practice of tagging its physical stock such as books with RFID. In conjunction with global positioning systems (GPS), this renders these physical items identifiable, trackable and locatable throughout their supply chain, as well as ensures that the data generated through such processes is enshrined within digital inventories.

The technological aggression of *Amazon* in the Internet's formative years has subsequently made the firm's founder, Jeff Bezos, one of the wealthiest individuals on the planet (Au-Yeung, 2019), while their IoT devices are the market leaders globally (Statista, 2019). *Stage 3* of the exemplar resembles this growing worldwide trend for IoT devices. As has been previously outlined, such products incorporate technologies like wireless Internet, RFID and GPS capabilities and are able to sense and monitor their environment and display feedback data. Most IoT products are *proprietary*, that is, they are designed and manufactured by *centralised*, corporate brands such as *Amazon's Echo* smart speaker range (Rowland et al, 2015). The past decade has, however, also witnessed the growth of *decentralised* technological practices like the *Maker Movement*, *Fab labs* and *open hardware/software* development. Within these sub-cultures, people use the aforementioned technologies in conjunction with other tools like CAD software and 3D printers to design and build bespoke Internet connected objects (McEwen & Cassimally, 2013). It appears that, while writing *Shaping Things*, Sterling was heavily influenced by many of the nascent technologies and practices that are outlined above. It can also be said that he was also prescient in positing how they might be employed. I argue, however, that *Stage 4* of his wine bottle exemplar – the *sustainable disposal* and *reuse* of a spime device's materials – has yet to come to fruition. Thus, I contend that it is this stage that separates a potential spime-like device from a present day IoT product.

Despite the latter disparity, it is unsurprising, given the preceding similarities, that in the mid-late 2000s, both the term spimes and the IoT would often get used interchangeably to denote an Internet-connected material object. The misappropriation of spime was predominately found within commercial design practice in relation to projects such as that depicted in Figure 25 – the 'Olinda Radio' (Ferne, 2008). While this prototype was technically innovative, it was an exercise in *connecting the material to the digital* and no consideration was given to the sustainable narratives that a potential spime-based product culture might help facilitate. In academia, the concept has mostly been discussed in primarily a theoretical manner with a focus on technical specifications. Thus, previous research has contextualised the design aspects of concept within computer science fields like *Ubiquitous Computing*, *Human-Computer Interaction*, and *Interaction Design* (Thomas, 2006; Greenhill and Fletcher, 2009; Saffer, 2010; Speed, 2011), as opposed to framing it in relation to sustainable design discourse and praxis. One academic project that does examine some of the sustainable implications of Sterling's concept is Bonanni et al's (2009) *Spime Builder* protoype (Figure 26). The authors visualised a speculative prototype for a *Tangible User Interface* – an immersive design tool which merges physical and digital design processes into a single practice. Bonanni et al posit that this is in 'preparation for a future where connectedness will become central to the value of most physical products.' They planned to introduce product *Life Cycle Assessment* capabilities into the next iteration of the prototype to allow designers to more easily incorporate sustainable material, manufacturing and disposal strategies into their connected product designs. Another academic interpretation by Maciag et al (2010) used the concept when examining the supply chains of the food sector and envisioned how adopting spimes might make such processes more sustainable in the future. This paper shares parallels with the work carried out by *Provenance* (2019), a commercial firm which aims to help other businesses cultivate sustainable supply chains for their products using technologies like RFID and *blockchain*. The company's founder, Jessi Baker, cited the spimes concept as the basis for her Royal College of Art Master's project which explored how digital technologies could facilitate greater sustainable behavior amongst consumers particularly with regards to food and fashion (RCA, n.d.). Baker subsequently developed the project into the *Provenance* business (Wheeler, 2017).

Figure 25: A prototype developed by the *BBC Audio & Music* and design firm *Schulze & Webb*, the *Olinda Radio* iss often described as a *spime* merely for the fact that the device is connected to the Internet. Unlike a potential spime object however, *Olinda* has not been designed with sustainability in mind. Source: berglondon.com/projects/Olinda. Image is unavailable due to copyright restrictions.

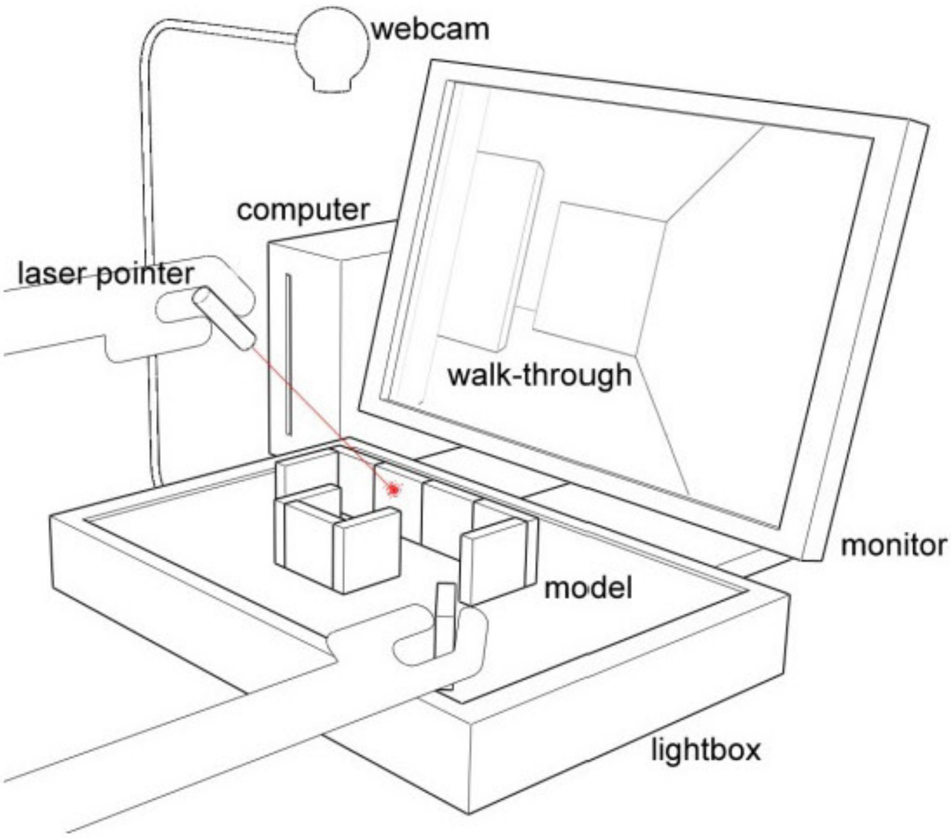


Figure 26: Bonanni et al's *Spime Builder* protoype is an immersive design tool which merges physical and digital design processes into a single practice.
Source: Bonanni et al (2009).

4.4 Spimes & Futures

Figure 27 is a diagram based upon one which Bruce Sterling produced in 2006 with the aim of depicting the potential lifecycle of a spime object (Sterling, 2006). As one can see, around the edges of the diagram are the neologisms and terminologies often used for describing the practice of connecting material artefacts with digital technologies. Included are terms I have previously outlined like Weiser's *Ubiquitous Computing* and *Calm Technology*, Greenfield's *Everyware* and Ashton's *Internet of Things*. More centrally, the key phases of a spime device's possible lifecycle are mapped. The material (atoms) stages include *fabricating* and *recycling*, while the digital (bits) processes involve *designing* and *datamining*. I believe the most significant aspect of the diagram is perhaps the title – Sterling named his original sketch *Spime Theory Object.* As noted in the previous section, Sterling determines that a spime-based techno-culture came into effect from 2004 – a year prior to the release of *Shaping Things*. I contend that he chose to do this in order to affirm the notion of product lineage across techno-cultures. At the time of writing his book, Sterling considered the origins of spimes to be – both *pragmatically* and *ideologically* – in the present. He envisaged spimes developing out of *gizmo* techno-culture and having done so, they would share some characteristics with *gizmo* products like connective technologies and design practices.

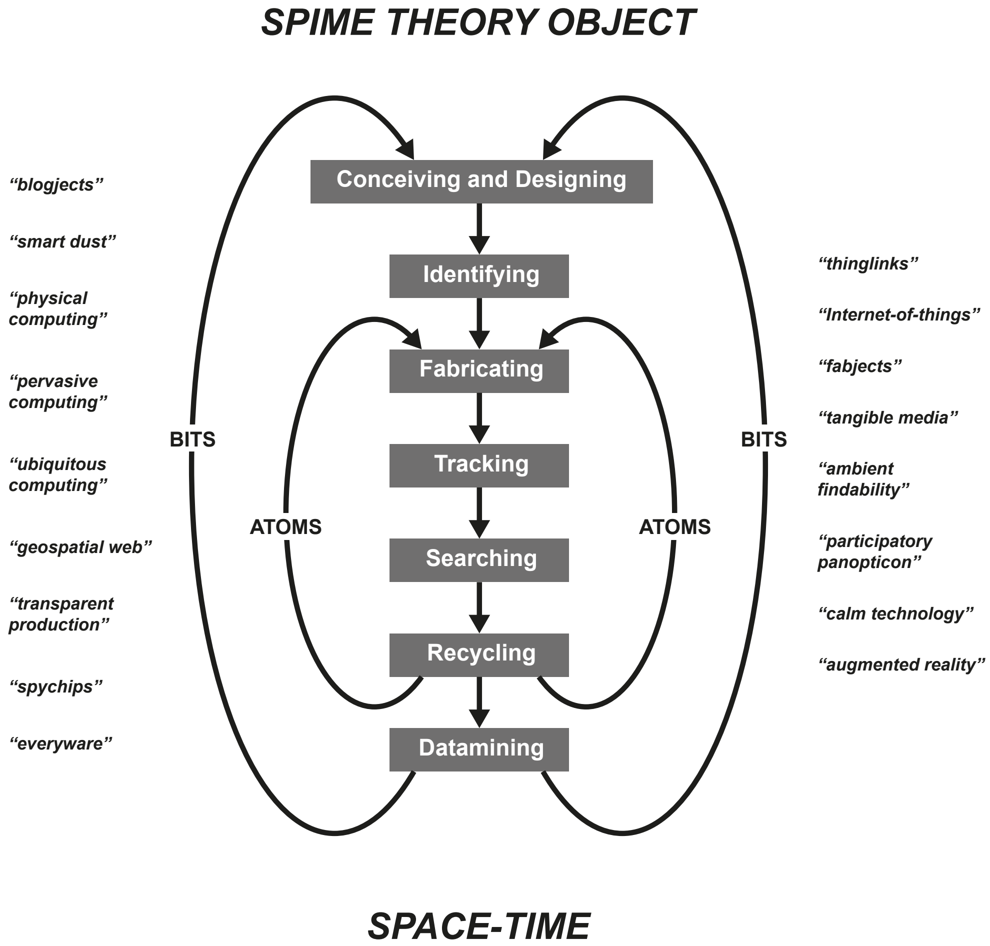


Figure 27: A diagram detailing the proposed lifecycle of a potential spime object by Bruce Sterling. Source: Author, after Sterling (2006).

However, the informational support spimes would potentially offer would be very different to those of *gizmos*, specifically with regard to *sustainable disposal* and *material reuse*. Thus, I argue that although spimes might share some common attributes with many of the IoT products and services that have been developed since *Shaping Things* was published in 2005, the IoT is still strongly representative of a *gizmo techno-culture* and *not* spimes. The design, informational support and 'material instantiation' of IoT products are yet to become distinctly spime-like. Although more and more material things have been given digital capabilities in recent years, they will soon be replaced by newer alternatives and eventually discarded. Consequently, today's connected things will enter the electronic product waste stream with their precious materials and embodied energy forever lost to landfill. I would go as far as to describe the present as hopefully a 'transitionary period' from the IoT to spimes but we are yet to *definitively* begin designing, manufacturing and consuming the latter. As Figure 28 shows, I assert that the unsustainability of the IoT is a symptom of design and consumption cultures that the paradigm has inherited, while spimes could be the embodiment of a new future sustainable connected product era.

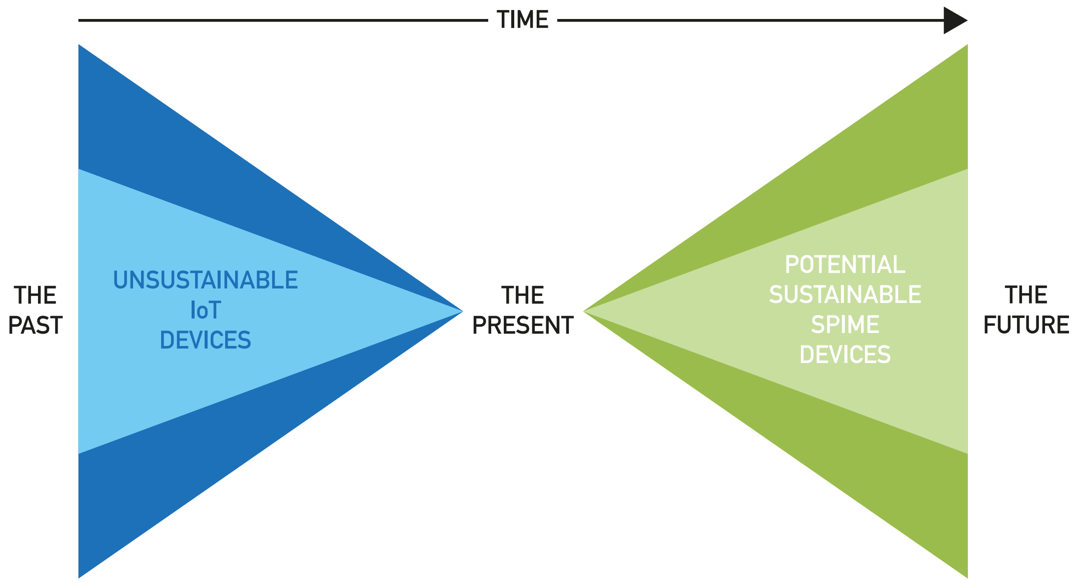


Figure 28: I argue that spime objects are still yet to be sufficiently designed and therefore are of the future, while IoT devices remain tied to the unsustainable design and consumption models of the past. Source: Author.

With this mind, while I accept that spimes and IoT devices will share a lineage, I counter Sterling's hypothesis that spime objects began to be designed and produced as early as 2004. Due to the IoT's unsustainability, I think the descriptor for his diagram is more apt – spimes remain *theory objects* for the time being. My supposition in many ways concurs with Hales' (2013) description of the concept. He describes spimes as 'rhetorically futuristic… a category of imaginary object that is also an intervention in the present and [which] are 'forward looking' akin to the actually futuristic objects they create'. If we consider Sterling's early discourse as laying the foundation for the 'rhetorically futuristic' nature of spimes, it is my intention that my doctoral research will further develop the theoretical parameters of the concept as well as try to determine how this exploration can help envision 'actually futuristic' spime objects through design praxis.

4.5 Criticism of Spimes

A charge that may be leveled against Sterling's concept is that it places sustainability at the centre of a technologically driven *utopian* narrative, the kind that aligns with the *Californian Ideology* (Barbrook & Cameron, 1995), or the more recent stance of *Ecomodernism* (Nisbet, 2014). I discussed during my literature review how the former is rooted in *technological determinism* – the notion that technology is unambiguously a 'tool for good' – and was forged in the 1960s amidst the hybridization of left-wing counter-culture politics and right wing neoliberal economics. Steve Jobs, the late co-founder of *Apple* is often portrayed as an technological innovator whose ideology was founded on similar principles. He professed socially and environmentally centred 'hippie' ideals, namely that technology could bring people together and resultantly change the world for the better, yet he envisioned that computing devices could also become an icon of *free market capitalism* (McGuigan, 2014). It can be argued that the spirit of the *Californian Ideology* can still be seen to run through the current doyens of IoT infrastructure – *Apple* and the other tech firms that make up the *The Big Five*. *Google*, while pursuing its hegemonic expansion into the Internet's premier search engine, had the motto 'Don't Be Evil' enshrined as part of its code of conduct (Montti, 2018). The rhetoric appears to also trickle down to smaller technological enterprises such as *Technology Will Save Us* which produces educational *do-it-yourself* computing kits for children (Techwillsaveus.com, 2019).

The discourse surrounding *Ecomodernism* shares much in common with the *Californian Ideology* and is exemplified by the *Ecomodernist Manifesto* (Asafu-Adjaye et al, 2015) which was produced by a multi-disciplinary group of academics, technologists and environmentalists. In simple terms, the manifesto promotes the notion that the pursuit of technological efficiency alongside population control can maintain the exponential economic growth sought by Western societies, while at the same time providing solutions to the unsustainable issues that threaten earth's environmental wellbeing. In a harsh critique of the manifesto, Monbiot (2016) warns to 'beware of simple solutions to complex problems. That is a crucial lesson from history; a lesson that intelligent people in every age keep failing to learn.' Linked to the *Ecomodernist* standpoint is *bright green environmentalism*. This stand of thinking favours a convergence of technological innovation, social responsibility and radical design processes as a means to form practicable sustainable outcomes. Alex Steffen is regarded as the progenitor of this approach and chose the moniker 'bright green' in order to distinguish the movement from what he deems to be 'dark green' perspectives to sustainable change, principally ones which emphasise *post-materialism* strategies including de-industrialisation, population control, anti-consumerism and rigid limits to economic growth (Steffen, 2006). As such, Robertson (2009) states that *bright green environmentalism* as 'less about the problems and limitations we need to overcome than the 'tools, models, and ideas' that already exist for overcoming them. It forgoes the bleakness of protest and dissent for the energizing confidence of constructive solutions.'

Bruce Sterling is known for his advocacy of *bright green environmentalism* and produced the online blog *Viridian* (so named after a particular shade of *bright green*) throughout the 2000s to discuss such thinking. Thus, spimes can, to a certain degree, be seen to embody the rhetoric of the *bright green* stance, namely that a combination of technology, social innovation and design can help shape *constructive* sustainable futures. Steffen (cited in Rinde, 2016) encapsulates this view when he concludes 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.' I understand why, as a result of the alignment between spimes and *bright green* discourse, that it may be easy to regard spimes as a 'symbol' of a sustainable utopian ideology. To counter this interpretation, I would point to Sterling's own criticisms of his concept, some of which were made during his SIGGRAPH presentation in 2004 – his very first framing of spimes. In practicable terms, Sterling stresses that while the adoption of a spime-based paradigm would herald sustainable advantages, such a shift would also usher in a raft of new issues. So, while spimes would be a 'work of progress [and] handled correctly, [they] can undo the harm of the past and enhance what is to come' (Sterling, 2004a), they would also have disadvantages:

> *Are there dark sides to this vision? Oh yes indeed. Genuine menaces… spime spam, pushiness, abuse of customers, intrusion; spying and eavesdropping capabilities; brooms that bellow ads, mops that demand money; subtle software faults that make even a simple shovel unusable… security flaws, hacking, theft, fraud, malware, vandalism and pranking… industrial hazards: spime kitchens that fry the unwary, spime cars that follow outdated software maps and drive right off broken bridges… organized spime crime; unpredictable and emergent forms of networked behavior from clouds of objects… legal, ethical and social responsibilities for semi-autonomous objects; objects that used to be inert, and are now expensive, fussy, fragile unpredictable, too fluid, hopelessly complex, and subversive of established values; And just plain ugliness: tacky, goofy, tasteless, cheesy, lethal, vulgar, dirty, worthless, obscene, impractical, and dangerous spimes* (Sterling, 2004a).

In respect to the above concerns, Sterling pointedly states that the spimes concept 'is not a vision of utopia' (Sterling, 2004a) and further outlined the problems that would likely come to pass as a result of adopting them in his *Wired* magazine article (2004b), book *Shaping Things* (2005) and later during various conference presentations. While I acknowledge that technological progress – particularly connectivity – is an important aspect of the spimes concept, I take the view that Sterling is not presenting spimes in *technologically determinist* manner. As previously noted, since originating the spimes concept, Sterling has also strongly critiqued the increasing moral vacuity and avarice that characterises IoT design culture (Sterling, 2014). In light of this, I make the case that spimes sit contrary to the 'smart agenda' and the utopian narratives that surround the IoT. Critically, I argue that, today, it is in fact the IoT that embodies the range of a harmful traits outlined above and *not* spimes – as we are yet to begin actually designing the latter. Further, by conducting research into the spimes concept, I am able to foreground technological progression at the centre of a *design narrative* – one in which human creativity is key to changing our future ways of living – specifically how designing new technologies might make us lead more sustainability conscious lives. Essentially, it is not our material objects or technological systems that have led us into an era of unsustainability, but how we have designed those objects and systems.

I concur with Taylor & Harrison (2008), who argue that spimes would '*offer an entirely new way of understanding how artefacts relate to their environment, not just their users, breaking centuries-old habits that have resulted in the build-up of detritus across our planet*'. Importantly, I do not view spimes as a panacea to combat the problem of planetary unsustainability. I see the concept more as a useful *lens* to both critique the unsustainable issues arising from contemporary Internet connected product design culture, whilst also providing a way to envision future, more sustainable approaches to said praxis. To this end, I contend the spimes concept aligns with the core perspectives put forward by key sustainable thinkers Fuller (1967; 1981), Papanek (1971) and later Fry (1999, 2009), principally, that design is a tool for *constructive* environmental, social and technological change – both from a practicable and theoretical standpoint.

4.6 Key Questions

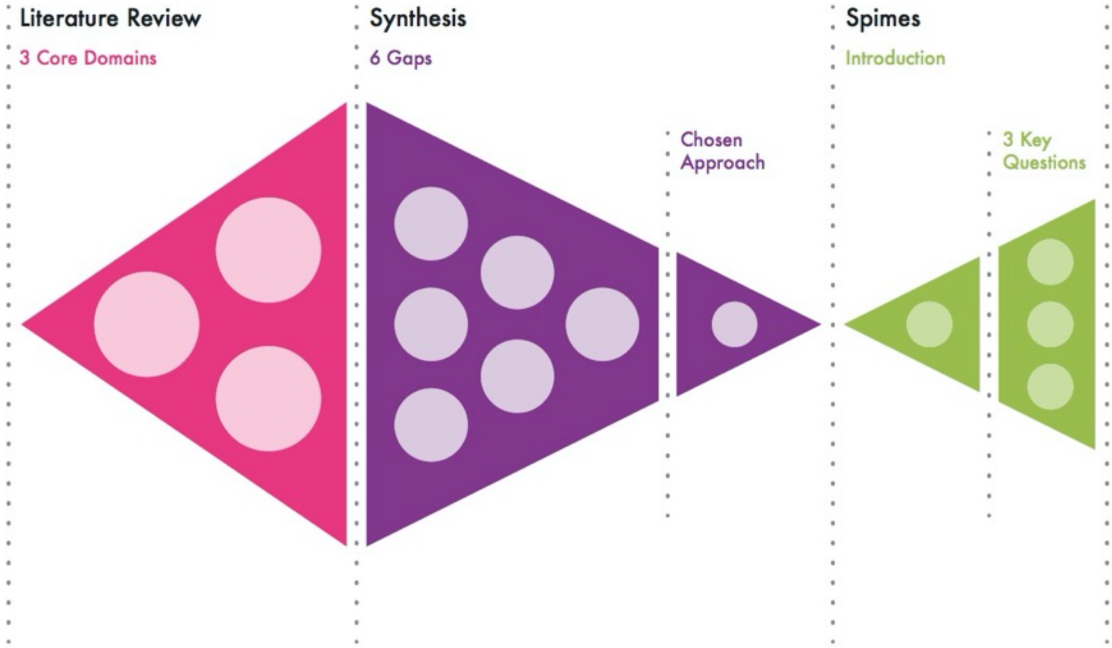


Figure 29: The process of *divergence* and *convergence* that characterises my doctoral thesis thus far. Source: Author.

In Figure 29, I have endeavoured to illustrate the process of *divergence* and *convergence* that has characterised my thesis thus far. Through synthesis of my literature review, I concluded that the current approach to designing IoT devices simply perpetuates the unsustainable design culture that various sustainable product design strategies have long sought to redress. In light of this, one might reasonably ask, *why bother to keep trying to design a more sustainable world?* I take the stance that, while completely reversing the unsustainable quagmire modern societies now find themselves in may be a near impossible task, this does not mean that the connected device design culture should simply turn a blind eye and blissfully continue to contribute to environmental degradation. Thus, in response to the growing e-waste and material scarcity issues that the IoT currently facilitates, my research contribution centres on re-characterising IoT devices as *spimes*. In doing so, it is my intention to provide an alternative sustainable methodology for future connected product design praxis where sustainability is baked-in and product obsolescence and end of life are managed effectively. To this end, I assert that the aims and intent of my doctoral research embodies Sterling's view of how a spime-based techno-culture might come to fruition – this being principally through the work of impassioned design practitioners, who he describes as:

> *A class of aware, well-informed, trained and educated people who can navigate their way through this field of complexity, negotiating the snaky processes of technosocial change guiding them toward the sustainable. People who will make it their professional business, no, even their calling,*

> *their practice, their very mode of being… Who would that be, then?* ***Designers.*** *Who else is there?* (Sterling, 2005).

Taking the above statement as a *call to arms*, my spime-orientated practice-led research will update and extend upon Sterling's concept by exploring the following three key questions:

- **What are spimes?** Whilst Sterling's early synopsis provides a rich canvas, I intend to expand upon his ideas and develop both the theoretical and practicable underpinnings of the concept as a counterpoint to today's unsustainable IoT paradigm.

- **Can we begin to design spimes?** Although Sterling suggested some possible technologies and features that could be incorporated into a spime device's design, he has never attempted to envision how spime objects might be designed, nor how people might interact with them. Other design practitioners and researchers are also yet to sufficiently do so. Through practice-led methods, I intend to envision potential spime objects, understand how they might begin to be designed, and *concretise* the kind of near future worlds in which they might possibly exist.

- **What does spime-orientated research mean for unsustainable Internet-connected device design practice?** Whereas the majority of sustainable design theory and praxis has focused on the development of sustainable *non-connected* devices, a credible strategy for the design of environmentally friendly *Internet-connected* physical objects has yet to be put forward. Moreover, can spimes be developed in such a manner that their 'value' is more than the design of mere devices? Might they be presented more as a mindset that practitioners, technologists and researchers might adopt for sustainable product design in the IoT era?

Now that I have confirmed that spimes will be the prime focus of my thesis' contribution, in the next chapters I will identify the core methodology and methods that I wish to employ in order to carry out my spime-orientated practice-led research.

5 Research Methodology

5.1 Introduction

Creswell (2003) determines that a research methodology is the overarching approach that a researcher adopts to conduct their research, from the theoretical underpinning to the collection and analysis of data. Crotty (1998) describes methodology as the ‘plan of action’ upon which the choice and application of specific methods is founded. Taking a more philosophical perspective, Sapsford & Jupp (2006) state that a methodology is an embodiment of the researcher’s *worldview* which resultantly underpins and informs the type of research conducted. My interpretations of Buckminster Fuller’s (1967; 1981) stance on the progressive nature of environmental sustainability and Tony Fry’s notion of *phronesis* (1999) have begun to provide some philosophical grounding for my research into the spimes concept. However, they do not provide a thorough methodological substrate for my thesis. Thus, in this chapter I will detail my chosen overarching methodological approach – *Research through Design* (RtD). Gradinar (2017) describes the methodology as a means for knowledge production which comes about through ‘the union between making and thinking’. Though originally outlined in 1993 by Christopher Frayling, there remains no definite consensus regards how to pursue RtD (Savic & Huang, 2014; Godin & Zahedi, 2014). However, as I will discuss, this plurality is perhaps RtD’s ‘greatest strength’, in that, its fluidity and generative nature provides a footing for creative and experimental research that other, more entrenched methodologies, might not necessarily facilitate.

5.2 Research Through Design

5.2.1 Introduction

In his seminal paper for the *Royal College of Art*, Frayling (1993) determined that the relationship between research and art and design can be delineated into three distinct paradigms: research *into* art and design, research *through* art and design and research *for* art and design. Specifically focusing on the interactions between *research* and *design*, Findeli (2004) further elaborated upon Frayling’s intellectual framework. Originally published in French, the following are translated synopses of Findeli’s augmentations:

- **Research *into* Design** is the approach that has most commonly been explored within academic design research, traditionally across disciplines like history of art and ergonomics but more recently within fields such as semiotics, anthropology, cognitive psychology and sociology. This approach primarily contextualises design as a practice in relation to the world and other fields of study. It conforms to the canon of academic research in that it often produces knowledge and makes theoretical contributions *about* design, yet these advancements usually lack relevance for the processes inherent to design itself.

- **Research *through* Design (RtD)** differs from the above methodology in that it frames design activity – the act of creating artefacts – *as research*. As such, it is an approach that seeks to take advantage of the unique insights gained *through the process* of design practice. In essence, application of this methodology can be a means to gain a deeper understanding of the complexities of a researcher's engagements with materials and the act of *designing* itself.

- **Research *for* Design** is the most common type of design research and is implemented as part of a design project that leads to the creation of an artefact of some description. As such it is focused on *outcomes*. This approach guides much of professional practice because it is the one most frequently taught across design education. Akin to art, the designed artefact is deemed sufficient in itself to testify to the 'results' of the research. Such artefacts in effect embody all the knowledge that is produced and communicate it in primarily a visual manner (Findeli, 2004).

In Figure 30, I have sought to depict the core precepts of the three paradigms. Gradinar (2017) points out that, while the paradigms to a certain extent 'inform each other', if we are to refer to *research as knowledge production*, 'the [paradigm] which is most relevant [is] RtD'. Importantly, Godin & Zahedi (2014) assert that Findeli's framing of RtD is particularly significant because it 'formalised the academic merit' of the methodology. They contend that it has consequently emerged as the pre-eminent definition of RtD that is most often cited in academic literature and provides the basis for much of the work in the field. Indeed, the predication of RtD as a methodology for *scientific enquiry* which facilitates the production of *scientific knowledge* has led to a growing RtD discourse across fields with *scientific pedigree*, notably computer science, Human Computer Interaction (HCI) and Interaction Design by authors including Biggs & Bütchler (2007), Jonas (2006), Chow (2010) and Koskinen et al (2011). Zimmerman and colleagues (Zimmerman, Forlizzi & Evenson, 2007; Zimmerman & Forlizzi, 2008; Zimmerman, Stolterman & Forlizzi, 2010) have perhaps made the strongest argument for RtD's scientific underpinnings. They assert that generating 'research artefacts' allows RtD practitioners and researchers to address complex issues (such as *wicked problems*)

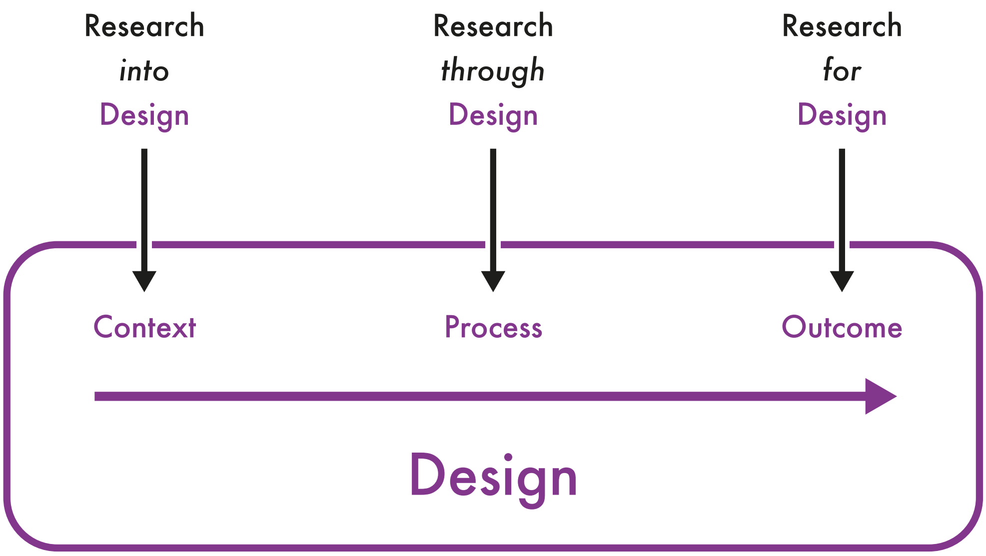


Figure 30: The distinctions between *Research 'for', 'into' and 'through' Design* methodologies. Source: Author, after Frayling (1993), Press (1995) and Findeli (2004).

and create knowledge regards the future impacts of emerging technologies and systems upon society. However, they also highlight what they see as an absence of 'criteria for specifying appropriate approaches and for evaluating the quality of contributions' in conjunction with a lack of 'method to document the knowledge… that emerge from this kind of research' (Zimmerman, Stolterman & Forlizzi, 2010). Consequently, they take the view that the methodology should evolve into an *evaluative framework* for theory development. In order to do this, they argue that the implicit nature of RtD must be more thoroughly 'formalised' into a set of 'agreed forms' with regard to 'practice, evaluation and outcome' (Zimmerman & Forlizzi, 2008). In view of this, Savic & Huang (2014) assert that although RtD has, to a certain degree, come to stand for a cross-disciplinary approach to design research, the common thread amongst a number of scholars is a shared interest in, and the use of, *design practice* to achieve *scientific results*.

In contrast to these scientific leanings and what I deem to be a *reductive* stance on RtD, I believe that Storni's (2015) position is a more useful way of viewing the methodology. Storni states that, as an approach, RtD 'can produce different forms of knowledge in different ways depending on research questions, epistemological stances [and] ways of operating'. Bowers (2012) similarly concludes that the artefacts generated through RtD embody *design thinking* that is highly 'varied, multi-faceted, heterogeneous.' Further to this, Blythe (2014) stresses that RtD does not focus on commercial product development nor market research but *exploration*:

> *In brief, Research Through Design often describes: an approach, a practice, a process, a framework, a method, or a technique. It is usually developed for: a community, a group, participants or people. It frequently describes: a product, an application, a system, a technology or an interface and these are likely to be – multi-media, smart, new, unexamined or emergent. The work is usually an exploration but if it does not explore then it will: consider, discuss, investigate or reflect.*

The position of Storni, Bowers and Blythe holds significance for my research, in that, I believe it frames RtD in the manner that Frayling originally intended – as a more creative and generative methodological approach. If we return to Fraying's initial outline, he considers design research to be distinctly different from *scientific* and *positivist* methodologies – 'the research scientist is orderly, he… has conjectures and hypotheses and he sets about proving or disproving them according to a set of orderly procedures. [Whereas] changing order… involves irrationality, craftsman's knowledge, negotiating reality rather than hypothesising about it, above all tacit knowledge rather than propositional knowledge' (Fraying, 1993). While I concur with Findeli and Zimmerman et al that RtD should be fundamentally concerned with how knowledge *about designing* is produced *through the act of designing*, like Frayling, Storni and Bowers, I argue that the resulting knowledge does not necessarily have to be 'scientific' in nature, nor contribute to established scientific disciplines nor be 'valid' or replicable as is designated by scientific traditions.

My stance in many ways aligns with Gaver's (2012) interpretation of the methodology, which he argues is 'a route to discovery [where] the synthetic nature of design allows for richer and more situated understandings than those produced through more analytic means'. Gaver also laments the scientific tendencies of HCI and computing RtD discourse, asserting that such disciplines 'should be wary of impulses towards convergence and standardization, and instead take pride in its aptitude for exploring and speculating, particularising and diversifying, and – especially – its ability to manifest the results in the form of new, conceptually rich artefacts.' Law (2004) writes that 'research methods passed down to us… tend to work on the assumption that the world is properly to be understood as a set of fairly specific, determinate, and more or less identifiable processes.' He terms the difficulties inherent to cross-disciplinary research as ‘messiness’ and echoes Gaver’s sentiment, stating ‘regularities and standardisations are incredibly powerful tools but they set limits.’ Although Blythe (2014) concedes that there are ‘some patterns in the literature’, his stance is similar. He surmises that RtD ‘is a vibrant and dynamic field, which is still forming and therefore likely to change.’

While I intend to apply a generative as opposed to a scientific form of RtD methodology for my doctoral research, *how is knowledge, for all intents and purposes, produced through the application of RtD methodology?* To begin exploring this important issue, in next sections I explain the deeper philosophical foundations that will characterise my particular application of RtD and how this will pertain to ‘knowledge production’ regards the spimes concept.

5.2.2 Ontological & Epistemic Foundations

Kuhn (1962) defines the notion of a *research paradigm* as a ‘set of common beliefs and agreements’ which researchers share in order to understand and address particular intellectual problems. Saunders, Thornhill & Lewis (2009) and Yin (2002) agree that a *research paradigm* constitutes a specific way of perceiving the world – a *worldview* – that has significant bearing on how researchers will explore their research questions. Guba (1990) meanwhile, determines that research paradigms are typically characterised by four key modalities – *ontology*, *epistemology*, *methodology* and *methods*. As outlined in the previous section, RtD is my chosen methodology because it centres on the production of knowledge and understanding through the designing of artefacts. Thus, I intend to apply RtD as a means to produce knowledge and understanding about spimes *through* the process of designing spimes. Having said this, Storni (2015) argues that the key questions that those intending to apply RtD as a methodology should ask themselves are *‘how can* [it] *be used to produce new knowledge?* [And,] *what type of knowledge can it produce, for what purpose, and for whom?* To consider these questions, I must unpack the *ontological* and *epistemological* roots upon which underpin *my application* of RtD methodology and, ultimately *my worldview*. As Edirisingha (2012) notes, by appreciating *ontology* and *epistemology* as concepts, researchers can better understand the *implications* that these modalities have in terms of one’s own methodological process – in my case, the implications for how I go about designing spime objects.

Ontology has been described as the *nature of reality* or *the study of being*. It essentially deals with *what kinds of things exist* (Hudson and Ozanne, 1988; Crotty, 1998). Cohen, Manion & Morrison (2007) contend that epistemology deals with the *nature of knowledge* or *how we can know what exists.* Carson et al (2001) highlight the importance of the *epistemic relationship* between a researcher and *reality*, or in other words, how reality is ‘captured or known’ by those carrying out research. I think Edirisingha (2012) provides a succinct explanation of the interdependence between both terms:

> *Ontology is concerned with identifying the overall nature of existence of a particular phenomenon. When we seek answers (reality) to our research questions, we are referring to a particular type of knowledge that exists external to the researcher… Epistemology is about how we go about uncovering this knowledge… and learn about reality… Epistemology is internal to the researcher. It is how they see the world around them.*

Both Grix (2004) and Scotland (2012) stress that it is impossible to partake in any type of research activity without assuming – often *implicitly* – particular positions with regard to ontology and epistemology. Consequently, the disparities between researchers’ stances on these modalities often leads to the adoption of different methodological approaches towards the same phenomenon. Grix (2004) and Saunders, Thornhill & Lewis (2009) also assert that a researcher's choice of methods can often reveal their epistemological and ontological position. Scotland (2012) concurs, emphasising how 'differing assumptions of reality and knowledge [will] underpin [a researcher's] particular research approach.' Crotty (1998) argues that it is beneficial for the researcher if they adopt a clear position with regards to their ontological and epistemic perceptions. In light of this, Guba & Lincoln (1994) assert that there are two main perspectives for producing knowledge – *Positivism* and *Interpretivism*. Based on Guba & Lincoln (1994) and Creswell (2003), I have framed *my research paradigm* (illustrated in Figure 31) in accordance with an *Interpretivist* position:

- **My ontological stance**: I consider reality to be contextual and subjective, and as such, I believe multiple, alternative realities exist, though they are not directly accessible. Consequently, within a research context, I argue that the nature of reality will be *constructed* by the researcher involved in carrying out said research. Adopting this *Interpretivist ontology* means that as the researcher, I will interpret the research focus (spimes) based upon my perspective and beliefs. This interpretation will therefore be different to other researchers exploring the same subject as well potential readers of the research. My *Interpretivist* stance differs from a *Positivistic ontology* which subscribes to the view that there is a singular, objective reality. *Positivists* see reality as independent of the researcher, regardless of their perspective and beliefs. Therefore, those that adopt a *Positivistic ontology* believe that two or more researchers would always arrive at the same research results.

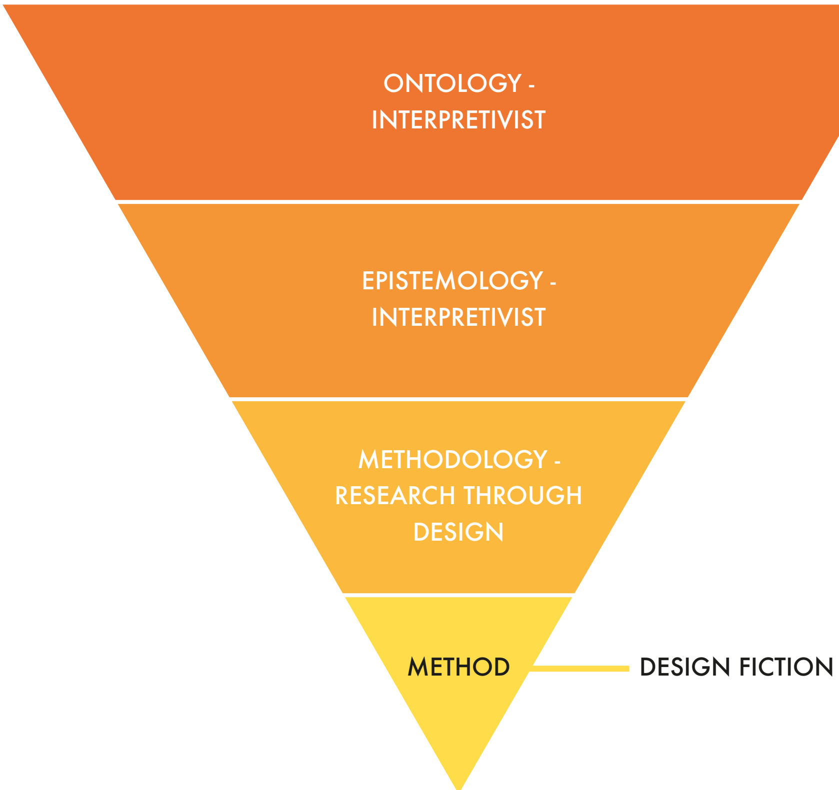


Figure 31: My *research paradigm*. Source: Author, after Guba & Lincoln (1994) and Creswell (2003).

- **My epistemological stance:** As my research will involve producing knowledge about spimes through the process of designing spimes, *my interpretation* of the phenomena being researched will play an intrinsic role in the research process itself as opposed to being wholly external to it. Further to this, as noted I perceive there to be multiple, alternate realities and that *my interpretation* of reality is different all others. Resultantly, I argue that the intended research results that I present – the potential knowledge regards spimes – cannot be established as 'truth' because my interpretation will be one of many possible interpretations. My *Interpretivist epistemology* sits in contrast to a *Positivistic epistemology* where, in order to cultivate results which can then be subject to empirical and scientific verification, the relationship between the researcher and the knowledge they seek to produce is 'controlled' as a means to restrict bias and establish 'facts'. Here, the phenomena would be observed and recorded but the researcher would remain 'detached' and therefore, would have no apparent impact on the results. As such, *Positivistic* researchers often present their results as 'objective truth'.

- **Methodological implications:** In my literature review's discussion of *Design Futures*, I noted the impact upon design research of Herbert Simon's (1969) decree, that *all design* resolves to *change existing situations into preferred ones*, and as such, *all design* is, in essence, a future-orientated activity. I also discussed how, in his 1969 book *The Sciences of the Artificial*, Simon argued that everything which is 'designed' should be considered as *artificial*, as opposed to *natural*. In making this distinction, Simon helped to legitimize the 'scientificity' of design research which was further augmented and validated in scholarly terms by figures such as Cross (1982; 2001), Dorst (2010) and Kroes (2002). Rodgers & Yee (2016) argue that Schön (1983; 1987) was one of the first to robustly challenge the *Positivistic* disposition put forward by Simon. Schön instead argued for a new kind of epistemology for design research that would be 'implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict'. As I have shown, despite Schön's contempt, research paradigms which are ontologically and epistemologically *Positivistic* still permeate design research, not least the more reductionist interpretation of RtD as espoused by Zimmerman et al (2007; 2008; 2010). Conversely, I contend that my *Interpretivist ontology* and *epistemology* are closer to the stance advocated by Schön, and, as such, will enable my RtD methodology to align with the generative approach envisioned by Frayling and Gaver.

To make the distinction between my *Interpretivist* approach to RtD and other *Positivistic* applications of the methodology even more explicit, I will next discuss the concept of *Interpretivism* in greater detail and how embracing this as my core ontological and epistemic position will lead to spime orientated practice-led research which is both *Constructivist* and *Constructionist* in character.

5.2.3 Interpretivism, Constructivism and Constructionism

Ontology	Positivist	Interpretivist
Nature of being	Direct access to real world	No direct access to real world
Reality	Single external reality	Multiple realities
Epistemology		
Grounds of knowledge + Relationship between reality & research	Possible to obtain hard, objective knowledge	Understood through perceived knowledge
	Research focus on generalisability	Research focus on contextual insights
	Thought governed by hypotheses & stated theory	Seeks to understand specific context
Methodology		
Focus of research	Concentrates on description & explanation	Concentrates on understanding and interpretation
Role of researcher	Detached, external observer	Researchers experience what they are studying
	Clear distinction between reason and judgement	Personal value judgements help govern research
	Aim to discover external reality	Partially create what is studied - meaning of phenomena
	Use rational, consistent and logical approach	Use of pre-understanding is important
	Distinction between science & personal beliefs	Accept influence from multiple perspectives

Figure 32: The key differences between *Positivism* and *Interpretivism*. Source: Author, after Carson et al (2001).

Figure 32 depicts the key differences between *Positivism* and *Interpretivism* and how the latter extends throughout my *research paradigm*. As the diagram emphasises, *Positivist* researchers will take a ‘controlled’ and ‘structural’ approach to conducting their research. They often do this by identifying appropriate hypotheses which they then seek to ‘prove’. Throughout their research process, they maintain distance between themselves and the phenomena they are researching. This, they contend, means that there is a clear delineation between the neutral and logical ‘hard facts’ that they pursue using scientific reason, and other subjective types of research knowledge obtained through personal experience and *value judgements*. (Carson et al, 2001; Hudson & Ozanne, 1988; Carson et al, 2001). Conversely, those undertaking research in an *Interpretivist* manner, in effect ‘experience’ what they are researching and personal judgement often governs their choice of action. As such, the distinction between ‘facts’ and value judgements is much more opaque. Hudson & Ozanne (1988) argue that *Interpretivists* will often commence their research with a degree of prior insight of the research context but accept that this understanding is insufficient to form a fully rounded view of the phenomena being studied. Consequently, they will remain open to acquiring new knowledge throughout the duration of the study. This means that *Interpretivists* tend to avoid rigid structural frameworks and adopt more dynamic, generative and even emergent approaches to research which are better suited to help generate meanings and understanding as their research progresses (Berger & Luckmann, 1967; Hirschman, 1985; Hudson & Ozanne, 1988; Carson et al, 2001; Black, 2006).

As Figure 33 illustrates, *Positivism*[6] tends to lead to the acquisition of *Empiricist* type knowledge which primarily comes about through what Crotty (1998) terms *rational problem-solving*. This knowledge is often *objectively* 'measured' and 'formalised' through the use of quantitative methods, namely by statistical and mathematical means (Saunders, Thornhill & Lewis, 2009; Creswell, 2003). In contrast, knowledge that is acquired through *Interpretivism* is *subjectively* 'constructed' by the researcher involved in the research circumstances (Robson, 1993). According to Crotty (1998), this is the 'view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and the world and developed and transmitted within an essentially social context.' Looking at Figure 33 again, we can see that an *Interpretivist* position can lead to two types of knowledge acquisition – *Constructivism* and *Constructionism*. In terms of design research, both of these types of knowledge are predominately produced through what (Crotty, Ibid) calls *reflective making*. Despite this commonality, Gradinar (2017) stresses that it is important to understand that the terms *Constructivism* and *Constructionism* 'have been used and abused in literature to the point of furthering confusion as opposed to providing clarity.' Further to this, Lindley (2018) writes that confusion arises because 'the two approaches are so similar' and both align to 'theories of learning, as well ontologies, and epistemologies', therefore they are 'often used interchangeably.' As a result of this muddiness, I feel it is conducive for me to briefly discuss both terminologies in more detail as well as to determine how these positions might be useful for my particular application of RtD.

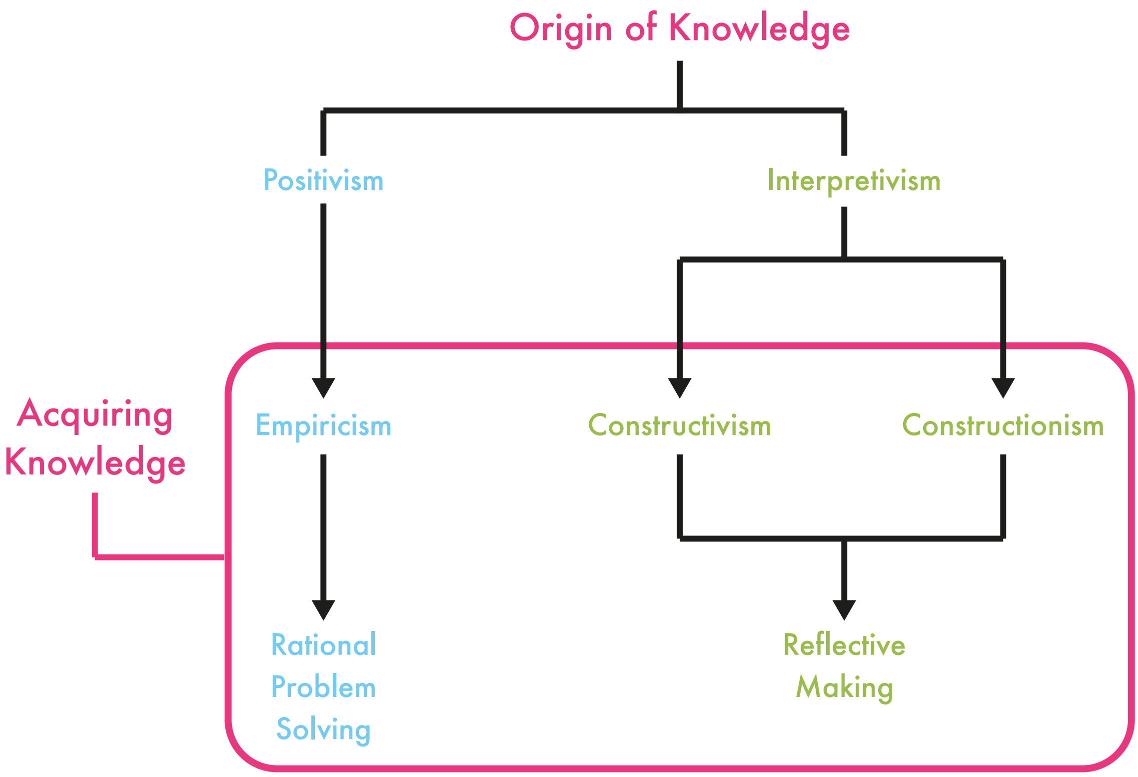


Figure 33: An *Interpretivist* stance leads to *Constructivist* and *Constructionist* knowledge acquisition. This differs from *Empiricist* knowledge which characterises *Positivism*. Source: Author, after Crotty (1998).

[6] Crotty (1998) uses the term *Objectivism* in lieu of *Positivism* to describe essentially the same concept. While some scholars stress differences between *Objectivism* and *Positivism*, I argue that the disparities do not have implications for my argument. To maintain consistency, I therefore have continued to use the term *Positivism* throughout my discussion.

Von Glaserfeld (1995) helps clarify the 'individual' and 'unique' scope of *Constructivist* knowledge production by stating that it 'starts from the assumption that knowledge, no matter how it be defined, is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience.' Crotty (1998) meanwhile describes how *Constructionism* helps shape a more social view of the world based on the 'the collective generation [and transmission] of meaning.' Tracing the histories of both terms, Lindley (2018) highlights the close working relationship between the originators of each position – Piaget (*Constructivism*) and Papert (*Constructionism*) – and how this has likely resulted in their conceptual overlap from a very early stage. Based upon Ackerman (2001), Lindley (ibid) also provides an effective overview of the differences between the two concepts:

> *In education, a Constructivist approach might involve providing a set of examples – of a mathematical problem, for instance – for students to consider, and then allowing them time and space to determine their own conclusions based on those examples. Significantly, all of this happens cognitively. In contrast, a Constructionist may encourage a tangible engagement with the problem; one that happens in the physical world, and that, one way or another, forces the students to construct (i.e. build) the relevant constructs (i.e. ideas).*

In essence, we can infer from the above that *Constructivism* centres around the notion that reality, knowledge and meaning are all constructed cognitively within an individual's mind. And, while internal reflection is still a crucial part of *Constructionism*, it focuses more on how knowledge is constructed through social, direct and tangible engagements with reality. Ultimately, in terms of my methodological approach. I believe there is a crossover between both *Constructivism* and *Constructionism*. However, I do also concur with Lindley (2018) that the *Constructionist* position 'takes some precedence because it privileges tangible, material, construction – in other words, making stuff.'

To further augment their respective applications of RtD, Gradinar (2017) and Lindley (2018) both look to Ramierz's (2009) interpretation of the methodology. Ramierz's framing traverses both *Constructivism* and *Constructionism*. Moreover, he points to the philosophical disparities between *modernism* and *postmodernism* as a means to further emphasise how a *subjective* consideration of reality and knowledge production characterises the *Constructivist/Constructionist* position, and, how this sits in contrast to an *objective* understanding typically espoused by researchers and practitioners adhering to a *Positivistic* school of thought. As I discussed in my literature review, *modernity* was predicated on the ideals that emerged during the *Age of Enlightenment*, principally the intellectual shift to *scientific pragmatism*. In bringing forth widespread industrialisation and mass-production, *modernity* helped cement the 'scientificity' of progress which still typifies many of today's cultural, technological, economic and philosophical structures. These narratives underpin the adjoining concept of *modernism* (Thackara, 2005). I also noted earlier that *postmodernity* is said to have begun to emerge as early as the 1990s. It is considered to be a 'state of flux', a period which is characterised by uncertainty and change (Lyotard, 1984). The prevailing tenets of *Postmodernity* are similarly embodied within *postmodernist* thought. Ramierz (2009), Gradinar (2017) and Lindley (2018) all argue that the strong relationship between the *Constructivist/Constructionist* position and *postmodernism* has significant implications for notions of 'objective truth.' As Maclure (1995) contends, the 'grand narratives' or 'truths' of *modernism* which have long been substantiated through science, progress and reason, are 'fragmenting' as we move further into *postmodernity* which is increasingly being characterised by a ‘disorderly array of little, local stories and struggles, with their own, irreconcilable truths.’ Crotty (1998) agrees, emphasing, that whereas *modernism* ‘evinces great faith in the ability of reason to discover absolute forms of knowledge’, *postmodernism* is a ‘thoroughgoing rejection of what modernism stands for and an overturning of the foundations on which it rests.’ In effect, *postmodernism* rescinds ‘absolute truths’ and ‘commits itself to ambiguity, relativity, fragmentation, particularity and discontinuity’ (ibid). Gradinar (2017) concludes that *postmodernism* – ergo the *Constructivist/Constructionist* position – adopts ‘a worldview where everyone’s voice is as equal as anyone else’s, an epistemological plurality which naturally implies an acknowledgement of multiple sources of knowledge creation.’

In light of all the above discourse, I argue that a *Interpretivist* stance, where subjective knowledge is constructed through *reflective making* (*Constructivism/Constructionism*) is the most appropriate substrate for my RtD methodology. This sits contrary to the *Positivistic* position of acquiring knowledge through objective *rational problem solving* (*Empiricism*). In the next two sections, I outline the particularities of *reflective making* and how this understanding helps me choose an appropriate method which will act as the driver of my practice-led design research into the spimes concept.

5.2.4 Reflective Practice

Archer (1979) argues that design practice is a route to ‘thinking and communicating that is both different from scientific and scholarly ways of thinking and communicating [but] as powerful as scientific and scholarly methods of inquiry when applied to its own kinds of problems.’ Building upon Archer and others, Saikaly (2005) contends that design practice might therefore be described as a ‘third area of human knowledge’ because as Pollastri (2017) asserts ‘while a science or humanities research approach can be adopted for studying theoretical or historical issues in design, inquiries into [the] methodological matters [of design] arguably call for the direct engagement of the researcher with practice.’ Thus, design research can be said to sit apart from other types of research which traditionally follow two main research trajectories, those being *quantitative* and *qualitative* lines of inquiry (Bryman, 1988; Saunders, Thornhill & Lewis, 2009). Though Creswell (2003) notes how the methods adopted by *Interpretivists* are regularly *qualitative* in nature, as discussed in the previous section Crotty (1998) considers *constructed* knowledge to be predominately produced through what he terms *reflective making*. Further, Crotty argues that ‘designing in itself is not research unless it is also accompanied by reflection upon the process of making. Phenomena – such as design practice – are artefacts of the social context in which they develop.’ I see Crotty’s *reflective making* as strongly corresponding with Gaver’s (2012) description of the designer-researcher conducting RtD, the process of which culminates in artefacts that embody designers’ ‘judgements about valid ways to address the possibilities and problems implicit in such situations, and reflections on these results allow a range of topical, procedural, pragmatic and conceptual insights to be articulated.’ Crotty’s and Gaver’s accounts both mark the importance of reflection within design research. In doing so, they echo the notion of the *reflective practitioner* as articulated by Schön (1983):

> *The reflective practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation.*

Schön developed his concept in response to what he saw as the scientificity and rationality that characterised commercial design practice. He contends that *reflective practice* can occur via two principal modes – *reflection-on-action* (thinking after-the-event) and *reflection-in-action* (thinking while doing). He describes the first mode – *reflection-on-action* – as reflecting on past design practice by analysing it and evaluating it, the objective of which is to gain insight to develop and improve potential future practice. Schon defines the second – *reflection-in-action* – as reflecting on the design practice as it is occurring, thus enabling changes to be made that may affect and improve the designed outcome. Schön stresses the inherent tacit, intuitive and creative nature of both these modes and how these attributes help those carrying out *reflective practice* to navigate 'situations of uncertainty, instability [and] uniqueness.'

Schön also stressed how the *reflective practitioner* can at once be innovative and tread new ground, while, at the same time, draw upon their previous practical experience and elements of theory. Tvede Hansen (2009) has similarly highlighted the importance of how a design researcher should not only generate new knowledge but also reflect and draw upon their prior insights when carrying out their research. This way design research 'can utilize the researcher's background as a practitioner and make the practice central for the research.' Moreover, Tvede Hansen notes how this results in a position where 'design research and design practice can be seen not as two separate and parallel tracks.' Taking a comparable stance, Gradinar (2017) argues that, due to the ontological and epistemic foundations upon which a *generative* RtD methodology is built (*Constructivism/Constructionism*), the role of the design practitioner and design researcher are *one*. Theory and practice are indelibly tied together through the philosophical and material processes of *reflective making*. Building upon my prior tacit product design expertise, my application of RtD will be characterised by a symbiotic relationship between the role of practitioner and researcher. As a result, it will also be marked by the dual modalities of *reflection-on-action* and *reflection-in-action*.

5.2.5 Macro Material Engagements

Archer (1979) characterises design as being 'concerned with the making and doing aspects of human activities.' Under the auspices of RtD, Blythe (2014) writes that design is essentially 'a material exploration of a problem.' Pollastri (2017) meanwhile, argues that 'any research project seeking to bring a contribution to design must also somehow engage directly with practice.' From these excerpts, we can ascertain that 'practice' in design research, particularly that of RtD, involves direct and tangible engagement with materials. Despite this, due to the acknowledgement of my *Interpretivist* stance and RtD's generative nature, the *reflective making* that I intend to conduct with regards to spimes could potentially manifest in a multitude of ways. It is my intention then to outline with more clarity how my *reflective making* in relation to spimes might begin to take shape.

Pollastri (2017) asserts that 'the ultimate particulars for any given RtD case - the reason why a researcher might engage with a material in a specific way – relate directly to the type of material(s) that case is constructed from.' Due to the particulars of their approaches to RtD taking lead from Ramierz (2009), Pollastri (2017) and Gradinar (2017) both choose to employ research mechanisms derived from other methodologies, namely *Action Research* (AR), *Grounded Theory* and *Situational Analysis*. The reason for this appropriation is that each of these methodologies, to varying degrees, embrace the *Interpretivist* position of the design researcher and the fluidity and *messiness* that culminates when taking such an approach. AR methodology is considered as a way to produce new knowledge through the concrete actions and interventions taken by the researcher (Brydon-Miller, Greenwood & Maguire, 2003).

Grounded Theory, Jonas (2007) explains, 'aims at theory building, while accepting the modification of its subject matter.' Clarke (2005) describes *Situational Analysis* as approaching 'situatedness, variations, complicatedness, difference of all kinds, and personality/relationality very seriously in all their complexities, multiplicities, instabilities, and contradictions.' In essence, each methodology allows researchers to interpret and generate their own idiosyncratic understanding of the research findings. While I appreciate their advantages for RtD, I personally do not wish to subscribe to the use of *Grounded Theory* and *Situational Analysis*. I do however intend to build some of the principles of *Action Research* into my RtD application, particularly its correspondence with *reflective practice.* Moreover, Pollastri (2017), and Lindley (2018) provide what I consider to be an effective framework for imbricating said principles into RtD.

Archer's (1995) summary of AR is indeed very much in line with the practice-led design research that I intend to conduct – 'there are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculated to explore, embody or test it.' As AR is predicated on action and experience, both Swann (2002) and Dick (2007) argue that, like design practice in general, AR is a *generative* process and therefore provides a means to *create change*. When outlining what he sees as the subjective and generative nature of RtD, Gaver (2012) contends that the judgements made by design practitioners and researchers as part of a design processes are rarely analytic. They are more likely the result of tacit design knowledge and constitute 'best judgement.' Like in RtD, the personal perspectives and value judgements of the researcher are important in AR which results in the process being non-objective (Brydon-Miller, Greenwood & Maguire, 2003). Huxham (2003) emphasies that the contingent nature of AR means that the specifics of the research (e.g. research aims, context, choice of methods) are contextually bound to the particular researcher conducting the research. This means that AR's methods and knowledge outputs are more often than not *emergent* in scope. Pollastri (2017) argues that because of the above attributes, it is appropriate to adopt AR, or at the very least, elements of the methodology, into programs of RtD. Perhaps the aspect of AR that I consider most significant for my application of RtD is the notion that the knowledge it helps produce emerges through *cycles of action* and *cycles of reflection*. Framed by Kemmis, McTaggart & Nixon (1988) as 'plan, act, observe and reflect', and by Stringer (1999) as 'look, think, act', these cycles are agile and iterative, in that, *reflection-on-action* (Schön, 1983) is made after the event with the intent of gaining a deeper understanding of the particularities of the action. In turn, this new understanding informs the planning and development of the successive action(s) (Dick 2000; 2007). Based on this discourse, I have illustrated in Figure 34 how I consider *cycles of design practice* (action) and *cycles of reflective study* (reflection) to characterise my RtD process. I term these cycles my 'macro material engagements.'

Though I have embraced and augmented Dick's (2000; 2007) cyclical approach, I also agree with Pollastri (2017) when she stresses that whilst models such as Figure 34 help to provide a conceptual overview of the research process, 'attempting to adhere too strictly to these cycles might negatively affect the [research program's] emergent and responsive nature.' In addition, she notes how those adopting AR approaches often 'take an eclectic approach to the methodology and incorporate in their studies additional modes of research beyond the [established] cycles of 'plan, act and observe, reflect'.' Resultantly, in order to afford a better understanding of her RtD process, Pollastri (ibid) proposes an alternate diagrammatic interpretation (Figure 35 – Top) of how *material engagements* capture the implicit 'textures, details, ephemerals, and irregularities' found in 'messy' contextual and emergent design research (Law, 2004). Lindley (2018) appropriated Pollastri's model, transposing its focus away from AR to accommodate his research into the concept of *Design Fiction* (Figure 35 – Bottom). I intend to also use *Design Fiction* as the core method within my RtD methodology and will accordingly outline this application in greater detail in the next section. Resultantly, I consider it best to present my own augmentation of Pollastri's diagram which centres on my research into the spimes concept in the following section also (see Figure 45, page 92). Akin to Lindley, my diagram will reorient towards the application of *Design Fiction* as opposed to AR. In addition, it will also serve to demonstrate how my practice led research incorporates *reflection-in-action* processes.

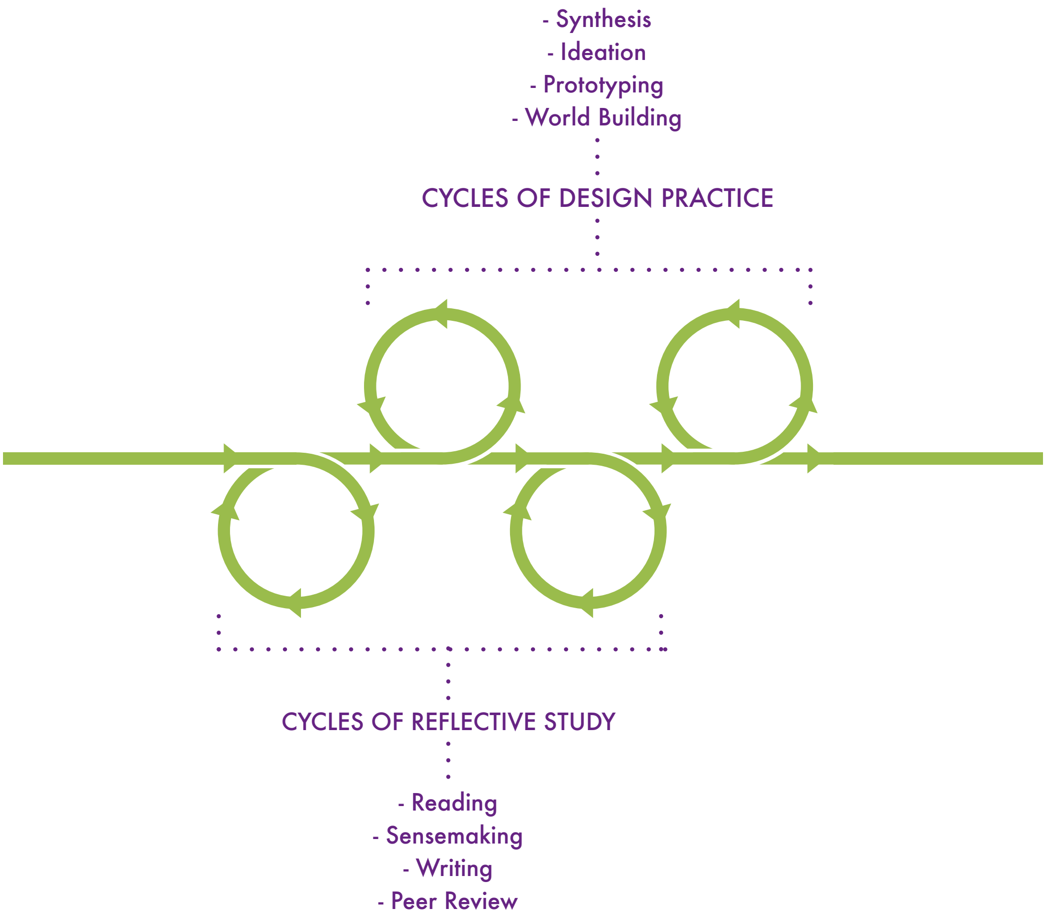
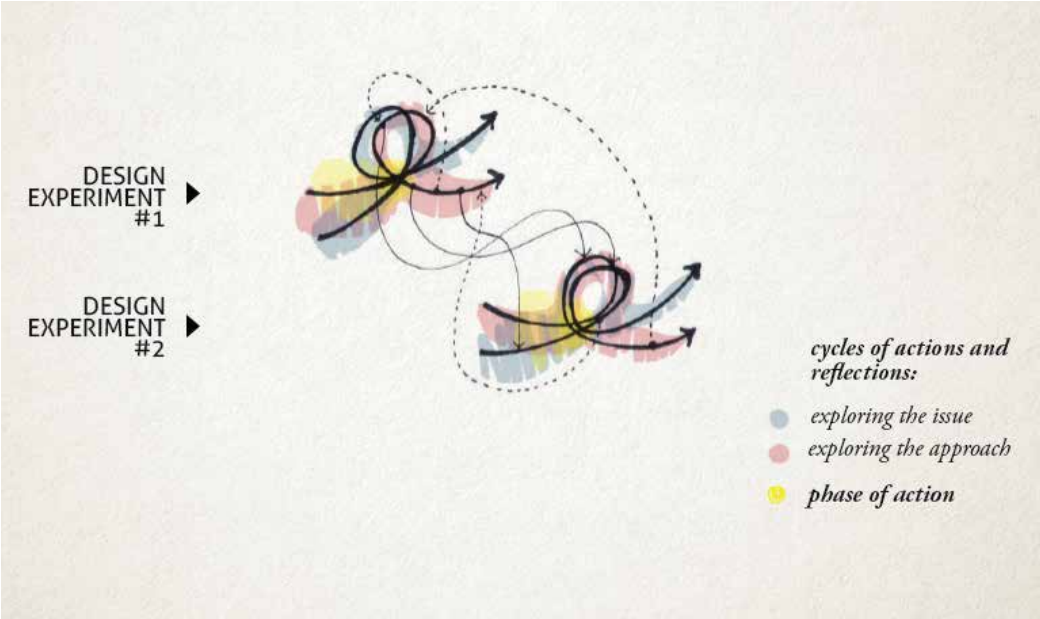


Figure 34: My RtD methodology encompasses several 'macro material engagements' – iterative *cycles of design practice* (action) and *cycles of reflective study* (reflection). Source: Author, after Dick (2000; 2007).



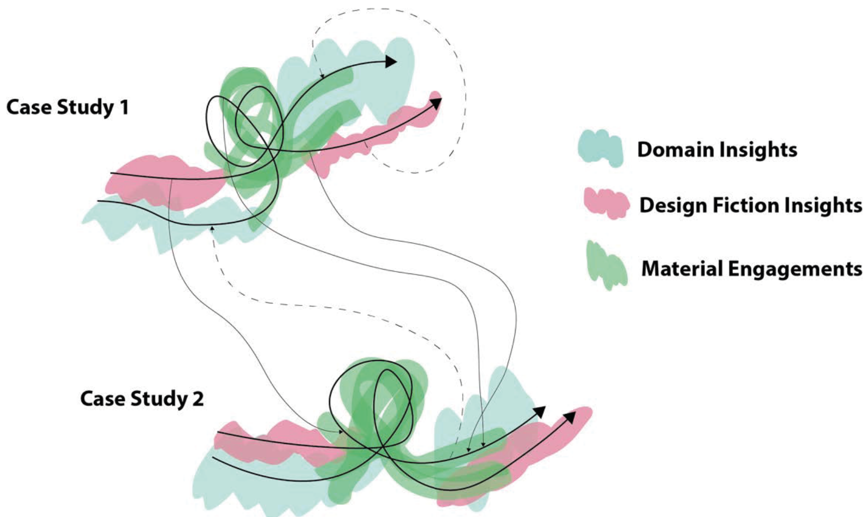


Figure 35: Pollastri's (2017) (top) and Lindley's (2018) (bottom) interpretation of *material engagements* in the context of their research – AR and *Design Fiction* respectively. Source: Pollastri (2017) and Lindley (2018).

5.3 Methods

5.3.1 Introduction

In my Literature Review, I outlined some of the key approaches that are harnessed within academia as a means to exploring *design futures* (*2.4 Design Futures – 2.4.3 Academic Perspectives* – page 30). The nascent method *Design Fiction* was one such approach and as stated in the previous section, I intend for *Design Fiction* to be the core method within my RtD methodology. This section therefore serves as a more robust introduction to *Design Fiction* and its role as a method that can be applied within practice-led design research, specifically as part of my RtD methodology. Further, I also provide the rationale for why I consider it the most appropriate technique with which to generate knowledge in regard to the spimes concept.

5.3.2 Design Fiction

How can I produce knowledge *about designing* spimes *through the act of designing spimes*? Moreover, how can this knowledge be used to highlight the growing unsustainability of the IoT? When I first introduced the spimes concept (*4 Spimes: An Introduction – 4.5 Spimes & Futures* – page 59), I argued that present day Internet-connected devices cannot be classified as spimes because unlike proposed spime objects, IoT products are inherently unsustainable. I therefore asserted that spimes currently only 'exist' as what Sterling (2006) terms *theory objects*. I noted how Hales' (2013) also describes spimes in a similar vein, calling them 'rhetorically futuristic… a category of imaginary object that is also an intervention in the present and [which] are 'forward looking' akin to the actually futuristic objects they create'. The circumstance in which Hales discusses spimes is important – he touches upon the concept amidst his exploration of the discourse that surrounds the *Speculative Design* method *Design Fiction*. *Design Fiction* is an effective method for creating fictional artefacts which:

1) aim to help facilitate a greater understanding of the future implications inherent to new products and/or emerging technologies, and,

2) also seek to highlight and critique present day cultural, technological, environmental, political and economic values and concerns (Hales, ibid).

As a consequence, I argue that while we should consider Sterling's *Shaping Things* (2005) as the initiatory theoretical foundation for the 'rhetorically futuristic' construction of spimes, *Design Fiction* is an appropriate method that can be applied to envision "actually futuristic" spime objects. By designing fictional spime-orientated *Design Fiction* artefacts, I contend that I can gain a more thorough understanding of the possible connected product futures spime-like devices may bring forth, as well as put such spime artefacts forward as examples of potential connected products which sit counter to the unsustainable IoT devices of today. That said, over the next sections I will further contextualise the theory and practicalities that underpin *Design Fiction* as a practice-led design research method.

5.3.2.1 Diegetic Prototyping

As with *spimes*, Sterling also originated the term *Design Fiction* (DF) in his book *Shaping Things* (2005). While it has been posited that this origination might have been incidental

(Coulton et al, 2017), the context in which Sterling used the term is noteworthy. Discussing the influence that design – particularly *industrial product design* – has had on his writings in the science fiction and cyberpunk genres, Sterling describes DF as ‘more practical, more hands on [than the] hand-waving hocus pocus [of science fiction]’ and it ‘reads a great deal like science fiction; in fact it would never occur to a normal reader to separate the two.’ Following Sterling’s initial musings, Julian Bleecker (2009) published a paper which has provided much of the theoretical substrate which has characterised the majority of DF practice over the last ten years. DF has grown as a method since the publication of Bleecker’s paper, and, like *Critical Design*, has been adopted as a mode of practice for designing futures across various fields of academic research. Despite this growing acceptance as a method, DF remains a nascent approach. Lindley (2018) uses Gaver’s (2012) term *pre-paradigmatic* when describing DF as a means to denote that it still stands upon unstable footing in terms of its position as an academic field. Having all said this, there are patterns and indeed tenets across DF literature. Perhaps the most influential early precept is the role of *diegesis*, or more specifically, that of *diegetic prototyping.*

Though Bleecker (2009) integrated several seemingly unconnected theories throughout his primer, the correlation between the influence of science fiction literature on *Ubiquitous Computing* discourse (as originally made clear by Dourish and Bell, 2011; 2014), and how emerging technologies can develop through a relationship with feature films (as outlined by Kirby, 2010) has, for all intents and purposes, come to define contemporary DF. Figure 36 is Bleecker’s visualisation of Kirby’s theory:

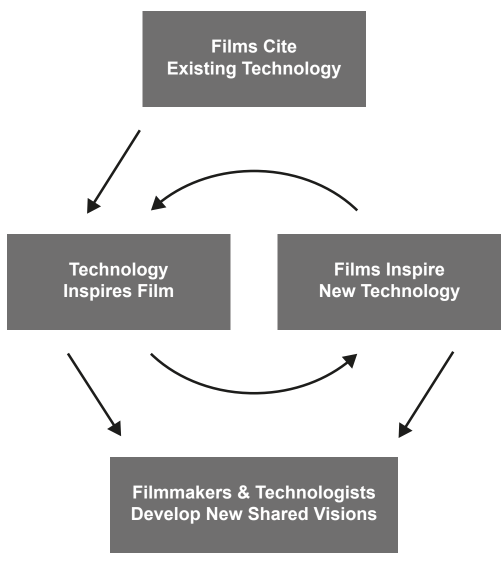


Figure 36: Inspired by Kirby (2010), Bleecker’s diagram visualises how some technologies can develop through a relationship with feature films. Source: Author, after Bleecker from the Near Future Laboratory’s TBD Catalog (2014).

Building upon this theory also led Bleecker to embrace Kirby’s notion of *diegetic prototyping* which the latter developed from the concept of *diegesis* which, in simple terms, can be defined as *narrative* or *plot*. Diegetic prototyping is used to describe a prototyping method through which fictional and often *futuristic* technologies and products can be rendered 'material' or 'functional' within *diegesis*, in other words, as a 'prop' embedded in a fictional narrative environment or story (Bleecker, 2009; Kirby, 2010). Sterling's adoption of Bleecker's framing of DF and appropriation of Kirby's terminology has also helped the notion of diegetic prototyping evolve into a key tenet of DF practice. The following description by Sterling has arguably become the 'go-to' definition of DF as a method:

> *The deliberate use of diegetic prototypes to suspend disbelief about change... It means you're thinking very seriously about potential objects and services and try to get people to concentrate on those – rather than entire worlds or geopolitical strategies. It's not a kind of fiction. It's a kind of design. It tells worlds rather than stories'* (Sterling cited in Bosch, 2012).

Similar to Sterling, Tanenbaum, Tanenbaum & Wakkary (2012) and Tanenbaum, Pufal & Tanenbaum (2017) argue that the positioning of the designed artefact within diegesis is central to DF as a method because the said artefact can be made to appear 'real' or as if it 'actually exists' when it is presented to potential audiences within a *credible context of use*. Tanenbaum (2011) further states that the *plausible* fictional frame enables designers to 'make an argument about a potential future by demonstrating that future in a context that a large public audience can understand.' The notion of the 'audience' is thus also seen as an important element of a DF proposal. This can again perhaps be traced back to Bleecker's (2009) primer, where he contends that DF proposals seek to create a so-called *discursive space* where the diegetic prototype challenges peoples' perceptions by subverting the 'insular, habituated forms, experiences, rituals and expectations of the role products and services play in their everyday life.' Based upon a diagram by Coulton (2016), in Figure 37 I have depicted how the *discursive space* generated by a DF proposal can emerge due to the fictional diegetic prototype being free of the design constraints that characterise normative commercial design practice. Ultimately, Bleecker (2009) asserts that DF proposals should not be seen as an attempt to predict the future or design a specific 'product solution' but as a strategy for opening up inclusive debate about how and why future technological products are designed and what they might possibly mean.

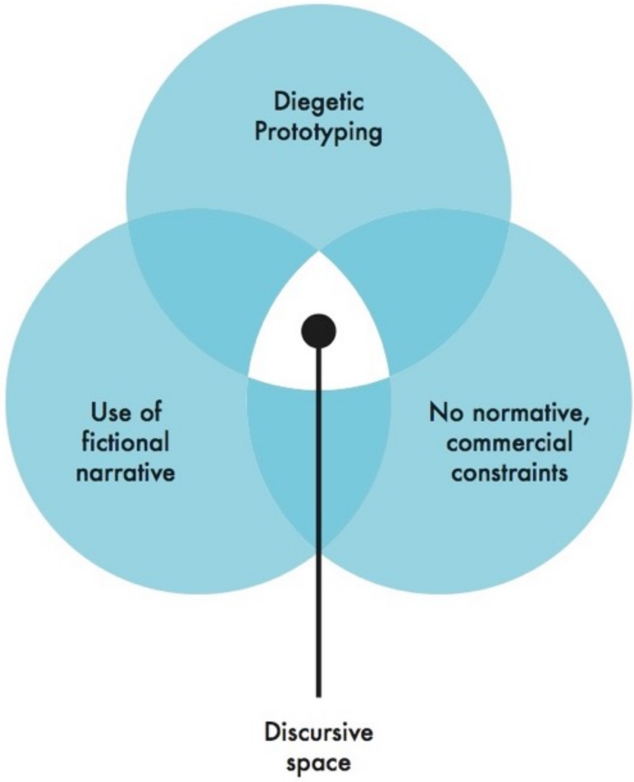


Figure 37: DF proposals aim to create a *discursive space* through which potential audiences can consider alternate technological product futures. Source: Author, after Coulton (2016).

5.3.2.2 Design Fiction as World Building

If we return to his oft-cited definition, I would argue that Sterling (Sterling cited in Bosch, 2012) presents somewhat of a contradictory position. He argues that in applying DF, designers should very much centre on the designed artefact(s) as the key means to create debate and generate a *discursive space* as opposed to the contextual frame – 'It means you're thinking very seriously about potential objects and services and try to get people to concentrate on those – rather than entire worlds or geopolitical strategies.' Yet Sterling also proclaims that a broader, holistic context for such prototypes is crucial, stressing that DF proposals tell 'worlds rather than stories' (Sterling, ibid). The latter statement has proved to be of particular interest to Coulton et al (2017) who have, in the past 2-3 years, developed a new, emergent strand of DF practice which they term *Design Fiction as Worldbuilding* (DFasWB). They argue that the focus on diegesis and by default, diegetic prototyping has 'led to an over emphasis on the importance of story and narrative… as the foundation upon which to create Design Fictions.' Coulton et al (ibid) assert that Kirby's original framing of 'diegesis' and 'fiction', have, to a degree, been misconstrued. They note the *problems associated with subtleties of meaning* and cite how 'fiction' can denote *unreality* and therefore mean 'made up' or refer to 'story' and the notion of *literature*. That Sterling originally contextualised DF in relation to his writing, the link to stories and literature is perhaps unsurprising. In response to these subtle yet persistent traits, Coulton et al (ibid) draw upon Dourish's (2006) critique of 'genre conventions' within computing research to conclude that 'storytelling and narrative [are genre conventions] that can stifle the flexibility of Design Fiction as an approach.' They go on to propose that DF 'is in fact a 'world building' activity, with no inherent link to 'narrative' or 'storytelling'. As a consequence, they contend that framing DF proposals as *built worlds* is 'more useful because, unlike stories, the frame can be applied to *all* Design Fictions' (Coulton et al, ibid).

By moving beyond the singular diegetic prototype, Coulton et al (ibid) argue that through the prism of DFasWB, effective DF proposals are 'collections of [prototypes], that, when viewed together build a fictional world.' Figure 38 illustrates how by following the DFasWB approach, the various fictional artefacts that are generated can come together to define multiple 'entry points' into said artificial world. Each of these entry points describes the constructed world at a different scale or from a different perspective. However, in order to preserve a plausible world, Coulton et al (ibid) emphasise that it is important that the individual artefacts 'are mutually consistent and congruent with one another.' Also significant is the notion that all entry points are navigable to, and from, each other. Figure 39 depicts how, by undertaking DFasWB as an approach, practitioners educe a *reciprocal prototyping relationship*, where 'the artificially built world is a prototyping platform for the very designs that define it, meanwhile those designs reciprocate in kind and prototype the world' (Coulton et al, ibid).

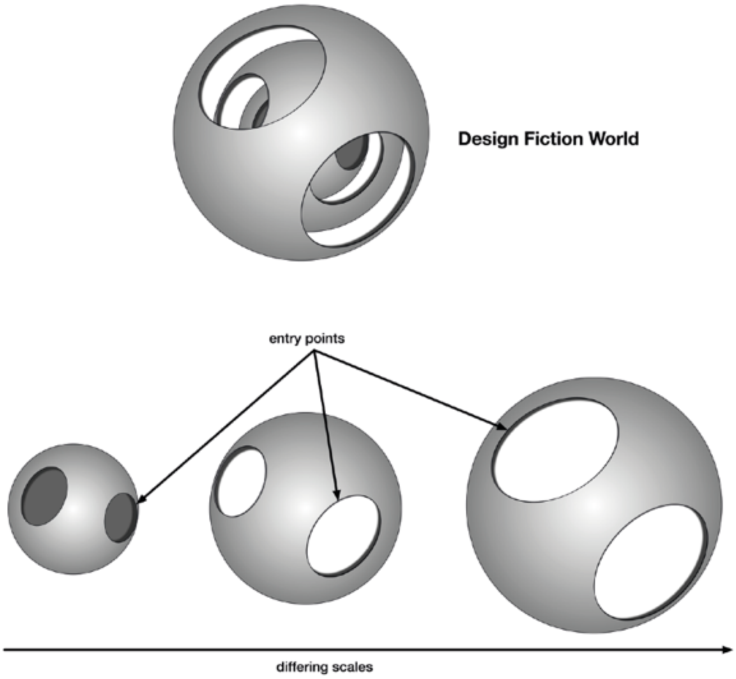


Figure 38: The artefacts that build design fiction worlds represent views of those worlds from a range of scales while also acting as 'entry points' to the world. Source: Coulton et al, 2017.

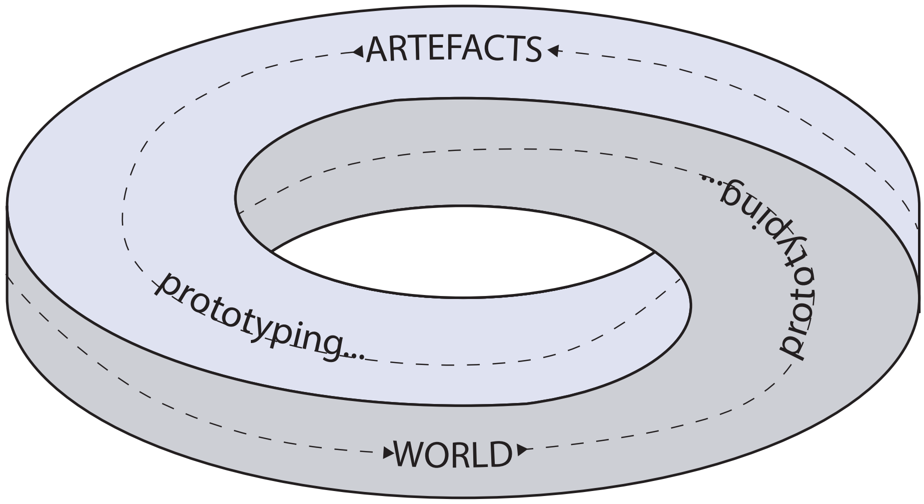


Figure 39: The *reciprocal prototyping relationship* which results from DFasWB. Source: Coulton et al, 2018.

In essence, Coulton et al (2017; 2018) and Lindley (2018) argue that a DF proposal generated via the DFasWB approach should fundamentally comprise of:

(i) something that creates a fictional world;
(ii) has something being prototyped within that fictional world, and,
(iii) does so in order to create a discursive space.

Thus, whilst diegetic prototypes remain vital as 'entry points' in DFasWB practice, 'creating the *world* is the principle task of the designer when creating a Design Fiction' (Coulton et al, 2017). Furthermore, by moving away from tropes like storytelling, narrative and characters, DFasWB positions DF more so as a method which places utmost importance on the technological implications and values inferred by the world and how this discourse might form a *discursive space* amongst potential audiences (Coulton et al, 2017; 2018; Lindley, 2018).

5.3.2.3 Relationship To Other Methods

Despite the recent development of DFasWB, the significance of framing DF around earlier narrative driven diegetic prototyping techniques persists across DF literature. I contend that this propensity has typically led to the method being sub-categorised as a corollary of the more established practice of *Critical Design*, as well as being positioned within the broader field of *Speculative Design*. There are indeed similarities between the three terms and in Figure 40, I have illustrated some of the commonalities that are often derived as a result of their theoretical overlap within design futures discourse (Dunne & Raby, 2013; Bleecker, 2009; Blythe, 2014; Auger, 2013). All three methods are regularly used interchangeably to describe an approach to design practice that researchers can apply in order to generate prototypes that speculate about the values and meanings of potential alternate future products and technologies and pose questions about their relationship to the future. As such, the designed artefacts and the process of designing them provides a means for design practice to transition beyond purely aesthetics, solving problems and/or exploring conventional material concerns. The *provocations* or *discursive artefacts* (Tharp & Tharp, 2013) also serve then as a means for designers and potential audiences to reflect upon and critique prevailing worldviews in relation to political, cultural, economic, ethical and technological structures (Dunne and Rady, 2013; Mitrović, 2015; Auger, 2013; Bleecker, 2009).

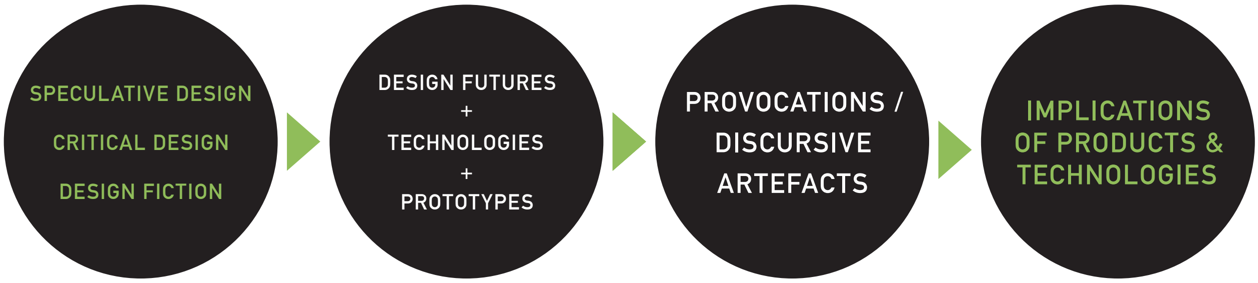


Figure 40: Some of the theoretical and practical similarities between *Speculative Design*, *Critical Design* and *Design Fiction*. Source: Author.

I outlined the nature of *Critical Design* in my Literature Review (*2.4 Design Futures – 2.4.3 Academic Perspectives* – page 30). In their 2013 book *Speculative Everything*, the progenitors of that method, Dunne & Raby, attempted to subsume DF and *Speculative Design* under the *Critical Design* banner. Likewise, the same year, Auger (2013) argued that confusion arises from the different terminology and advocates the use of *Speculative Design* as an 'umbrella' term for all related design futuring practices within academia. Bleecker and Sterling have not however discussed DF alongside *Critical Design* nor *Speculative Design* to any discernible degree. In academic circles, the lineage of DF has been traced back to some of the same motivators as *Critical Design,* namely the subversive and irreverent culture of 1960s/70s *Italian Radical Design* such as *The Continuous Monument* by *Superstudio* and *A Walking* City by *Archigram* (Lindley, 2015). The main commonality between the three practices is perhaps summerised by Dunne & Raby (2007) when they describe the types of design proposals in question as the 'opposite [to] affirmative design: design that reinforces the status quo.' They define 'affirmative design' as normative commercial design practice, one which is principally driven by market forces and caters for mass consumption. Figure 41 depicts the *Human-Centred Design* (HCD) trifecta, a framework originated and espoused by the US design consultancy IDEO (2009; 2011). The trifecta promotes the notion that innovative, effective and profitable products and technologies can be conceived through the confluence of main three criteria – *Desirability, Feasibility* and *Viability*. Its adoption within commercial 'affirmative' design practice and across design education was facilitated through its inclusion in the book *Change By Design* written by IDEO co-founder Tim Brown (2009). Indeed, the trifecta was advocated during my very own *Masters in Product Design* programme (2009/2010). IDEO (2015) describe HCD as follows:

> *By starting with humans, their hopes, fears, and needs, we quickly uncover what's most desirable… Once we've determined a range of solutions that could appeal to the community we're looking to serve, we then start to home in on what is technically feasible to actually implement and how to make the solution financially viable.* [It's] *absolutely crucial to designing solutions that are successful and sustainable.*

IDEO's trifecta, at first glance, appears clear, sensible and perhaps even achievable. Arguing that it is a useful tool to help multiple stakeholders to begin to think critically about possible alternate futures, Bowen (2009; 2010) integrated the HCD perspective into his framing of *Speculative Design*, applying the approach as a mechanism within a broader *Participatory Design* enquiry. In contrast, Sterling (2013) produced a similar diagram to IDEO's, but one that, in many ways subverts and exposes the limitations of their HCD framework. Titled *Anticonventional Objects* (Figure 42), note how the *Buildable* and *Profitable* segments on Sterling's trifecta are annotated with commercial yet nefarious, harmful and superfluous types of products (Trash, Pollution, Fraud, Theft), while *Desirable* are defined as *the magical, the mythical* and *the miraculous* – highlighting their perhaps *unobtainable status*. Interestingly, Sterling positions diegetic prototypes at the intersection between *Desirable* and *Profitable*. In this way, Sterling is perhaps placing the rhetorical stance of DF closer to commercial (affirmative) practice than that which *Critical Design* sits – certainly if as is evidenced by the writings of Dunne & Raby. As I noted earlier, like critical designs, DF proposals are free of commercially driven constraints such as usability, aesthetics and cost (Tanenbaum, Tanenbaum & Wakkary, 2012). And yet, though Bleecker (2009) asserts DF prototypes envision futures beyond standard cycles of product iteration, he also contends that they aim to provoke and offer *possibilities* for technological innovation. In light of this, I argue that DF, with its focus on design-innovation, displays closer ties to commercial technological development than the steadfastly academic offerings of *Critical Design*. This difference is perhaps substantiated in the growing application of DF beyond academic institutions by commercial design studios such as *Superflux* and the *Near Future Laboratory* (Nova, 2019).

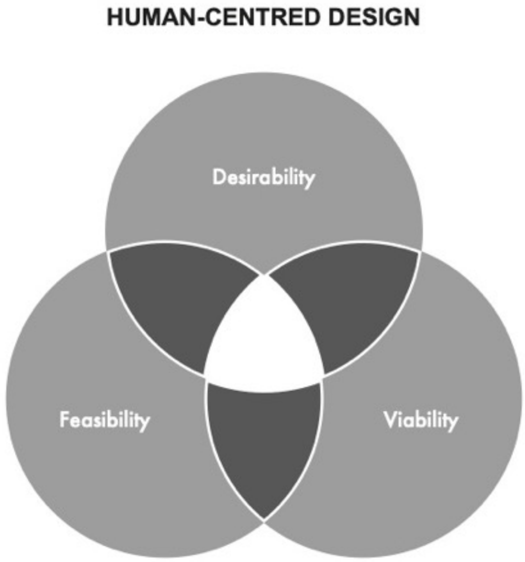


Figure 41: IDEO's *Human-Centred Design* trifecta. Source: Author, after IDEO (2011).

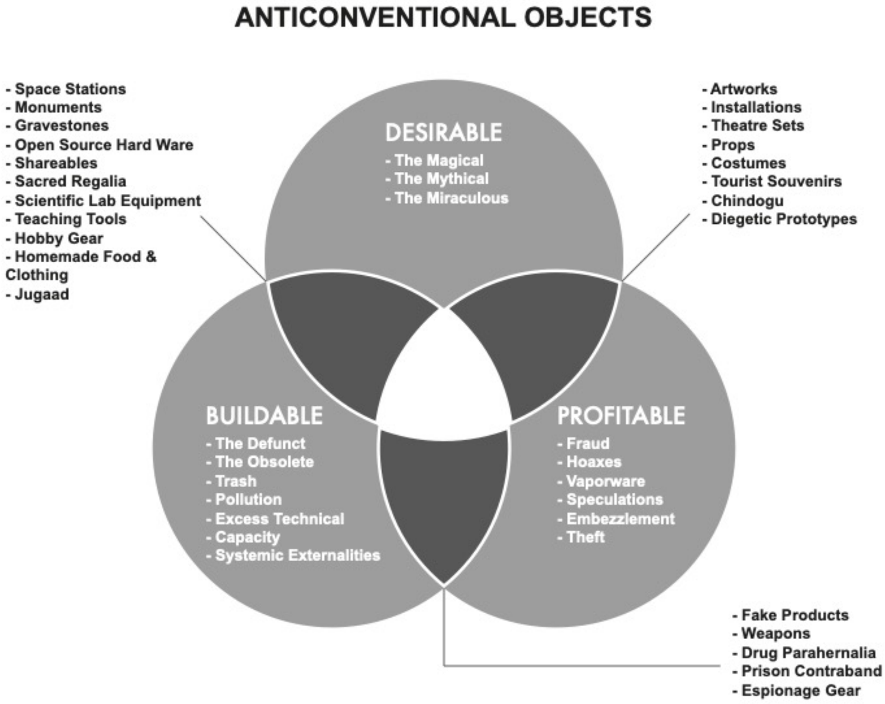


Figure 42: Sterling's *Anticonventional Objects* trifecta. Source: Author, after Sterling (2013).

Another key attribute that differentiates DF proposals from those of *Critical Design* has been in their distinct 'styles of presentation'. As noted, *Critical Design* is deemed to have a predominantly artistic heritage – through its lineage to the works of mid 20th century *Conceptual Art* (the significance of artistic outcomes embodying 'ideas' as opposed to exploring material properties), as well as the method emanating out of practice conducted at the *Royal College of Art* through the *Design Interactions* programme. I have acknowledged that DF is different due to it being rooted in *science fiction literature* through Sterling (2005), Bleecker (2009) and Dourish & Bell (2011; 2014) and *cinema* via Kirby (2010). This disparity can be seen in Figure 43 which places an example output of each method side by side. *Critical Design* aligns closely with fine art tradition by predominately presenting its design outputs to *informed audiences* in the context of art galleries and design museums (Nova, 2019). Consequently, proposals like Dunne & Raby's 'Needy Robot' (Figure 43 – left) in many ways retain the aesthetic, and, to a certain extent, the socio-cultural values typified by venerable artworks (Malpass, 2015). Conversely, Coulton et al (2017) argue that 'design fictions invoke such worlds and prototypes through the crafting and sculpting of a miscellany of different media and forms.' Hales (2013) concurs and notes that the wider variety of 'new media' DF proposals employ to visualise prototypes can include three-dimensional artefacts, graphics, web-based content, computer games, illustration and video/film. I think *Design Fiction's* use of popular media corresponds with Marshall McLuhan's (1964) phrase 'the medium is the message.' McLuhan proclaimed that there is a symbiotic relationship between the way that the medium used to convey a message influences how the message is perceived. For Tanenbaum, Pufal & Tanenbaum (2017), this broad canvas of prototyping media means DF practitioners can pose arguments about potential futures by demonstrating these futures in a context which potential *wider audiences* might more easily understand, as opposed being limited to their primary academic readings. As noted in my Literature Review, practice across the field of

Speculative Design as a whole has been criticised in recent years, often due to the privileged Western worldview from which much of the work emanates but also because of the lack of engagement with broader audiences (Tonkinwise, n.d.; Voss, Revell & Pickard, 2015). Auger (2013) has stressed that 'the core motivations of [Speculative Design practices] is to shift the discussion on technology beyond the fields of experts to a broad popular audience.'

Figure 43: Examples of the difference in presentation styles of *Critical Design* and DF proposals. Source: Author, with images from www.dunneandraby.co.uk and the Near Future Laboratory's TBD Catalog (2014).

Auger (2013) also separates the broader field of *Speculative Design* practice into two categories – *existing paradigms* where 'speculative futures imagine, through the extrapolation of contemporary systems and product lineages, near future products and services' and *alternate presents* where designs' 'utilise contemporary technology but apply different ideologies or configurations to those currently directing product development.' Figure 44 depicts how Coulton (2016) has appropriated Auger's categorisation but also identifies where DF is situated as a method. He surmises that DF proposals can 'operate' as either 'far' or 'near' speculative futures. Moreover, he asserts that 'the present is the future mundane.' Auger (2013) is more reticent regards the notion of far futures. He argues that in order for these kinds of design proposals to be 'successful', one must ensure 'careful management of the speculation; if it strays too far into the future to present implausible concepts… the audience will not relate to the proposal.'

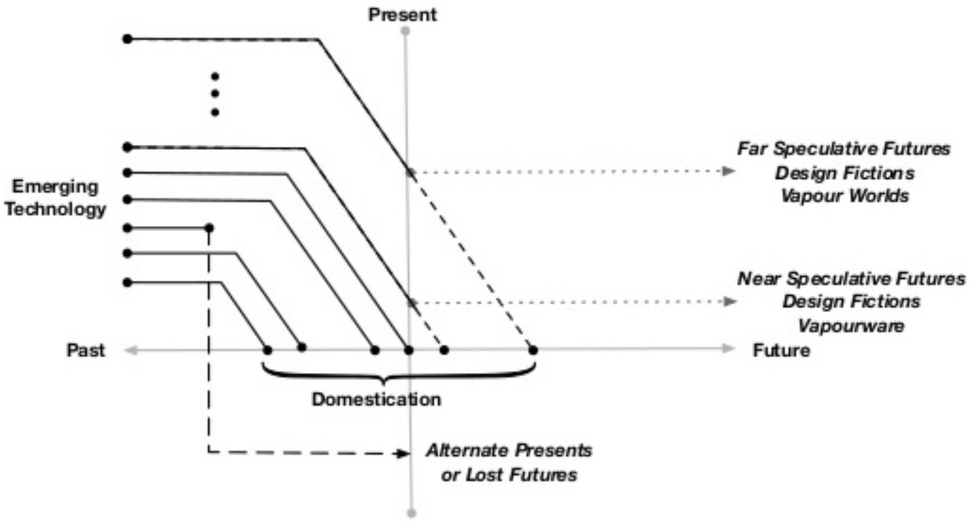


Figure 44: Coulton's augmentation of Auger's *Speculative Design* futures diagram which incorporates *Design Fiction*. Source: Coulton (2016), after Auger (2013).

5.3.2.4 Alignment with RtD

Having summarised the key characteristics of *Design Fiction*, I wish to now establish why I consider it to be the most appropriate method for my RtD methodology. Like DF, RtD methodology is forward looking and ultimately a means to consider the future – as Gaver (2012) states, 'research and practice in design and the arts, in contrast, do not describe a single, independent world, they are generative, investigating how to create new ones.' My application of RtD is underpinned by my ontological and epistemic position, this being an *Interpretivist* stance whereby I intend to construct knowledge (*Constructivism/Constructionism*) via *reflective making*. Such a position implicitly suggests that I will engage with materials in a practical capacity in order to gain a better understanding of my chosen research phenomenon – the spimes concept and its relationship to the unsustainability of the IoT. Having outlined each approach in the previous sections, it is clear that DF shares much in common with RtD, in particular their mutual focus on practical *material engagements* which result in the embodiment of ideas and knowledge production through the generation of designed artefacts. As such, the methodology and method could also be said to both pivot upon Simon's (1969) oft-cited dictum – the act of 'designing' is concerned with 'changing existing situations into preferred ones' and that designers are 'concerned with how things ought to be.'

Having provided grounds for DF to be a significant method for knowledge production within design research – in particular through the application of DFasWB – Lindley (2015; 2018) views DF as being especially compatible with RtD. He in fact goes further and contends that *Research through Design* and *Research through Design Fiction* are, for all intents and purposes, one and the same – a future-orientated practice-led design research methodology. In addition, he argues that the theory generated through such an approach is 'likely to be generative, aspirational, and contingent (and by extension accepting of its own temporal limitations; i.e. it may change over time)' (Lindley, 2018). From this standpoint, my combined application of RtD and DF provides a means for me to produce novel insights regards future sustainable spime devices that is both generative and transformative; a dynamic process which allows said insights to develop and potentially shift in focus and inference during the course of the research. Moreover, the way in which knowledge develops within this process is both during (*reflection-in-action*) and after (*reflection-on-action*) my Design Fiction based *material engagements*.

As Figure 45 shows, Lindley (2015; 2018) also asserts that the insights developed through the combined application of RtD and DF become part of what might be described as a 'knowledge feedback loop' where said insights provide the theoretical and contextual basis for further research. The diagram illustrates how such knowledge will be of particular value to researchers and practitioners conducting other *Research into Design*, *Research through Design* and *Research for Design* inquires, but also to those working across and within other disciplines too. This supposition is important for my research as it begins to give credence to the notion that while my spime orientated research will be heavily contingent upon my ontological/epistemic position, the knowledge generated as a result of conducting the research may also be of greater benefit beyond the strictures of my thesis.

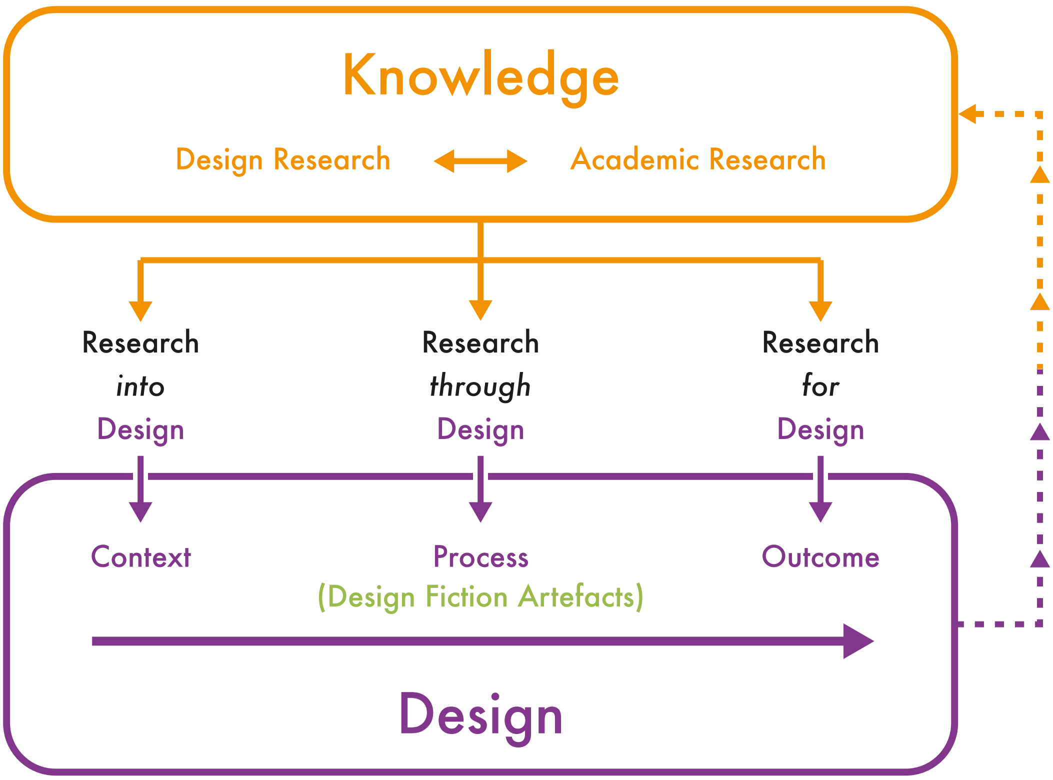


Figure 45: *Design Fiction*, as its core method, correlates with my RtD methodology. Moreover, this relationship produces knowledge that feeds back into further research. Source: Author, after Lindley (2015; 2018).

5.3.2.5 Micro Material Engagements

Figure 46 depicts my augmentation of Pollastri's and Lindley's *material engagements* diagrams (see Figure 35 – page 80) with respect to my research into the spimes concept and, akin to Lindley (2018), my reorientation of method from the application of *Action Research* to that of *Design Fiction*. In contrast to Figure 34 (see page 79) which depicts the broader, more holistic 'macro material engagements' that characterise my RtD methodology, Figure 46 is intended to visually represent the implicit 'messiness' that define my three practice-led *Design*

Fiction based engagements. Importantly, I see this diagrammatic representation of my 'micro material engagements' as corresponding with Schön's (1983) *reflection-in-action*, in that, reflective improvements and changes to the design outputs are carried out during the practice itself. This contrasts with my 'macro material engagements' (Figure 34), which as stated, I consider to be closer in nature to Schön's concept of *reflection-on-action*, that is, reflection that occurs after the design activity has passed.

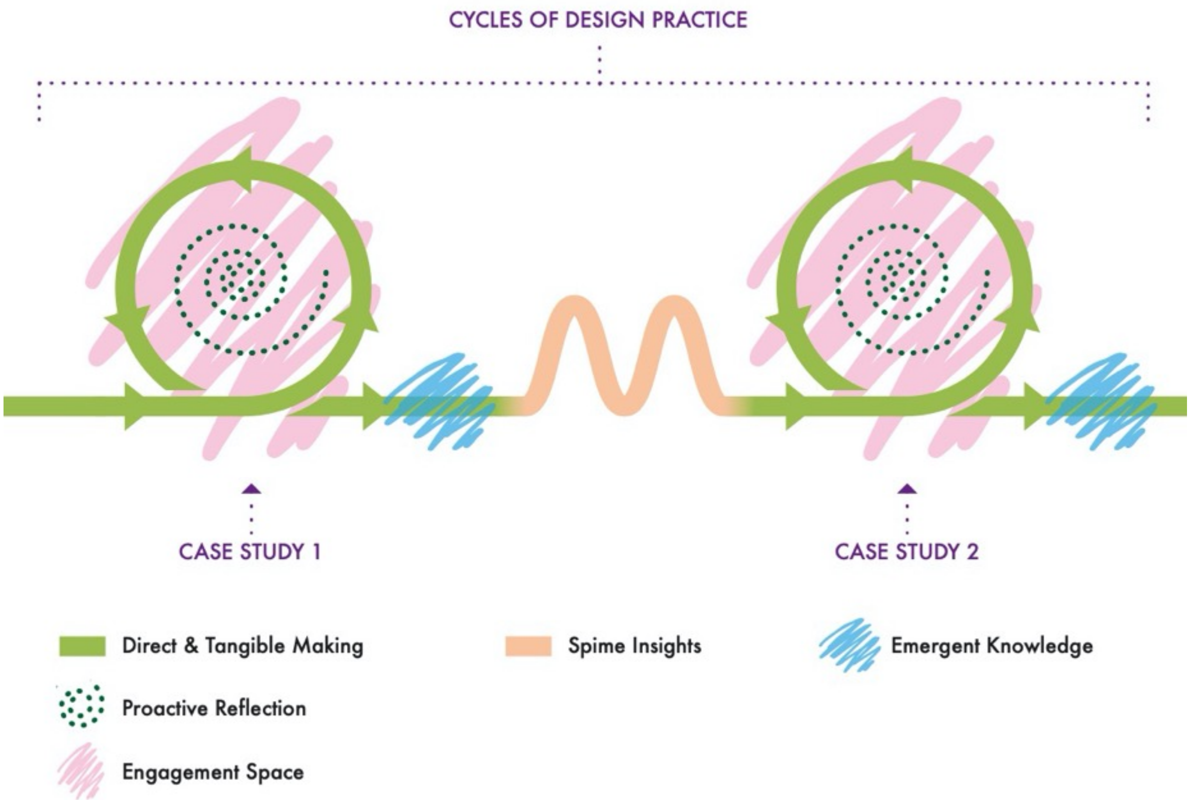


Figure 46: The 'micro material engagements' of my RtD methodology represent my messy, contextual and emergent engagements with the *Design Fiction* method. Source: Author, after Pollastri (2017) and Lindley (2018).

Like Pollastri (2017), Figure 46 is intended to depict the implicit, nuanced and dynamic contextual details that 'make up' my DF practice. As such, the diagram seeks to emphasise:

1) *Direct and tangible making* (solid green arrows) – this denotes the 'situated' design practice where I apply DF as method and negotiate its associated media in order to generate fictional spime orientated artefacts.

2) *Proactive reflection* (dark green dotted spirals) – is the ongoing reflections I make in relation to the *Direct and tangible making* activity. This reflection may lead to rethinking my earlier assumptions about spimes and as well as causing me to carry out what I consider to be improvements to the spime artefacts in a dynamic and intuitive manner.

3) *Emergent knowledge* (smaller patches of blue strokes) – this knowledge results from the confluence of the above making and reflection processes. It could be characterised

as what Pollastri (2017) terms the 'learning outputs' and as such, might go on to 'inform decisions to be taken later on, both in the same or in a following [design engagement].'

In addition to the above, my three engagements are also characterised by the broader *Engagement Space* (big light pink strokes) – which covers the dilating yet 'situated' design practice that results from *Direct and tangible making*; and, the *Spime Insights* (salmon pink wavy connecting lines) – knowledge about designing spime objects through DF methods and considerations of how to potentially embody sustainable parameters in such devices. The latter crucially pertains to my thesis' key questions. Further, as one can see, I 'transplant' *Spime Insights* with me as I 'enter' and 'leave' each engagement. Ultimately, my three 'micro material engagements' resulted in the design and production of a variety of fictional artefacts. As has been outlined in previous section, within the context of RtD and DF endeavour, these artefacts are representative of *constructed knowledge* in regard to the phenomena being researched – in my case, the spimes concept and its relationship to the unsustainability of the IoT. Moreover, as with DF practice, the intention is for these fictional artefacts to be a means for generating a *discursive space* in which the implications, values and meanings inherent to potential spime objects can be debated amongst differing potential audiences. This has led me to appropriate the term 'case study' to more formally describe each of my three spime orientated *Design Fiction* engagements. I contend this appropriation helps to both provide further *structure* to my RtD methodology and will also likely foster better understanding should I present my DF artefacts to wider audiences in the future, that is, beyond their primary academic readings through peer review and conference presentations.

5.3.2.6 Use of Case Studies

As stated above, to provide further structure to my RtD methodology I have appropriated the term 'case study' to more formally describe each of my three spime orientated *Design Fiction* engagements. The notion of the *case study* has been subject to wide and varied academic discourse. For example, Yin (2002) describes the case study as a 'comprehensive research strategy', arguing that it can thus be considered as a *research methodology* in its own right. Providing another definition, Merriam (1998) discerns a case study to be 'an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit.' While far removed from Yin's stance, my usage of the terminology could be seen to correspond, to a certain extent, with Merriam's framing of the concept. However, although my case studies do seek to provide a *holistic description* of the *processes* inherent to each of my three *Design Fiction* engagements, I do not apply the same degree of academic rigour to my appropriation of the term. Instead, I draw parallels between my usage and that of Lindley (2018) who employs the term in more of a 'general sense' without its academic 'excess baggage'. Here he is referencing Robson (1993) who warns that 'there is some danger in using a well-worn term like case study. All such terms carry… surplus meanings and resonances from [their] previous usages.' Lindley (2018) goes on to provide a simple and succinct dictionary definition for his application of the term – '*case study*: a particular instance of something used or analysed in order to illustrate a thesis or principle.' I argue that my application of the term should be viewed in much the same light. My three case studies serve as a means to illustrate how different aspects of the spime concept might potentially be incorporated into the design of future connected devices, and in doing so, highlight the unsustainability of the IoT.

5.3.2.7 Generalisability

Storni (2015) notes that design as both a discipline and a practice is often perceived as 'arbitrary and subjective' which prompts the question 'how could you use it as a reliable means of learning about something else?' He goes onto proclaim that 'when used as a method of research, design changes the very reality you are trying to understand in a way that is idiosyncratic and too difficult to measure, raising issues about reflexivity, replicability, the validity of the data, and the generalisability of the research findings.' I have previously discussed the theoretical underpinnings of *multiple realities*, *constructed knowledge* and *subjectivity*, and how these theories are fundamental to my *research paradigm*, that being my underlying *Interpretivist* ontological, epistemological and methodological position. However, I am yet to explore the 'issues' that Storni believes might arise from taking such an approach to design research, namely *replicability*, *validity* and *generalisability*. Although writing in regard to AR, I believe Archer's (1995) viewpoint helps me to begin this discussion. He determines that when 'research activity is carried out through the medium of practitioner activity' it is almost always 'situation-specific'. Furthermore, he argues that it can 'hardly ever be objective… pursued through in and on the real world, in all its complexity, its findings only reliably apply to the place, time, persons and circumstances in which that action took place. Noting the 'crossover and synergy' between AR approaches and RtD, Lindley (2018) describes both as 'generative practices, and as such alter their own realities; they change the nature of the situation upon which they act.' In consideration of the tacit and practice-led nature of RtD, Blythe (2014) arrives at a more seemingly definitive conclusion, stating that 'Research through Design does not offer generalisable or repeatable findings but rather discussion, exploration and reflection.' These excerpts hold the position that through both RtD methodology, and indeed DF, *knowledge production* is context-specific to the context from which it was produced. Coghlan and Brannick (2005) define AR in similar terms and further note that such knowledge is seemingly only relevant to that *particular* context. This raises questions such as, *is the knowledge I produce through my doctoral research of importance beyond my thesis? Will the design knowledge I produce regards spimes be of any significance to other researchers and/or practitioners?* As I noted earlier when outlining my ontological and epistemic position (*5 Research Methodology – 5.2.2 Ontological & Epistemic Foundations* – page 69):

> *Adopting this Interpretivist ontology means that as the researcher, I will interpret the research focus (spimes) based upon my perspective and beliefs. This interpretation will therefore be different to other researchers exploring the same subject as well potential readers of the research…* [With regards to my *Interpretivist epistemology*] *I argue that the intended research results that I present – the potential knowledge regards spimes – cannot be established as 'truth' because my interpretation will be one of many possible interpretations.*

As Storni contends above, this type of stance does appear to present ostensible issues regards the *replicability*, *validity* and *generalisability* of the ensuing knowledge. *How then might these issues be suitably navigated if one is undertaking a RtD programme?* Approaching research from a sociological perspective, Law (2004) argues that researchers should not be concerned with objective reasoning because the world 'defies any attempt at overall orderly accounting.' For him, 'the task is to imagine methods when they no longer seek the definite, the repeatable, the more or less stable… adapted to a world that included and knew itself as tide, flux, and general unpredictability.' In light of Law's comments, I must return to Gaver's (2012) interpretation of RtD through which he argues the 'synthetic nature of design allows for richer and more situated understandings than those produced through more analytic means', while its practitioners 'should be wary of impulses towards convergence and standardization, and instead take pride in its aptitude for exploring and speculating, particularising and diversifying, and – especially – its ability to manifest the results in the form of new, conceptually rich artefacts.' Chow & Ruecker (2006) take similar position to Gaver, writing that with the importance placed on generalisability in the sciences, it is 'not surprisingly, presented as one of the evaluation criteria for design research… but the design and development of artefacts are highly unpredictable and do not follow any fixed rules.' Taking Law's and Gaver's lead, if we again reject the reductionism and scientificity 'demanded' by other research methodologies and other academic disciplines, I therefore argue we can begin to move beyond issues of *validity* and *replicability* as this is clearly not the intent of RtD nor DF. *Generalisability* however remains pertinent to our discussion. As has been discussed in regards to Figure 45, Lindley (2018) argues that the whilst the knowledge generated through an RtD/DF methodology is at once 'extremely contingent' to the context in which it was produced, it may also have 'broader applicability' and provide grounding to further design research, and, indeed research within other disciplines. Though she concurs, Pollastri (2017) is keen to stress the difference between the production of *knowledge* and *theory*. She maintains that as design practices generate context-specific knowledge, the construction of theory based on such knowledge can come about by adopting a distinct epistemic position, integrating seemingly disparate theories as well as combining different methods. This triad can facilitate the production of *generalised theory* – or what Friedman (2003) terms 'broad explanatory principles' – which can be extended to new contexts beyond the realm of the original design practice.

It is argued that the generalisability of design research can also be aided by bringing together multiple examples of research (Gaver, 2012; Pollastri, 2017; Gradinar, 2017). As such, Gaver suggests three possible formats for RtD research which emphasise multiple examplars – *frameworks*, *annotated portfolios* and *manifestos*. In the spirit of his approach to RtD, Gaver does not provide formalised explanations for the three formats. He does contend that by collating design proposals, 'a balance is achieved between descriptions of specific, detailed examples of design practice, and articulations of the issues, values and themes which characterise the research among the collection, and to which the [design] examples suggest answers.' With respect to *manifestos*, he describes them as:

> *A form of theory often produced as a part of research through design practice. These go beyond theoretical treatments drawn from other disciplines or developed from reflection on practice to suggest certain approaches to design as both as desirable and productive of future practice… a great deal of design theory tends to be generative and suggestive, rather than verifiable through falsification. This seems self-evident in the case of manifestos.'*

In the manner outlined by Pollastri (2017), I assert that my *Intepretivist epistemology*, confluence of sustainable design, the IoT and spimes as a research topic, and combination of RtD and DF, provide a robust substrate from which my doctoral research can construct, not only knowledge but also theory. Furthermore, by producing multiple examples of spime orientated DF practice and framing them together as a *manifesto*, my research affords further grounding for the production of *generalised theory* that may be of significance to other researchers-practitioners. As Gaver (2012) affirms 'manifestos will describe design practice to illustrate their approach [however] their primary function is to build an account of a practice to be pursued in the future.'

5.4 Evaluating RtD and Design Fiction

As outlined earlier in this chapter, *Positivist* researchers predominately aim to 'prove' their hypotheses by generating 'controlled results' that can subsequently be subject to empirical and scientific *verification*. As such, this knowledge is often *objectively* 'measured' and 'formalised' through the use of quantitative methods with *Positivists* likely to present their final results as 'truth' (Saunders, Thornhill & Lewis, 2009; Creswell, 2003). In contrast, those undertaking *Interpretivist* research will aim to 'experience' what they are researching. Personal judgement often governs an *Interpretivist's* choice of action and they tend to avoid rigid frameworks and adopt more dynamic approaches which can help elicit meanings and understanding as their research progresses (Hudson & Ozanne, 1988; Carson et al, 2001; Black, 2006). *Interpretivist* knowledge is therefore likely to be *subjectively* 'constructed' by the researcher involved in the research circumstances (Robson, 1993).

The reason I have repeated the above passages is because the ontological and epistemic foundations that differentiate a *Positivist* approach from an *Interpretivist* one will likely have a bearing on how a researcher will go about *evaluating* their research. This is certainly the case in the context of my doctoral work. Having chosen to apply an *Interpretivist* form of RtD, my approach to evaluating my spime case studies builds upon Frayling's (1993) and Gaver's (2012) exploratory interpretation of the methodology. I have *personally, directly constructed* the form of RtD and *Design Fiction* praxis that has characterised my research through *the very act of carrying out* my RtD and *Design Fiction* praxis. As such, evaluation of my work initially comes through the reciprocal cycles of tacit design practice and of reflective study (Figure 34 – page 79). Further to this, it is my intention for my doctoral research to lay the *academic foundations* for future spime-based theory and practice. I will detail in later chapters how the generation of both the *multidimensional lens* and *manifesto for spimes* are the fruits of this *academic endeavour* and are *the* prime foci of my research. Appropriately then, each phase of my research has also been evaluated through *international academic peer-review*. I will discuss this peer-review evaluation where relevant in succeeding chapters.

Having said all of the above, I have also noted at several junctures how DF proposals are designed with the intention that they 'speak' to wider publics as effectively as they do to academic audiences. Indeed, Voss, Revell & Pickard (2015) have highlighted the lack of engagement with broader audiences across speculative design culture in general, lamenting that 'despite explicitly advocating [their] potential for 'helping people participate more actively'… many speculative design projects either operate as stand-alone spectacle, or… with those deemed to have 'expertise' – scientists and technologists, political scientists, economists.' As I will outline further in later chapters, my spime-based design fiction case studies have indeed been designed to also engage with a spectrum of audiences. This is a key attribute of DF prototypes and distinguishes the practice from *Critical Design*, in part due to DF's application of 'new media' when constructing such proposals. Thus, whilst I assert that wider public engagement is not a core objective of my doctoral research, I recognise that different audiences' interpretations could lead to new insights and fresh discourse regards spimes that is beyond the scope of what I have developed through my *tacit and reflective practice* and that which has been evaluated through peer-review. Hence, this is why I intend to collate the case studies and associated theory in the form of a *design manifesto* – one which has been generated with the intent to inspire *future spime-related design praxis* beyond the confines of this thesis and amongst non-academic audiences in general.

Within computing, it is arguably HCI research from which the most DF oriented practice has originated. Due to its scientific pedigree, there is a strong tendency for HCI DF proposals to be ratified via a 'user study' with the researcher(s) aiming to facilitate *quantification* of results and the generation of a set of 'implications for design' – formalised tenets which other researcher-practitioners can potentially take forward and imbue into their own research. An example of HCI research which engages participants in the discussion and evaluation of a design fiction proposal is Elsden et al's (2017) work exploring so-called *speculative enactments*. They contend that because HCI is a 'broadly pragmatic, experience-centred, and participant-focused field [it] is well placed to innovate methods that invite first-hand interaction and experience with speculative design projects.' Resultantly, the authors outline three case studies that they contend enabled sampled participants to 'experience' a fictional performance, event and service and subsequently reflect on the value and meaning of these enactments. For example, in their *Metadating* case study, the authors used methods including ethnography and interviews to build an applied and empirical account of participant evaluation of the fictional speed dating event. In doing so, Elsden et al surmise that such user studies allow them to delineate *speculative enactments* from a merely being a set of practical guidelines into a set of 'conceptual resources for researchers and practitioners to critique the different contributions that speculative approaches make to HCI discourse.' Above all, they assert that there is a need to 'engage people more viscerally in futures conversations' and stress that their empirical analysis of studies like *Metadating* goes 'beyond stimulating discourse about speculation' and instead develops a 'means to act amidst it.'

Another example of evaluating DF practice within HCI is Noortman et al's (2019) *HawkEye* project which describes their apparent 'real-world' *deployment* of what they term a *design fiction probe*. The fictive *HawkEye* device and accompanying artefacts embody the authors' speculative ideas regarding how dementia care might be managed in future domestic settings. Noortman et al perceive their DF process to be 'a pragmatic user-centred design method' to generate insights and 'quantify design fiction results' on future technology use, specifically the use of assistive tech by dementia sufferers. Interestingly, the key concept upon which this work builds – the *design fiction probe* – was first introduced by Schulte et al in a paper titled *Homes For Life* (2016). That paper originated the concept using a combination of a literature review and a textual design fiction narrative. Thus, one might argue that *Hawkeye* should be viewed as a secondary stage in a DF process which seeks to transition *academically evaluated theory* into a *practical evaluated activity*.

To learn how people might respond to *HawkEye* and 'elicit their data,' Noortman et al deployed the probe into the homes of eight participants for three weeks. This activity was followed up by audio-visual interviews with the participants. Based upon this data, the probe was further evaluated through interviews with six HCI experts. All interviews were 'thematically analysed' where 'recurring general themes were observed around feedback on the presented technologies, implications for technology in dementia care and the effects that were specific to the design fiction probe method. Data were then iteratively coded until sub-themes were defined.' Importantly, whilst the authors are keen to stress the 'real-world' credentials of their process when compared to previous DF work – 'we present a wide range of insights about both the development and deployment of the probe that can be useful to other practitioners in the field' – these insights were *not* gathered from a wide range of *non-academic* stakeholders. In addition to the six HCI experts, each of the 8 deployment study participants were also *researchers*.

Instead of the 'top-down' user study approach that many HCI projects like *Hawkeye* pursue, I feel that collaborative methods like *engagement workshops* would be a more useful form of evaluation to explore spimes post-thesis. Such workshops would likely provide new forums for fresh and valuable discourse regards different audiences' perceptions of unsustainable Internet-connected devices and the potential for sustainable spime-based futures. DF practice has increasingly begun to be adopted as a 'tool' for engagement in recent years. *Engagement workshops* could therefore be a method for creatively embodying other worldviews, stances and ideologies *directly within* any ensuing spime-oriented design practice. As Lyckyi et al (2018) note, 'researchers have started to explore the practices of creating and using fictions more thoroughly [and] participatory activities are increasingly being adopted in the creation and use of design fictions.' Similarly, Huusko et al (2018) stress that 'design fictions can be also used as a workshop tool [but] while the workshop context creates certain needs for the tool, design fictions can help in building the workshop.' In some instances, DF proposals are presented as design exemplars or *provocations* and used as a means to 'kickstart' discourse and ideation practices amongst workshop participants (Knutz et al, 2014). In other cases, the empowerment of participants to directly generate design fictions themselves has become a central workshop praxis (Lyckyi et al, 2018). Baumann et al (2017) argue that by using the latter approach, fiction generation can provide an effective means of tackling more sensitive societal issues – especially when participants have conflicting interests.

This more democratic type of design workshop is commonly referred to as *co-design* practice. Steen, Manschot & De Koning (2011) emphasise that through *co-design* approaches, participants are indisputably *essential* to the design process. Empowering participants means that they can creatively employ their personal experience, knowledge and expertise to generate new insights within the collaborative environment (Sanders & Steppers, 2014). Whilst acknowledging that its role is more often than not 'fluid', Huusko et al (2018) have identified three main modalities in which DF can be employed across *co-design* contexts:

- **Setting the scene –** '*Design fictions can be used to set the scene for a workshop by providing a way to promote the workshop and to get people interested in the workshop. Design fictions can also offer a chance to build a storyline to connect different workshop tasks into a whole with bigger goals.'*

- **Structuring the tasks –** *'For the organisers, the design fictions were a tool for suggesting values and ideas, for setting the participant roles for the workshop tasks and for facilitating and structuring the tasks. For the participants, the design fictions were a starting point and a frame to work on, which provided different perspectives and encouraged to imagine what the future would be like.'*

- **Embedding values –** *'Design fictions can participate in presenting various speculative and contrasting values into workshop tasks and context… design fictions became a platform for embedded values: for the organisers to include the topics that were seen relevant in the background work, and for the participants, a platform that suggested ideas to take in or discuss upon.'*

Co-design approaches have been embraced by researchers working in both HCI and design contexts. Like Noortman et al's (2019) *HawkEye* project, Tsekleves et al (2017) also applied DF methods in relation to future healthcare technologies. Differently however, Tsekleves et al's work provides a germane example of DF infused *co-design* practice. Their *ProtoPolicy* project explored how co-designed DFs could be used to 'help older citizens imagine the future implications of policy initiatives through the lens of technology.' Through two workshops, Tsekleves et al engaged groups of older UK citizens in debate and fictive prototype ideation regards the issues of assisted living/smart-homes and assisted dying/euthanasia. A variety of tools and activities were used in the workshops to facilitate participants in applying DF techniques to negotiate the implications for age related policy:

> *These included… considering nascent policy statements; making exercises that explored people's values through their relationship with technologies of the past and of imagined futures; activities exploring linkages between the group's ideas and policy statements through discussions and table-top affinity mapping; using making exercises to design and prototype a range of services and products for potential futures in response to their understanding of the policy statements; introducing emergent technology to develop 'what if?' scenarios set five, ten and an indeterminate number of years into the future.*

This collaborative process led to the development of a series of co-designed 'low-fidelity' fictions. These proposals were then collectively evaluated and ranked by the participants. Tsekleves et al (2017) stress how this was a critical part of the process as it clearly identified what the main future age-related concerns were for the elderly participants. In addition, it specified which issues should be translated into two further 'higher fidelity' post-workshop DFs – the *Soulaje* self-administered euthanasia wearable and the *Smart Object Therapist* service. These polished prototypes were then used to inform the next stages of the wider *ProtoPolicy* project.

6 Unpacking The Spimes Concept

6.1 Introduction

In Chapter 4 (*4 Spimes: An Introduction* – page 53), I discussed the initial origins of the concept and began to contextualise it in relation to the IoT and explain how potential spime objects would differ in both design and intent when compared with contemporary connected devices. I also considered the relationship between spimes and some of the broader debates across sustainability discourse including *technological solutionism*, *Ecomodernism* and *Bright Green Environmentalism*. Most importantly however, I concluded that the current approach to designing IoT devices simply perpetuates unsustainable 20th century design cultures and, in response, my research contribution centres on re-characterising future IoT devices as *spimes*. As stated, it is my intention to put forward spimes as an alternative sustainable methodology for future connected product design praxis where sustainability is baked-in and product obsolescence and end of life are managed effectively. Thus, having now defined my methodology, in this chapter I will begin to unpack and extend the concept of spimes beyond Sterling's original outline. In doing so, I will begin to establish what I consider to be the primary value and intent of spimes as a concept and its implications in the designing of sustainable connnected product futures. I have determined that my spime-orientated research will investigate three key questions. This chapter will therefore begin to extend spimes as a concept by exploring the first of these questions – *What are spimes?*

6.2 An Early Definition

Several neologisms with similar definitions to that of the IoT have emerged over the past decade, and, as a result, have been used to denote material objects that connect to the Internet. These include *hyperlinked objects* (Bonanni et al, 2009), *enchanted objects* (Rose, 2014) and perhaps most prominently *smart objects* (Porter & Heppelmann, 2014). Kuniavsky (2010) also appropriates the 'smart' modifier, coining the term *smart things* to describe Internet-connected material objects that have what he calls 'information shadows' as well as separating the 'material' and 'digital' facets of these objects into two distinct 'entities.' I assert that the term *spimes* sits apart from these descriptors with the key difference being the *reciprocal relationship* between a spime's 'material instantiation' and 'digital instantiation.' Depending on *context*, I contend that 'spime' can be used to refer to both the archetype object – the original digital instantiation as created by the designer – and a user-specific iteration of the same object – the material instantiation with which a person physically interacts.

To provide context and aid understanding, at the beginning of my literature review (page 6) I put forward an initial 'working definition' for the term spimes:

> *'Spimes' denotes a class of near future, sustainable, Internet-connected manufactured objects, which, unlike the disposable IoT products which permeate our society today, would be designed so that they can be managed*

sustainably throughout their entire lifecycle. This would have the goal of making the implicit consequences of product obsolescence and unsustainable disposal explicit to potential users.

To extend and develop the concept into a more robust and meaningful counterpoint to today's unsustainable IoT paradigm, and push the concept beyond Sterling's initial work, I consider it crucial to understand the sustainable value of spime objects and their potential impact in greater depth. Thus, to provide a deeper theoretical and practicable foundation for the practice-led spime case studies that follow, and I unpacked the concept further and, in the process, developed a set of six *key classifying design criteria* for potential *near future* spime objects. The next section contextualises each of these six criteria in detail.

6.3 Key Classifying Design Criteria for Spime Objects

6.3.1 Technology

As I argued in section *4.4 Spimes & Futures* (page 60), we are in the midst of a 'transitionary period' between IoT gizmo and spime *techno-cultures*. To reiterate, the term *techno-culture* denotes the relationship that humans have with the technological tools that are created either by themselves, by fellow humans, and/or with fellow humans. Today's *gizmo* techno-culture is characterized by highly unstable, user alterable and programmable multi-functional objects with short lifespans that are commonly linked to network service providers. In the transition from *gizmos*, the earliest near future spime objects would likely share some common design attributes with these contemporary devices, not least, their initial technological specifications. Accordingly, I argue that the earliest instantiations of spimes would likely be characterised by a convergence of the following six technologies and practices (adapted from Maly, 2012):

I) *RFID tags* – Small, inexpensive means of remotely and uniquely identifying a spime object over short ranges.

II) *GPS* – A mechanism to precisely locate a spime object on Earth.

III) *Internet Search Engine* – Search functionality affording a front end to mine the enormous amounts of data that a spime object constantly collects and transmits.

IV) *CAD Software* – Tools to digitally construct and manipulate endless iterations of a spime object.

V) *3D Printers* – Sophisticated, automated and robust means to rapidly fabricate a 'digital instantiation' of a spime object into a 'material instantiation.'

VI) *Eco-materials* – Materials which are ecologically safe and durable but also highly versatile. When a spime object is no longer required, they can be cheaply returned into the production process as a raw material for future spime objects.

6.3.2 Sustainability

Many contemporary Internet connected products are designed, manufactured and function as a combination of the previously listed technologies/practices. It could be argued then that products such as a 'smart speaker' can be described as a *proto-spime*. Smart speakers such as *Google Home* and *Amazon Echo* possess functionality which allows them to be location aware (through GPS), networked (through wireless mobile Internet), environment sensing (through embedded sensors/actuators) and provide search capabilities (through an Internet search engine) amongst other attributes. Likewise, with its ability to sense, track and display a household's energy consumption, some might also view the *Nest Smart Thermostat* as a *proto-spime*. Indeed, Nest's product is commonly seen as a more sustainable alternative to conventional domestic energy monitoring, as people who use it can ostensibly manage their energy consumption via their smart phone or tablet. *Proto-spime* does appear to be a logical descriptor for such products, given that we may be, as argued earlier, in the midst of a 'transitionary period' between IoT *gizmo* and spime techno-cultures. However, in wanting to make an explicit distinction, I argue that products such as smart phones, tablets, and those characteristic of the IoT like wearable fitness trackers and energy monitors, cannot be classified as spimes. They do not embody Stage 4 of the exemplar, that is, they have not been designed to ensure that their entire existence can be managed sustainably – from initial design to rebirth as a future object ad infinitum.

In expanding the theory of *Ubiquitous Computing*, Weiser and Seely-Brown (1995) envisioned a future world where widely dispersed computation is 'calm' or 'ambient'. I argue that IoT products such as the Nest Thermostat more closely resemble Weiser and Brown's vision than that of spimes. Nest's device may encourage people to reflect upon, and subsequently modify, how and when they consume household energy. Despite this, it is only 'when the metrics count for more than the object they measure [that] *gizmos* become spimes' (Sterling, 2005). Like most IoT products, the informational support afforded by the Nest Thermostat centres on the 'use phase' of the product lifecycle and fails to communicate other crucial sustainable information regards the design, production, distribution, maintenance and disposal of the product. IoT *gizmos* like Nest remain largely 'unseen' and preserve the distance between people and the environmental impacts of the device itself. The inherent unsustainability of today's IoT devices is designed to be *out of sight and out of mind*. In contrast, spimes would have the potential to cultivate stronger people-product relationships, relationships that go 'beyond the object' and make implicit environmental impacts more visible, tangible and sustainable.

Since sustainability has been identified as the defining attribute of spimes, I think it is judicious to also frame the concept within the wider discourse of sustainable design theory and praxis. I think the *Cradle-to-Cradle* model (Braungart & McDonough, 2008) is analogous to the more incisive and progressive form of product sustainability that spimes embody. Unfortunately, very few products are yet to adopt this approach. Industry is perhaps unwilling to invest in alternative methods when established mass-production processes are already considered cost effective. Nevertheless, Braungart & McDonough's method represents a possible antecedent for the production of future spime-like objects. Like *Cradle-to-Cradle*, *modularisation* could well be incorporated into spimes' design to help people better manage their objects' protean lifecycles. Modular products founded on *Design-for-Disassembly* (Chiodo, 2005) principles have also failed to come to prominence in IoT era. Although not intended for consumer use, the data generated by a product's *Life-Cycle Assessment* (LCA) (Shedroff, 2009) shares similarities with the notion of a spime object's informational affordances. A spime object would generate similar kinds of data only in *real-time, all the time*. Sterling's notion of *designing for opportunity costs and cognitive load* would therefore become crucial to maintaining efficient relationships between people and their spime data.

Blevis (2007) asserts that '*software and hardware are intimately connected to a cycle of mutual obsolescence*.' Through his theory of *Sustainable Interaction Design* (SID), he calls for designers to thoroughly consider the lifecycle of new product hardware and software by '*linking invention and disposal*.' Moreover, he argues that even before designing new products, it is imperative designers do their utmost to '*promote renewal and reuse*' of those that already exist. As outlined, 'spime' can refer both to the digital instantiation and the user-specific material instantiation of the same object. In light of Blevis' theory, the simplicity of this distinction is made more evident. A spime object's material instantiation would not be material per se – software and other digital elements would be embedded *in the material*. Thus, a *spime wrangler* would need to carefully consider the additional design constraints this would impose to ensure a spime object's software is as sustainable as its hardware.

Design for Behaviour Change (DfBC) is a research field that examines peoples' consumptive habits with a view to identifying methods for developing behaviour moderating devices. The aim is to bridge the *value-action gap* between a person's implicit values and their explicit everyday actions (Niedderer, Clune & Ludden, 2017). DfBC shares common ground with *Persuasive Computing* as both draw upon behavioural science research. Fogg (2002) describes the latter as '*a way of thinking clearly about target behaviours and how to achieve those goals using technology.*' With sustainability fundamental to its existence, a spime-like object would sit apart from today's IoT products even though both generate data. In addition to its innate material sustainability, a spime's informational transparency would also engender its user with greater sustainable awareness, and quite possibly lead to changes in their behaviour. As a result, spimes might well begin to correspond with the 'interventionist' aims of DfBC and *Persuasive Computing*.

The subject of products changing peoples' interactions, expectations and behaviours leads us to further consider the sustainable credentials of decentralised, open and distributed design practices. Seeking to reframe unsustainable industrial product design as a more democratic and socially constructive activity, Papanek (1971), argued that '*all men are designers…* [as] *the planning and patterning of any act towards a desired, foreseeable end constitutes the design process*.' Papanek's words echo the 'new industrial revolution' rhetoric which permeates today's maker, hacker and open source cultures. In a Latourian[7] sense (1999), the growth in localised, democratised production and consumption can be seen to be empowering 'ordinary' people to 'open up the technological black-box' and become more involved in the provenance, repair and recycling of their digitally augmented material artefacts. With emphasis firmly placed on the use of modular hardware and reprogrammable software such as Arduino (Jalopy, Torrone & Hill, 2006), these practices closely correlate with strategies like *Design-for-Disassembly* and SID, and in turn provide a precedent for the synchronic production of spimes. I also see distinct parallels between Sterling's idea of a *Synchronic Society* and a *Circular Economy* which denotes the development of an economy based on cyclic resource-efficient

[7] Across scientific discourse, the term *black box* is used to denote devices and systems whose explicit workings can be readily viewed, that is, their inputs and outputs can be recognised and understood, yet their internal workings remain ostensibly implicit or 'hidden' from view. The French philosopher and sociologist Bruno Latour (1999) reframed the term in relation to socio-technological practices. In doing so, he describes 'blackboxing' as 'the way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become.'

principles as opposed to the linear 'take, make and dispose' model that most industrial societies currently adhere to.

6.3.3 Temporality

In stating that spimes 'have the capacity to change the human relationship to time', I argue that Sterling is raising two important points:

I) The notion that societies tend to live in the present and fail to consider their collective future. He cites our profligate materialism and its detrimental effect on the planet's ecosystem as the prime example of our lack of foresight.

II) It is our tools, rather than our philosophies, that have caused "the most radical changes in our temporal outlook, [that is], tools of temporal perception, [for example] clocks, telescopes, radio-carbon daters, spectrometers" (Sterling, 2005).

Spimes could therefore be the next significant tool of *temporal perception*. On a *macro level*, a spime-based techno-culture's innate transparency and material sustainability could change people's outlook, shifting society to a preferable future beyond the unsustainable practices that blight our present. On a *micro level*, spimes could transform the temporal nature of the relationship that people have with their products. This shift would, however, come about in a way that sits contrary to conventional sustainable design discourse. Established theory advocates the need to slow the pace of change, thereby extending the *use phase* of products and technologies which, in turn, reduces obsolescence and waste. Conversely, though spime objects would afford stronger, more transparent people-product relationships, these relationships would be built on *faster* technological product lifecycles. In a spime techno-culture, product obsolescence is actively embraced. Spimes can only come to be, if the products 'getting manufactured [are] as easy to dispose of as [they are] to make' (Maly, 2012). Thus, spimes are not only *ideologically of the future* – a manifesto for moving beyond the unsustainable production and consumption models of today – but also *pragmatically of the future* – as the physical, infinitely recyclable eco-materials required for their sustainable existence are yet to exist.

Framing obsolescence as a potential positive attribute of spimes enables me to build a critique of 20th century design practices, particularly *functionalism*; the modernist credo which originated at the Bauhaus design school in 1920s Germany. Dieter Rams, the Chief Design Officer at *Braun* consumer products for over 30 years, is a prominent advocate of such thinking. Rams has argued for a type of 'good design' to combat planned obsolescence and ensure that mass-produced electronic products remain 'timeless' – functionally, aesthetically and emotionally relevant for many generations (Lovell, 2011). Rams began to develop his *Ten Principles for Good Design* (Figure 47) in the mid-1970s, two of which specifically focus on product sustainability – *Principle 7. Good design is long-lasting* and *Principle 9. Good design is environmentally friendly* (Rams, cited in Klemp & Ueki-Polet, 2010).

Rams' ethos continues to be celebrated throughout industrial product design practice today, not least by Jonathan Ive, the Chief Design Officer at *Apple Inc* and designer of the *Apple Watch*, *iPod* and *iPhone* (in Hustwit's 2009 film about industrial product design 'Objectified'). Figure 48 depicts 'functionalist' products designed by Rams and Ive. I argue that whilst Rams put forward his principles in earnest, his strategy has unfortunately failed. Our present technological product culture is built upon capital logic which allows unsustainable modes of design, commerce and consumption to flourish. Irrespective of whether they might be considered ‘good’ or ‘bad’ design, today’s products will eventually become obsolete in the wake of changes to markets, fashion, materials and technologies. Furthermore, peoples’ individual and collective needs, desires and values significantly alter *over time* – a product that is ‘good’ *today*, may not be ‘good’ *tomorrow*.

TEN PRINCIPLES FOR GOOD DESIGN

- Good design is innovative
- Good design makes a product useful
- Good design is aesthetic
- Good design makes a product understandable
- Good design is unobtrusive
- Good design is honest
- Good design is long-lasting
- Good design is thorough, down to the last detail
- Good design is environmentally-friendly
- Good design is as little design as possible

Figure 47: Dieter Rams’ *Ten Principles for Good Design*. Source: Author, after Rams (2010).

Figure 48: Examples of ‘good’ or ‘bad’ design? Top left and top right – the Braun SK 4 Radio-Audio Combination (1956) and FS 80 TV (1964) designed by Dieter Rams. Bottom left and bottom right – the Apple iPod music player (2001) and iMac desktop computer (2007) designed by Jonathan Ive. Source: www.braun.com and www.apple.com. Image is unavailable due to copyright restrictions.

I conclude that established thinking such as Rams' is undermined by time, we should instead begin to consider designing particular products that incorporate with *protean lifecycles*. A spime-based techno-culture would afford people latitude to dispose of their material objects quickly, and/or, cultivate longer-lasting relationships through product care and maintenance. As I see it, eco-materials would enable spimes' material instantiations to be *enhanceable*, *customisable*, *repairable* and *recyclable*. Rather than forever remaining the same in the manner of Rams' 'good design', spimes would have the innate ability to transform and reflect changes in technology, cultural trends and peoples' needs.

6.3.4 Synchronicity

Sterling (2005) suggests that we must 'combine the computational power of an information society with the stark interventionist need for a sustainable society. The first one is happening anyway; the other one has to happen.' The ensuing synthesis would lead to what he terms a *synchronic society*. Different to the centralised, proprietary infrastructures that dominate today's IoT techno-culture, this paradigm could well be built on more *open* and *distributed* forms of design-innovation practices like the *Maker Movement*, 'hacking' and *Fab labs*. These decentralised practices are often cited as having the potential to radically reshape industrial product design activities in the near future. Certainly, in the years since *Shaping Things* was published, there has been a distinct growth in the number of people engaging in such practices. However, I maintain that they still cannot be considered 'mainstream' approaches to the design, production and disposal of products. They remain niche activities conducted in the shadows of mass manufacturing and consumption. Nevertheless, I contend that this does not diminish their potential with regard to sustainability, nor their possible role in helping society transition to a spime-based techno-culture.

How then would decentralised design-innovation practices lay the foundations for a spime-driven synchronic society? The route from design to market for most of today's products is protracted and expensive. As a result, firms strive to retain the intellectual property rights for their product designs which restrict other companies from developing similar devices. Recent years have, however, also seen an increase in firms collaborating with external sources such as academic institutions, technologists and customer groups in order to draw upon a wider body of knowledge and expertise. While proprietorship is still key, it is argued that this *open innovation* model (Chesbrough, 2003) enables firms to remain at the *bleeding edge* and continue to produce innovative products. I contend that although such activities may engage a broader demographic in product design-innovation processes, for the most part *open innovation* simply reinforces our present models of production and consumption. The emphasis remains on corporate profitability and not environmental sustainability.

In my view, Rodgers' *diffusion of innovation* theory (1962) provides a more effective model for a future synchronic society. Put simply, diffusion is the process by which an innovative idea or technology is communicated through various channels over time among the participants in a social system. Rodgers separates those who adopt new innovations into five main categories: *innovators*, *early adopters*, *early majority*, *late majority* and *laggards* (Figure 49). He stresses that in order to become self-sustaining, an innovation must be widely adopted and to do so, it will rely on social capital – a 'resource' which 'actors derive from specific social structures and then use to pursue their interests; it is created by changes in the relationship among actors' (Baker, 1990). I assert that today's decentralised design-innovation practices remain the preserve of *innovators* and *early adopters* and a broader diffusion of spime orientated design activities would be heavily contingent on collective creativity and skills (social capital), the Internet (communication channel) and the future (time).

This interpretation of diffusion also enables similarities to be drawn between spimes and *memes*. Dawkins (1976) coined the term *meme* to explain the spread of cultural phenomena such as speech, rituals, fashion and technologies. In doing so, he was making an analogy with the way in which human genes *virally* self-replicate, imitate and compete according to Darwinian selection. In more recent years, his term has been re-appropriated to denote when an idea has 'gone viral', that is, it is replicated and widely distributed online. The key difference between Dawkins' definition of memes and 'Internet memes' is that the former are always accurately assimilated as they diffuse. Internet memes, on the other hand, are deliberately changed by human creativity during diffusion. With their innate informational transparency, malleability and ability to be mined, I argue that the same might well be said of spime objects and their associated design practices. In the future, a spime could easily 'go viral'.

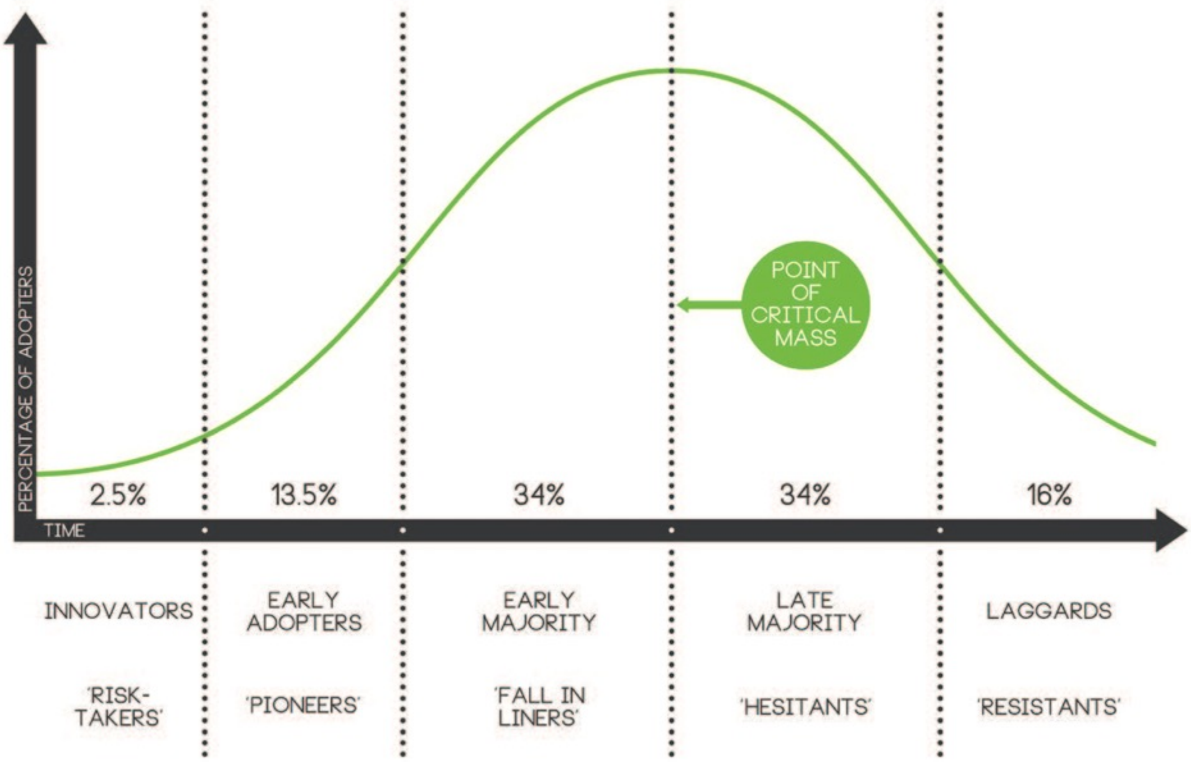


Figure 49: Rodgers determined that new innovations 'diffuse' via five different types of adopters and reach 'critical mass' between early majority and late majority user groups. Source: Author, after Rodgers (1962).

6.3.5 Wrangling

In having to negotiate *new materials* and a *new ideology* for sustainable connected product design, the transition to spimes would be both a major opportunity and a challenge for tomorrow's designers. In addition to this shift in how to design, there would also likely be a shift in who designs. As Sterling (2005) stresses, 'in a spime world, designers must design, not just for objects or for people, but for the techno-social interactions that unite people and objects.' I contend that this description shares similarities with *Interaction Design*, the field that bridges the disciplines of industrial product design and *Human Computer Interaction*, and which has gained increasing significance in today's era of digitally augmented material products. *But are the creators of spimes likely to be interaction designers or product designers or something different?*

Spimes would be a set of relationships first and foremost and a physical object some of the time. By shifting peoples' sense of value from materials to information, material scarcity might begin to be redressed and people – both individually and collectively – will have a deeper affinity with their information. Importantly however, such as paradigm could lead to the scarcity of a different asset – *time*. The innate *informational transparency* of spime objects would grant their users access to vast quantities of data. This raises the question – would people give more of their precious time to sift through sustainable product data ad hoc? Consequently, it is critical that spimes, and the relationships that they would afford, be designed with fluidity and efficiency firmly in mind. Those who would design these future human-object relationships would be referred to as *wranglers*.

I posit that more open, distributed design-innovation practices would also broaden the types of people who would engage in *wrangling*. Unlike today, in a *synchronic society*, the acts of creation and consumption would no longer be mutually exclusive. With design expertise and tools more widely dispersed, *wrangling* would not only be limited to established practitioners such as interaction designers or product designers. Multitudes of people would be consuming the products that they themselves have had a hand in creating. From this perspective, the concept of wrangling shares similarities with both Toffler's notion of *prosumers* (1980) and Von Hippel's *lead users* (2005).

6.3.6 Metahistory

In Chapter 4 (*4 Spimes: An Introduction – 4.2 What Do We Already Know About Spimes?* – page 54) I presented the bottle of wine exemplar which helped to illustrate how such an artefact would potentially manifest in a spime-based paradigm. As noted in Stage 2 and 3 of this exemplar, a near future spime object would generate data throughout its entire lifecycle. Moreover, in Stage 4 of the exemplar it is stated that all spime data 'is saved and remains available online for historical analysis by you and any other interested parties.' It is at this point then that we should return to the idea that the informational support a spime product would offer is more significant than its material form. Although I have argued that spimes are yet to come into existence, I would also contend that we, in today's IoT *gizmo* techno-culture, interact with products in ways analogous to a world of spimes. For as Csikzentmihalyi and Rochberg-Halton (1981) showed in their seminal work on western material culture, we have relationships with each and every material thing that we own. For example, one may still have the copy of the favourite book that was first read as a teenager or may be continually perplexed by the television remote control that one has never quite fathomed how to use. Whatever the personal history between a person and their things, this history is, for the most part, only recorded in a physical manner on the objects themselves as *patina* – signs of age and use – and as thoughts and memories to which, by and large, only the individual is privy.

I see the adoption of spimes as potentially deepening the relationships that people have with their material products by recording the histories of these relationships and making them *accessible* and *searchable*. This would lead us to a future where silos of people-product histories are data mineable informational resources. In other words, in a world of spimes, our product metahistories will become a valuable commodity. Over the last 15 or so years, the increasing pervasiveness of the Internet coupled with growth in use of data sensing mobile devices such as smart phones and tablets, has led to a booming *information economy* which thrives upon acquisition of personal user data. As discussed in both my Literature Review and Synthesis, this so-called *big data* has become a key source of revenue for tech companies and IoT platforms, particularly when allied to the associated practice of *data mining*. As has been shown, *The Big Five* firms like *Google* and *Facebook* surreptitiously capture, mine and monitise the personal data that is generated by users when they operate their IoT devices. They build customer profiles and sell such information onto other commercial entities such as advertisers.

Unlike *big data*, *open data* sets are made freely accessible, as the emphasis is not placed on profit making. Rather, such data is shared and mined to help inform decision-making (Kitchin, 2014). For example, mining governmental open data may lead to changes to public policy or legislation. Mining spime metahistories meanwhile could help inform sustainable decision-making, particularly in relation to the lifecycle of material goods. In a spime techno-culture with protean product lifecycles, we would have the ability to make 'a great many small mistakes fast [and] it's not necessary that every experience be sensible, logical or even sane – but it's vitally important to register, catalog and data mine the errors' (Sterling, 2005). Thus, if we were able to identify patterns of unsustainability within vast amounts of spime metahistories, we may be able to know in advance which design decisions were environmentally damaging and in turn, limit the probability of developing harmful products any further.

6.4 Summary

To provide a technical and theoretical foundation for the three practice-led spime *Design Fiction* case studies that will follow, in this chapter I unpacked and extended the value and intent of spimes as a concept. This development enabled my research to move beyond Sterling's original vision and resultantly put forth a set of six *key classifying design criteria* for potential near future spime objects. In summary, the criteria are as follows:

- **Technology** – the earliest spimes would likely share some of the same technologies we see in today's IoT culture like GPS and RFID but instead of being exploited for commercial gain, they would be incorporated into a spime object's design to make it more sustainable.

- **Sustainability** – the prime reason for connecting physical (atoms) with digital (bits) elements, and fundamental to all spime objects.

- **Temporality** – rather than forever staying the same, becoming redundant and eventually ending up as landfill, spime objects would have *protean lifecycles* meaning they could be changed and updated as often as required.

- **Synchronicity** – in a *synchronic society* built on spimes, the design and production of connected devices would be more democratic and collaborative with the required skillsets and knowledge *openly shared* for the benefit of communities, as opposed restricted to a few corporate entities.

- **Wrangling** – people who develop and use spimes, and freely share their design expertise would be called *wranglers*.

- **Metahistory** – a spime device would generate important data about itself throughout its entire lifecycle and this *metahistory* would be saved and remain searchable, trackable and mineable at any time – *for the benefit of sustainability*.

This chapter provided the basis for a journal paper which was evaluated by peer review. The paper *Spimes And Speculative Design: Sustainable Product Futures Today* was published in the *Strategic Design Research Journal* in 2017. In the next chapter, my three practice-led spime *Design Fiction* case studies will build upon the six criteria as a means to demonstrate how the design attributes of potential near future spime objects would significantly differ from the manner in which unsustainable IoT *gizmo* devices are currently designed.

7 Spime Design Fiction Case Studies

7.1 Introduction

With the six *classifying design criteria* providing a robust theoretical foundation for further research into the spimes concept, in this chapter I will explore my thesis' second key question - *can we begin to design spimes?* As previously outlined, whilst Sterling suggested some possible attributes and technologies that might be characterise a spime's design, he, nor other practitioners, have sufficiently envisioned how spime objects might be 'actually' be designed. Thus, using my chosen core research method *Design Fiction*, I will next explore how to visualise potential spime objects, understand how they might begin to be designed, and *concretise* the kind of near future worlds in which they might possibly exist. My case studies will aim to give credence to my argument that the IoT is an inherently unsustainable design paradigm and that the spimes concept should be viewed as credible alternative sustainable paradigm for future connected device design.

Exploring different *key classifying design criteria*, each *Design Fiction* case study is composed of the following three sections:

1. *Framing* – this first section contextualises the particularities of the spime *Design Fiction* in relation to specific unsustainable aspects of the IoT.

2. *Prototyping* – the second section describes the *material engagements*, or in other words, the 'doing' of the *Design Fiction* – the pragmatics and practicalities of producing the fictional spime-orientated artefacts.

3. *Insights* – Each case culminates in findings relating to the potential design of future spime objects and their possible societal, technological and environmental implications. I also present insights in regard to my use of RtD methodology, the DF method and how these relate to knowledge construction and potential generalisable theory with respect to the design of spimes.

As will be explained further after the three case studies, the ensuing knowledge regards the spimes concept generated by each case culminates and consolidates in what I term the *Spime-based Design Fiction practice space*.

7.2 Case Study 1: Toaster for Life

7.2.1 Framing

As a method *Design Fiction* is often discussed in relation to science fiction literature and film, not least because Sterling is a noted science fiction author but due to most practitioners' application of *diegetic prototyping* which is rooted in the ways new technologies are introduced and 'actualised' within the narratives of Hollywood science fiction films (Kirby 2010; Bleecker, 2009). Whilst not seeking to discredit science fiction's influence upon the method, I argue that spimes are best framed in relation to mundane, everyday objects as opposed to the fantasy and spectacle often used to present futuristic technologies. Foster (2013) sees the juxtaposition of possible new technological products in relation to present day artefacts as an effective way of framing mundane futures:

> *We should embrace legacy technologies when conceiving new ones… to show potential disconnects between the new and established, places where technology sticks out like a sore thumb. This is a useful tool for all designers and using it well can help us depict a more tangible future.*

Sterling (2005) begins to do this by describing how a near future spime object might manifest as a bottle of wine. Other design fictions such as the short film *A Digital Tomorrow* (Nova et al, 2012) and those presented in the Bleecker edited *To Be Designed Catalog* (2014) also pose mundane near futures. Similar to Foster, Auger (2013) contends that one must ensure 'careful management of the speculation; if it strays too far into the future to present implausible concepts… the audience will not relate to the proposal.' Thus, rather than attempting to design a radical 'game-changing' spime product, the *Toaster for Life* case study expands upon the above approach by embodying a near future spime in the form of a banal and ubiquitous contemporary domestic object – the humble toaster. As such, the *Toaster for Life* is a diegetic prototype which aims to embody three of the *key classifying design criteria for spime objects*, namely, *technology*, *sustainability* and *temporality*. The design (Figure 50) represents an early material instantiation of a spime object; a physical product which incorporates a series of innate sustainable attributes. To do this, the study extrapolates a range of present day technologies, practices and behaviours and marries them with fictitious possibilities including domestically 3D printable eco-plastics and 'nano-RFID' tracking capabilities. It is envisaged that this projected convergence would result in new sustainable user-product practices and interactions. However, as people often find it difficult to imagine how disruptive technologies and practices can bring about change that is different to their present and past experiences, the unfamiliar practices and interactions afforded by a spime toaster have designed to be appear mundane, 'everyday' and, most importantly, *plausible* to potential audiences. It is hoped this will lessen the potential for the product's features and technologies to be considered as fantastical, unreal or, as Auger (2013) implies – 'too futured'.

Figure 50: The *Toaster for Life* represents an early 'material instantiation' of a sustainable spime object. Source: Author.

Further, the framing of the concept in relation to a mass-produced artefact also facilitates critique of the unsustainability of IoT devices. Household consumer products like smart kettles, smart TVs and smart speakers are some of the most visible and commonplace types of IoT devices that people use today. I argue that redesigning a toaster to be *spime-like* is an effective way to make the sustainable features of a potential spime object appear plausible in an object with no apparent need to be connected to the internet. Increasing material scarcity and e-waste are evidence that we often take commonplace 'non-connected' objects like toasters for granted. Moreover, as I have shown, IoT products continue to adhere to these unsustainable models of production and consumption. How long will it be before we throwaway more and more of our non-connected products and replace them with IoT devices? Are these connected products likely to be any more sustainable? What are the long-term implications for material scarcity and e-waste due to an expanding IoT paradigm?

In light of the above issues, the case study not only seeks to envision or 'embody' a near future spime object but also aims to make the oftentimes abstract concept of environmental sustainability more practical and tangible to potential audiences. As has been noted, the issue of sustainability is often framed within utopian or dystopian narratives. I argue that, rather than facilitating engagement, these extreme visions can *disengage* people from taking part in this important dialogue. Accordingly, I have purposely sought to avoid presenting the speculation as an 'idealistic utopia' or 'end is nigh' style dystopia. Situated in the mundane, the *Toaster for Life* aims to make sustainability more of an 'everyday concern'. This aligns with Sterling's (2005) view that a design fiction is most successful when it presents new products and technologies as 'practical [and] more hands on.' In the next section, I will discuss how I incorporated and visualised key sustainable attributes – including the ability to be repaired, recycled and tracked – as main elements of the fictional toaster's design.

7.2.2 Prototyping

Alongside the increase in proprietary IoT *gizmos* such as smart phones, wearable fitness trackers and wireless energy monitors, recent years have also witnessed growth in decentralised IoT practices like the *Maker Movement*, 'hacking', *Fab labs* and open hardware and software development. Within these sub-cultures, people use technologies like RFID, computer-aided design software and 3D printers to design and build bespoke Internet-connected objects (McEwen & Cassimally 2013). I contend that it is within this latter strand of technological product development that Sterling identified potential for a more sustainable material culture. The *Toaster for Life* fiction can be seen as a means of reassessing the above technologies and practices to potentially realign them with Sterling's sustainable vision as opposed to the corporate rhetoric of the IoT. I have posited that the earliest, material instantiations of spimes would likely be characterised by a convergence of six main technologies and practices - *RFID tags*, *GPS*, an *Internet Search Engine*, *CAD Software*, *3D Printers* and *Eco-materials*. Yet, if many contemporary unsustainable products are designed and manufactured using these technologies/practices, how would the lifecycle of an early spime be made potentially more sustainable with similar means? Bonnani et al (2009) suggest that the design of spime objects would rely 'on a life-cycle approach… to account for materials and energy over multiple generations. [This] could empower a tinkerer to repair a product; it could offer information about available upgrades and customization; and as technology evolves… could provide new strategies for re-use and recycling.' Like any contemporary toaster, within its fictional world, the *Toaster for Life's* design means it could toast bread. However, as Figure 51 shows, in contrast to the toasters of today, the prototype also has been designed to allow potential users' to sustainably manage its lifecycle by partaking in effective product repair, upgrade, customisation, recycling and tracking practices.

Near future eco-materials would potentially make the material instantiations of spime objects infinitely enhanceable. People would have flexibility to dispose of their material spimes quickly, cultivate longer-lasting relationships with them through care and maintenance, or practice something in-between. Thus, rather than forever remaining the same, spimes would have the innate ability to transform and reflect changes in technology, cultural trends and peoples' needs. With this lineage to past, present and future product cultures, a spime object would be *atemporal*, the title of design the *Toaster for Life* therefore connotes notions of *time*. Atemporality is also reflected in the use of the design fiction method itself. The 'actually futuristic' spime toaster is 'materialised' within a fictional future world and is therefore asynchronous to the present. Despite this theoretical rationale, the *Toaster for Life* does not require specific pre-text. My supervisor Professor Paul Coulton suggested the title because it similarly does much to convey the concept of product longevity and sustainability without indepth explanation.

Figure 51: The *Toaster for Life's* spime-like sustainable attributes. The prototype has also been designed to toast bread like any present day toaster. Source: Author.

As has already been noted, 'plausibility' is a principle reason for representing the spime concept as a toaster. Toasters are a staple of the domestic setting, of routine interactions. In addition to this, the 'toaster', like the 'fridge', is often cited as an archetypal IoT device, an everyday product that, if made 'smart' and networked, would enrich its users' lives in new and beneficial ways. Sterling (2014) laments this corporate rhetoric where the connection between the physical material object and the digital world is often being made for connection's sake – 'making your refrigerator talk to your toaster is a senseless trick that any competent hacker can achieve today for twenty bucks.' The *Toaster for Life* seeks to subvert this rhetoric by shifting emphasis away from the production and consumption of superfluous connected *gizmos* and instead focusing on the responsible and sustainable ownership of ubiquitous electronic objects. In modern western societies, toasters, like many other domestic electronic products, are often seen as disposable. If such a product breaks in some way, it can be more cost effective and convenient to purchase an entirely new product rather than to the spend time, energy and money trying to repair the original artefact, either personally or through professional means. Most proprietary electronic objects make use of glues, screws, hidden seals and irreplaceable parts. They are purposely designed to be difficult to maintain and upgrade, forcing people to buy a newer iteration when their current device ceases to function correctly (Slade 2007). Having said this, the *Toaster for Life* prototype should not be seen as a potential 'solution product' to the unsustainable issues described above, but as a means for generating discussion about those issues. Bleecker (2009) outlines this distinction:

> *Design fiction objects are totems through which a larger story can be told, or imagined or expressed. They are like artifacts from someplace else, telling stories about other worlds.*

In order for the world in which the *Toaster for Life* exists to appear plausible, the 'design fiction object' itself must also appear plausible, that is, seem as if it had actually been designed and could be manufactured. With this in mind, the process of designing the spime toaster was more intricate and time-consuming than I had first anticipated. What appears to be a relatively simple and banal object grows increasingly complex when one begins to consider integrating several sustainable strategies into its design. Furthermore, uncertainties arise when designing for a combination of emerging technologies and materials that presently do not exist. These issues also impacted the adoption of the *key classifying design criteria for spime objects*. Rather than including all seven in this first speculation, I made the decision to focus on the design potential of only the *technology*, *sustainability* and *temporality* criteria. I felt that this combination would 'do enough' to convey the sustainable credentials of an early material spime object without losing the essence of the spime concept.

In Figure 46 (page 93), I presented my 'micro material engagements' diagram – a visual representation of my RtD methodology and my contextual and emergent engagements with the *Design Fiction* method. As depicted, a core component of my spime case studies is *direct and tangible making*, that is, the 'situated' design practice where I apply DF techniques and negotiate its associated media in order to generate fictional spime orientated artefacts. The diagram shows that I also undertake ongoing, *proactive reflection* in relation to the *Direct and tangible making* activity. As outlined, such reflection may lead to rethinking my earlier assumptions about spimes and as well as causing me to carry out what I consider to be improvements to the spime artefacts in a dynamic and intuitive manner. I began these reciprocal processes by wanting to gain a greater understanding of the design, manufacture and provenance of an existing toaster (Figure 52). As a result of this initial analysis, I considered using the purchased product as the template for my fictional iteration. Figure 52 also depicts my initial Computer Aided Design (CAD) model based upon the existing toaster. Reflecting on the spimes concept however, I soon realised that in order to accommodate various spime-like attributes, I would have to rethink the design in a more holistic manner.

Inspired by the sustainable design strategies *Design-for-Disassembly* (Chiodo 2005) and *Design-for-Recycling* (Gaustad, Olivetti & Kirchain, 2010), I decided to strive to incorporate modular capabilities into the *Toaster for Life* prototype. In recent years, modularisation has been subject to increased interest within the mobile phone sector where manufacturers have been heavily criticised for perpetuating planned obsolescence. While the highly publicised *Google Project Ara* phone and independent projects *PhoneBloks* and *PuzzlePhone* remain in the development stages, responsible manufacturer *Fairphone* has brought two modular smart phones to market. Each of these four projects are pictured in Figure 53. In the main however, modular approaches are yet to be adopted into the design of most mass-produced proprietary consumer electronic appliances, despite growing calls to do so from ethical electronic repair organisations such as *Restart* (2015) and the *Great Recovery Project* (2013).

My material engagements took shape in the form of hand sketching but largely computer aided design (CAD) parametric modelling. Figure 54 shows some initial sketches for the overall form of the modular toaster. It was in these early stages that I concluded that the *Toaster for Life's* aesthetic should seek to also strongly reflect sustainability. As such, I was inspired by both Daniel Weil's 1981 design *Radio In A Bag* (Figure 55 - left) and by a range of consumer

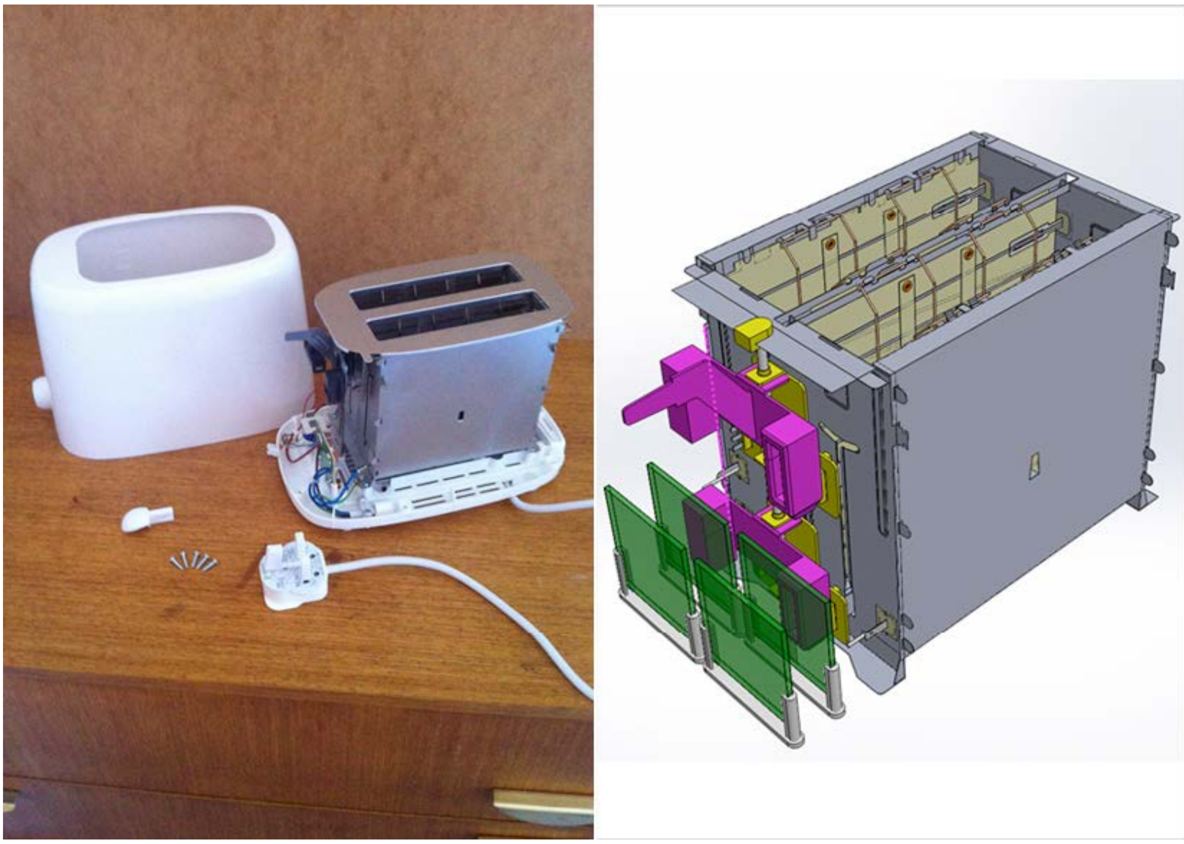


Figure 52: Left - the existing toaster that I purchased and deconstructed; right – my initial CAD model based on the purchased toaster. Source: Author.

Figure 53: Modular smart phone concepts. Clockwise – www.fairphone.com, www.projectara.com, www.phonebloks.com, www.puzzlephone.com. Image is unavailable due to copyright restrictions.

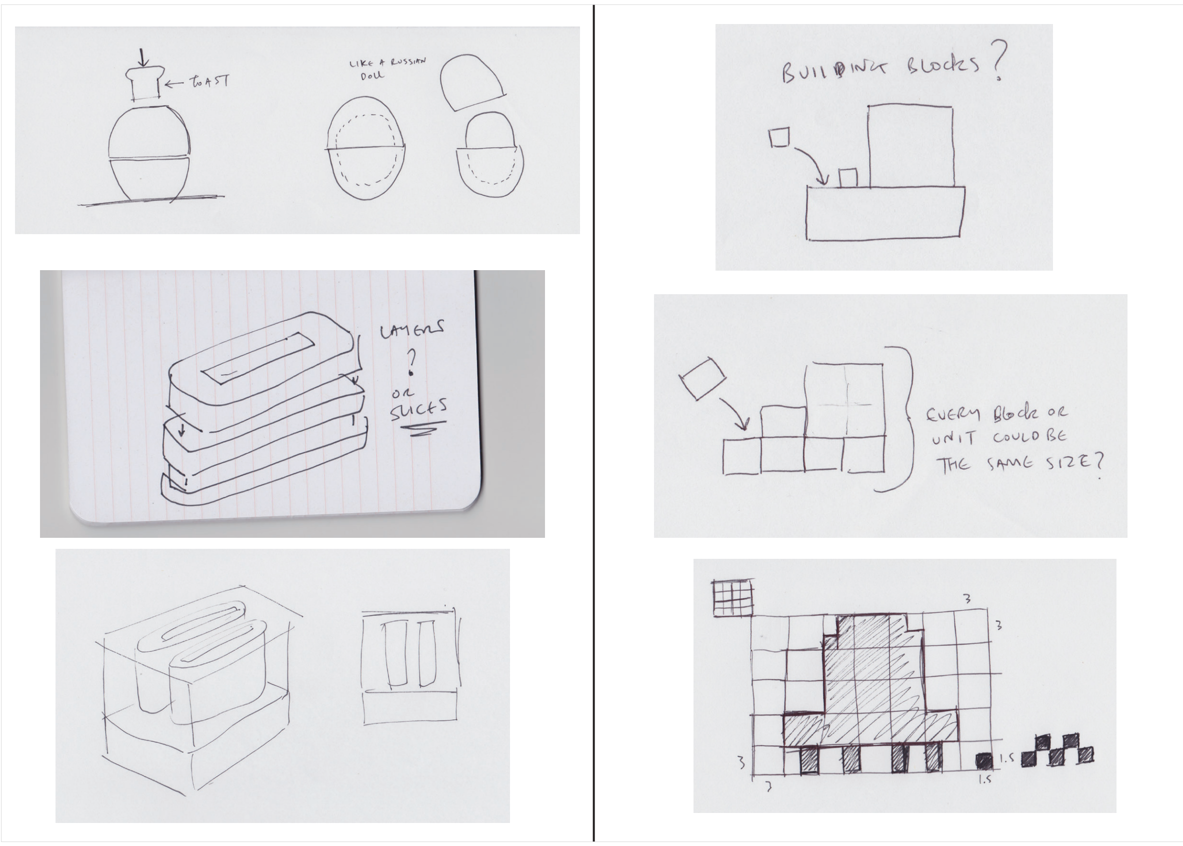


Figure 54: Initial modular toaster design sketches. Source: Author.

Figure 55: I took inspiration from these designs – Daniel Weil's *Radio In A Bag* (www.collections.vam.ac.uk) and *Freeplay* products (www www.freeplayenergy.com). Image is unavailable due to copyright restrictions.

products made by *Freeplay*. Housed in transparent casings, *Freeplay's* radios and torches (Figure 55 - right) are extremely popular in developing nations, where self-repair, customisation and 'off the grid' cultures are, by necessity, more prevalent. I therefore determined that I wanted the *Toaster for Life* prototype to also have a transparent casing. In my mind, this would showcase the design's accessible assembly and would perhaps also be a way of inviting users to also 'touch' and gain deeper practical insight into the object's construction, materiality and functionality. In essence, the prototype's casing would effectively be a metaphor for 'transparency' and 'openness' with regard to both form and function. As illustrated by Figure 56, several different iterations of the prototype thus followed, while the sketches in Figure 57 show how the toaster's overall form began to become more refined.

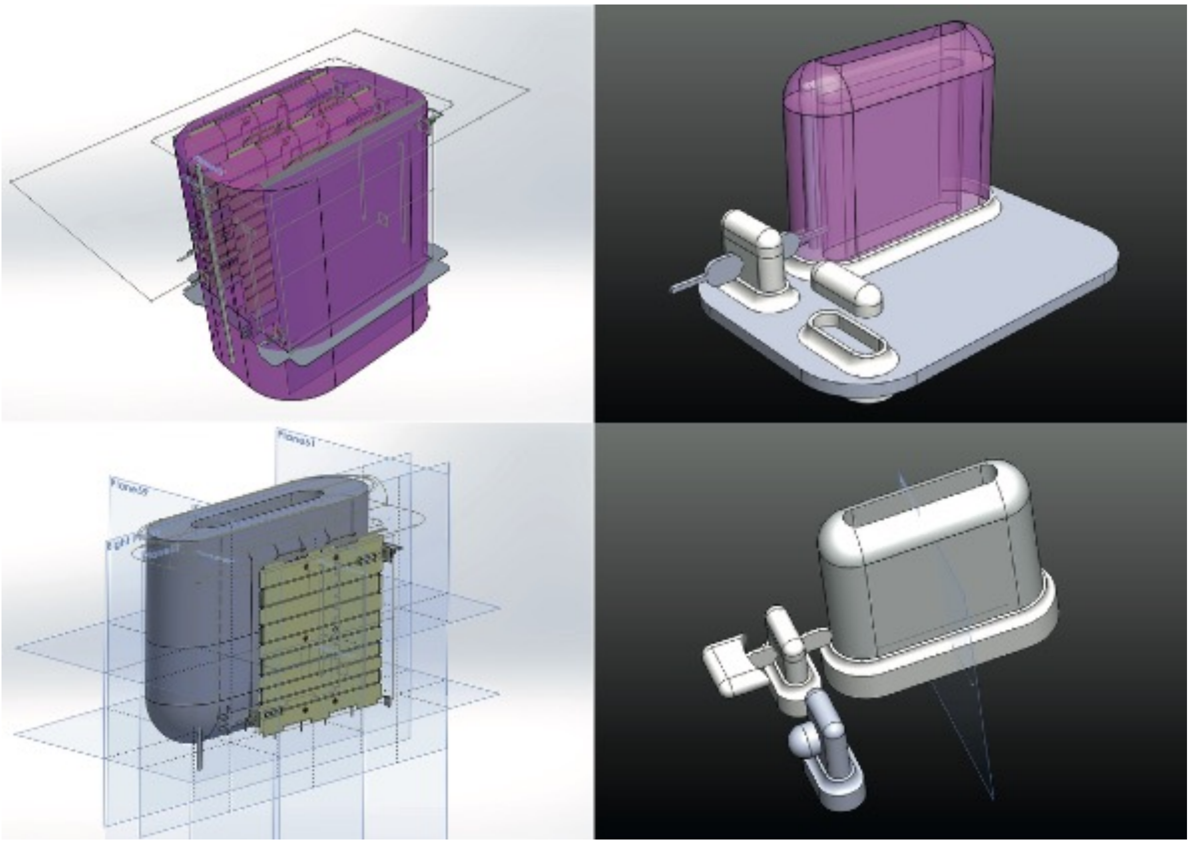


Figure 56: Iterations of the toaster as sketches and CAD models. Source: Author.

Having adopted the core Design Fiction technique *diegetic prototyping*, I chose to present the near future spime toaster within its own *product launch catalogue* (Figure 58). This framing aims to 'suspend disbelief about change' (Sterling, cited in Bosch, 2012) and make the fiction relatable to peoples' everyday lives and help the device appear as if it 'exists' within a credible context of use. To reinforce this framing, I created a fictional connected product manufacturer and associated branding for the device. Figure 59 depicts iterations of some of the graphical branding elements that feature within the catalogue. To continue to connote the notion of 'modularity', I aimed to make the letters that comprise the *Toaster for Life* logo have visual modular components. Figure 60 shows the how I constructed on the fictional catalogue's running order and determined what content to include within it.

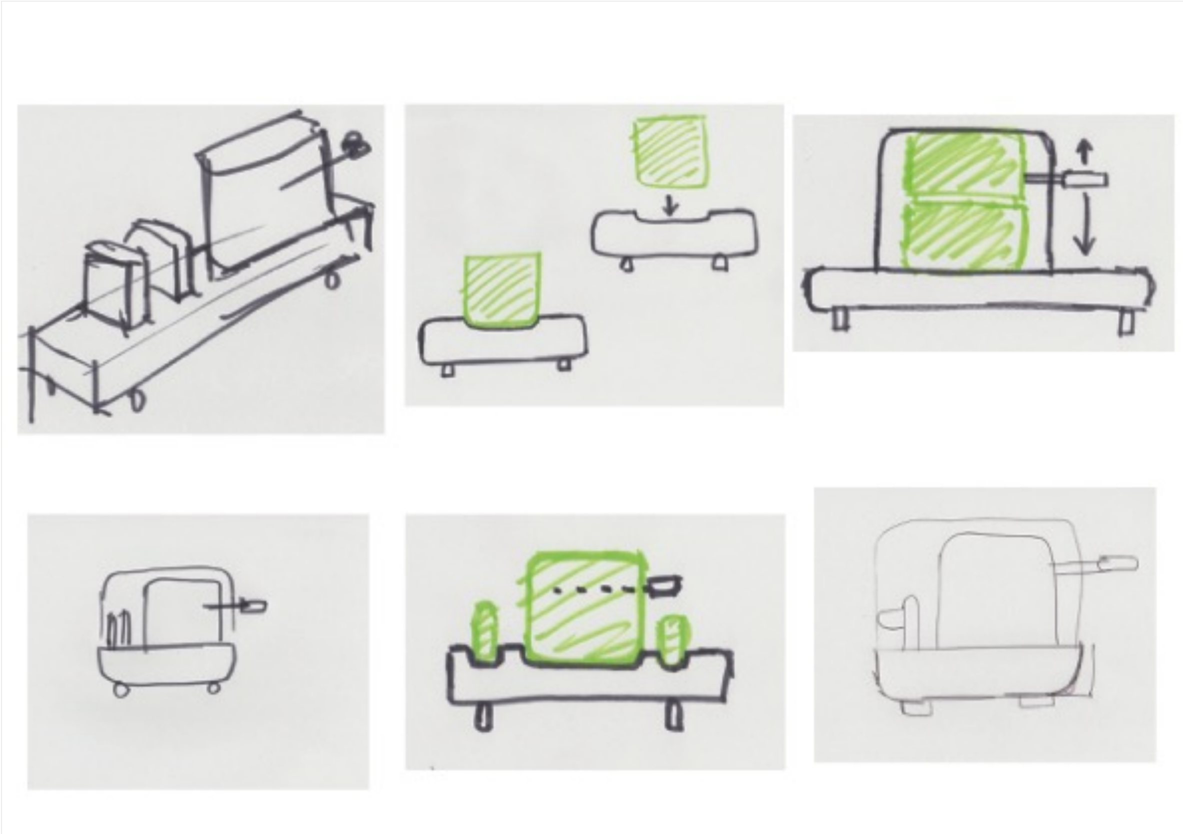


Figure 57: Refining the design's overall form. Source: Author.

To further help the catalogue appear plausible, I created a backstory which outlines reasons for its development (Figure 61). Importantly, the catalogue also demonstrates how the design and adoption of the new toaster would help combat the increasing problem of connected product waste which, by 2030, has reached environmentally untenable levels (Figure 62). The content featured on these pages is based on current literature and statistics, with some details extrapolated The catalogue goes on to detail the five primary sustainable attributes that are fundamental to the spime toaster's design. As noted earlier, modularisation is said to extend product lifecycles and reduce use of materials, energy, packaging and distribution emissions (Greenpeace 2014). In Figure 63, one can see how I have integrated accessible parts and efficient component separation into the toaster's design in an attempt to allow more effective self-repair and recycling by potential users. No glues, screws or hidden seals are featured. Figure's 64 and 65 depict a selection of sketches of the prototype's modular elements. As seen in Figure 64, a core design feature which facilitate's the toaster's modularity is the inclusion of small magnets. The adoption of this feature came about through the design's evolution through the sketching process.

Figure 58: The product launch catalogue's front cover. Source: Author.

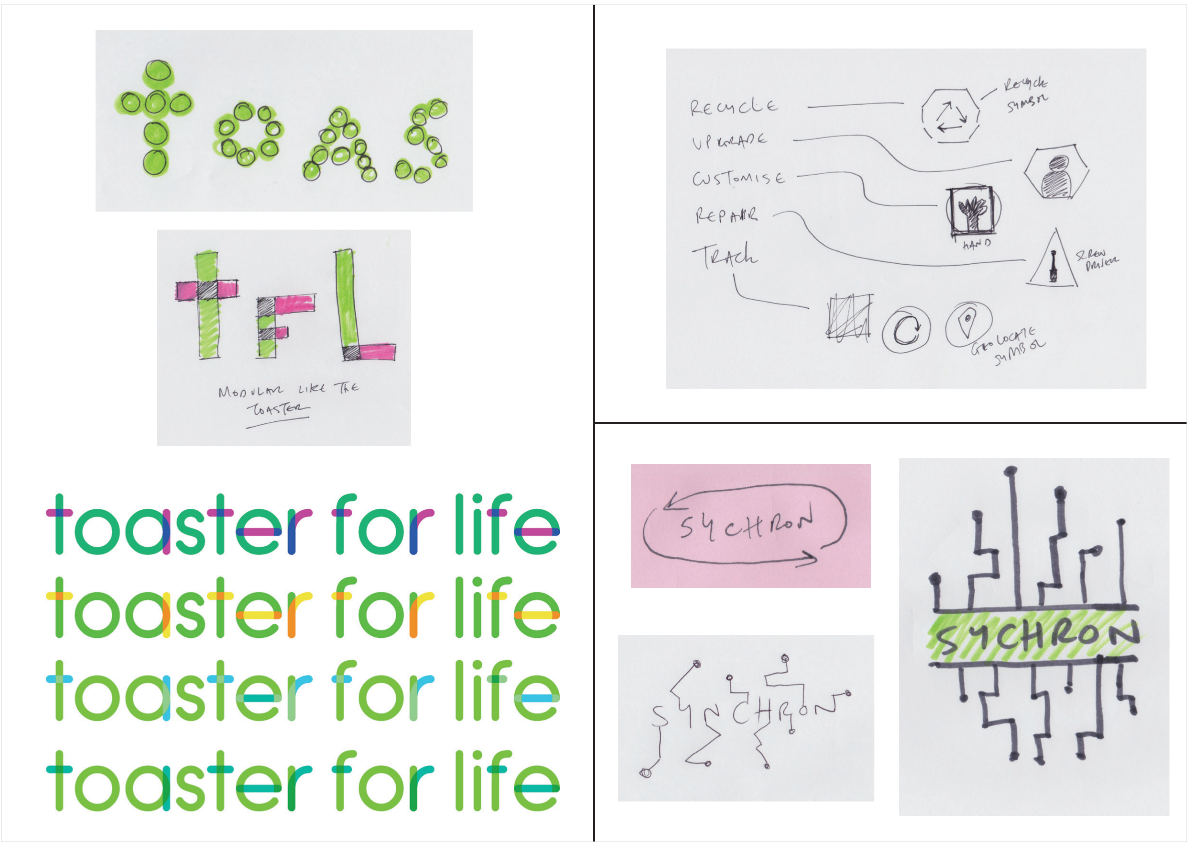


Figure 59: Creating graphic elements for the catalogue. Source: Author.

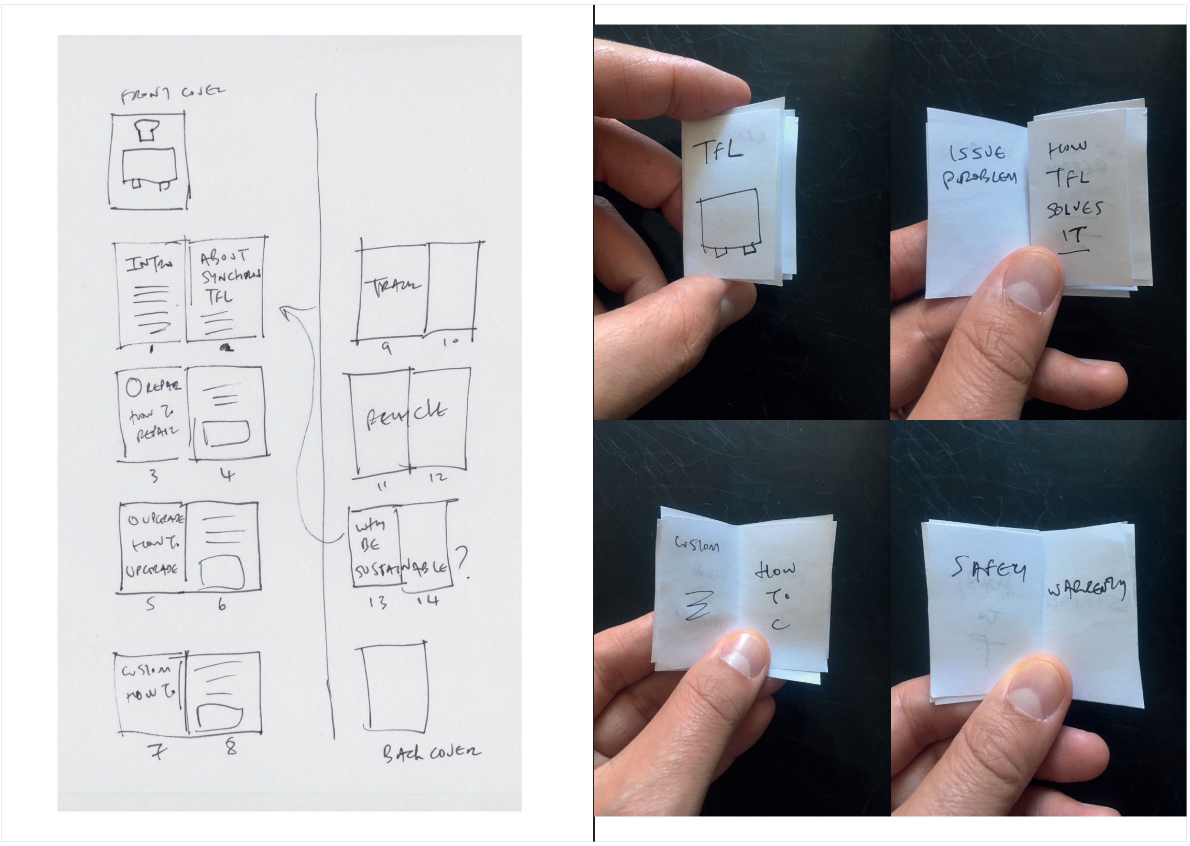


Figure 60: Constructing the fictional toaster catalogue. Source: Author.

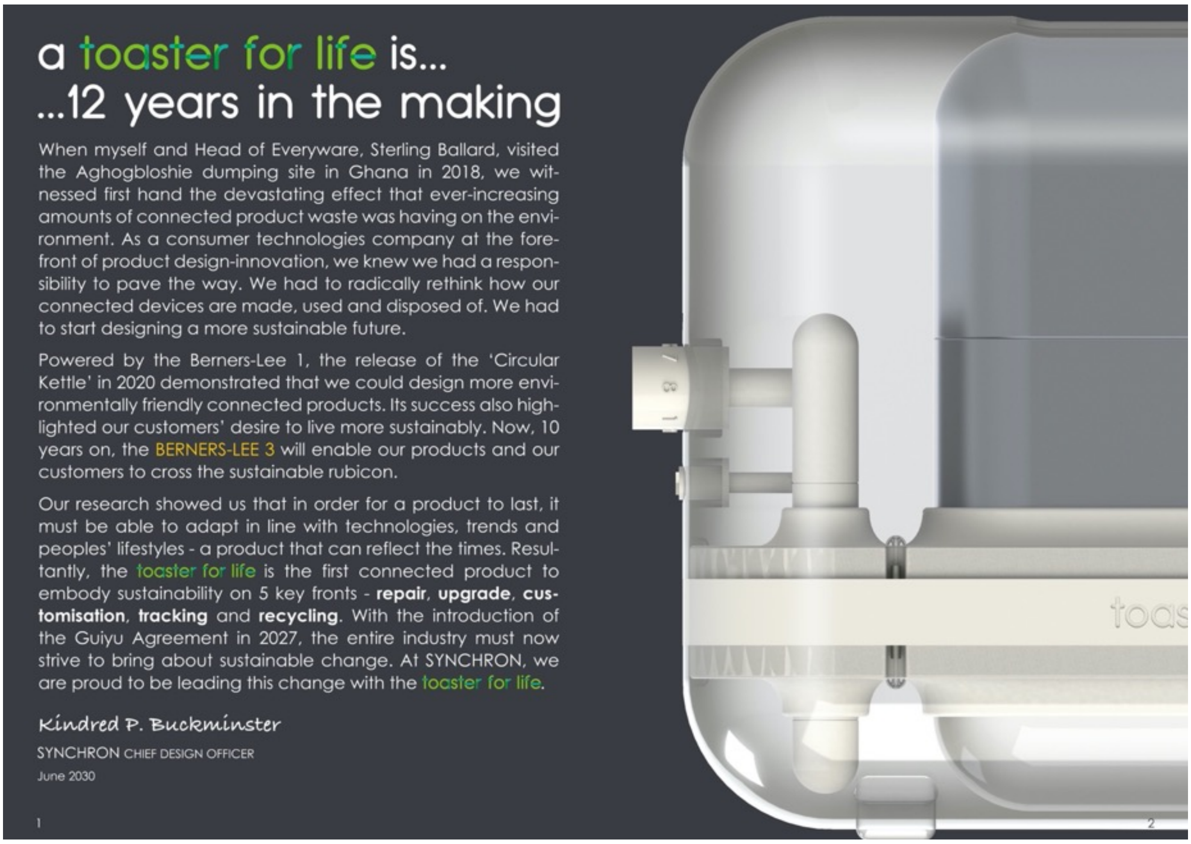


Figure 61: The toaster's fictional backstory opens the catalogue. Source: Author.

Figure 62: The catalogue laments the disposability of most other connected devices. Source: Author.

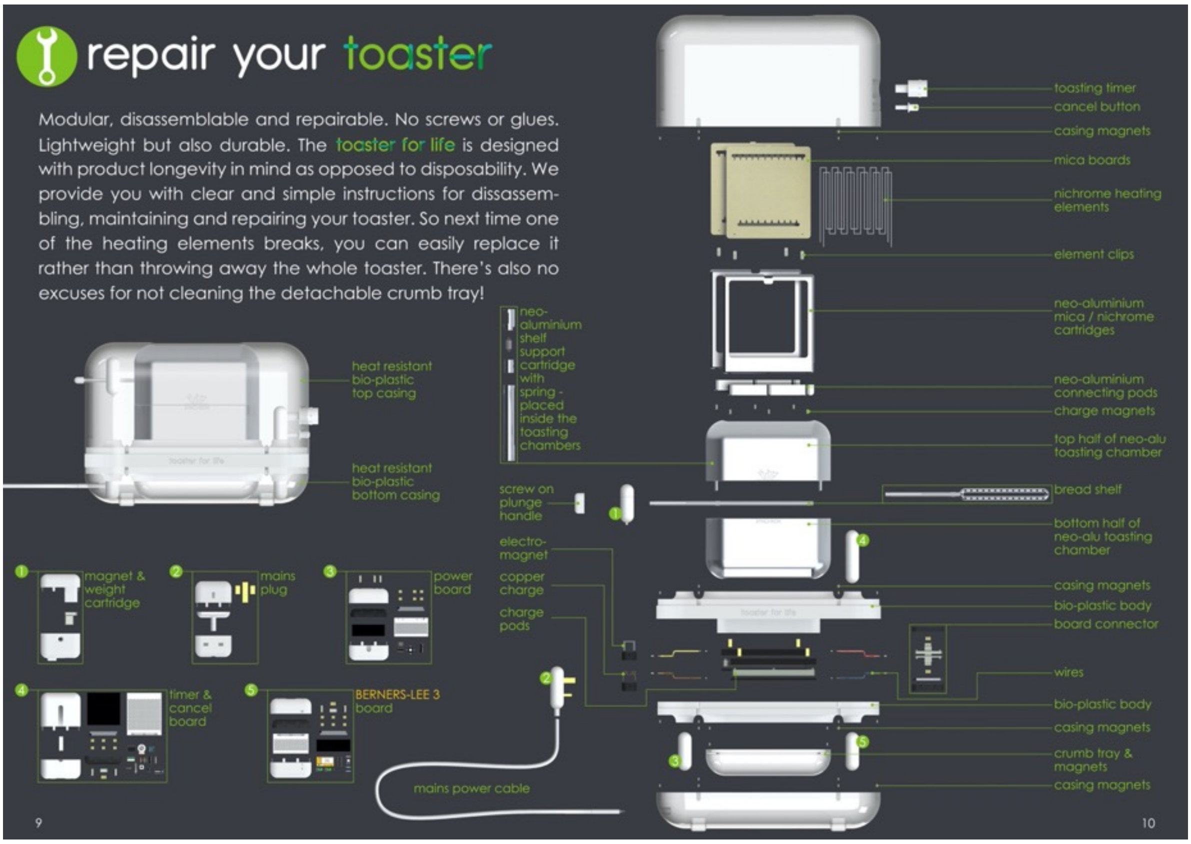


Figure 63: The prototype is modular with no screws, glues or hidden seals. Users would therefore be able to easily disassemble and repair the toaster. Source: Author.

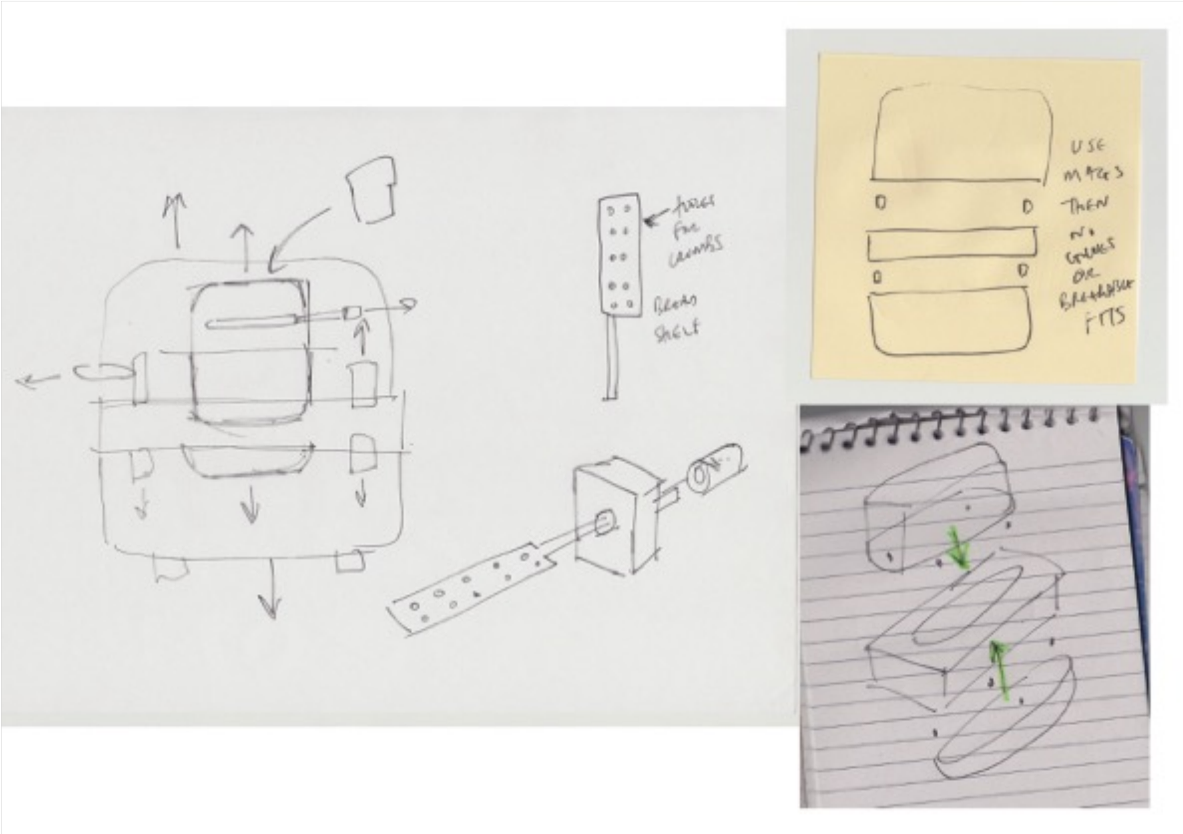


Figure 64: Iterations of sketches of the prototype's modular parts. Source: Author.

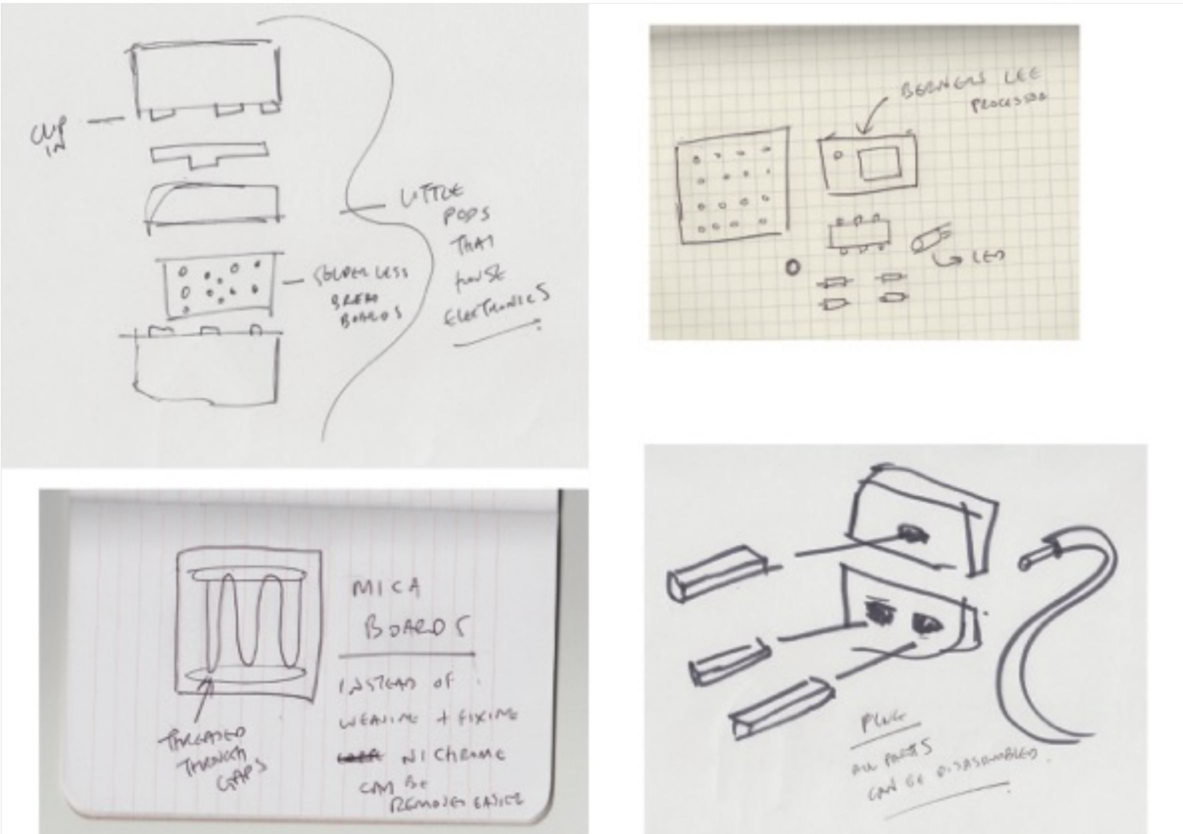


Figure 65: Sketches of key modular details. Source: Author.

Upgrades to inner componentry would also be possible because the design would operate via modular next generation open source hardware and software. These design features were developed through sketching (Figure 66). It is common for electronic components to be soldered directly to printed circuit boards making them immovable without the correct equipment and expertise (this is the case with the purchased toaster). The *Toaster for Life's* design incorporates *solderless breadboards* allowing components to be simply exchanged if they break and/or upgraded should new functionality become available (Figure 67). Modularisation and use of would-be eco-materials would also enable users to recycle, customise and track its individual parts. The fiction implies that CAD and domestic digital fabrication have become mainstream activities in the near future. *Neo-aluminium* and heat resistant *bio-plastics* would be readily accessible for home 3D printing and both materials could be efficiently and repeatedly recycled (Figure 68). Domestic fabrication would also give people the freedom to customise their spime toaster as and when they please, perhaps altering the colour of the product's casings or even adding an additional toasting chamber (Figure 69).

Figure 66: Use of open source hardware and software like solderless breadboards means the toaster's components could be exchanged and reconfigured to allow upgrades. Source: Author.

Figure 67: The toaster is made from 3D printable and repeatably recyclable *bio-plastic* and *neo-aluminium*. Source: Author.

Figure 68: Within the fiction domestic 3D printing is considered a cultural norm. New customised 3D printed parts/features like can be made when desired. Source: Author.

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 (Figure 69). This would enable potential users to ascertain the whereabouts of collective/individual componetry throughout the product's entire lifecycle in cooperation with GPS technologies. 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 *Synchron Berners-Lee 3* micro-processor board (illustrated in Figure 66 – page 126). The *Berners-Lee 3* would be equipped with wireless and geo-location abilities and would therefore be able to continually log details online about the toaster's current state of operation. Similar 'synching' interactions would occur at different stages of each part's lifecycle, for example, at manufacture, points of distribution, during usage and then finally at disposal when they are returned to *Synchron* – the fictional environmentally conscious manufacturer of the *Toaster for Life* – for recycling and reuse in the production of future spime products.

Figure 69: Almost every part is 'nano-RFID' tagged making them all inherently trackable and traceable throughout their lifecycle. Source: Author.

The previous summary begins to demonstrate how the *Toaster for Life* study explores the first three key design criteria for spime objects – *sustainability* (through the prototype's range of sustainable features), *technology* (through the extrapolation of various connective technologies), and *temporality* (through the prototype's cyclical lifecycle). In essence, I included the range of sustainable attributes to ensure that the device's lifecycle is *cyclical*, *ongoing* and *sustainable* – hence the decision to name the prototype the *Toaster for Life*. In theory, users would be able to repair and upgrade the device perpetually, customise it to fit every change to their lifestyle, and they would never have to dispose of the product in its entirety as they could recycle parts and replace them with new ones which have also been made from recycled/recyclable materials. In addition, trackability means it would be a 'connected product' but this also distinguishes the design from present day IoT *gizmo* products as such devices' parts and components are disposable and *not* trackable or traceable. Thus, unlike the manufactured connected *and* non-connected products that permeate our society today, a spime object would be an *ongoing means* rather than an *end*. I also generated the prototype as a means to provoke questions regards how manufacturers might potentially begin to embrace new cyclical connected product-service relationships with customers – akin to McDonough and Braungart's *cradle to cradle* model (2008) and *circular economy* thinking (Weetman, 2016) – as opposed to continuing to pursue a 'cradle to grave' strategy and allowing planned obsolescence to be integrated into their IoT products' lifecycles. I envision what form a circular connected product relationship between manufacturer and users might potentially take, and how these changes could affect services like product warranty and safety, in the final pages of the *Toaster for Life* launch catalogue (Figure 70).

Figure 70: The *Toaster for Life's* inherent sustainability would change how its manufacturer provides additional services like product safety, warranty and customer support in more innovative ways. Source: Author.

7.2.3. Insights

The *Toaster for Life* should be seen as an initial *Design Fiction* prototype that seeks to embody the spimes concept, that is, a near future, sustainable, manufactured object designed to make the implicit impacts of a connected product's entire lifecycle more explicit to its potential users. By presenting a spime as 'actually futuristic' within a fictional world, the case study seeks to challenge the ongoing legitimacy of centralized industrial product design in an era of increasing material scarcity, electronic waste and climate change. By envisioning an alternate strategy for the design, manufacture and consumption of an Internet connected device, the proposal aims to provoke potential audiences to also consider the sustainable possibilities of lesser-known practices and technologies which are central to today's decentralised technological sub-cultures. In doing so, I hope the fiction provokes consideration regards the future implications, meanings and values that spimes may bring and also raises questions regards whether such futures would be a more preferable and sustainable alternative to our present day unsustainable methods of production and consumption. As such, the *Toaster for Life*, like other design fictions, strives to 'inspire an audience to think not only about what they do want for their future… but also what they do not want' (Auger, 2013).

Having framed the prototype within the fictional *product launch catalogue*, I contend that the use of what Hales (2013) calls 'new media' can also help to bring the sustainability of everyday objects into sharper focus. Whereas art galleries have played a significant role in the dissemination of *Critical Design* proposals, design fictions more actively 'encourage debate using social/viral media and popular culture' (MIT MediaLab, n.d). The appropriation of such media can extend the 'reach' of a design fiction, enabling the proposal to 'speak' to potential audiences beyond academia, the design sector and artistic elite. Moreover, playful subversion of marketing material and advertising promo films – the media most associated with 'real' industrial product design – can mean that a *Design Fiction* does not require an in-depth *pre-text*. Unlike critical designs whose 'readability' can be undermined by their gallery context and academic framing, potential audiences are often 'well versed' in the *semiology* that can underpin design fictions, in other words, they are already adept at 'reading the signs.' This inherent readability is crucial for the *Toaster for Life* proposal as audiences do not have to negotiate a 'layer of theory', they can instead consider the most significant aspects of the design – its sustainability and how this relates to their day-to-day lives.

While 'good' for the ensuing fiction, I consider the use of 'new media' to be a highly nuanced approach which can also have important implications for how design fictions are 'crafted.' Hales (2013) notes that 'as media objects, design fictions are deeply implicated in the ecology of the media situation… they cannot be untangled from that milieu.' As a self-described *conventionally trained service to industry product designer*, I have found this 'entanglement' difficult to negotiate. Although the method removes the constraints of normative market-led product design, 'constraints still exist… without them the design speculations could drift off into neverlands and dreamscapes' (Auger, 2013). Essentially, the crafting of the *Design Fiction* required the same level of attention to detail and expertise that would be needed if I were actually trying to design and produce the 'real' product. This created a *blurred boundary* between normative product design practice and *Design Fiction* practice and was consequently a source of tension during the design process.

With its focus on narrative and the embodiment of ideas, the use of Design Fiction could begin to facilitate 'alternative value systems for designers' (Voss, Revell & Pickard, 2015). Chapman & Gant (2007) contend that, 'creation and consumption is both a natural and integral facet of human behaviour… problems arise when these deep motivations are expressed physically (e.g. objects, materials and new technologies), as opposed to metaphysically (e.g. stories, ideas and friendships).' As an approach, Design Fiction negotiates the 'metaphysical' in that it is not concerned with the commercialisation of product designs but the meaning of products and the futures they might bring. Having said this, questions remain regard the rhetorical and ideological nature of 'design fiction objects.' As Gaver (2012) stresses, artefacts created as part of *Research through Design* processes embody 'the designer's best judgement about how to address the particular configuration of issues in question.' Like Sterling, I do see the spimes concept as a more preferable alternative to today's unsustainable models of production and consumption. The *Toaster for Life* is thus representative of my values and my ideology. However, I also understand that the notion of what is preferable varies from person to person. I therefore maintain that the *Toaster for Life* prototype is a 'conversation starter', not an 'end product.' Whether or not others see spimes and sustainable futures in the same manner as myself is up to them, the *Toaster for Life* is a means for getting people to talk about such views.

As a means to 'open up' a discursive space amongst potential audiences, my diegetic prototype could also be described as a 'discursive product.' Tharp & Tharp (2013) have used the term *Discursive Design* to denote a method similar to *Design Fiction*, one which they characterise as 'the creation of utilitarian objects/services/interactions whose primary purpose is to communicate ideas – artefacts embedded with discourse. These are tools for thinking; they raise awareness and perhaps understanding'. As outlined throughout my *Research Methodology* (pages 67–100), Frayling separates design-led research into three sub-categories: Research *into, through* and *for* Design. I see some parallels between Tharp and Tharp's definition and Frayling's (1993) description of *Research for Design* (RfD) – 'Research… where the thinking is… embodied in the artefact, where the goal is not primarily communicable knowledge in the sense of the verbal communication, but in the sense of visual or iconic or imagistic communication.' This indicates that the relationship between RfD and RtD is perhaps more fluid than Frayling's original delineation suggests. The conception of the spime-based *Design Fiction* was an inherently reflective process. Sterling (n.d,) also acknowledges this, stressing that, 'the best way to understand the many difficulties of design fiction is to attempt to create one.' For me, the creating the diegetic prototype was, like RtD, 'a route to discovery [where] the synthetic nature of design allows for richer and more situated understandings than those produced through more analytic means' (Gaver, 2012). As a result of this, I conclude that spimes should begin to be viewed, not only as potential class of future sustainable connected objects, but also as a *lens* for speculating and reflecting upon alternate worlds in which sustainable technological products exist – both for the potential audiences that designers seek to their work to engage with and the designers who seek to envision these worlds.

7.2.4. Evaluation

The previous sections of this first spime case study provided the foundation for an academic paper – *A Toaster for Life: Using Design Fiction To Facilitate Discussion On The Creation Of A Sustainable Internet Of Things* – which I published at the *Design Research Society* conference in August 2016 in Brighton, UK. Overall, the paper received a positive response – both from reviewers during the submission process and from audience members during its presentation. Amongst the presentation feedback I received, one attendee commented on the effectiveness of the mundane and everyday nature of the potential spime device and how framing the spimes in this manner allowed them to 'get to grips' the concept more easily. They also felt that the framing helped them to begin to envision how other everyday objects might possibly also have spime-like characteristics. Another member of the audience made comparisons between my work and that of Thomas Thwaites who produced *The Toaster Project* (2011) and suggested I was perhaps 'covering old ground.' I countered that while I understood such a comparison because both projects centre on the design of a toaster, where Thwaites was interested in the first principles of an analogue mass-produced physical object, my research focuses on the first principles of mass-produced physical-digital object. The implications of Internet-connectivity are key to my work.

One attendee found the prototype's modularization to be an interesting design strategy and posited whether it could be incorporated into many more consumer products. However, she felt that while the *Toaster for Life* began to show how product modularity could potentially be achieved, the way in which I had framed and presented it was too 'constricted', specifically through the combined use of a fictional future lens and product catalogue setting. I replied that due to the material and technological advancements required, *spimes* cannot actually be designed and manufactured as yet and therefore they *are of the future*. I conceded that while I could have situated the prototype in various other contexts, I felt the catalogue was a good way to cover the range of possible spime attributes with detail. Another audience member thought the design was 'too masculine' – both in terms of its aesthetics and the language and culture of the catalogue. Further, they argued that *'not everyone would want that particular toaster for life!'* I responded that *Synchron* was, to some degree, modelled on the manufacturer *Dyson* and therefore the catalogue purposely displays the aesthetic and tone of a high-tech consumer durables brand. More importantly, I reasserted the conclusion that I make in the *Toaster for Life* paper – that the toaster design is not intended to envision an end product that people could eventually purchase and own but it in fact aims to be a conversation starter and create a 'discursive space' with regards to the concepts and ideas it embodies – which is what was being achieved through the very presentation in question.

A significant exchange I had during the presentation was regards Sterling's evolving viewpoint on spimes. An attendee described how they had met Sterling in person a year or two before and they concluded that he had begun to 'distance himself' from his concept. They suggested that this might be because the IoT had rapidly expanded in the decade since Sterling had published *Shaping Things* and that spimes had yet to be adopted as a concept. They also noted that he had written *The Epic Struggle of the IoT* in 2014 which mainly critiques IoT culture rather than offering any potential remedies like *Shaping Things*. I found this analysis fascinating to hear. The attendee said that while they felt they should share their story; it should not deter me from exploring the spimes concept further as no one else really had done so. I agreed and stated that a sustainable IoT was still very much needed and spimes were an effective and interesting way of exploring such a proposition.

Returning to Figure 46 (page 93), one can see that *emergent knowledge* is a core element of my 'micro material engagements' diagram. As stated, this knowledge results from the confluence of the making and reflection processes and could be characterised as the 'learning outputs' of my case studies, and as such, might go on to 'inform decisions to be taken later on, both in the same or in a following [design engagement].' Reflecting back upon the prototyping process as well as the peer-review feedback, the key 'learning outputs' I was able to take forward from the *Toaster for Life* study is that sketching and CAD together provide a solid combination of techniques that can be used to design and develop a convincing spime prototype. In addition, I believe the application of a fictional 'context of use' was also successful in making the prototype's sustainable specifications appear sufficiently plausible so that an audience can easily grasp and interrogate them. The principal *spime insight* that I was able to take forward from this first case study and onto the next was that *modularisation* would likely need to be a core design specification for early spime objects.

7.3 Case Study 2: HealthBand

7.3.1 Framing

For my second case study, I wanted to use *Design Fiction* methods to unpack the spime design criteria *synchronicity* and *wrangling*. Working with colleagues Professor Paul Coulton and Dr Joseph Lindley, we developed the said design criteria by exploring the relationship between *decentralised* and *democratised* design innovation activities and the IoT. In recent years, such practices and technologies like open source hardware, crowdfunding and the maker movement have increasingly been cited as more environmentally friendly alternatives to the long established *centralised* and *closed* strategies that currently characterise the IoT (Smith & Light, 2017; Kohtala & Hyysalo, 2015). This is said to be primarily because decentralised products are usually designed for specific purposes in short production runs which effectively eliminates the huge environmental impacts that result from mass manufactured and widely distributed devices. To develop a spime prototype which embodies decentralised principles, we chose to frame the fictional design as a multi-purpose *Do-It-Yourself* (DIY) medical wearable device called *HealthBand* which can support various medical conditions (Figure 71). Ensuring adequate provision for patients is becoming more and more challenging due to ever increasing demands on healthcare services around the world. By focusing on future healthcare provision – specifically exploring how DIY medical devices might become widely adopted – the *HealthBand* case study is able to move beyond the technological practicalities of the spime concept as highlighted by the *Toaster for Life* prototype, and instead consider the *implications* of spime-like devices, technologies and practices on *future connected product policy* and *regulation*.

Figure 71: A patient wearing the fictional *HealthBand* DIY medical wearable. Source: Stead, Coulton & Lindley (2018).

DIY healthcare has become a significant topic of discussion in medical and financial forums in recent years as they increasingly explore the potential of smart and wearable devices to provide greater accessibility to health monitoring and facilitate care directly in patients' homes (Pang et al, 2015). One of the drivers for these discussions is the proliferation of IoT wearables devices like fitness and activity trackers (Figure 72) which are able to monitor aspects of their environment and their users' lives, display real-time data, and also to share this data with other devices:

> *In the rest of our lives we're seeing the difference that innovative tech makes, and now the NHS will have a streamlined way of getting ground-breaking and practical new technologies into the hands of patients… frontline nurses, doctors and other staff. By doing that, we can transform people's lives* (Stevens, cited in NHS England, 2016).

Given the current popularity of wearable devices, we concluded that a 'spime wearable', like a 'spime toaster', could be another type of IoT product that various forms of potential audience would readily identify with. Whilst research investigating the use of body-worn technology to collect data has been ongoing since the 1970s (Riphagen et al, 2013), scholars have recently taken to appropriating Wolf (2009) and Kelly's term *Quantified Self* to describe such work. *Quantified Self* research examines all aspects of participants' daily lives including gathering data regards the food they eat, their sleep patterns, changes in mood and biometric information such as blood pressure and heart rate. It has been argued that *Quantified Self* tracking not only allows individuals to learn more about themselves but may also help them take action to become healthier and improve their lives (Lee, 2013). A *Quantified Self* approach to DIY Healthcare is thus primarily driven by the value associated with data collection (Dimitrov, 2016), which historically, has been fundamental to improving public health and patient care, whether it was driving sanitary reforms in nineteenth century Europe, or recent quality improvement in surgery (Carrera & Dalton, 2014). Involving patients in data collection using commercial devices as part of their treatment presents considerable challenges to expected norms, regulations and practices, but the notion of patients developing their own DIY Medical Devices is even more radical. This is not a new idea though; in 1965, Frederick Fascenelli presented 'Electrocardiography by Do-It-Yourself Radiotelemetry', a proposal (Figure 73) to allow anyone with basic electronics knowledge to build their own electrocardiogram machine and transmit results to their doctor (Greene, 2016). Although his device never took off – primarily due to the complexity of creation and use – Fascenelli was driven by the same desire to improve access to high quality healthcare through technology that we currently see promoted through DIY healthcare.

Figure 72: Consumer IoT wearable devices. Source: www.fitbit.com and www.jawbone.com. Image is unavailable due to copyright restrictions.

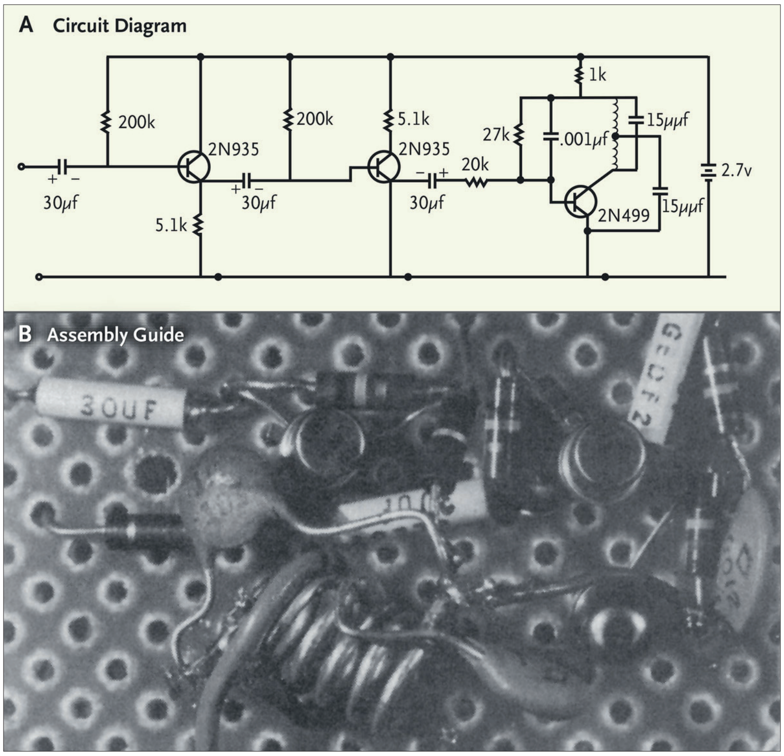


Figure 73: Fascenelli's 1965 *Electrocardiography by Do-It-Yourself Radiotelemetry* prototype. Source: Greene (2016).

More recently the interest and discussions around DIY medical devices has seen a resurgence through association with the so-called *Maker Culture*. Maker Culture is a grass roots technology centric social innovation culture in which participants aim to create new devices, repair and reuse old ones, or to simply 'tinker'. This activity has been enabled by the decreased cost of componentry, increased access to experimental hardware platforms and new forms of fabrication technologies (Figure 74). The term *Democratised Innovation* (von Hippel, 2005) is also used to denote practices whereby products and services are developed by the same people who ultimately use them. Within traditional proprietary innovation models, designers and manufacturers exploit internal assets and intelligence to develop standardised, 'closed' products. In contrast, when developed with *Democratised Innovation* principles, knowledge, resources and technologies relating to new products are diffused quickly, efficiently, and more often than not, 'freely' through networks of online and offline communities. This collaborative activity results in products which directly benefit those who created them and frequently also have positive impacts on society at large (von Hippel, 2005). Figure 75 illustrates the main differences between a centralised, closed design innovation model and a decentralised, democratised model.

In the case of DIY medical devices, this form of innovation is evident in a variety of emerging activities such as the proliferation of access and availability of 3D printing through 'fab labs' and 'maker spaces' which have provided wearers of prosthetics with new opportunities for designing and modifying their own prostheses (Buehler et al, 2015) – as seen in Figure 76. Demonstrating a DIY mind set, the convergence of the insulin pump with easy and efficient ways of connecting devices to the Internet has resulted in insulin-dependent patients, frustrated with their pumps' limitations, sharing their personal continuous glucose monitoring data and strategies for augmenting their own devices, through online communities. Perhaps the most notable example of this is *Nightscout* which is an open-source platform developed and run by a global community of patients with type-1 diabetes. The platform (Figure 77) combines a CGM (Continuing Glucose Monitor) device which provides constant updates on glucose levels, a DIY data transmitter, and freely available software which enables the CGM data to be shared across throughout the community via cloud data storage (Lee, Hirschfeld & Wedding, 2016).

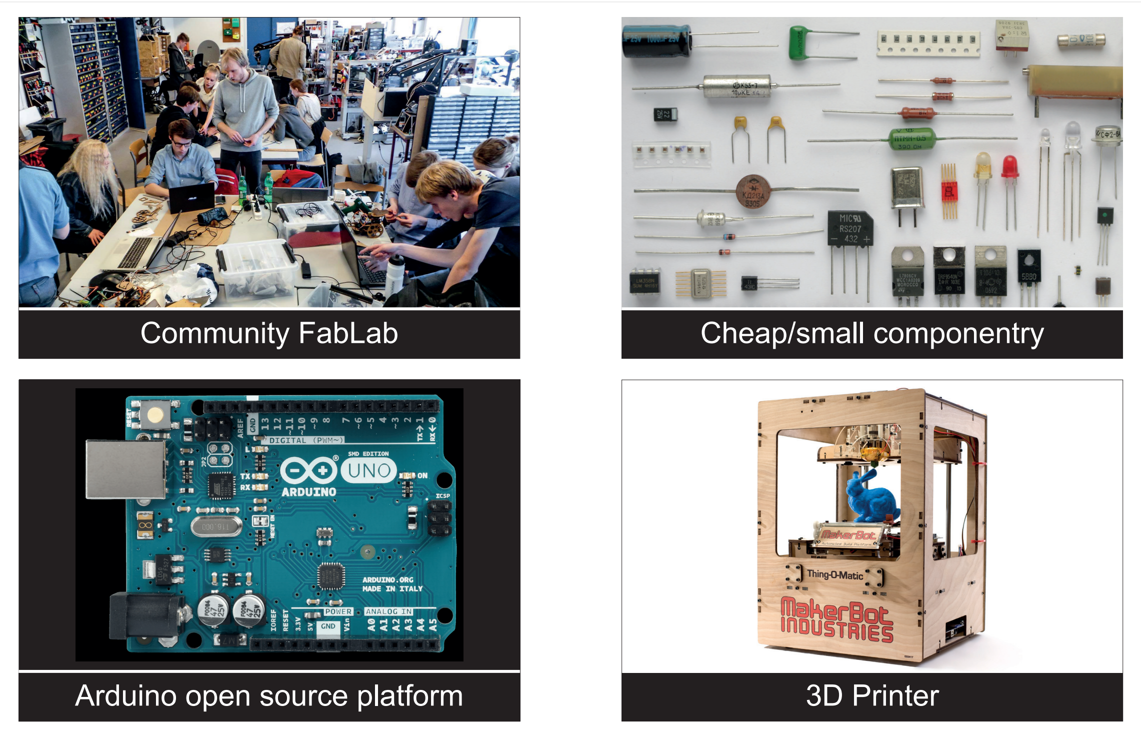


Figure 74: Key technologies and practices that characterise the *Maker Movement.* Source: www.aalto.fi, www.en.wikipedia.org, www.arduino.cc, www.makerbot.com.

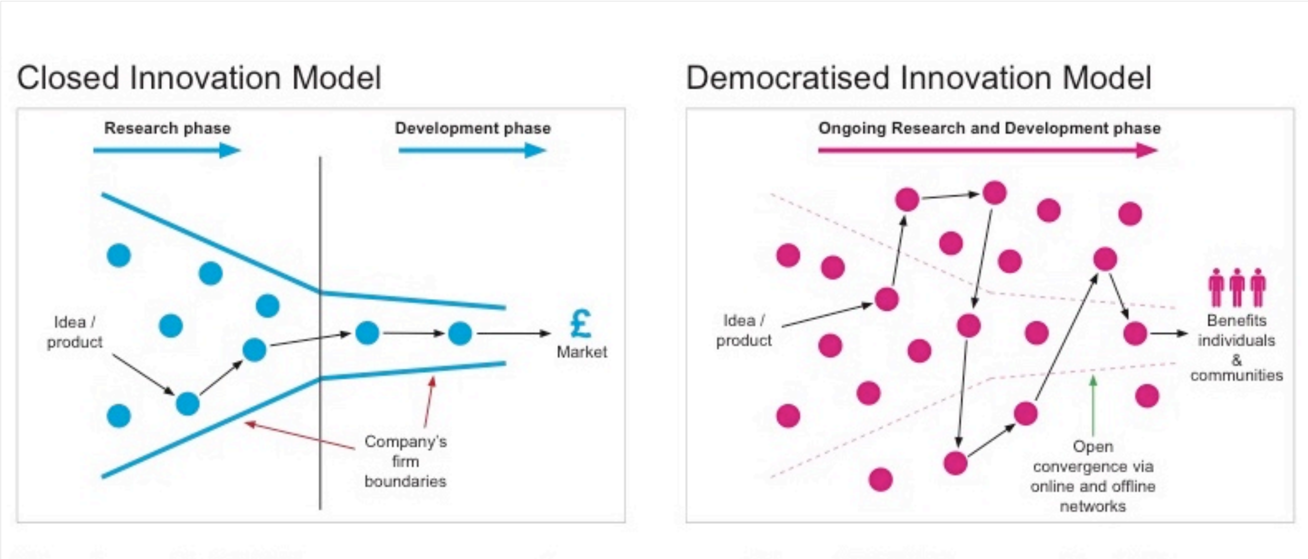


Figure 75: The differences between *centralised*, *closed innovation* and *decentralised*, *democratised innovation*. Source: Author, after Chesbrough (2003) and von Hippel (2005).

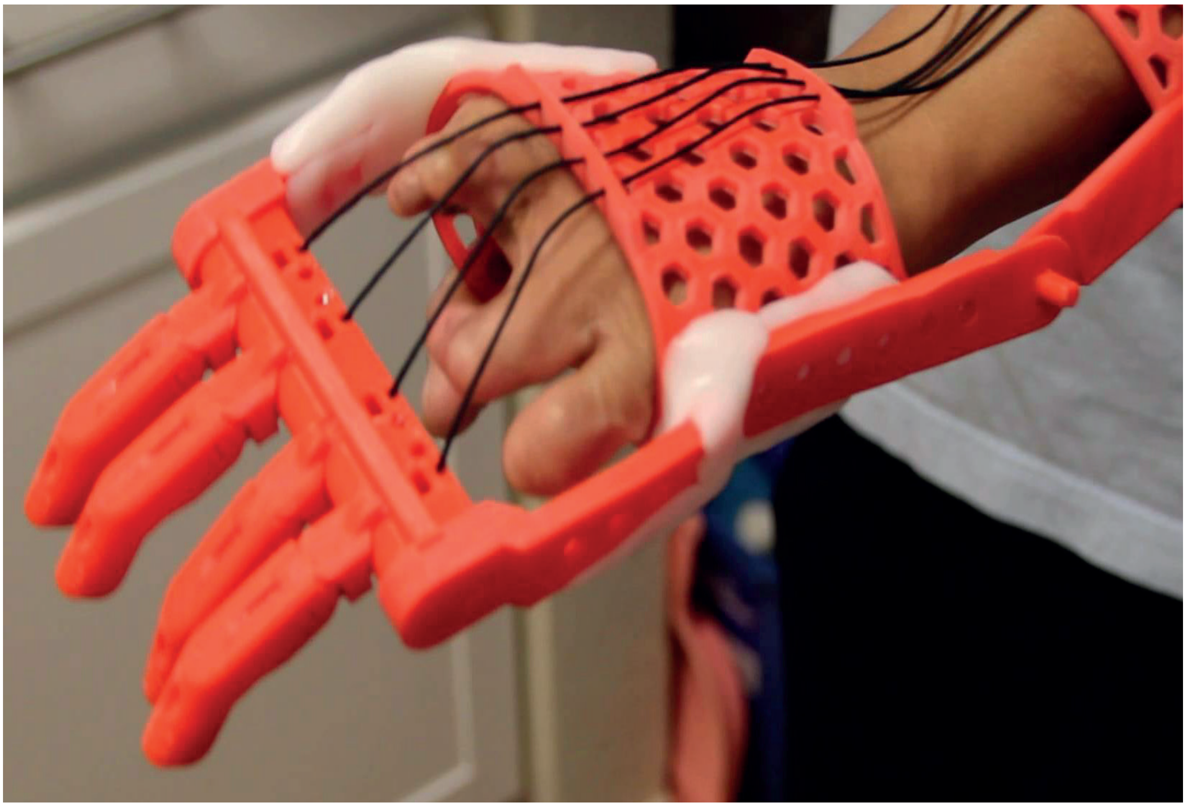


Figure 76: Wearers of prosthetics are using CAD software and 3D printers to design and modify their own prostheses. Source: www.enablingthefuture.org.

Figure 77: *Nightscout* is an open-source platform developed and run by a global community of patients with Type 1 diabetes. Source: www.nightscout.info.

Fostering visions of technologies, in particular DIY medical devices, as things that users have a role in producing – as opposed to simply using – is a powerful, egalitarian idea, however, such practices also carry forward risks associated with individuals taking technologies on which their life depends, into their own hands. Regulation pertaining to the production of medical devices is in place to prevent risk to patients from equipment that has not undergone a rigorous approval process. Currently in the UK, medical devices are classified under European regulations (European Commission, 2017b) before undergoing a certification assessment relative to the class of device. Depending on its intended purpose, a medical device may be classified within *Class I*, *IIa*, *IIb* or *III*, with *Class III* covering the highest risk products (GOV.UK, 2017). The higher the classification, the greater the level of assessment required. Classification of a medical device will depend upon several factors including:

- how long the device is intended to be in continuous use;
- whether or not the device is invasive or surgically invasive;
- whether the device is implantable or active;
- whether or not the device contains a substance, which in its own right is considered to be a medicinal substance and has action ancillary to that of the device (Halliday, Kutty & Rakos, 2017).

Classification is primarily the first step towards conformity assessment and obtaining the *CE mark* – a logo placed on medical devices to denote that they conform to the requirements in the regulations (Figure 78). The *CE mark* shows that the device is fit for its intended stated purpose and that it meets legislation designed to ensure patient safety. Further, such approval signifies that a product can be freely marketed and sold anywhere within the European Union. In the

UK, this activity is overseen by the *Medicines and Healthcare Products Regulatory Agency* (MHRA) which is responsible for regulating medicines, medical devices and blood components for transfusion in the UK. In the context of *Democratised Innovation*, fulfilling these classification requirements can be prohibitively expensive and hence severely restricts the participation of those with the technical skills to create or modify their own devices, and subsequently stifles community growth. If we are to move beyond this situation, we need to first conceive a future which accommodates the potential for future DIY medical devices to be fully exploited. However, getting authorities to engage with futures is often difficult as they can get bogged down within discussions of the present, that are, in turn, more often than not based upon the past (Gonzatto et al, 2013).

In the next section, I explain how we utilised *Design Fiction* to concretize and explore a future world in which DIY medical devices plausibly exist, and subsequently enable meaningful discussions around the social and ethical implications of such DIY medical cultures. This process, in turn, is a way to further expand the nature of spimes and posit the impact of the concept upon potential policy and regulation for Internet connected devices.

Figure 78: Regulated medical devices must all display the *CE mark*. Source: www.flickr.com. Image is unavailable due to copyright restrictions.

7.3.2 Prototyping

Like the *Toaster for Life* study, we initially generated a diegetic prototype of the *HealthBand* device. Figure 79 shows the three variations that we created – a diabetes monitor, a dementia memory aid, and a Parkinson's hand stabiliser. With commercially produced wearables helping to make the practice of self-tracking an everyday and routine practice amongst wider publics, and *Quantified Self* research giving academic credence to capturing such data, designers and manufacturers have begun to identify opportunities for devices which specifically monitor serious health conditions. The *Kardia Band* by *AliveCor* (Figure 80) is a prominent example of this and provided inspiration for the design of the *HealthBand* prototype. It takes an electrocardiogram (ECG) reading of its wearer's heart with the aim of detecting atrial fibrillation (AF). The device integrates with *Apple's Watch* device by replacing the latter's non-functional strap. When the wearer places their thumb onto *Kardia Band's* metal sensor it completes an electrical circuit. ECG data is sent to the *Apple Watch* via high-frequency audio and wearers' can view their heart reading on the watch's screen (AliveCor, 2016).

As part of the *HealthBand* study, we wished to address the question of how the development of such devices might possibly be funded if the expectation is that it would effectively exist outside current commercial and closed models for medical device production. Inspired by the way in which many Internet of Things (IoT) product-services are presently being financed, we posited that DIY wearables would likely be *crowdfunded*. Healthcare wearables are a popular trope of the IoT, thus appropriating the crowdfunding model lends plausibility to the *Design Fiction*, particularly if the potential audience is familiar with developments in IoT. In my evaluation of the *Toaster for Life* study, I noted that by reflecting upon the fictional toaster prototype as well as considering peer-review feedback, I concluded that *modularisation* would likely be a core design specification for early spime objects. Based upon this, we chose to also integrate significant modular attributes into the *HealthBand* design. Modularisation and open source technologies like *Arduino* are seen as tenets of democratised and decentralised 'making' and 'hacking' cultures. Indeed, such techniques are central to Make Magazine's influential *Owner's Manifesto* (Jalopy, Torrone & Hill, 2006). The modular specifications of the *HealthBand* prototype were heavily inspired by the *Blocks* modular smart watch (Figure 81) which was first developed during the *Intel Make It Wearable Challenge 2013*. After being selected as one of the finalists and receiving $50,000 funding from the tech giant *Intel*, the team behind the product then sought further capital via the *Kickstarter* crowdfunding platform (Charara, 2016). Thus, we concluded that the integration of modularity sits well alongside the notion of a potential crowdfunded medical wearable like *HealthBand.*

Figure 79: The three variations of the *HealthBand* Do-It-Yourself medical wearable. Source: Stead, Coulton & Lindley (2018).

Figure 80: AliveCor's *Kardia Band* device provided inspiration for the design of the *HealthBand* diegetic prototype. Source: www.alivecor.com. Image is unavailable due to copyright restrictions.

Figure 81: The Blocks modular smart watch concept also influenced *HealthBand's* modular functionality. Source: BBC (2015). Image is unavailable due to copyright restrictions.

Figure 82 depicts some of the initial sketches that were made for the modularity of the fictional *HealthBand* wearable using the *Blocks* design as inspiration. Finding it difficult to sufficiently represent the interlocking modularity of the potential device through hand-sketching, I chose to move on to using CAD software to enable us to more easily construct and understand the constraints of the prototype in three-dimensions. Figure 83 shows the development of the foundational CAD model and its structural design details. I began by building around the flexible fushsia 'Snap-On' wristband. It was during this process that I made the design decisions to both 'connect' each module via 3.5mm jacks and also use a rear 'clip' to attach them to the 'Snap-On' wristband. My colleagues agreed that these were effective design choices as other solutions like the miniature PCB connectors featured in the design of the *Blocks* smart watch might be too high-tech and likely not affordable for 'ordinary' citizens engaged in decentralised and democratised innovation practices such as crowdfunding IoT design.

Having constructed the foundational CAD model, we began to think about some potential branding for the device. We looked to real-world crowdfunded IoT examples on sites like *KickStarter* and *Indiegogo* for the types of the design language used to promote similar device development projects. Based upon this research, Figure 84 depicts the evolution of the branding and iconography for the *HealthBand* prototype. We initially sought to adopt a black and red colourway – principally because a 'red cross' has often been used to connote the notion of medicine and health at different junctures across society. However, upon further reflection, because we wanted the device to plausibly appear as if it was originated and developed by younger group of 'netizens', we chose to incorporate fuchsia alongside black as opposed to red. Once we felt we had constructed the basis of CAD model to a satisfactory standard, I was tasked with detailing the design further. Figure 85 shows some of my sketches for *HealthBand's* variety of features and functions alongside their eventual representation on the CAD model. Similarly, Figure 86 depicts sketching and graphic iterations that I made for the diabetes monitor and dementia memory aid module interfaces.

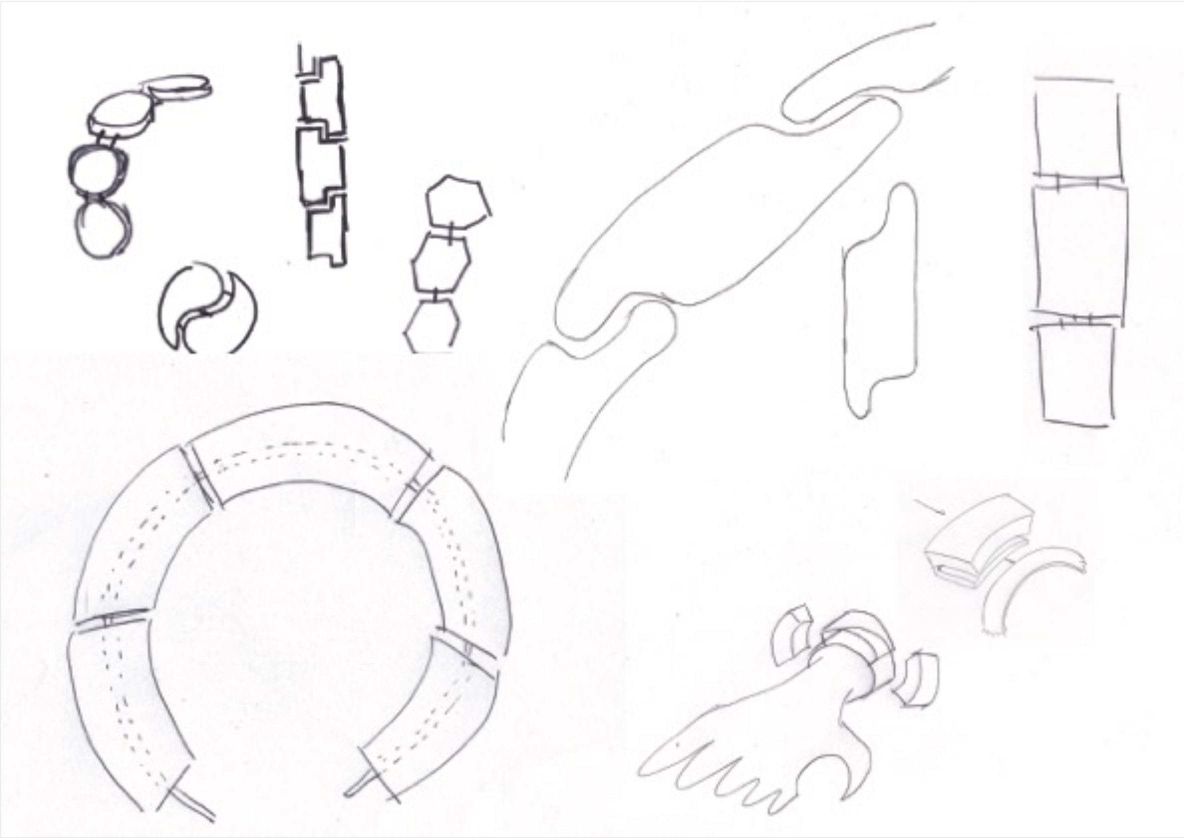


Figure 82: Initial sketches for the fictional *HealthBand* wearable. Source: Author.

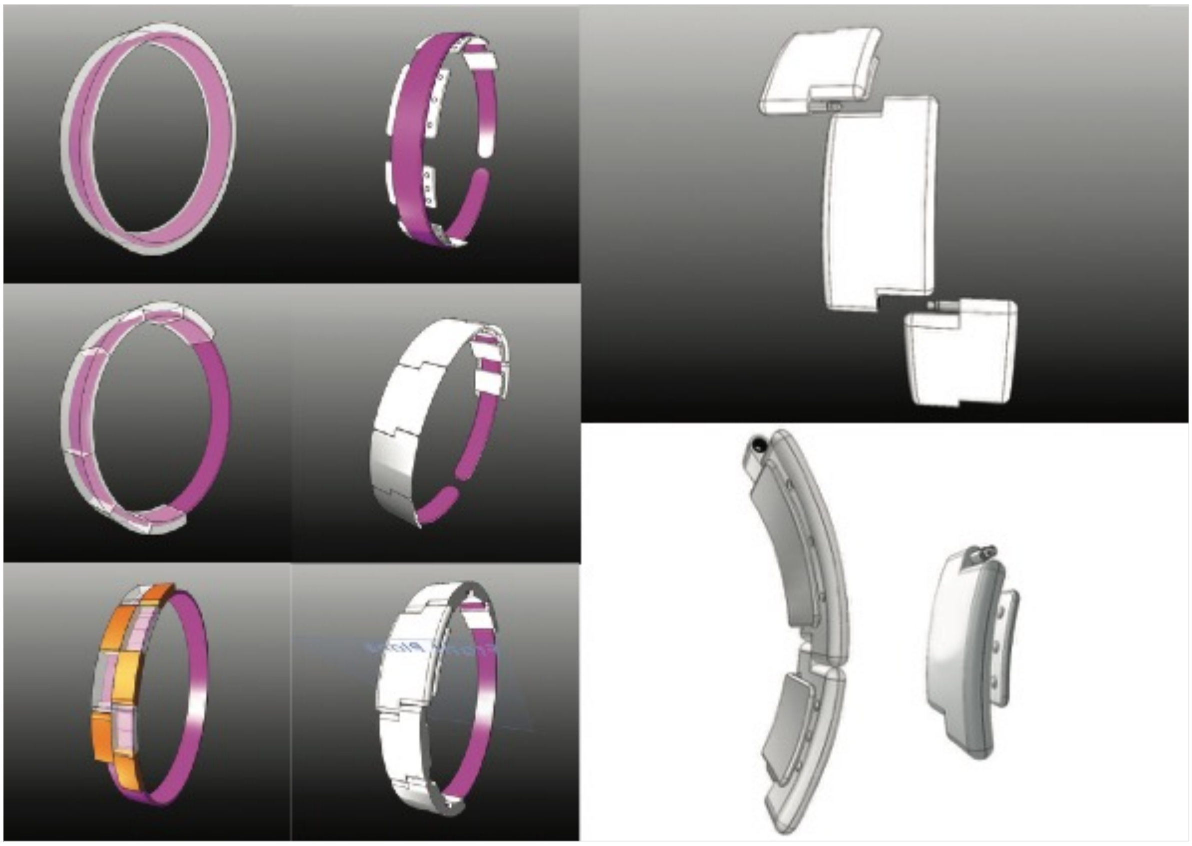


Figure 83: Working out structural design details. Source: Author.

Figure 84: *HealthBand* branding and iconography tests. Source: Author.

Figure 85: Detailing the CAD model. Source: Author.

Figure 86: Additional detailing through sketching and graphics. Source: Author.

As discussed in the previous section, individual patients' needs and symptoms can be quite varied, particularly when treating complex conditions such as dementia which unfortunately often develops alongside a range of other challenging health issues. Further, as dementia is a degenerative illness, the needs of a particular patient will vary over time. Technological solutions should seek to address different aspects of a condition and the platform should therefore be flexible enough to allow devices to be configured and reconfigured in order to meet the dynamic needs of users. Figure 87 depicts an exploded view of the final *HealthBand* prototype and illustrates how each of its modules connect together via the aforementioned 3.5mm jacks. Similarly, the modules each have the rear 'clip' which must be used to secure them to the fuchsia 'Snap-On' wristband. In the fiction, the band is said to be comprised of a flexible metal strip coated in a layer of durable but soft to touch silicone. This feature means that the design is versatile, in that it would be able to fit a wide variety of wrist sizes (Figure 88).

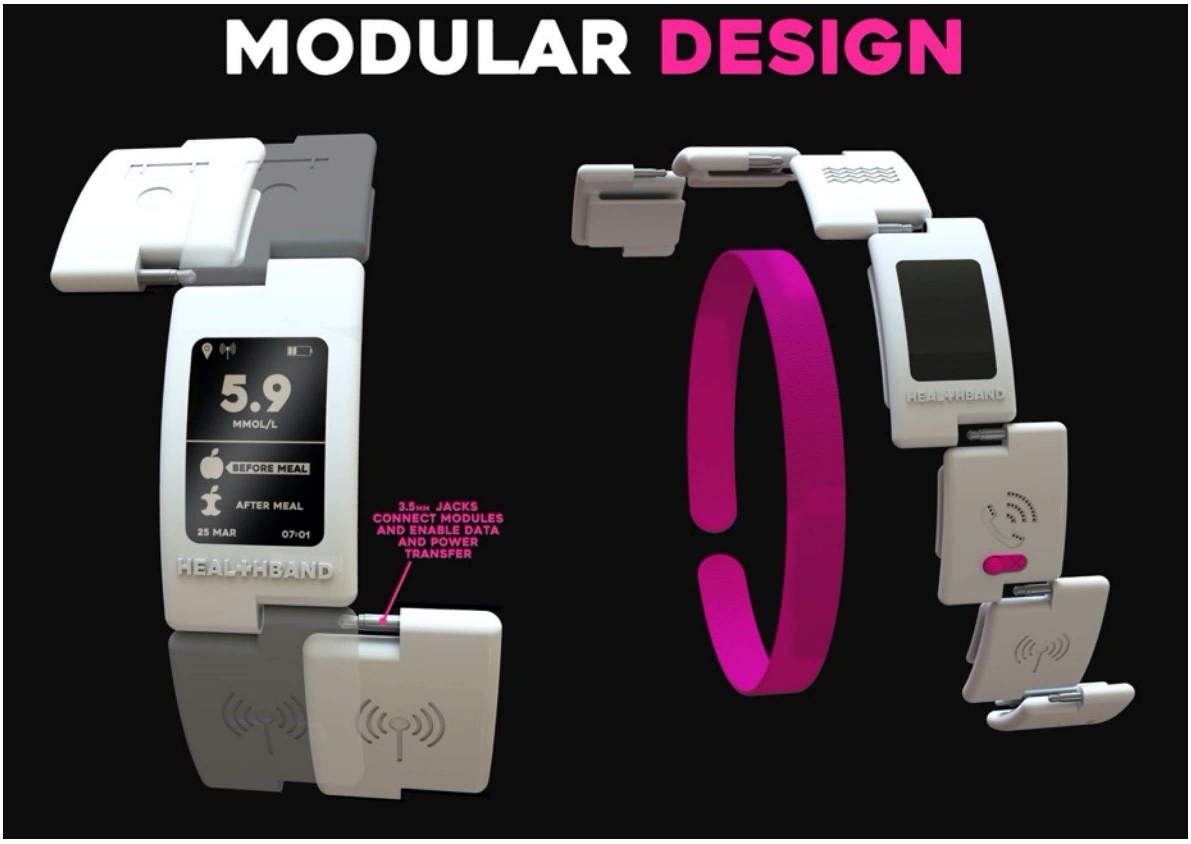


Figure 87: Modularity would enable new functionality to be incorporated into the device as new modules are developed. Source: Stead, Coulton & Lindley (2018).

Figure 88: While the ergonomics of the pink ‘snap on’ band means *HealthBand* could easily be used by a wide demographic of users. Source: Author.

Having generated the diegetic prototype, we realised that in order to better emphasise the broader implications that decentralised spime objects might yield, we would need to also adopt *Design Fiction as World Building* (DFasWB) techniques. This would help to contextualise the prototype within a more fully rounded *world* as opposed to merely within a narrow 'story' or narrative as I had done so with the *Toaster for Life*. In line with DFasWB (outlined on pages 84 – 86), we produced several other related artefacts that provide extra 'points of entry' for potential audiences to engage with the fictional world at differing scales. Each artefact also has a different focus, with the aim of facilitating multiple different 'readings' or interpretations of this future world. As the principle aim for a *Design Fiction* is to enable, rather than shutdown, a wide a range of discussions as possible, these artefacts are presented in forms that are likely to be recognisable in relation to their potential audience's current experience. It was our aim to present the future in which *HealthBand* exists as mundane, for it is through this mundanity that the potential audience's own lived experiences might come into relief. Further, such framing helps to realistically situate the artefacts within a plausible near future (Coulton et al, 2017). As noted in my evaluation of the *Toaster for Life*, mundanity and plausibility were key to the framing of the toaster prototype, and we therefore sought to work these elements into our worldbuilding practice in relation to the *HealthBand*. Figure 89's sketches depict some of the development of worldbuilding elements.

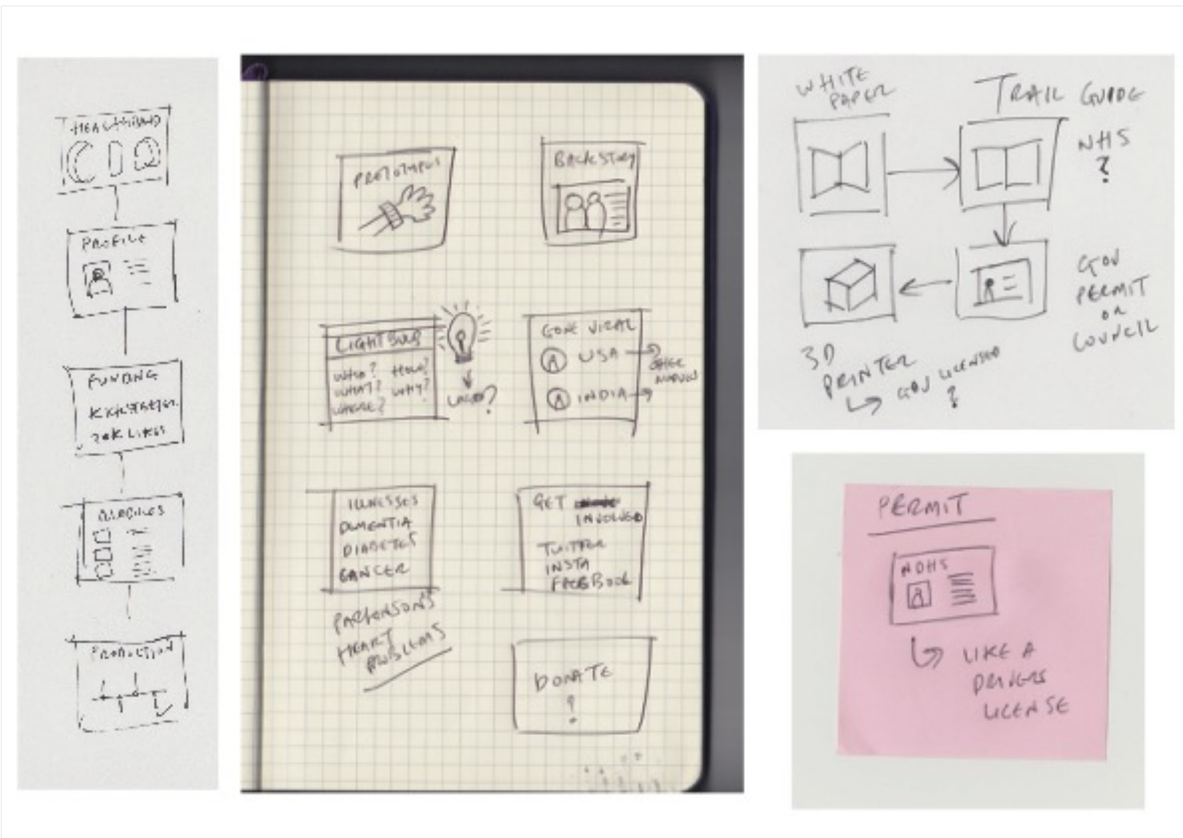


Figure 89: Working out worldbuilding elements. Source: Author.

As previously discussed, present day legislation overseen by the MHRA would prohibit the use of DIY medical devices such as *HeathBand* in a clinical setting unless these products can be proven to meet all the current regulation. Interestingly however, whilst the guidelines explicitly state that CE marks cannot be obtained for custom made health devices as they 'must still meet the requirements in the directives and the type of device should be labelled clearly'

(MHRA, 2016), they also suggest it is not completely out of the question: 'You don't need to get these checked by a third party to show they conform with the requirements but you need to draw up a statement to declare their compliance for custom-made devices, clinical investigations and performance evaluation devices' (MHRA, 2016). This means that a change in the law, rather than a completely new law, would be a necessary component of any plausibly wide adoption of such a technology. In order to highlight this point, Figure 90 presents an extract from a fictional *white paper* entitled 'Legislating Do-It-Yourself Wearable Health Devices.' In the UK, white papers are policy documents produced by the Government that set out their proposals for future legislation. White papers may include a draft version of a Bill that is being planned to change existing law or introduce new legislation. This provides a basis for further consultation and discussion with interested or affected groups and allows final changes to be made before a Bill is formally presented to Parliament. As white papers are aimed at facilitating discussions about the future, it would arguably make it the most appropriate artefact to engage those who are able to facilitate the changes in legislation required for DIY healthcare and medical devices. As a white paper is particular to the UK, it would not necessarily make sense in the context of another country and thus highlights how the forms of a particular *Design Fiction* need to be chosen relative to their intended audience (Coulton, Lindley & Akmal, 2016).

Our adoption of the fictional frame of crowdsourcing is illustrated in Figure 91 which introduces 'Gary', the protagonist of the campaign, and outlines his reasons for developing a DIY medical wearable. Against an increasingly privatised UK health service and exorbitant treatment costs, Gary and his friend Phil from Manchester in the UK started to develop *HealthBand* to help manage his young cousin's Type 1 diabetes. Alongside the reduction in size of components, the internet has made digital technologies like open source electronics highly accessible and cheap to buy. Consequently, the last decade has witnessed a growth in 'ordinary people' getting involved in physical-digital 'making' practices who have the freedom to innovate and manufacture products without the intervention of conventional corporate stakeholders or industrial scale processes. From physical products created using rapid fabrication tools like CAD and 3D printing, to digital internet-based apps and services, this 'open sector' is challenging the established norms of centralised, profit driven design culture (Anderson, 2012). Von Hippel (2005) designates people who personally innovate in this way as *lead users*. He argues that those who engage in such activities mostly do so because the mainstream marketplace does not satisfy their specific needs. He posits that the enjoyment gained from the creative process itself – learning and problem solving – is also a prime motivator for lead users. Figure 92 depicts the positive response Gary and Phil received when they uploaded their DIY diabetes monitor to a fictional online crowdfunding site called *LightBulb* which is intended to mimick sites like *KickStarter*, *Fundable* and *Indiegogo*. Figure 93 meanwhile shows the timeline for the campaign.


22 Legislating 'Do-It-Yourself' Wearable Health Devices

Department of Health

The case for change

1.1 Rising aging populations living with chronic health conditions like diabetes, dementia and Parkinson's disease have put an incessant strain on the NDHS. Although it has been proven that these conditions can be successfully managed by patients using wearable health devices, due to abstruse health product legislation, too few devices have been made available to patients over the last decade. At the end of January 2027, 345 of the 418 local health authorities had put forward 'autonomous patient digital health' policies for consultation. Since then, the National Digital Health Framework has also published its report on 'home-made' wearable health devices,[20] as a means to fulfil the terms of service pledged by the NDHS in 2021.

1.2 Changes to digital health services have remained slow, expensive and bureacratic, with arguments about how many patients will be able to manage their own healthcare autonomously and what level of services are offered

1.4 In response, this chapter sets out our proposals to reform health product legislation as well as identifying sufficient funding and expertise to make the most of the proposed changes; with community involvement to make the best outcomes for both 'autonomous citizens' and those continuing to use limited health services.

1.5 A number of the proposals build on consultantions and reviews conducted over the last year: the report of the Local Health Device Group; consultations on changes to the National Digital Health Framework;[21] frontline service reviews (the results of patient-led care trials at different sites across the country); and the National Patient Wearable Review also provided evidence.[22] The Government has taken account of responses to these consultations in deciding the way forward . A summary of the responses to each consultation is being published alongside this White Paper.

Getting tech in place

Making sure every UK citizen has access to digital technologies and

Figure 90: A *white paper* proposing legislation that would allow DIY medical devices to be produced in the UK. Source: Stead, Coulton & Lindley (2018).


DOING IT OURSELVES

Hi, my name's Gary. On the left is a photo of me with my cousin Arthur. He was diagnosed with Type 1 diabetes when he was 2 years old. My Auntie and Uncle have found managing Arthur's illness very difficult. The government's privatisation of the NHS in 2026 has left them with little to no support for Arthur. Like so many people, they can't afford extortionate private healthcare rates. It means that they have had to rely on old and often complex equipment plus hand outs from health banks and other charities.

I studied creative technologies at university and now work as an interaction designer in Manchester, UK. I know a fair bit about user experience design, electronics and coding. My best friend Phil works as a commercial fabrication engineer and is really good with rapid prototyping technologies including 3D printing. Together, we decided to try and come up with a better way of monitoring and managing Arthur's diabetes - a way that didn't require expensive trips to the doctor or equipment fees.

This was the beginning of HealthBand...

Figure 91: Within the fiction, 'ordinary people' like Gary are developing socially beneficial connected devices like *HealthBand*. Source: Stead, Coulton & Lindley (2018).

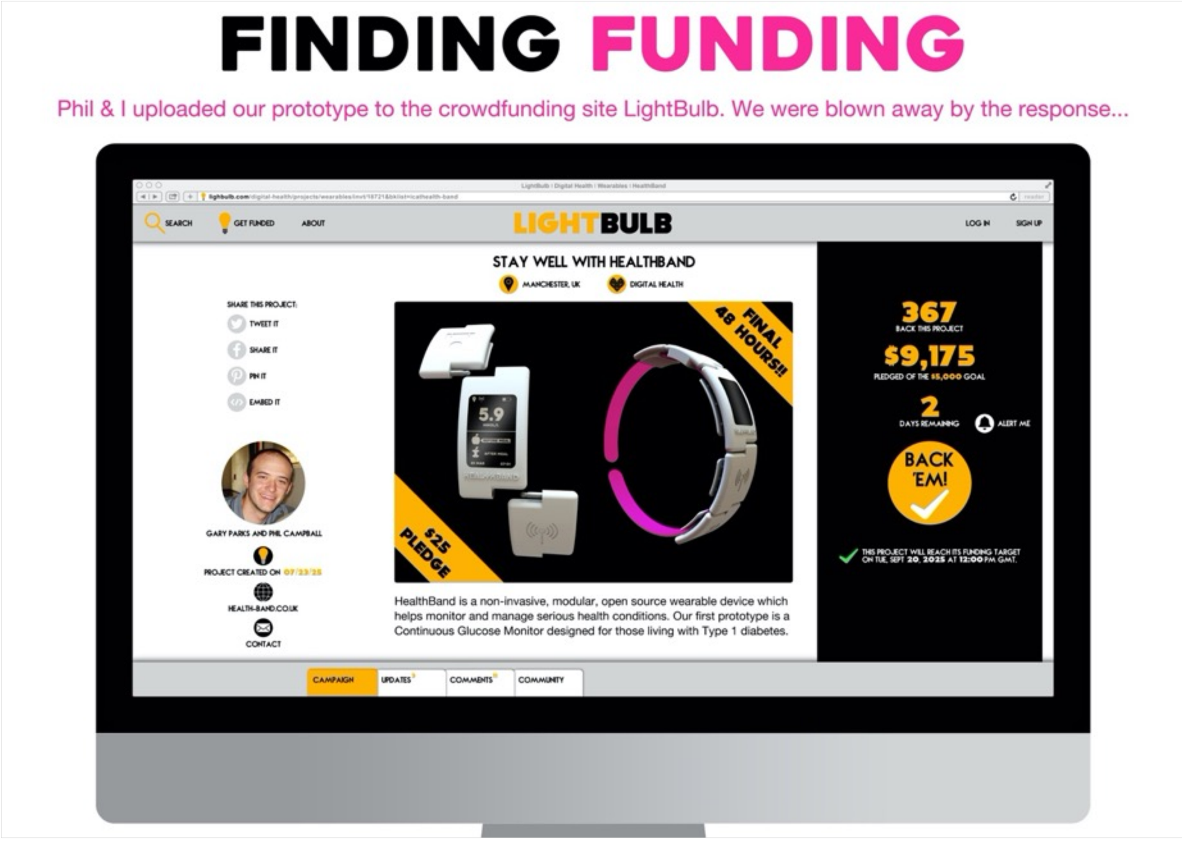


Figure 92: The development of the *HealthBand* device was framed as an online crowdfunding campaign. Source: Stead, Coulton & Lindley (2018).

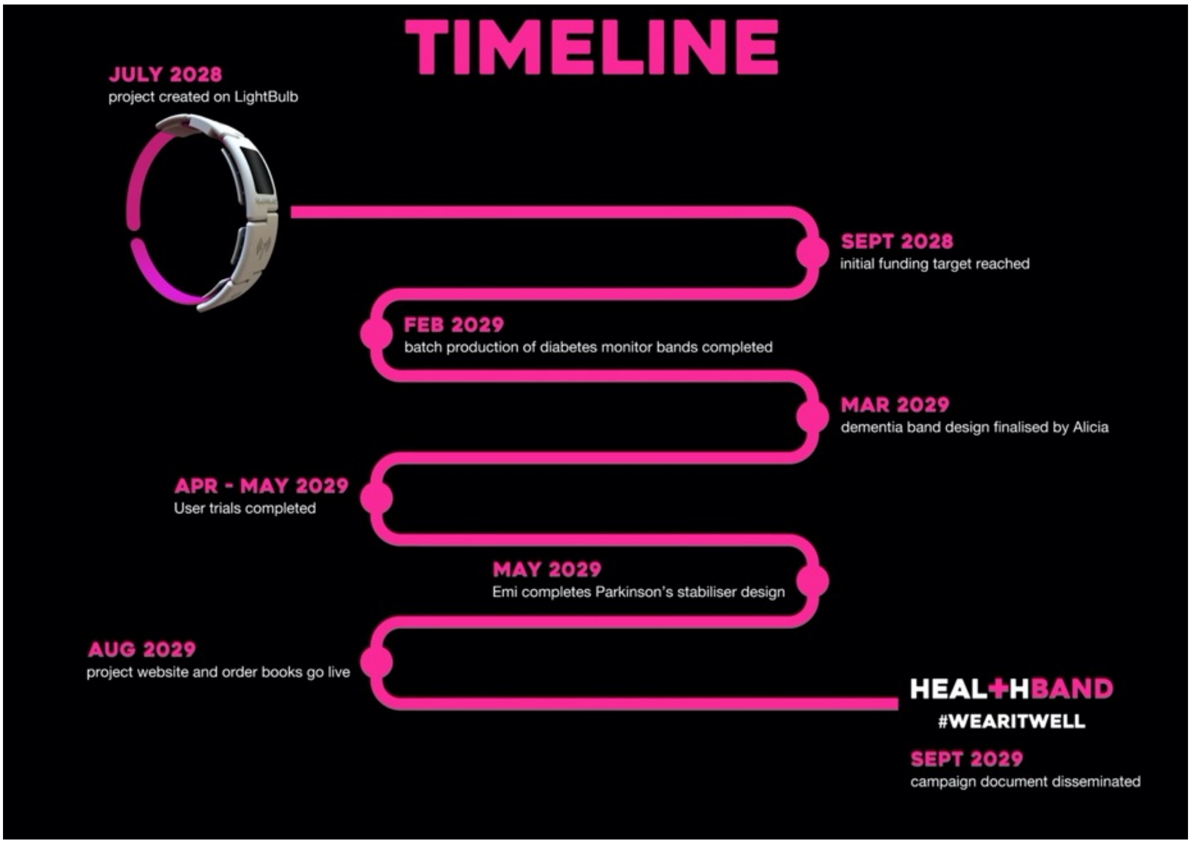
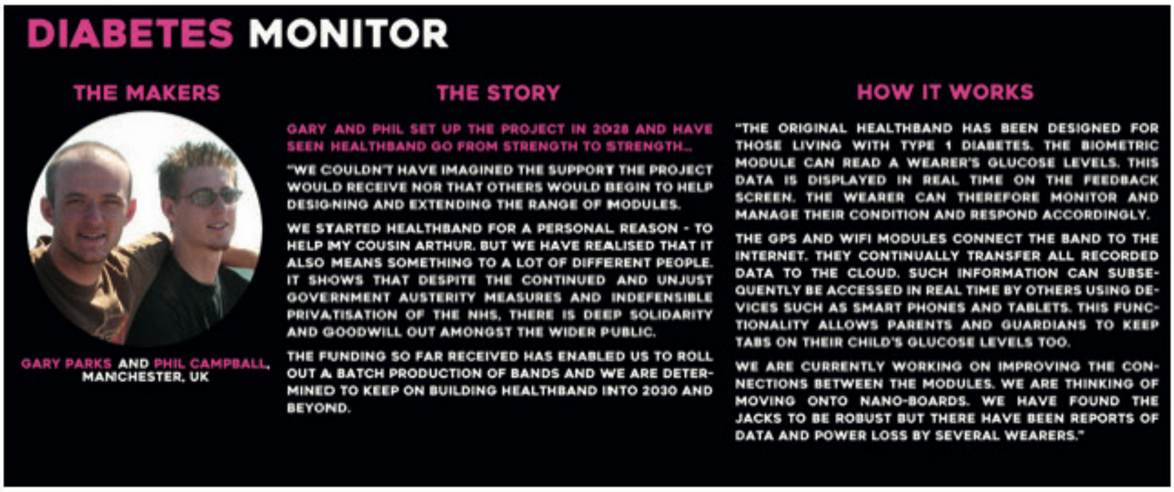
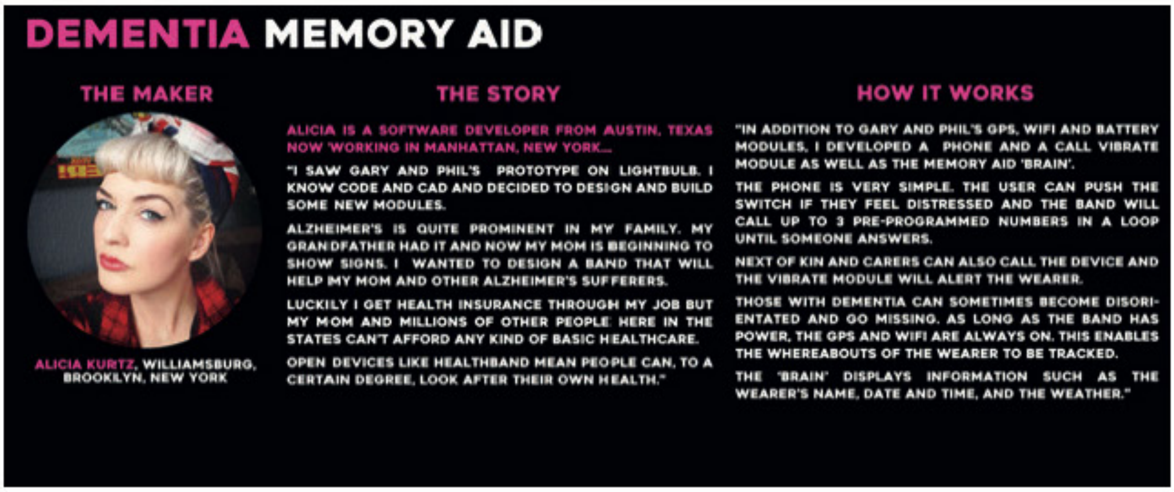


Figure 93: The fictional timeline for the crowdfunding campaign. Source: Stead, Coulton & Lindley (2018).

To illustrate the how and why it was created, each of the *HealthBand* prototypes is presented in more detail as a 'Developer Story' (Figure 94). I have previously noted that in a spime-based *synchronic society*, it is likely the acts of creation and consumption would no longer be mutually exclusive. With design expertise and tools more widely dispersed, spime *wrangling* would not be limited to established practitioners such as interaction or product designers. More open, democratised design-innovation practices would broaden the types of people who would engage in *wrangling*. Resultantly, we created the set of *Developer Stories* as a way to personify the design criteria *synchronicity* and *wrangling* within the case study. The three 'wranglers' have each produced and shared their connected devices in an altruistic manner through decentralised networks rather than for monetary gain through conventional corporate, centralised channels. The first story, Gary and Phil's diabetes monitor, argues for the importance of personalisation, hence proposing a modular design, which encourages others to innovate on the *HealthBand* platform. This particular component of the design fiction draws inspiration from *Nightscout,* in that it focuses on self-monitoring of diabetes symptoms. It also seeks to extend the concept such that medical devices themselves become open-source hardware platforms.

The second story concerns Alicia based in Williamsburg, New York, USA, who, having been excited by seeing the original diabetes monitor, decided to create memory aid and tracker modules. Alicia was inspired to design the memory aid module both due to the prevalence of Alzheimer's in her family, and a in response to the difficulties faced by many in the USA of obtaining health insurance. In terms of the *Design Fiction*, it draws from health reports from the *Alzheimer's Society* (Alzheimers.org.uk, 2019) who highlight that Alzheimer's is the most common cause of dementia, affecting 62 per cent of people diagnosed with the syndrome. There are currently 850,000 people with dementia in the UK, with numbers set to rise to over 1 million by 2025 and are further expected to soar to 2 million by 2051. Introducing the USA perspective not only highlights that dementia is a global issue, but also emphasises that individual countries have particular problems with access to healthcare, in this case access to affordable, comprehensive medical insurance in the USA. The final story features Emi from Japan which highlights the issue of their increasingly aged society. Indeed, Japan's population is expected to see the number of over 65s to grow to nearly 50% by 2060 (McCurry, 2016) while also experiencing a declining birth rate (Soble, 2017). In this story, Emi has developed HealthBand modules which are specifically designed to stabilise hand tremors which are a common symptom of Parkinson's disease. We contend that his story, in part highlights that symptoms exhibited by patients vary from individual to individual which in turn emphasises the need for a flexible and reconfigurable design solution.





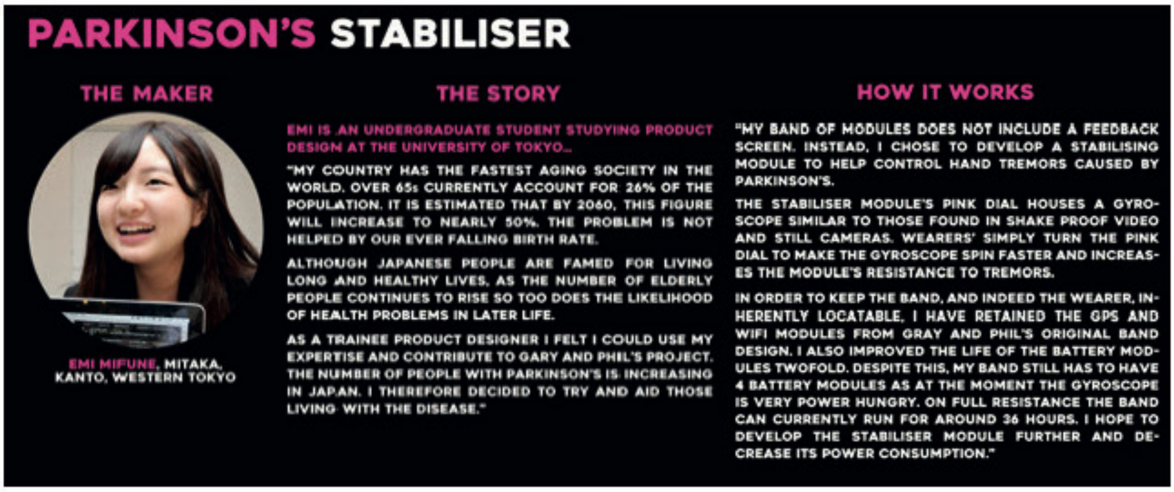


Figure 94: The three *HealthBand* module developer stories. Source: Stead, Coulton & Lindley (2018).

Returning to the example of *Blocks*, that device is quite representative of the current volatility across development of the IoT, in that it is a constantly evolving landscape with devices, services and companies entering and leaving the market at a rapid rate. Despite numerous release dates being announced since early 2016, the *Blocks* device has yet to be released to market. Given the continual delays, there is possibility that *Blocks* may suffer the fate of ultimately becoming *vapourware* – a term used to describe a device, service or system that is given a release date but never actually 'materialises', or in other words, reaches the consumer market (Coulton and Lindley, 2017). Whilst this precariousness may be acceptable for early adopters of these technologies, it is unlikely to instill confidence in those responsible for healthcare provision. Thus, while we wanted to explore the advantages of *Democratised Innovation* in the creation of such devices, there is a need to consider how trust can be facilitated in those creating DIY products, and to ensure some level of accountability amongst device developers, health service providers and legislators. Such a task is of course highly complex and whilst we are not realistically suggesting this as a solution as part of the *Design Fiction*, to begin considering notions of accountability, we created a *Domestic Fabrication Permit* (Figure 95). The permit draws upon present day medical device certification processes (MHRA, 2015) and also introduces the notion of linking a particular condition to the permit in a similar vein to how devices are currently classified. In this way, the risk to patients can be handled in a more nuanced manner and links directly to a developer's experience, as opposed to a simple, blanket legislation which might grant universal permission to fabricate medical devices.

In proposing something as radical as DIY medical devices, we are aware that the views of and impacts for healthcare professionals would be profoundly different. It is crucial that nurses, doctors, and other allied health professionals have confidence in the widespread use of such devices and the health-critical data that they collect. While many healthcare wearables can be positive feedback tools and motivational aids, doctors ultimately want clinically proven products whose data they can use to make clinical decisions (Wall, 2016). With this in mind, we created a pamphlet (Figure 96) which highlights a set of actions which device developers need to undertake before their device might be considered and put forward for clinical trials. Whilst the pamphlet follows similar requirements currently defined by the MHRA, it also introduces new requirements such as ensuring the software and hardware are open for both modification, the need for any data to be handled in a secure and ethical manner, and that devices would be considered by a specialised professional service before it could move on to the next stage of certification. As with the fabrication permit, this is not being offered as the solution to certification but rather providing a starting point for deliberations on what the actual requirements of a new certification process might be. Once a DIY device has been trialed and met the required performative and safety standards, people would be able to share their devices with others who could potentially benefit from them. Figure 97 shows development sketches for an app interface for each of the *HealthBand* modules. As we collectively felt a 'tremor intensity graph' would be the most interesting data visualization that may potentially derive from use of the three different modules, we chose to develop this interface further. As such, Figure 98 depicts our last artefact – a screenshot of a mobile app developed to accompany the *HealthBand* wearable. We posit that such an application may provide an effective way to convey to users personal Parkinson's tremor intensity data as generated during their use of the device.

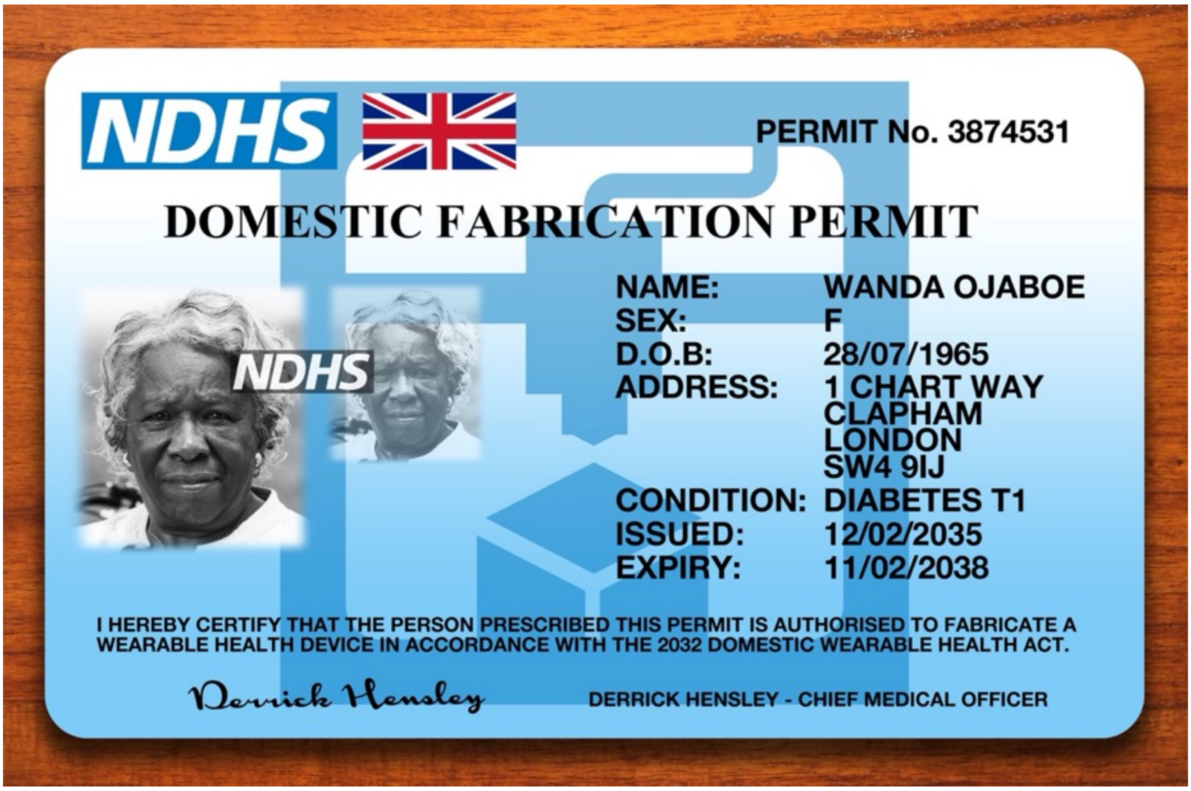


Figure 95: To regulate DIY production, people would need a *Domestic Fabrication Permit* granted by the *NDHS*. Source: Stead, Coulton & Lindley (2018).

Figure 96: Health service guidelines to ensure clinically safe DIY device production. Source: Stead, Coulton & Lindley (2018).

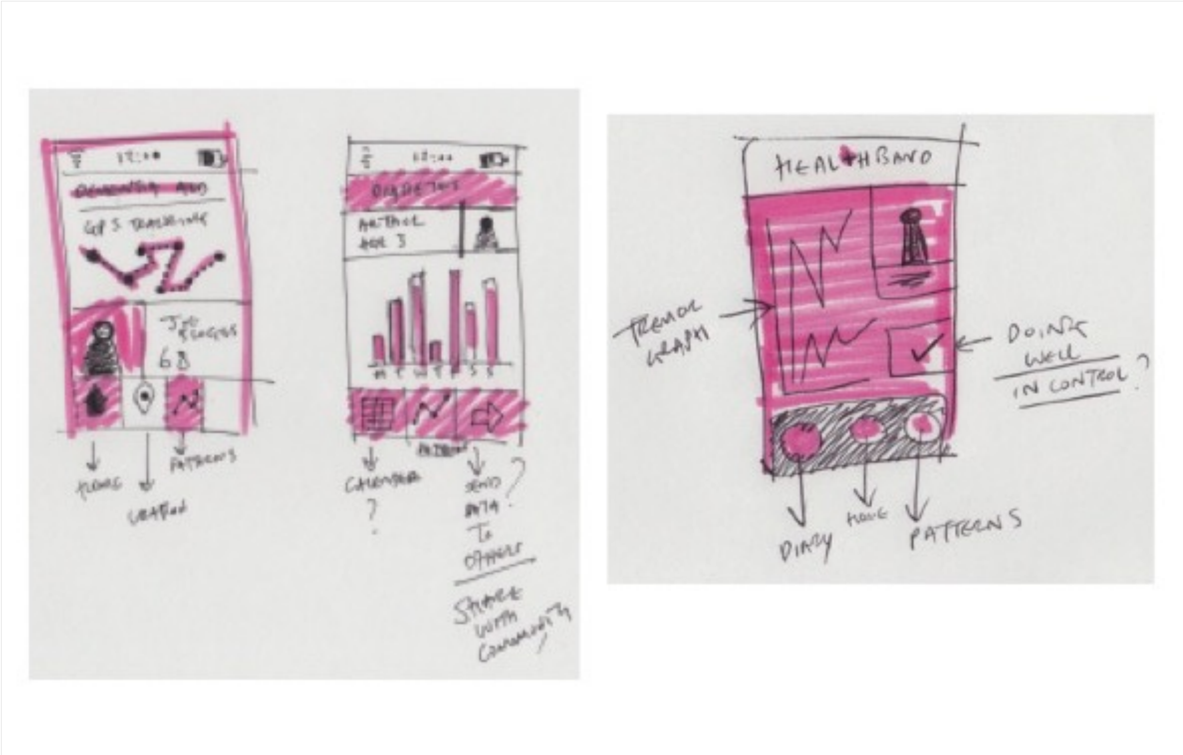


Figure 97: Sketches for the *HealthBand Patient Trial App*. Source: Author.

Figure 98: The interface for the *HealthBand Patient Trial App* including a patient profile, their wearable usage data and feedback diary entries. Source: Stead, Coulton & Lindley (2018).

7.3.3 Insights

Today, healthcare providers are actively trying to integrate wearables into frontline services because trials have shown such devices are effective in empowering patients to manage their own care while also reducing demand on medical services and staff. Despite this, the regulatory journey to enable a device to be used by patients is complex and oft protracted due to strict legislation. Health policy decision makers and medical bodies are, quite rightly, cautious to only allow safe and reliable wearables onto the wrists of infirm and elderly patients. In light of this, the *HealthBand* case study serves as a means to generate discussion regards how, in the near future, DIY medical devices might become widely adopted through decentralised social innovation practices, and what this would mean for current product design policy and associated legislation. In doing so, the *HealthBand* prototype also serves as a proxy for a potential s*ynchronic* and *wrangled* spime object.

Reflecting back upon the design fiction process itself raises several points for consideration. Like the *Toaster for Life*, I contend that the *HealthBand* case study further reinforces the notion that whilst the *Design Fiction* artefacts are fictional, if they are to facilitate meaningful questions around the futures they portray, they need to be conceived with the same commitment to detail as if they were actually being designed and produced. In addition, I argue that it is the *world building* approach which allows such detail to be developed and which can address some of the associated complexity which emerges during the transition from an emerging technology with interesting potential to one capable of reaching widespread adoption in a variety of sectors, that is, not only be limited to medical purposes. The aim of the case study is not to present solutions to this complexity but rather to ensure that there is discourse that considers what factors may need to be addressed during this transition. So, although the *HealthBand* prototype and accompanying artefacts are intended to appear realistic and plausible, the focus of the fiction is not to promote the creation of such devices, rather it is to provoke a debate that considers the changes to health product legislation that would be required to enable 'open' health wearables to exist at all. Further, if such products are produced what would be the potential impacts on society that these said devices would create. If future wearable health products and services are to be adopted, it is important that design researcher-practitioners, creative technologists and IoT device developers do not merely focus on creating novel prototypes using new technologies. If they truly believe in the value of their prototypes, they must also try to lobby for the regulatory change required so that such devices can be approved for use. I believe our design process in many ways underscores the above argument. We originally focused on creating the wearable diegetic prototype and intended for the campaign document to act as the sole 'situating device' that would both frame the prototype and build the fictional world. We soon determined however, that the prototype and document were not sufficient enough to facilitate the envisaged critique regards health product legislation. In order to shift emphasis from the wearable design itself and place greater focus on the changes open health wearables may have on future health product legislation, we concluded that, as per DFasWB, we needed to further 'concretise' the fictional world using additional artefacts.

Initially, we considered that legislation would be the most contentious factor in enabling future DIY medical devices, however, healthcare is an area that undergoes constant innovation with regards to medicines and associated products. As designer-researchers seeking to build a plausible fictional world for *HealthBand*, the bigger challenge was thus: how can we envision how *Democratised Innovation* could be adopted in the near future when existing present-day frameworks have been set-up to mitigate risk so stringently? The prototype and related artefacts themselves imply that these risks can be overcome and establish a case for change. However, the case study does not explore in depth how such risks could be mitigated and how any potential liability may be addressed. In hindsight, I posit that these issues could have perhaps been addressed to a further degree within the case study by presenting potential opponents to the envisioned changes to legislation which would allow DIY medical devices. Such opposition might have taken the form of reports from health policy think tanks, healthcare practitioners concerned with risks to public safety, medical ethics committees and competitors, that is, corporate medical device manufacturers, who currently must spend large sums of capital to develop medical devices which meet stringent design/production regulations. Legislatorial reform may also lead to a reduction in manufacturers' share of the medical device market and subsequently reduce their ability to increase profits.

When we created the crowdfunding campaign for *HealthBand*, it was primarily an artefact through which we chose to emphasise the patient-initiated innovation and provide a frame in which the individual developer stories could highlight the factors leading people to advocate for DIY healthcare and medical devices. To those familiar with crowdfunding and creating IoT devices, here the fiction perhaps lacks detail that might produce more meaningful discussions. For example, what would be a realistic funding goal to achieve the creation of a new device? What exactly would users get for their investment? Given that a number of crowdfunded IoT devices have obtained funding but not met initial delivery targets, or drifted towards *vapourware*, would the ethical requirements placed on those developing DIY Medical devices through these crowd funding platforms need to be different from those say developing products and services for the home entertainment market?

In terms of the modular design of the *HealthBand*, I see this aligning strongly with the current emphasis on providing greater focus on the needs of individual patients rather than particular conditions and how these needs are likely to change over time. This modular aspect is also particularly useful for extending the scope of the fictional DIY medical device world to include other conditions which may present very different challenges than those currently envisioned. The permit is primarily a means of linking current medical device certification with potential ways of how this might be adapted to allow *Democratised Innovation* and medical device production on a more individual level. There are possibilities that the permit leaves unanswered, for example, how is the permit obtained and what are the requirements for applicants regards fabrication qualifications, liability, insurance etc. As it is a 'fabrication' rather than 'developer' permit, it also suggests that designs might be outsourced to certified individuals, or even machines, to be built thus allowing innovations to be disseminated through open-source practices. The case study also primarily presents a positive perspective and other, more negative questions might relate to whether a black market for permits and devices might emerge and how such actions might be addressed. This would correspond with Sterling's (2004a) initial thoughts that in addition to the sustainable advantages that a spime-based paradigm would create, like any other previous techno-culture, a shift to spimes would also bring about disadvantages.

Whilst DIY medical devices are garnering considerable attention in the media, academia and industry, they are drawing from a design-maker culture which are often less complex than those which manufacturing practices they seek to challenge, that is, the centralised mass-production of real, operational medical devices. Presently, the case study only explores one example of a possible future – that of the three developers who, despite their ingenuity and tenacity, can be described as 'lay users'. Envisioning how healthcare professionals might become involved with the *HealthBand* concept could no doubt provide other interesting points of entry into the fictional world. For example, might doctors and nurses also begin to fabricate DIY products to cater for specific patient needs? To progress the ideas initiated by the *HealthBand* fiction beyond their exciting potentiality, further exploration of the implications of DIY medical devices from multiple perspectives would need to be addressed if these types of devices are to develop to a point of widespread adoption. Crucially, the fiction is built upon our own subjective interpretations regards the subject. Real-world evaluations and interpretations regard *HealthBand* by a range of key stakeholders such as patients, healthcare professionals, regulators and medical device designers may well provide a rich source of insights which can in turn be used to instil the next iteration of the fiction with greater rigour and criticality. For example, the device trials pamphlet introduces the requirement for clinicians to have confidence that the devices have proven benefit that would draw from, rather than be separate to, existing practices. This artefact could therefore be a useful starting point for discussions with those involved in medical trials as to how such practices might potentially operate. Such evolution may result in a dynamic prototype usable by policy makers, community-based makers, patients, and technology developers to understand the safety challenges around widespread adoption of DIY medical devices, as well as the economic and health centric opportunities.

Despite the above issues, I argue that the *HealthBand* case study helps affirm that *Design Fiction* is a highly useful way to address the implications for adoption of DIY medical devices and associated practices, as it is a speculative design practice which has been specifically developed for engaging with such challenges (Lindley, Coulton & Sturdee, 2017). More so than the *Toaster for Life*, this second case study also better illustrates the process of envisioning, designing and building a *Design Fiction world*. In essence, I believe this case offers insights for those considering the futures of emerging technologies, not only in healthcare and medicine, but also across other sectors that must take similar complex ethical judgements into consideration during their design process.

7.3.4. Evaluation

Like the *Toaster for Life,* the *HealthBand* case study also led to academic outputs – three co-authored peer reviewed conference papers. Two of the publications in particular – *Old, Sick And No Health Insurance: Will You Need A Permit To Use Your Homemade Health Wearable?* (DIS 2017 -*Designing Interactive Systems 2017*, Edinburgh, Scotland) and *Do-It-Yourself Medical Devices: Exploring Their Potential Futures Through Design Fiction* (DRS 2018 - *Design Research Society Conference 2018*, Limerick, Ireland) provided me with a range of feedback during the submissions process.

The DIS paper predominately focused on outlining the case study's fictive crowdsourcing campaign and how, within the built world, it had galvanized democratized innovation activity in response to the growing medical needs of chronic health conditions and ageing populations. Overall, the DIS reviewing committee liked the paper, noting that *'the proposed design fiction method seems a good method to explore these societal problems.'* The first anonymous DIS reviewer highlighted how the work generated discussion and was also taken with the fictive campaign aspect, particularly its lifelike qualities:

> *'The design fiction is interesting, as well as the experiment and brings up all kinds of questions, even about making design fictions itself. If the crowdfunding attempt was indeed real, it is an interesting way to judge how convincing the design fiction can be, but it also has ethical implications…*

> *The finding funding bit could be real, so I think it should be stated somewhere that it wasn't.'*

The second reviewer also noted the discursive nature of the piece:

> *'Topical, timely and interesting to a broad audience… I found the subject matter engaging and I am fairly sure that broad sections of a DIS audience would be intrigued by the provocation sufficiently to want to discuss the work… I also think the basic premise of the provocation is entirely sensible. People do need to think through the implications of these technologies and their uses - and design fictions may well be a good way of engaging people in that discussion and for thinking through the design spaces that are opened up by these new technologies.'*

However, they also felt that *'the paper took a long time to get to the actual fiction [and places] a large focus on the background of wearables, health systems and design fiction, which could be edited down to allow space for more reflection on the fictional world.'* The third and final review gave a decidedly more mixed evaluation. The reviewer felt the work presented:

> '*A very interesting topic – both the focus on systems and organisations in which the technology is situated, and the use of design fiction as a method for better understanding those systems.'*

Nevertheless, they also awarded the paper a borderline score of 3, stating that, similar to the second review:

> *'A lot of the space is taken up with presenting the background of wearables, health systems, and design fiction, while the artefacts are referred to only briefly and in very small images. The result is a paper that is neither a straightforward discussion of a research challenge, or a design fiction. It is a shame that more space in the paper was not given to reporting the design fiction.'*

Largely influenced by the latter review, I decided I wanted to expand the scope of the *HealthBand* fiction and produced a co-authored paper for the *DRS 2018* conference that sought to present the artefacts and their design process in more depth, and which reflected more thoughtfully on how undertaking the research has helped my understanding of the potential of future democratized innovation design practices. The DRS paper specifically focused on how a device like *HealthBand* and its related implementation practices might make or require substantial changes to how the UK Government legislates and controls medical devices design, production and use. On the whole, the DRS peer review was positive and constructive. Of the more critical comments, the first DRS reviewer felt that:

> *'While the paper provides a good example of using 'design fiction' method on a speculative subject… it only provides one example of a possible future* [which] *only depends on authors' own subjective interpretations on the subject. I believe that healthcare professionals' and medical device designers' evaluations and comments on the generated design fiction, could also be very interesting to read.*'

The second review meanwhile determined the paper to be:

> *'Well structured, clearly written and an enjoyable read [and the] "mundane" "world building" approach was very welcome. The introduction suggests the author(s) understand existing related design research as well as the legislative context. The development of "design fictions" and narratives that include the legislative and financial contexts is interesting and has the potential to provoke debate beyond device design.'*

This reviewer also ended with a similar comment to the first but was more conciliatory. They stated:

> *'It's outside the scope of this paper but it would be great to see interpretations of the proposed scenario/fiction among other stakeholders e.g. regulators, patients, healthcare professionals.'*

The above assessments helped reinforce my objective of collating my case studies into a manifesto. As stated in my methodology, whilst the principal aim of my doctoral research is to firstly provide a theoretical foundation for spimes in an academic capacity, by reflecting upon the peer review of *HealthBand* case study, I determined that a *manifesto for spimes* could act as an effective means for my research to reach and engage with a broader audience post-thesis. I would consider this deduction to be the main *emergent knowledge* or 'learning output' that resulted from the second study (micro material engagement) and its associated peer review, and one that I sought to take forward into both the final case study and manifesto development. Drawn from this conclusion, the principal *spime insight* that I was able to take forward into the final case study is that perhaps I could and should also broaden the perspectives and interpretations of the spime-like technologies and practices *within the fictional world itself*, this being, prior to academic peer review and further potential engagement with wider publics post-thesis.

7.4 Case Study 3: The Future Is Metahistory

7.4.1 Framing

I wanted to follow the DFasWB approach from the outset for my third case study *The Future Is Metahistory*. Once again working with Professor Paul Coulton and Dr Joseph Lindley, for this case we generated several interrelated artefacts that provide potential audiences with plausible 'points of entry' to a fictional world which seeks to explore the final spime design criteria *metahistory*. By focusing on the possible sustainable implications of the data-driven 'digital instantiation' of a spime object, *The Future Is Metahistory* study differs from the *Toaster for Life* and *HealthBand* studies whose prototypes and related artefacts primarily embody a spime's physical, 'material instantiation'. Like IoT devices, a spime would generate data about itself throughout its entire lifecycle and this 'metahistory' would be saved and remain searchable and mineable. However, in contrast to the way today's Internet platforms acquire, share and mine IoT data for profit, the value of sharing and mining spime metahistories would be *sustainable change*.

Figure 99 depicts the case study's first DFasWB artefact - an advertisement for a spime-like Internet-connected clothes iron called the *Bosch Meta-Glide 3000*. We designed this prototype to emphasise the types of routine 'metahistorical product data' a spime device would likely generate about itself throughout its lifecycle – data to which users would potentially be privy to in a spime-centric near future world. Unlike today, where consumers know very little about the origins and history of their IoT products, in a future where spimes are commonplace, people would have the capability to know much more about the physical-digital objects that they buy. The *Meta-Glide 3000* advertisement is therefore an example of how metahistory data would create transparency in regards to the device's provenance and allow users to discover the 'untold story' of the product, for example, by providing information such as the materials the device is manufactured from, the supply chains it has travelled through to market, and its past and current data usage.

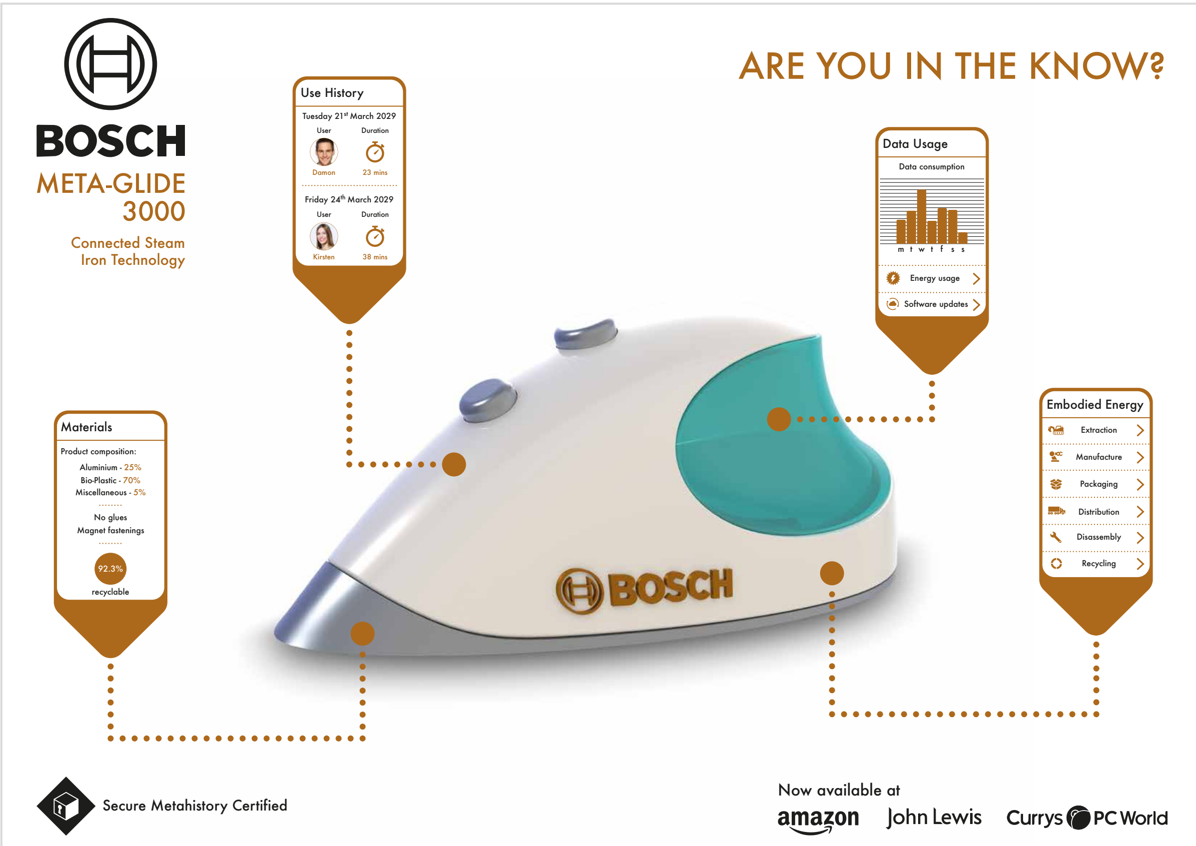


Figure 99: Everyday spime-like devices would generate metahistory data which, when made accessible to users, could facilitate sustainable behaviour. Source: Stead, Coulton & Lindley (2019).

With the IoT continuing to rapidly expand, people are accumulating increasing numbers of physical-digital assets and artefacts, in other words, everyday objects whose material elements are augmented by internet connectivity which allows them to be readable, recognisable, locatable, addressable, and/or controllable by computers. Everyday devices like fridges, kettles and locks, now not only perform their traditional function but they also collect and exchange data (Rowland et al, 2015). Whilst societies have long established value cultures in regard to 'purely' physical items, the different types of value propositions Internet-connected artefacts facilitate are less understood. I outlined in my *Literature Review* how the manner in which technology providers such as *Google*, *Amazon* and *Apple* surreptitiously harvest and monetise the personal data that people generate when using their connected product-services, is perhaps the most prominent example of how the IoT is changing our relationships with objects and artefacts. As Coulton, Lindley & Cooper (2018) have shown, the often simple and user-friendly nature of IoT devices' interfaces is in reality a frontage for extremely complex *constellations* of virtual processes and interactions. The *visible* elements of the IoT – the physical products – work in conjunction with the *invisible* aspects – creating expansive digital infrastructures which share peoples' personal data through a plethora of algorithms, 3rd party platforms, data concentrators and server networks.

The 'invisibility' of these processes and infrastructures is a source of growing concern (Sadowski, 2016). Recent controversies like *Cambridge Analytica's* alleged misuse of 87 million peoples' *Facebook* data to influence voting patterns during the 2016 US presidential election (Solon, 2018), highlights the privacy and security risks, and indeed ethical issues, which stem from internet platforms capturing, selling and manipulating users' personal data. Debate has thus begun regards the regulation of access to IoT product-service data and how such information may be put to purpose (Brass, Carr & Blackstock, 2017). In light of such discourse, I wanted to use this case study to posit that the notion of spime metahistories may provide a way to explore alternate value propositions arising from the acquisition and sharing of people's personal connected product-service data.

In defining *metahistory* as a criterion, I will return to Csikzentmihalyi and Rochberg-Halton's (1981) work on the *psychology of material culture*. They concluded that people have substantial personal histories with each and every material thing that they own. On the whole, such histories are only recorded on the objects themselves as patina – signs of age and use – and as thoughts and memories to which, by and large, only the user(s) of the artefacts are aware of. A spime device, conversely, would generate important data about itself and its interactions with its user(s) throughout its entire lifecycle and this rich and complex metahistory would be saved and remain searchable, trackable and mineable at any time. Sterling (2005) argues that moving to a spime-based paradigm would deepen the relationships people have with their material products as this future would see silos of metahistories becoming 'informational resources [which are] manipulable in real time.' In this respect, spimes share similarities with Iishi & Ullmer's (1997) notion of 'tangible bits', that is, by imbuing material artefacts with virtual properties, the boundary between our physical, man-made environment (atoms) and cyberspace (bits) will become more *seamless* and *symbiotic*. In Figure 100, I have visualised how a near future spime object's design would seamlessly intersect both physical and digital parameters, along with that of sustainability (natural environment) – all three attributes being of equal importance within the spime design process.

At this juncture, it would not be unreasonable to argue that through its expanding array of networked artefacts, sensors and AI capabilities, the IoT is beginning to bring forth eventualities which are similar to those which spimes might potentially yield. Indeed, the enormous growth in the use of data sensing physical IoT devices such as smart phones, voice activated speakers, connected televisions and fitness wearables has led to a thriving *information economy*. Like would-be spime objects, the digital histories generated by people as they use their IoT products are being captured, stored and mined. However, whereas the likes of *Google* and *Facebook* interrogate this 'big data' for commercial gain, the principal value of the 'informational resources' spimes would create would manifest through means to support *environmental sustainability*. As noted, Sterling (2005) believes that mining spime metahistories would help inform sustainable decision-making, particularly in relation to the lifecycle of material goods. He envisages that, once recorded, a spime object's metahistory data would remain 'available online for historical analysis by [its user] and any other interested parties'. Further, rather than the profits of big data, Sterling was likely inspired by the altruistic value inherent to 'open data'. Such datasets are often shared and mined to help inform decision-making with regards to public policy or legislation.

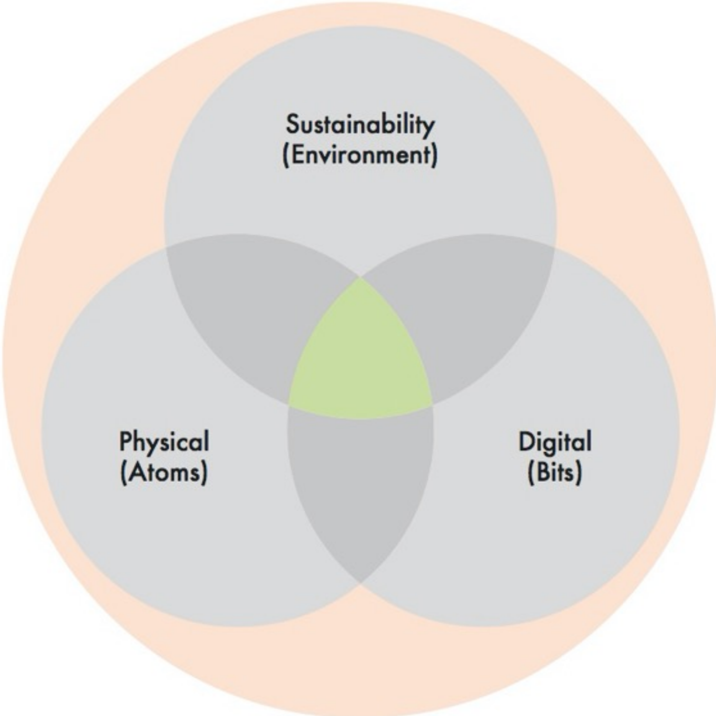


Figure 100: A Venn diagram visualising how a spime object's design would seamlessly intersect *physical*, *digital* and *sustainability*. Source: Stead, Coulton & Lindley (2019).

In the next section, I will go into more detail with regards to how *Design Fiction* was used to concretise a plausible world in which the transparency of spime data is every day and mundane. In this design fiction, it is *sustainable accountability*, with a view to countering connected product e-waste and material scarcity, as opposed to monetary value, that is the principal resource obtained from data sharing practices. As such, *The Future Is Metahistory* seeks to ask – would increase data transparency, alongside the adoption of particular emergent technologies and practices, influence people to embrace new, more sustainable modes of product ownership? Likewise, would transparent lifecycles place greater accountably upon designers and producers in relation to the resources they deplete to design and manufacture connected devices?

7.4.2 Prototyping

I have discussed how if spimes were to come into existence in the near future, it is probable that their early 'instantiations' would share some technological and design attributes with present day IoT devices. Thus, like the *Toaster for Life* and *HealthBand*, within this fiction, a notable emergent technology – *blockchain* – was extrapolated and framed within new *contexts of use*. A *blockchain* is a publicly distributed digital ledger whose immutable nature makes it a highly secure method for managing data transactions between different parties. It is the technology that underpins the much-publicised cryptocurrency *Bitcoin*. Blockchains are broadcast across global peer-to-peer networks which typically consist of thousands of computers and servers. Transactions are verified by *consensus*, that is, participants on the network confirm any changes between one another. This *decentralised* process eliminates the need for a *centralised* certifying authority, such as an established bank or financial broker. Once verified, a transaction is combined with others to create a new data block for the ledger, which is then added to the existing blockchain. In doing so, *cryptography* ensures the enclosed data becomes permanent and unalterable. Proponents argue, that as well as removing bureaucracy, reducing costs and increasing the speed of transactions, blockchain also makes data processes *transparent* and *traceable*. Many envision a plethora of future applications for the technology in addition to cryptocurrency. These include medical records management, the control of governmental voting activities, utility tokens granting access to resources like energy and water, and the trading of commodities and investments (Stallings, 2017; Morrison & Sinha, 2018).

Whilst acknowledging the current issues of blockchain in relation to the consumption of resources and energy (O'Dwyer & Malone, 2014), we felt it was still a useful way of approaching the potential of *The Future Is Metahistory* as it helps us concretise both the transparency of would-be spime product metahistories, and the inherent traceability of such devices throughout their entire lifecycle. Although a relatively young sector, several IoT manufacturers and platforms have already gone out of business, and, as has been seen with recently defunct firms such as *Jawbone* and *Berg*, all of the data and support services associated with these companies and their products, is consequently no longer available to their customers (Graham, 2017; Fairs, 2014). Having data stored on a blockchain would ensure that it is independent from manufacturers and service providers, and, as is an essential attribute of spime objects, this data would remain accessible to users should a connected product firm cease trading. Despite the hyperbole currently surrounding blockchain, we use the fictional artefacts to argue that the technology has yet to enter the mainstream consciousness. Figure 101 depicts a sketched diagram which is seeking to illustrate how metahistory/blockchain would run through the case study's collection of worldbuilding artefacts. Interestingly, one can see that we originally chose to prototype a metahistory driven *hairdryer* and not a steam iron. We decided to switch to developing the latter upon learning of Pschetz et al's *Distributed Energy* project (2019) which centres on an IoT hairdryer.

Our second artefact is a fictional Which? help guide entitled *Buying and selling your devices securely: Blockchain and Smart Contracts made easy* (Figure 102). Similar to the technology advice guides that are available today (Which?, 2019), it serves as a means to introduce a wide range of potential audiences to the technology and explain its complexities and advantages in terms that can be easily understood. 'Published' in 2029, the guide gives examples of near future applications for blockchain including crypto-transfers, speed voting, energy resource betting and, most significant for the purposes of our fiction, *the trading of physical-digital goods*. Within the fiction, the document has been produced together with present day technological bodies, the UK Government's *Digital Service* and the *Citizens Advice Bureau*, alongside the fictional *Alliance for Sustainable Blockchain Stewardship* (AfSBS). We reviewed several contemporary *Which?* tech guides and noticed that to aid understanding, some of them incorporate graphical icons and infographics to help explain technologies and related practices. We felt this technique would lend itself well to explaining blockchain oriented devices trading. Thus, Figure 103 shows some development sketches for the guide which focus on cultivating iconography for the blockchain infographic elements.

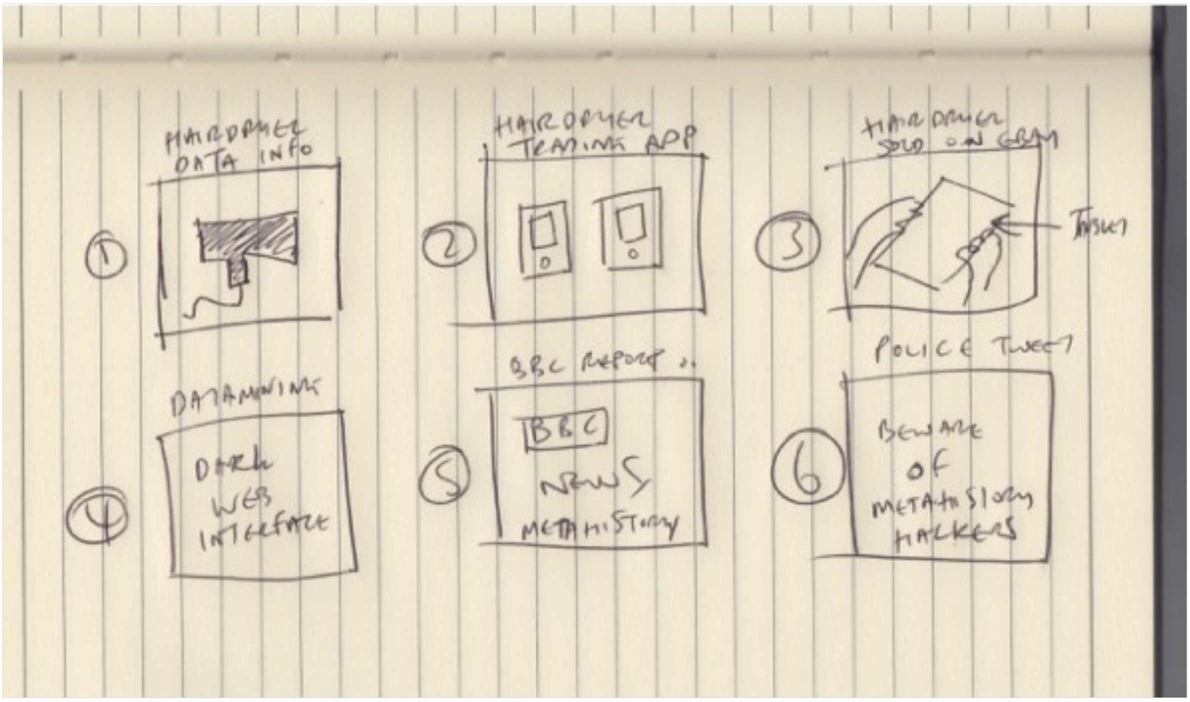


Figure 101: An initial sketch which shows ideas for how metahistory/blockchain would run through the case study's worldbuilding artefacts. Source: Author.

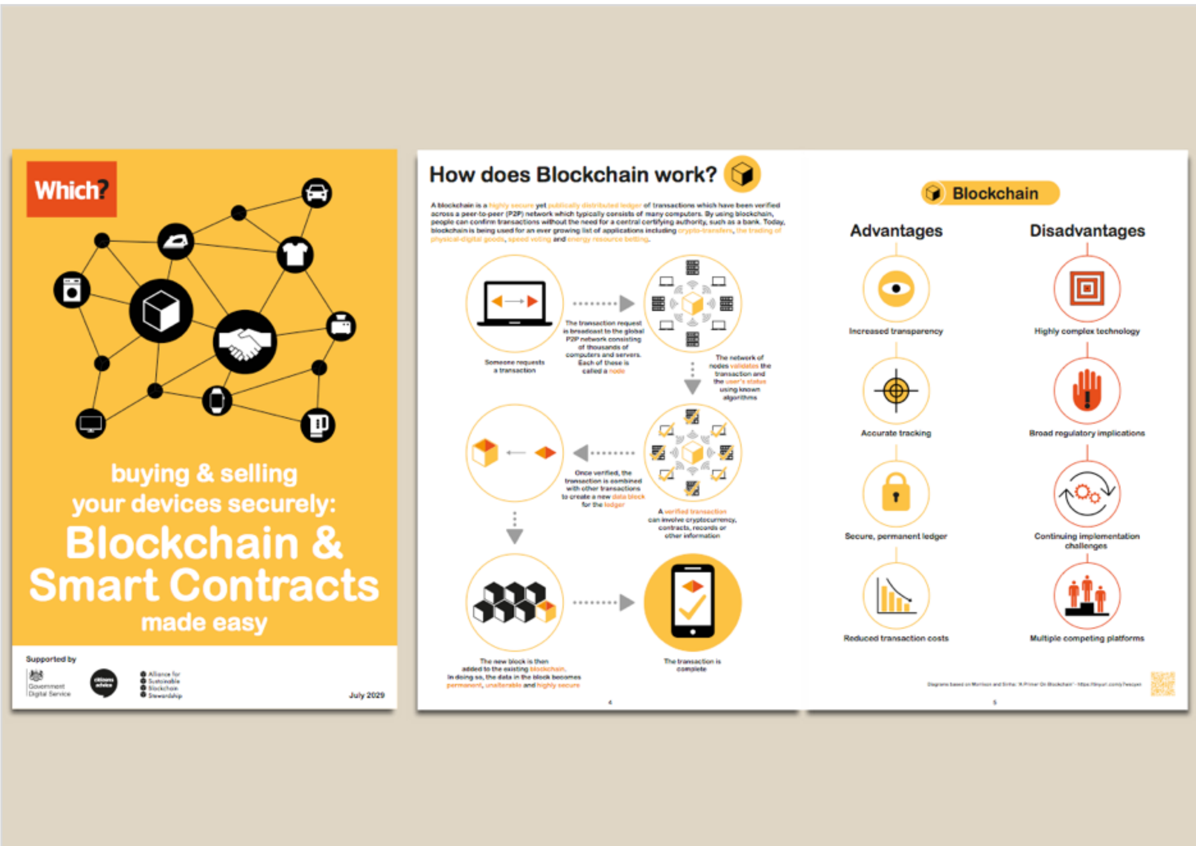


Figure 102: A near future Which? help guide for buying and selling physical-digital devices securely using blockchain and smart contract technologies. Source: Stead, Coulton & Lindley (2019).

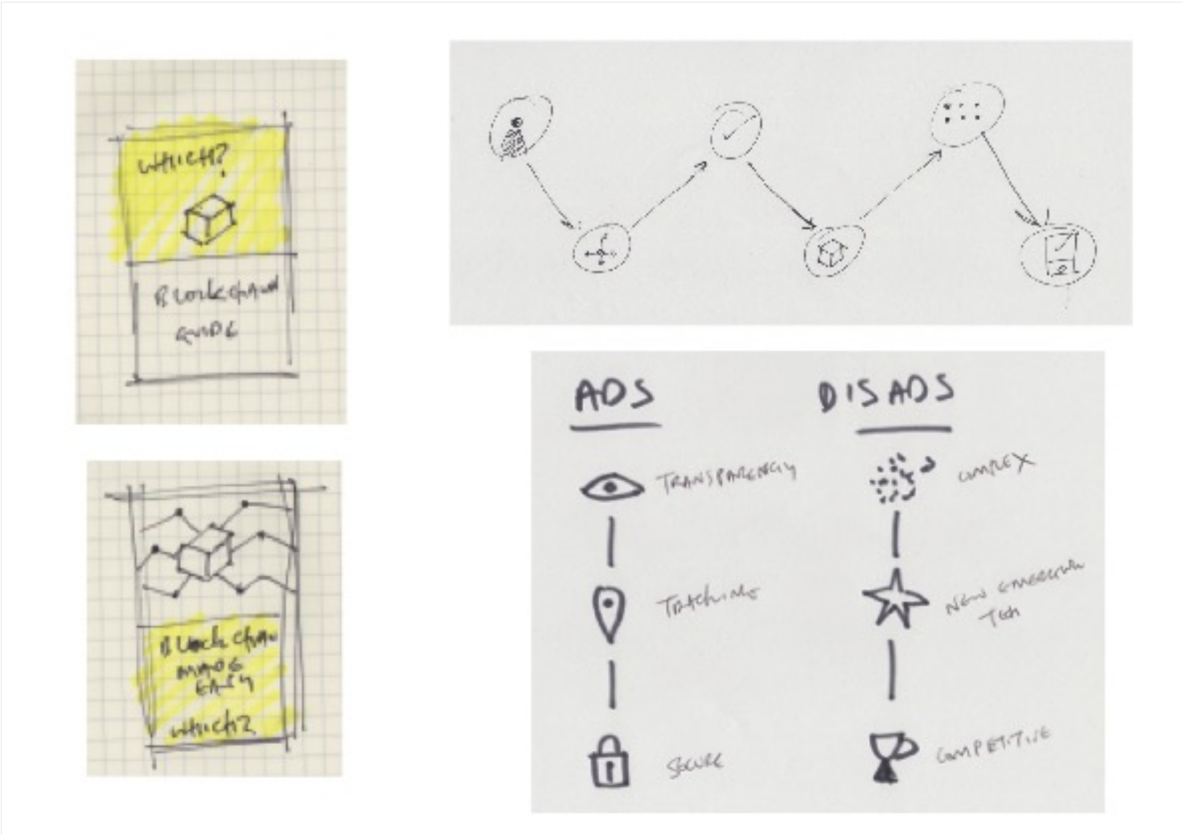


Figure 103: Development sketches for the *Which?* guide. Source: Author.

While distant visions of the future can be worthwhile, the previous two case studies have shown that plausible proximate futures are more useful for exploring the meanings and implications of emergent technologies and practices. With this in mind, we referenced the first two real organisations, and indeed *Which?*, to 'root' the guide within an 'everyday' and mundane future. As with the *Toaster for Life* and *HealthBand*, this sense of plausibility lessens the potential for the spime and metahistory concepts to appear fantastical, unreal or 'too futured'. In turn, we again world build using 'new media' (Hales, 2013) and 'familiar formats' (Coulton, Lindley & Akmal, 2016) as this enables the speculation to more meaningfully contribute to broader social, ethical and sustainability debates that are relevant to the implications of adopting spime metahistories. We followed this approach when conceiving all of the fictional artefacts. For example, to establish verisimilitude, we chose to brand the fictional steam iron (Figure 99 – page 161) as a *Bosch* appliance as opposed to fabricating a manufacturing firm. Figure 104 shows development sketches and CAD models for the fictive device. I initially sketched and modelled what could be described as a traditionally looking iron (top left). My colleagues and I reflected that given the metahistory driven world that we were building is 10-15 or so years into the future, we should present an iron prototype that, like the *Toaster for Life* and *HealthBand*, appears familiar yet to a degree 'futured'. This led me to produce the top right green cone like design, followed by the bottom left pink mouse like vision. As one can see in Figure 100, we finally settled upon a further iteration of the bottom right prototype.

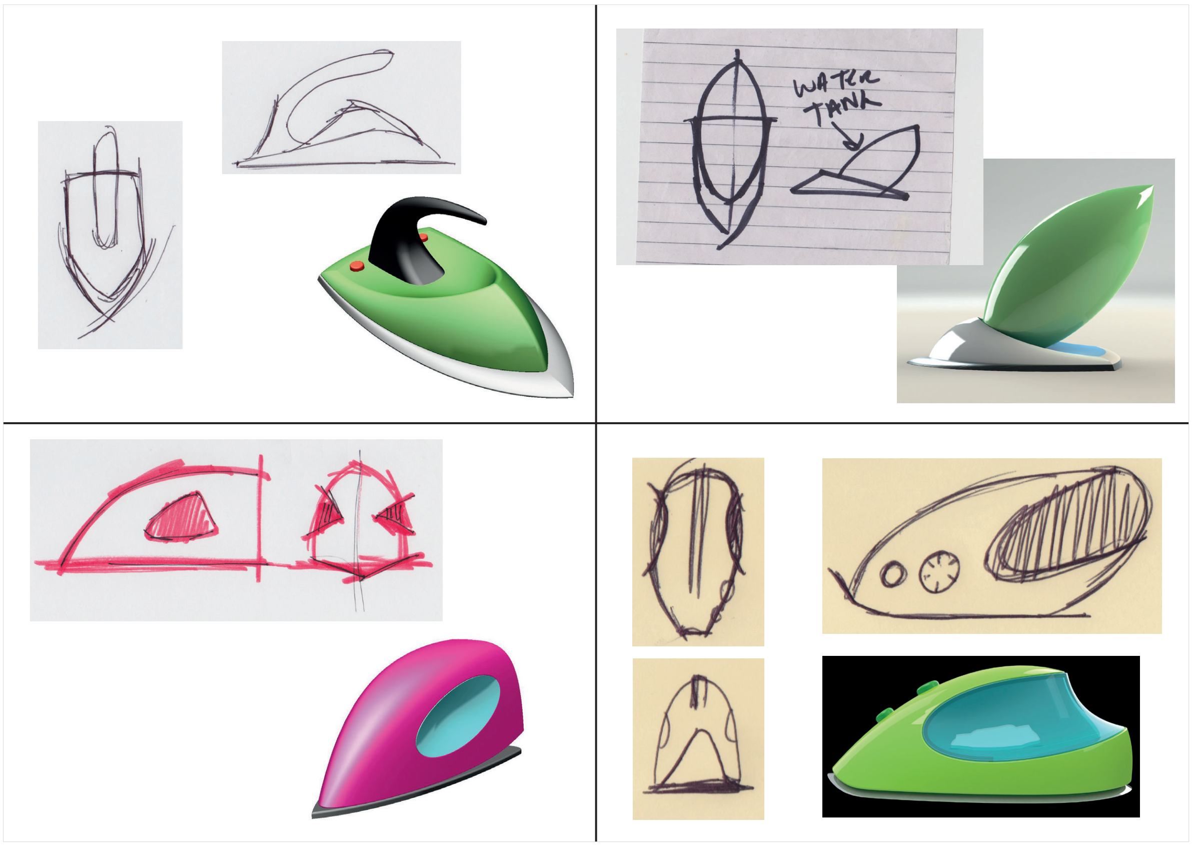


Figure 104: Steam iron sketch and CAD model development. Source: Author.

In other instances, fictional motifs are as equally as important as details appropriated from the present, such as the creation of the *AsFBS* which subtly relates the guide to the other artefacts and, thus, also helps to bolster plausibility and explicate a fuller, more rounded world. Our third artefact (Figure 105) is a press release written by fictional UK Government Chief Scientific Adviser, Dr Clement Benway, on behalf of the *Council for Science and Technology* and the imagined body *Better IoT Global*. Figure 106 depicts logo development for the fictive press release. Echoing the rhetoric that often besets new technologies, in our fictional world, metahistory data, in conjunction with blockchain, is considered to hold 'transformative possibilities for environmental sustainability'. Accordingly, the press release outlines how the sustainable benefits of these technologies will be 'optimised' by the UK Government. After a successful trial period, blockchain, with its transparency and traceability competencies, is deemed to be a secure and robust method for storing and transferring peoples' product metahistory data. The Government therefore seeks to implement its so called 'Open Traceability Protocol' which will allow retailers and platforms to trade in new or used physical-digital devices while ensuring secure and sustainable transfer of said devices' metahistories. To manage this initiative, the Government has sanctioned the formation of an accrediting body – the *AsFBS* – which retains the power to issue the *Secure Metahistory Certification Mark* (SMC Mark) to regulate any retailers or platforms intending to enter the sector. In the document the UK Government envisages that an optimisation of metahistories will create new markets, generate opportunities for platform development and increase employment in the data mining sector, all of which is expected to boost the UK's economy.

The Council and BIG announce the formation of the *Alliance for Sustainable Blockchain Stewardship* and the creation of the *Secure Metahistory Certification Mark*

For Immediate Release: 23/02/2026

The Council for Science and Technology and Better IoT Global are pleased to announce the formation of the *Alliance for Sustainable Blockchain Stewardship* and the creation of the *Secure Metahistory Certification Mark*. The announcement comes after implementation strategies for both initiatives were approved by Government following a year of research and consultation:

- The Department for Science and Technology's white paper *The Future is Metahistory: Blockchain, Ecology and the Economy* was published 18/01/25 and outlined potential benefits and possible issues with regard to corporate and public adoption and acceptability of Blockchain and the optimisation of consumers' metahistories.

- Technology and consumer trials held across summer 2025 were successful and provided valuable insights for efficient and secure implementation.

- *Open Traceability Protocol* and knowledge exchange - the increased transparency granted by metahistory data regards physical and digital materials is deemed to hold transformative possibilities for environmental sustainability.

- Optimisation will also create new markets and generate opportunities for platform development and data mining jobs which in turn will boost the overall economy.

- Blockchain's inherent decentralisation is a proven secure and robust alternative to traditional centralised transaction systems. There has been growing mistrust amongst the wider public for conventional banking culture since the UK was again plunged into a recession by banking malpractice in spring 2023.

The alliance will work closely with product manufacturers, data platforms and sustainable bodies on advancing open traceability for sustainable benefit.

The certification mark will be used by stores, platforms and applications to denote a secure and sustainable transfer of consumer's personal metahistories using blockchain and smart contracting processes.

Dr Clement Benway,
Government Chief Scientific Adviser (GCSA),
c.benway@gov.uk

Figure 105: In the fictional world, the transparency of product meta-histories underpinned by blockchain have been identified by the UK Government as having considerable sustainable benefits. Source: Stead, Coulton & Lindley (2019).

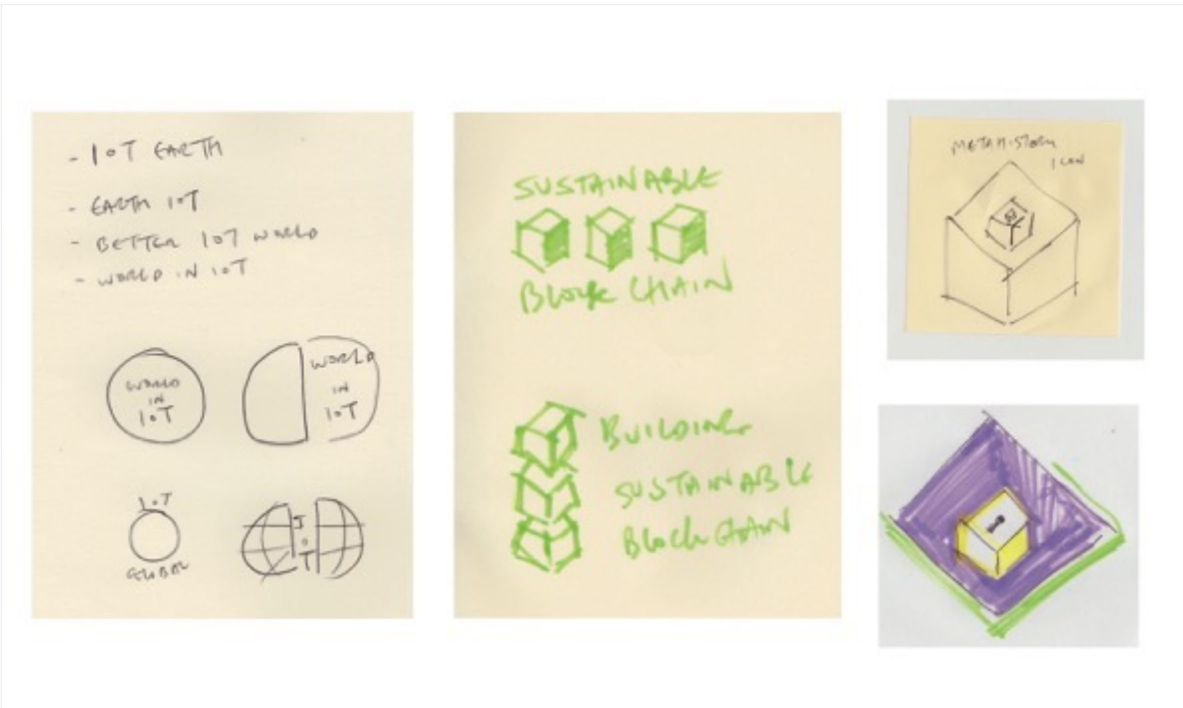


Figure 106: Logo development for the fictional press release. Source: Author.

Figure 107 depicts a user experience tableau for a near future mobile app called *Lazarus* which has been developed under the auspices of the 'Open Traceability Protocol'. Built on blockchain technologies, *Lazarus* enables people to grant access to the metahistories of transferred products. Consequently, users will be able to view gifted devices' provenance data and 'use-stories' – details of how previous users have interacted with such products during their period of ownership. Inspired by popular 'gifting' websites like *Freecycle* and *TrashNothing*, as well as 'buy and sell' platforms like *Gumtree* and *Craigslist*, we wanted this artefact to provoke questions regarding how spime objects might be designed to negotiate the complexities of being traded through second-hand markets. Figure 108 shows development sketches for the fictional app. As the app enables users to gift away devices that they no longer want and/or perceive to be redundant, such users could be considered to be 'reviving' these devices for reuse – or to put it another way 'bringing them back to life.' I therefore chose a name for the app that would connote this – as recounted in the Bible's *New Testament*, *Lazarus of Bethany* was said to have been raised from the dead by Jesus Christ. As one can see in the left-hand sketch, we initially planned to link the *The Future Is Metahistory* worldbuilding artefacts more overtly to those of the two earlier case studies by incorporating the *Toaster for Life* and HealthBand prototypes into the *Lazarus* tableau. Likely 'existing' in the same or similar world to the earlier prototypes, as the app's design evolved, we chose not to do this. The toaster does however feature in Figure 109. Although closer to the design of the app's final interface, one can also see a hairdryer featured in the bottom right hand sketch, it being completed shortly before we chose to refocus on a steam iron instead. In the *Lazarus* would facilitate greater 'asset transparency' by tracking the origins and histories of physical-digital products, verifying their provenance through blockchain and keeping the 'digital instantiation' of the product 'secured' to the 'physical instantiation' of the same product throughout its entire lifecycle. As Sterling (2005) asserts, spimes are 'always associated with a story. [They] have identities, they are protagonists of a documented process'. An app like *Lazarus* might help to empower sustainable behaviour by affording people the opportunity to easily and *securely* recycle, reuse and repurpose data-rich spime objects when they are no longer wanted or considered to be at the end of their useful life. This process sits contrary to the disposable nature of the IoT, where the underlying sustainable value of physical-digital assets are not maximised. An IoT product's data is often simply erased before its material elements are lost to landfill.

As per Sterling's outline, access to spime metahistories could aid people to make more sustainably informed decisions. People should understand that they, as individuals, are also *accountable* for the unsustainability of the connected products they purchase, through how the use them and, perhaps most importantly, through how they dispose of these devices. Likewise, could embracing metahistory also empower retailers and platforms to become a driving force for reducing e-waste and material scarcity? Figure 109 features a fictional customer email receipt from eBay detailing the purchase of a second-hand Internet-connected toaster. Here, we can see that *eBay* has complied with the Government's protocol and included the *SMC Mark* on the receipt to denote that the transaction involves blockchain processes in the transfer of the toaster's metahistory from its previous to new owner.

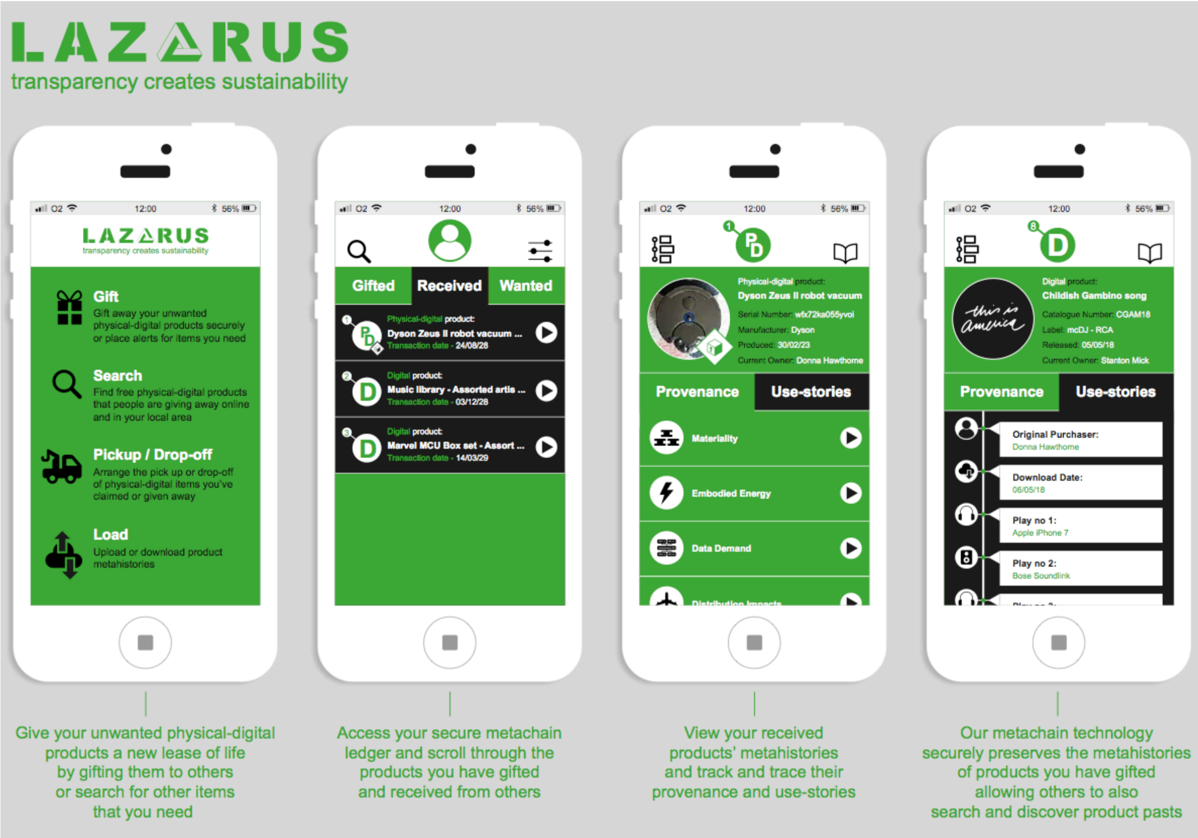


Figure 107: A user experience tableaux for *Lazarus*, a blockchain/metahistory based platform which promotes sustainable consumer behaviour. Source: Stead, Coulton & Lindley (2019).

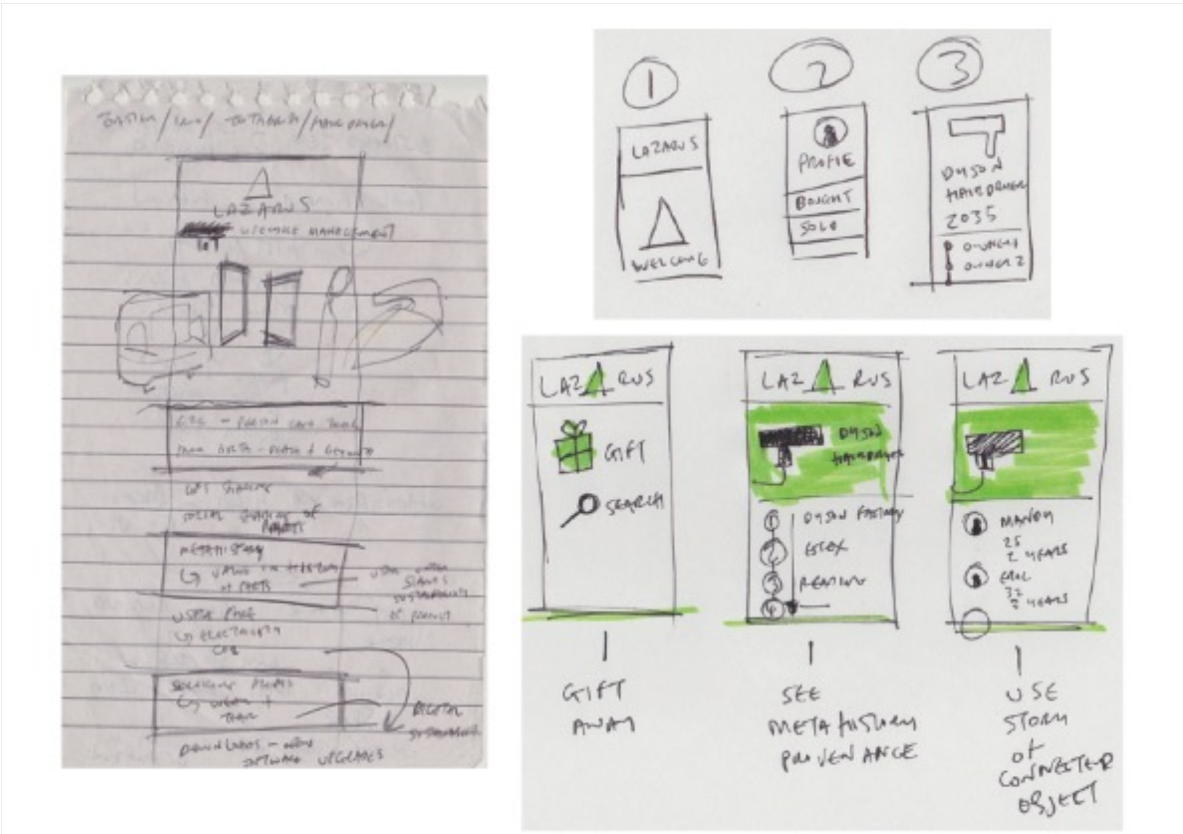


Figure 108: Development sketches for the *Lazarus* app. Source: Author.

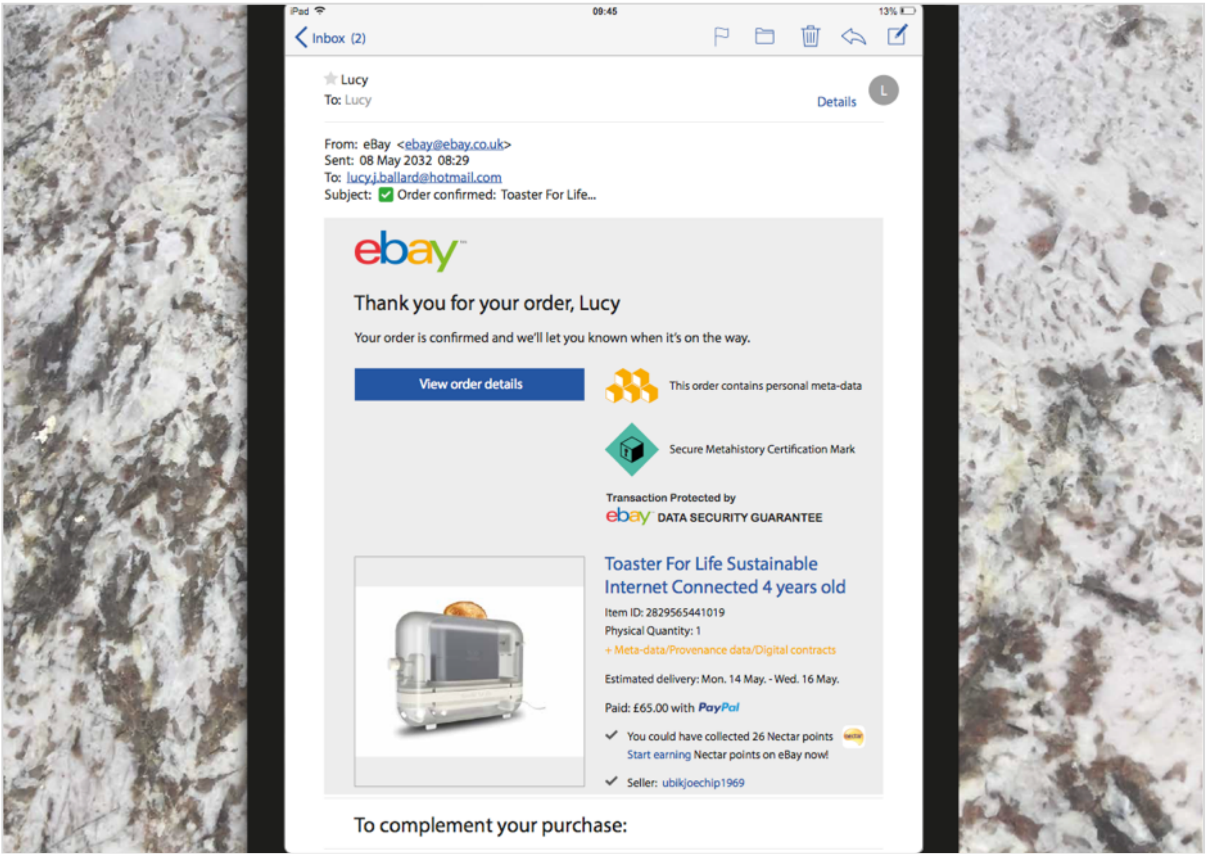


Figure 109: *eBay* has included the *Secure Meta-History Certification Mark* as the transaction involves blockchain & transfer of seller meta-history data. Source: Stead, Coulton & Lindley (2019).

Despite such compliance, some companies might seek to gain from mining the vast silos of metahistory data generated by billions of spime products. Figure 110 is a web interface for a cloud data mining platform operated by the internet giant *Amazon*. So-called 'excavators' can sign up to mine the spime silos for crypto-rewards with Amazon accumulating fees and percentages from their members who successfully mine metahistory blockchains. Figure 111 depicts development sketches for the *Amazon Excavator* interface's layout and graphic iconography. Through building the world, we have sought to frame metahistory as a counterpoint to the increasing anxieties presently being felt towards how Internet platforms acquire, share, and mine IoT data for profit. The transparency of metahistory data has therefore been presented in a positive light through the majority of our artefacts. The Amazon platform and Figure 112's *Change.org* petition however, begin to raise questions about the manner in which we have concretised metahistory, particularly concerning our extrapolation of blockchain technologies and data-mining activities.

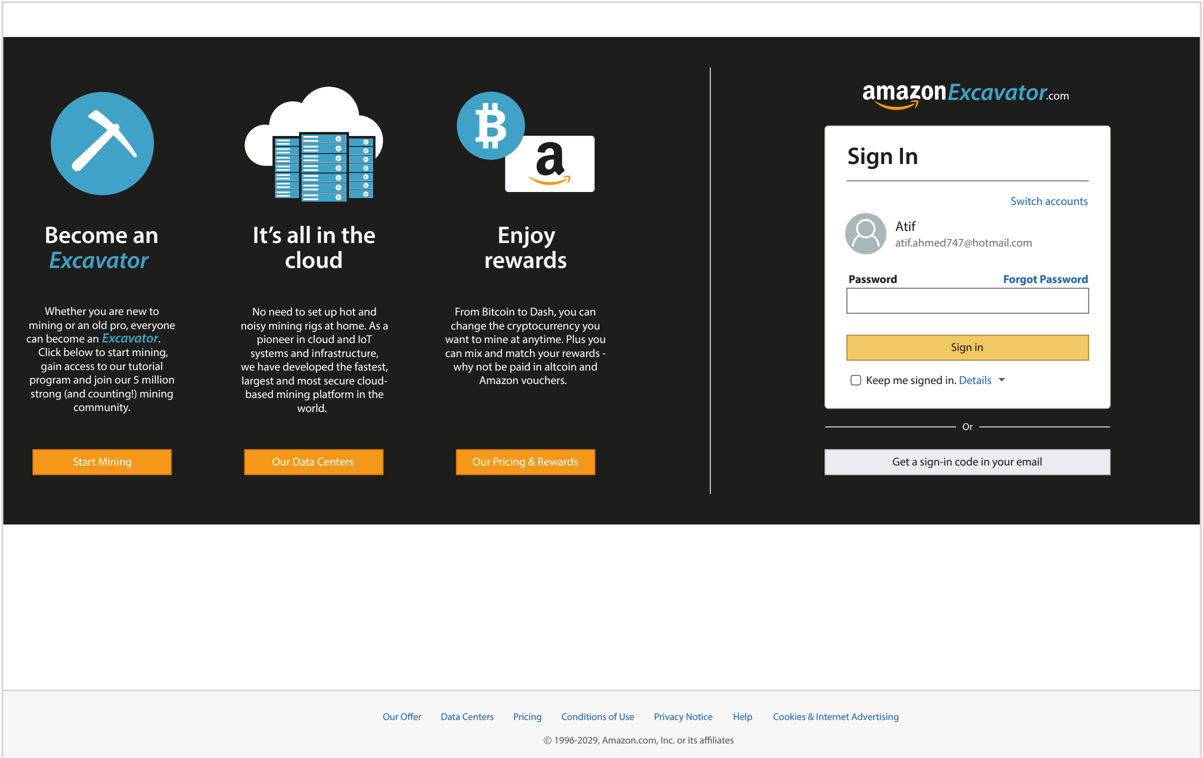


Figure 110: A web interface for a fictional cloud data-mining platform operated by the Internet giant *Amazon*. Source: Stead, Coulton & Lindley (2019).

Figure 111: Development sketches for the *Amazon Excavator* interface. Source: Author.

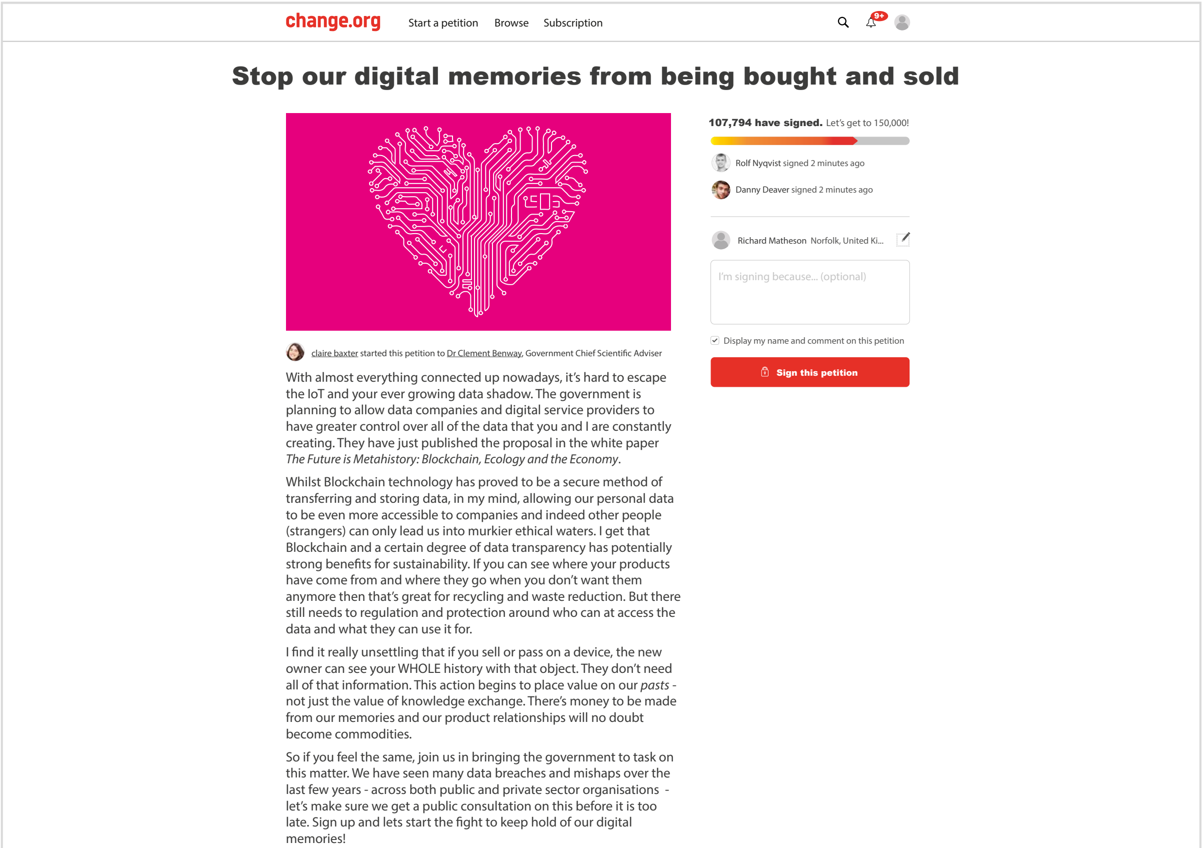


Figure 112: This petition highlights concerns that some people might have regards future 'open traceability' and widespread adoption of blockchain enabled meta-transactions. Source: Stead, Coulton & Lindley (2019).

Established thinking suggests that the side of the IoT that we do not see – the 'invisible' digital processes and infrastructure which covertly distribute peoples' data – should be made more explicit to *individual users* in order to restore and maintain user privacy and security (Coulton, Lindley & Cooper, 2018). Through *The Future Is Metahistory* case study, we have envisioned how the use of immutable blockchain technologies to permanently record and share spime metahistories could be a plausible means of achieving such a goal. But spimes would also go further. To return to Sterling's (2005) original synopsis, metahistory data would remain 'available online for historical analysis by [its user] and *any other interested parties*'. The latter characteristic is problematic, in that it suggests that metahistories would be explicit, not only to a product's owner, or the succeeding owner(s) of the device, but in fact, explicit to *everyone*. Indeed, the caveat of the metahistory concept is that such data would be accessible, searchable and mineable by anyone who is interested in doing so. This seeming contradiction rightly provokes the question – *if everyone has the ability to access metahistories, how is our personal data any more private or secure within the fictional future than it is today?* Emphasising the commercial rewards that could be made from mining personal metahistories, the *Amazon* platform begins to allude to this issue. The fictional *Change.org* petition is more overt, highlighting the concerns that people might have regards the widespread adoption of 'open transparency' and 'asset traceability'. Should the adoption of metahistory be viewed as a trade-off then? The data would be secure and unalterable when stored in a blockchain but it appears privacy would still be comprised. In this spime-based paradigm, are improved sustainability credentials more important than users' privacy?

Another issue that must also reflected upon is the known unsustainability of data mining practices. This is more subtly referenced within the fictional world through the anti-metahistory badges and photo of protestors with 'Say No To Server Farms' placards at the *Make Metahistory HISTORY* march through London in June, 2028 (Figure 113). While the impacts of blockchain technologies themselves are not of specific detriment to the environment, some of the mining activities that they facilitate – Bitcoin being a prominent example – have been shown to be incredibly resource intensive. Mining crypto-currencies consumes copious amounts of energy, increases carbon emissions, and generates large amounts of heat (O'Dwyer & Malone, 2014). Do the negative impacts of mining practices in general, and by association metahistory, nullify any sustainable benefits that might result from adopting spimes as an alternative to the IoT?

Figure 113: Protest badges and a photo of protestors at the *Make Metahistory HISTORY* march through London, June 2028. Source: Stead, Coulton & Lindley (2019).

The Future Is Metahistory case study does not aim to answer the preceding questions, but it does seek to provoke a debate around such issues. We have purposely included the artefacts in Figures 110, 112 and 113 to connote that the fictional world we have built is not a *sustainable utopia*. Instead, we aimed to build a mundane, *plausible* and sometimes messy world – not a pristine, didactic nor unquestionably *preferable* future. Consequently, the world depicted within the fiction is *one* of *many* plausible spime-based paradigms. Fundamentally, like any other techno-culture, spimes would likely have advantages and disadvantages. As noted in my evaluation section of the *HealthBand* study, the principal *spime insight* that I brought forward into the final case study was that I should also broaden the perspectives and interpretations of the spime-like technologies and practices *within the fictional world itself*. Figures 110, 112 and 113 were my attempt to emobody this thinking as part of *The Future Is Metahistory* study.

7.4.3 Insights

A benefit of practising Design Fiction is its capacity to elicit potential *implications for adoption* in regard to new technologies (Lindley, Coulton & Sturdee, 2017). Although the current concerns about the sustainability of blockchain are yet to be resolved, that doesn't mean that they cannot be in the future. I contend our framing of metahistory facilitates the building of a *plausible* world, as opposed to one which is *preferable*, and the case study helps to illustrate that making this distinction is critical when using the spimes concept as a means to envision sustainable connected product futures. In my literature review, I discussed how, to make more sense of the differences between *plausible* and *preferable* speculative futures, critical designers Dunne and Raby appropriated a diagram – the *Futures Cone* – as first put forward by Voros in 2001 (*2 Literature Review – 2.4.4 Futures and Sustainability* – Figure 16 – page 41). They argued that the idea of envisioning preferable futures presents difficulties because the practice raises the question 'what does *preferable* mean, for whom, and who decides?' (Dunne and Raby, 2013). In their interpretation, the diagram is separated into four 'design futures cones' – *probable*, *plausible*, *possible* and *preferable*. The preferable cone (purple) intersects both the *probable* and *plausible*. Figure 114 depicts my own version of the diagram which is based upon my reflection of the design process for *The Future Is Metahistory* fiction, and the previous case studies.

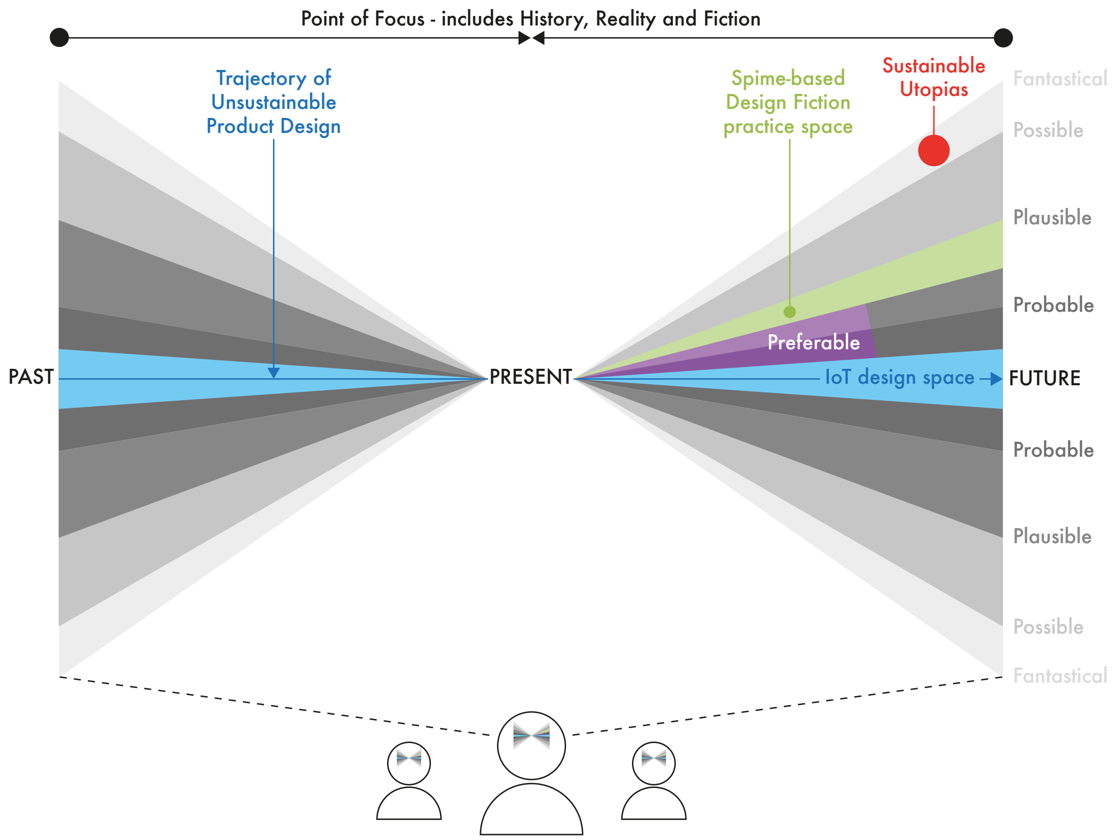


Figure 114: The *Futures Cone* diagram which distinguishes Spime-based Design Fiction practice from unsustainable IoT design practice and the notion of a sustainable utopia. Source: Author, after Voros (2001), Dunne & Raby (2013), Mitrović (2015), Johannessen's (n.d.) and Coulton & Lindley (2017).

I have positioned spime-based design fictions entirely within the plausible cone (green) and have also posited where I consider the ongoing trajectory of IoT design practice (blue) to be situated. As I outlined in my literature review, currently, the design of IoT devices follows long established models of production, consumption and disposal which are proven to be profoundly damaging to the environment (Papanek, 1971; Fry, 2009). As a result, I have positioned the IoT on a fixed path within the probable cone. This *Trajectory of Unsustainable Product Design* extends from the end of World War Two and is defined by mass-production, conspicuous consumption, free markets, globalisation and the adoption of the Internet. Augmenting the diagram further, I have included an additional *fantastical cone* within which I have placed the notion of *sustainable utopias* (red). This is to clearly distinguish mundane and plausible spime-based design fictions from these more chimerical visions of the future which are often marked by technological 'solutionism' (Morozov, 2013). The positioning of *sustainable utopias* is also based on Figure 16 (page 41), specifically Johannessen (n.d.) and Mitrović's (2015) vertical metric for identifying *utopian* or *dystopian* Speculative Design futures.

The diagram also makes reference to both the past and *pluralities of design futures*, that is, the notion that people interpret speculative futures and design fictions in their own individual way, based upon their past and current lived experiences. The benefit of this plurality is that different interpretations can lead to new insights and fresh discourse beyond the scope of what those who have envisioned the futures might have originally intended (Coulton & Lindley, 2017).

Despite the reframing of the *Futures Cone* diagram, I contend that *spime-based* Design Fictions, and indeed Design Fictions in general, should not be viewed as a means for *predicting* the future but rather as an effective way of extrapolating emerging technologies and practices in order to raise questions about the implications of adopting them *in the present*. We generated the range of artefacts for *The Future Is Metahistory* fiction in order to emphasise how IoT product manufacturers, governments, Internet service providers and ordinary citizens often brazenly embrace a developing technology like blockchain, yet never consider the wider impacts of such action, particularly the potential consequences for sustainability. The intent is not to provide the 'answers' nor an end solution to the unsustainability of the IoT, but to present a provocation that empowers and drives forward discourse about the growing problems of e-waste and material scarcity. We sought to do this by positing that increased transparency of connected product data would place greater accountably upon designers and producers in relation to the resources they deplete to manufacture connected products, as well as making these issues more explicit to the users of such devices. Further, through fictional artefacts like the *Amazon Excavators* interface and *Change.org* petition, we aimed to build a more fully rounded world in which spimes can be shown to plausibly exist.

7.4.4. Evaluation

The main objective of this final case study was to explore alternate spime-like value propositions arising from the acquisition and sharing of people's personal metahistory product-service data. Having done so, the case study once again provided the basis for an academic publication – *The Future Is Metahistory: Using Spime-based Design Fiction As A Research Lens For Designing Sustainable Internet of Things Devices* at *IASDR 2019, the International Association of Societies of Design Research Conference* held in Manchester, UK. The meta-review of the paper considered it to be *'a highly original and novel work and clearly demonstrates potential to contribute new knowledge.'* However, there was consensus that the paper also took *'too long to get to the design work',* while the *'complex argumentation of the paper, which, whilst well-articulated and referenced, dilutes the central thread of the paper.'*

The first anonymous reviewer was positive on several fronts:

’What I like about this is work is it is extending spimes – an idea introduced in 2005, when sustainable design and enduring product design and modularity and the like were popular approaches – and applying this within the IoT. One of the more novel contributions of the work is to combine spime thinking with blockchain and IoT. This renders these once science fiction ideas much more plausible and pertinent.’

This review went on to also sum up the paper’s ‘complex argumentation’:

‘The paper leverages several fictional spime-inspired products, prototypes and supplementary fictional materials designed by the authors. The discussed examples complement each other, are diverse, plausibly rich, and thought-provoking. ... The discussion featured in the paper is well-referenced, elaborate and multi-faceted. It provides a critical perspective on IoT’s sustainability, instantiated in presented designs and prototypes. It delivers a valuable reflection on the use of spimes in design fictions (and in critical design by extension). It also raises a number of valuable points on design fictions in general.

However, although they believed that the paper *‘contributes to a contemporary research area and one that will be of interest to the IASDR community’*, they also argued that:

‘There is a need for discussion of the research method and in particular a brief justification of why these methods are appropriate for the focus of the research. While the method and research focus are interlinked, there is a need to convey WHY this approach is adopted (the use of design fictions is presented with limited justification).’

Like the first, the second reviewer was complimentary:

‘This is an original and engaging contribution. The fictitious products are particularly appreciated… The subject area is well contextualised and referenced and generally accessible to most readers.’

They went on to assess the paper’s *spime based design fiction practice* as being:

‘A purposeful research lens through which design researcher-practitioners can explore the meanings and implications of sustainable connected product futures [while] *the findings provide a contemporary view of the reimagined futures cone* [which] *provides a key contribution to the field.’*

Yet an issue that needed further articulation for this reviewer was:

‘The beneficiaries of the research and how they may benefit from the research findings. While the paper provides a number of valuable research insights, it would be helpful to explicitly state which groups may benefits (and the manner in which they may benefit).’

Despite this latter concern, the reviewer concluded that *'overall, this is an interesting and well-conceived research paper that will contribute to debates at the conference.'* Based upon these reviews, I revised and augmented the paper to include more justification for the use of Design Fiction techniques to explore the spimes concept, alongside detailing the types of groups and fields that the research intends to contribute – both within academia and beyond. This resubmission process led directly to the principal *emergent knowledge* or 'learning output' from this final *micro material engagement*. In essence, I understood the need to explicitly identify the potential stakeholders whom my research could benefit. This became a main tenet in the production of the resultant manifesto for spimes and the academic paper that accompanied its creation. Reflecting back upon *The Future Is Metahistory* study, the key *spime insight* discovered through the process is that the impacts of IoT datafication, both environmental and social, also need to be considered to the same degree as the material implications of increased connected device design, production and usage.

7.5 Summary

To give credence to my argument that the design culture of the IoT is inherently unsustainable, in this chapter I presented three spime-based *Design Fiction* case studies. Each study explores different *key classifying design criteria for potential spime objects* as identified in the preceding chapter, whilst they also highlight the possible broader implications of adopting such designs. As such:

- The *Toaster for Life* study explores the *sustainability*, *technology* and *temporality* criteria as a means to examine how spimes could affect connected product business models and user behaviour.

- *HealthBand* explores the *synchronicity* and *wrangling* criteria as a means to examine how spimes might impact product design policy through the democratisation of design-innovation practices.

- *The Future Is Metahistory* explores the *metahistory* criteria as a means to examine what the implications of spimes are for digital ethics and data ownership.

In summary, the three case studies emphasise the sustainable value of spime objects, their possible impact, and how unpacking the concept through *Design Fiction* methods can help designers to begin to reframe connected product design practice. In the next chapter, I will outline how, when viewed collectively, my three case studies provide a series of contributions which have potential significance for both sustainable connected product design theory and practice.

8 Contributions

8.1 Introduction

Based upon the preceding research, in this chapter, I present the contributions that my doctoral research makes to academic knowledge and praxis. I conceptualise these contributions as generalisable theory in the following three forms: the *Spime-based Design Fiction Practice Space*, *Spimes As A Multidimensional Lens* and *Spimes Not Things: A Design Manifesto for A Sustainable Internet of Things.*

8.2 Spime-based Design Fiction Practice Space

The *The Future Is Metahistory* case study helped determine that whilst an IoT device can be characterised by the convergence of two core parameters – the *physical* (atoms) and the *digital* (bits) – in contrast, a spime object is defined by three core parameters – the *physical* (atoms), the *digital* (bits) and *sustainability* (natural environment). Although I have posited that the earliest, near future spime objects would likely share some technological attributes with present day IoT devices, spimes would not be a mere extrapolation of nascent connective technologies and design practices. As my case studies have made clear, within a spime techno-culture, the sustainability of its connected devices is as significant as their physical and digital properties. Thus, I argue that all three parameters are as of equal importance within the spime design process. Further to this, I contend that the confluence of the parameters results in what I term the *Spime-based Design Fiction Practice Space* (SbDFPS). To illustrate this intersection, I have augmented the original Venn diagram from the *The Future Is Metahistory* case study (Figure 115).

Perhaps the biggest challenge I was presented with when commencing my practice-led research was how to effectively embody the critical thinking that spimes represent 'within' their design. Furthermore, because spimes are for all intents and purposes 'theory objects', it is as yet not feasible to 'actually' design and manufacture spimes. As has previously been noted, normative, commercial design practice typically focuses on solving specific contextual problems, for example, a consumer product designer might create a prototype IoT device in order to figure out which materials it should be composed of, to test that its connective technologies operate correctly, and to ensure its manufacturing processes are as efficient and cost effective as possible. *Design Fiction* practice on the other hand focuses on using prototypes to ask questions and generate discussion about them. Instead of being created to be put into production and commercialised, *Design Fiction* prototypes are used as a means to encourage people to think critically about the issues the prototypes *embody*. I contend that my case studies demonstrate that, within the SbDFPS, it is possible to envision how things might be in a future where spimes exist, why things might be like that, all with a view to highlighting some of the potential opportunities and problems that might arise if societies were to adopt spime objects.

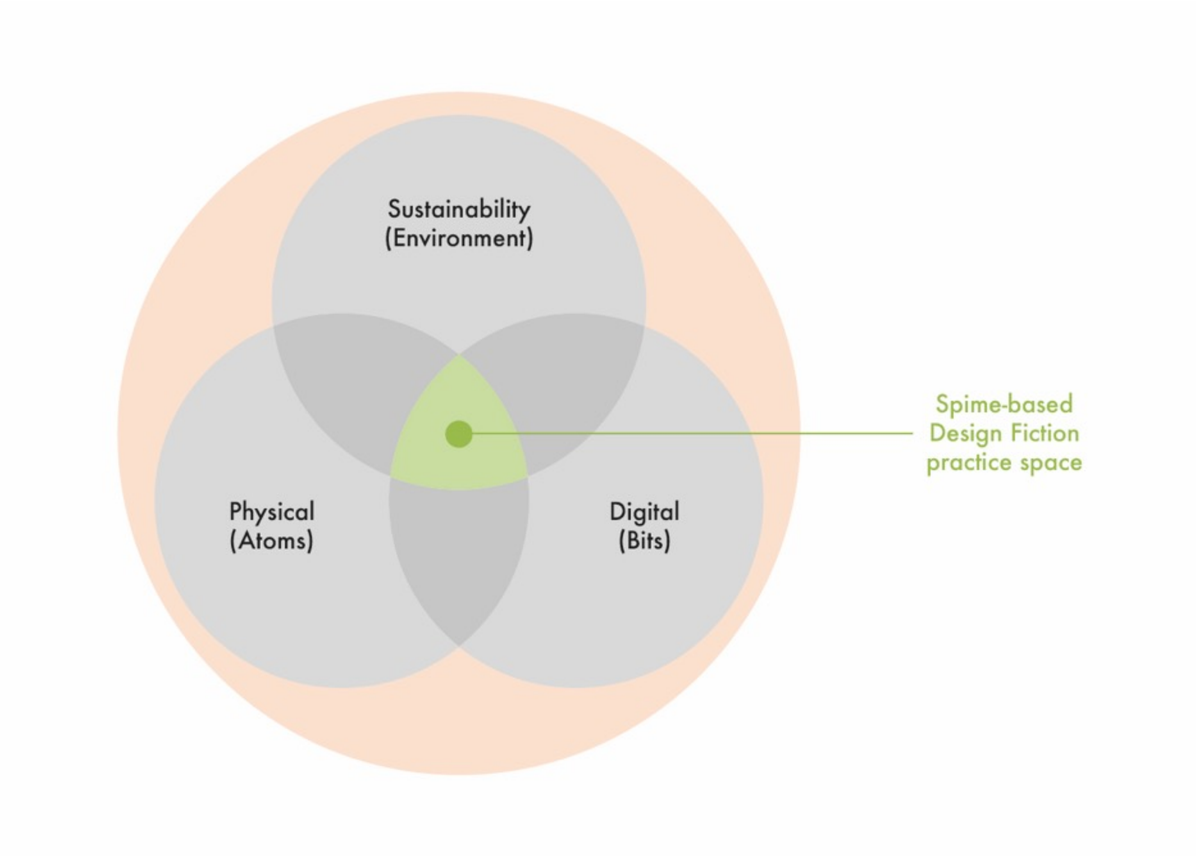


Figure 115: The confluence of the three core parameters that define a spime object results in the *Spime-based Design Fiction Practice Space*. Source: Author.

In addition, *Spime-based Design Fictions* should frame spime objects within *plausible*, proximate futures (10-20 or so years away). Although, distant visions of the future can sometimes be worthwhile, they can easily end up straying into *science fiction*. For example, flying cars, time travel and tyrannical robots are tropes of sci-fi which people often find fantastical or 'too futured'. Based upon the feedback I have received through peer review and conference presentations, I contend that the visions of spime-based *near futures* that I have generated are a useful way of helping audiences to consider the everyday, mundane and sometimes 'messy' implications and values that could possibly arise in a spime techno-culture. Having said this, *Spime-based Design Fiction Practice* should not be seen as an attempt to predict the future or design a specific 'spime solution' but more so as a strategy for opening up inclusive debate about how and why spime-orientated futures are designed and what they might mean. The spime prototypes were not designed with the intention of putting them into production, nor are they finalized 'end products' or concrete sustainable solutions. My *Spime-based Design Fiction Practice* aims to critique the growing unsustainability of the IoT whilst also imagining how connected objects could be designed to be more sustainable in the near future. In essence, the SbDFPS can be considered as a *discursive space* in which spime prototypes are free of the constraints of normative commercial design practice and can challenge peoples' perceptions and expectations of the role technological products and services play in their everyday life.

8.3 Spimes As A Multidimensional Lens

By presenting a near future spime object as 'actually futuristic' within a fictional world, designers can begin to consider the potential implications and meanings that spimes may bring and also question whether such a future would be a more preferable and sustainable alternative to present day modes of production and consumption. In addition, I also argue that conducting *Spime-based Design Fiction Practice* can help the designer themselves to reconsider the impacts and value inherent to their connected product design process. Indeed, the conception of a design fiction proposal is also an innately reflective creative process, as Sterling (n.d.) has been keen to stress, stating that 'the best way to understand the many difficulties of design fiction is to attempt to create one.' As I noted when introducing the concept, in simple terms one can view spimes merely as a type of future internet connected device which would be designed to be more sustainable than present day IoT products. Having generated the three case studies, I contend that the real *design value* of the spime approach lies when it is applied as a *research lens* through which the unsustainability of the IoT can be more thoroughly considered.

8.3.1 Three Sub-Lenses

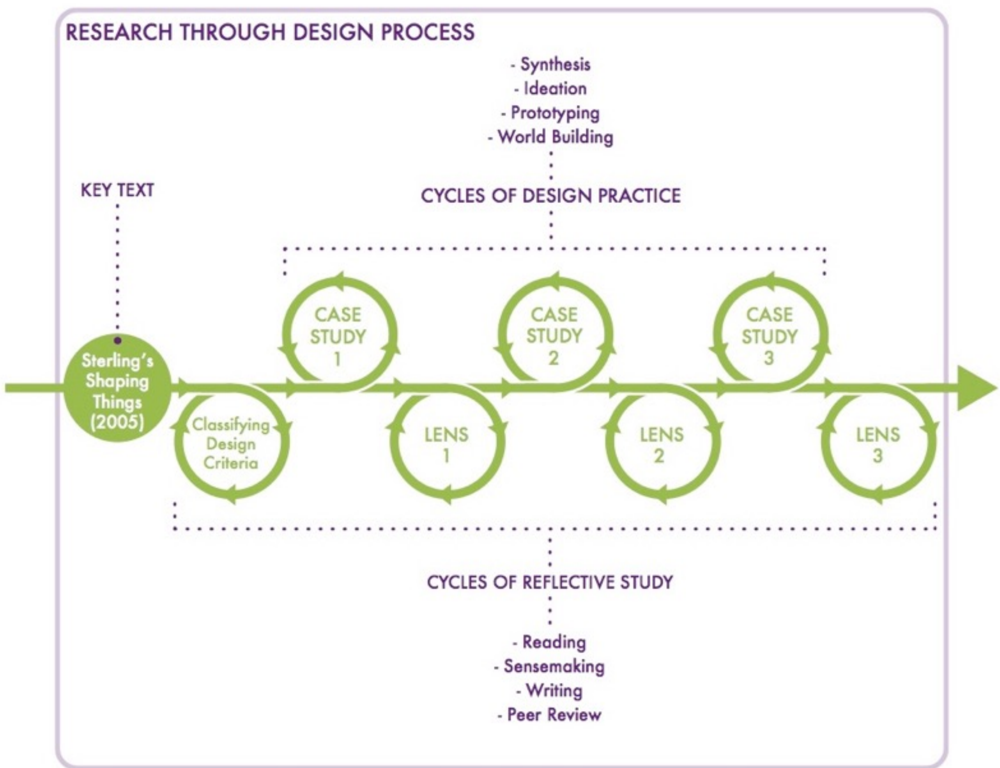


Figure 116: Through my 'macro material engagements' – iterative *cycles of design practice* (action) and *cycles of reflective study* (reflection) – I was able to identify three theoretical sub-lenses for spime design. Source: Author, after Dick (2000; 2007).

As is shown in Figure 116, during my RtD process, each *cycle of design practice* was followed by a *cycle of reflective study*. The latter would involve periods of sensemaking, further reading and academic writing. Each reflective cycle culminated in the production of a peer reviewed paper which both outlines and reflects upon the preceding cycle's practice-led case study. It was through the writing of these papers that I was able to identify three, distinct theoretical sub-lenses for spime design (Figure 117). Having explored the *key classifying design criteria for spime objects* through praxis in the three case studies, they accordingly also manifest in the diagram where they intersect all three sub-lenses. Importantly, the sub-lenses are wider in scope than the *classifying design criteria*. While the criteria centre on particular sustainable design *attributes* of a spime object (in other words, they are primarily concerned with the design of a spime's material and digital instantiation), the lenses' draw attention to some of the broader sustainable, societal and ethical *implications* of adopting a spime techno-culture. For example, I incorporated design specifications like repair and recycling into the *Toaster for Life* prototype as a way to help envision an environmentally sustainable connected product. However, by reflecting upon the prototype and the *Design Fiction* process that I followed to produce it, I have been able to develop a broader theoretical lens which emphasises the wider impact such sustainable design specifications could potentially have on *IoT Product Business Models* and *IoT Product User Behaviour*. Using this approach, the three lenses are as follows:

- Based upon the *Toaster for Life* case study, I identified ***Lens 1: Business models and Behaviours***. Current IoT business models would have to radically change in order to facilitate a device like the *Toaster for Life*. Manufacturers would need to start designing out *planned obsolescence* strategies, put long-term product after-care services in place and revise product warranties to allow for user customisation and repair. With regards to *user behaviour*, the *Toaster for Life* would actively involve its owner in its lifecycle. This would make users more accountable in regard to how they use their connected devices and how they go about responsibly disposing of them when they are no longer needed.

- Based on the *HealthBand* case study, I identified ***Lens 2: Policy and Innovation***. Looking back upon *HealthBand's* fictional crowdsourcing campaign and design process allowed me to more thoroughly consider what sustainable impact democratised technologies and practices may have on connected product design legislation and social innovation user engagement. For connected products such as *HealthBand* to be developed, policy and legislation would need to adapt to accommodate and nurture decentralised and democratised IoT design culture, allowing for localised production while maintaining adequate product safety and quality standards. In addition, with open source technologies and domestic fabrication tools becoming ever-more affordable and accessible, more should be done to encourage people to get involved in these types of activities, not only for sustainable reasons but also because of their creative and altruistic benefits.

- Based on *The Future Is Metahistory* case study, I identified ***Lens 3: Ethics and Ownership***. Through this case study, I aimed to highlight the potential sustainable advantages and disadvantages of making connected product data more transparent and traceable. Consequently, in order for spime metahistories to be optimised for sustainable change, technology platforms and services would have to make all their data processes and digital infrastructures much more transparent to users. The way in which peoples' personal data is handled throughout the IoT today is incredibly complex, difficult to trace, almost invisible to users, and probably unlawful in certain aspects. In light of recent breaches like the *Facebook/Cambridge Analytica* scandal, data transparency is something tech firms need to consider with a matter of urgency. Further to this, as it is difficult to keep track of what happens to it, we need take back ownership of our IoT data. We should do more to protect it by being more careful regards how we interact online and what information we share.

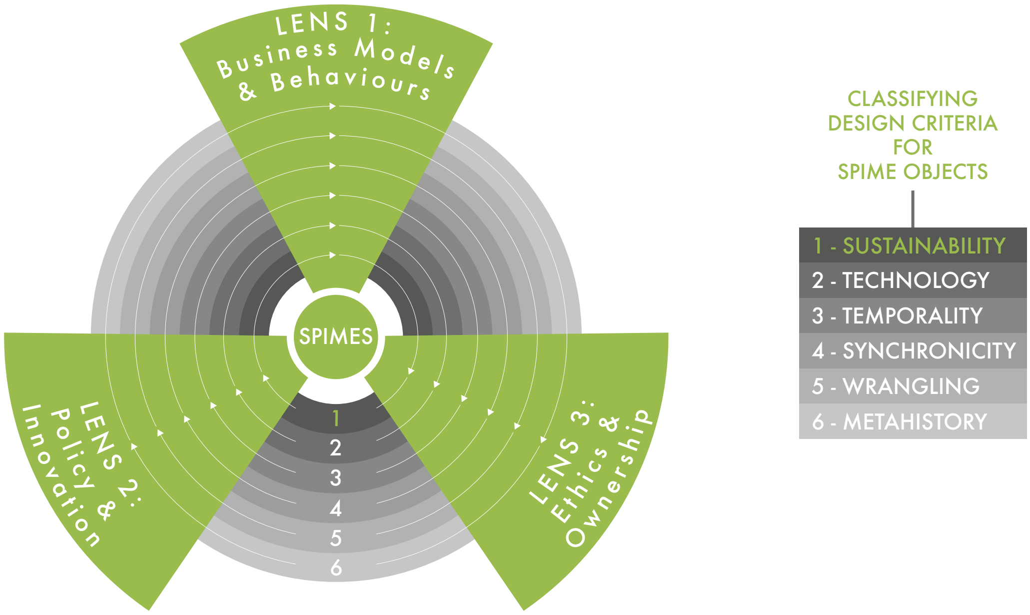


Figure 117: Reflecting upon each case study, I was able to elicit three sub-lenses which emphasise potential implications of adopting spimes. The *key classifying design criteria for spime objects* run through all three lenses. Source: Author.

8.3.2 Macro Lens

The interdependency of the three theoretical lenses is illustrated in Figure 98. One can see that when positioned together, they form an overarching *multidimensional lens for spimes*. It is through this overarching lens that I am able to demonstrate that spimes as a concept, is, in actuality, concerned with more than the technical specifications of near future connected devices. Spimes can, as my research corroborates, be applied as a credible and purposeful research lens through which design researcher-practitioners can explore the meanings and implications of sustainable connected product futures. With this in mind, I draw parallels between my *Spime-based Design Fiction Practice* and Donald Schön's (1983) notion that design should not centre on *problem solving* – for example the creation of specific spime-like 'end products' – but should in fact be more concerned with *problem framing*, that is, the potential meaning and value of said products and the futures they might bring. Consequently, I view the *multidimensional lens* as a gateway through which designers and researchers can conceive prototypes which have significance beyond mere technical experiments to ones that have a potential broader, tangible sustainable and societal impact. Further, such product futures provide means for highlighting such imperatives to the agencies and authorities responsible for facilitating critical change. As such, there remains space on Figure 118 for further lenses to be developed and integrated should I and/or other researcher-practitioners wish to elicit them through *Spime-based Design Fiction Practice*.

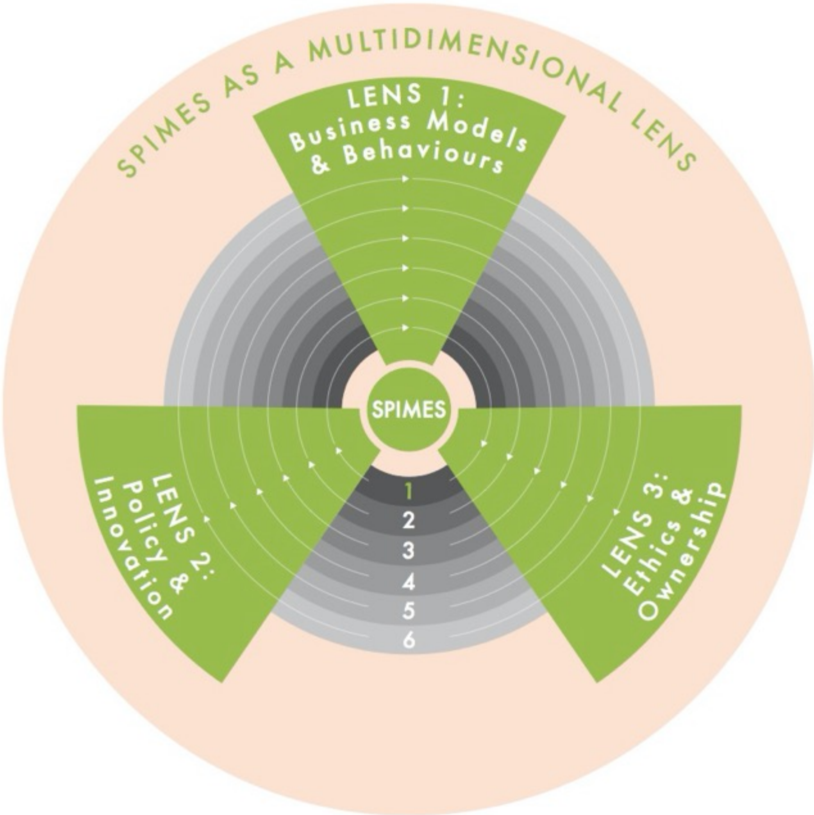


Figure 118: When viewed together, the three sub-lenses form the macro *Spimes As A Multidimensional Lens*. Source: Author.

8.4 Spimes Not Things: A Design Manifesto For A Sustainable Internet of Things

8.4.1 Designing the Manifesto

As outlined in my Methodology chapter (*5 Research Methodology: 5.3.2.7 Generalisability* – page 95), Gaver (2012) argues that manifestos are a compelling way to represent a body of RtD research, as they 'go beyond theoretical treatments drawn from other disciplines or developed from reflection on practice to suggest certain approaches to design as both as desirable and productive of future practice'. Thus, in addition to the traditional academic channels through which have published my spime orientated research including conference papers, journals and indeed this doctoral thesis, I chose to also produce a *design manifesto for spimes*. Entitled *Spimes Not Things: A Design Manifesto for A Sustainable Internet of Things*, Figures 119 and 120 depict the manifesto's front cover and internal pages featuring the second case study *HealthBand* (to view the manifesto in its entirety, please refer to *12 Appendix*).

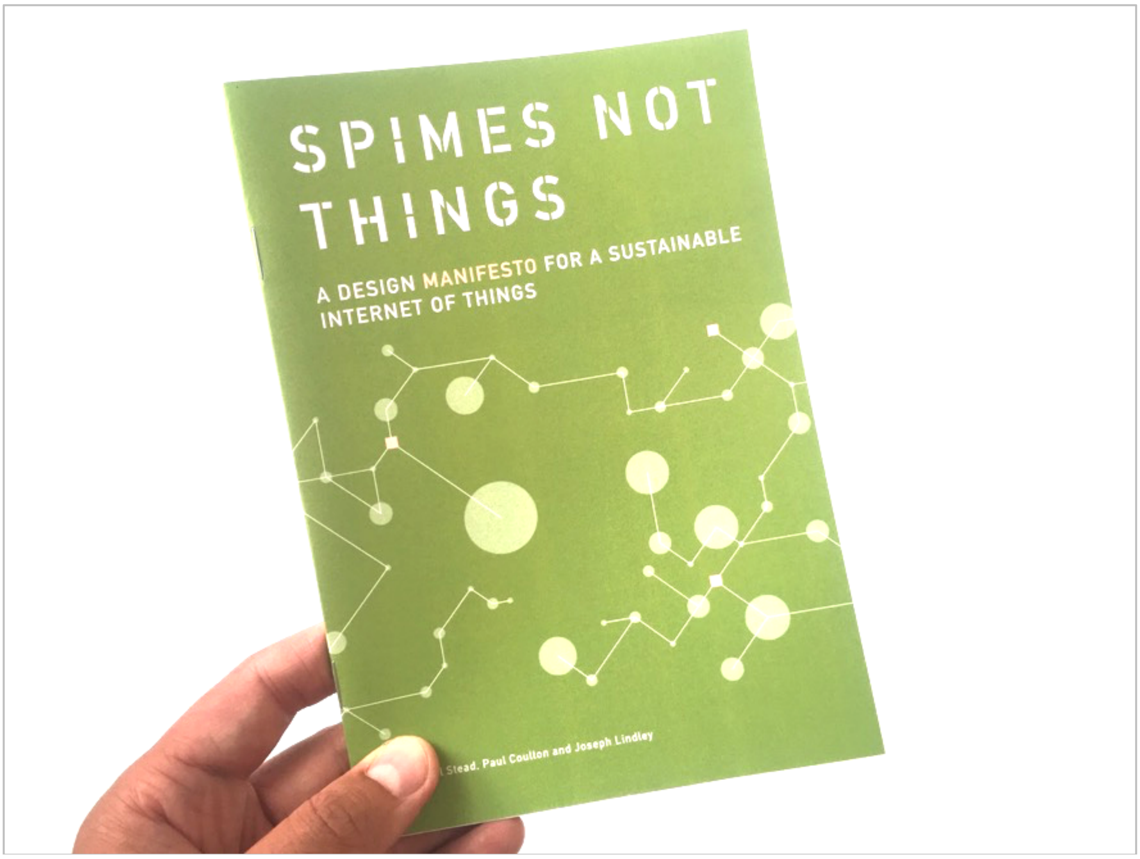


Figure 119: The front cover of the printed design manifesto for spimes. Source: Author.

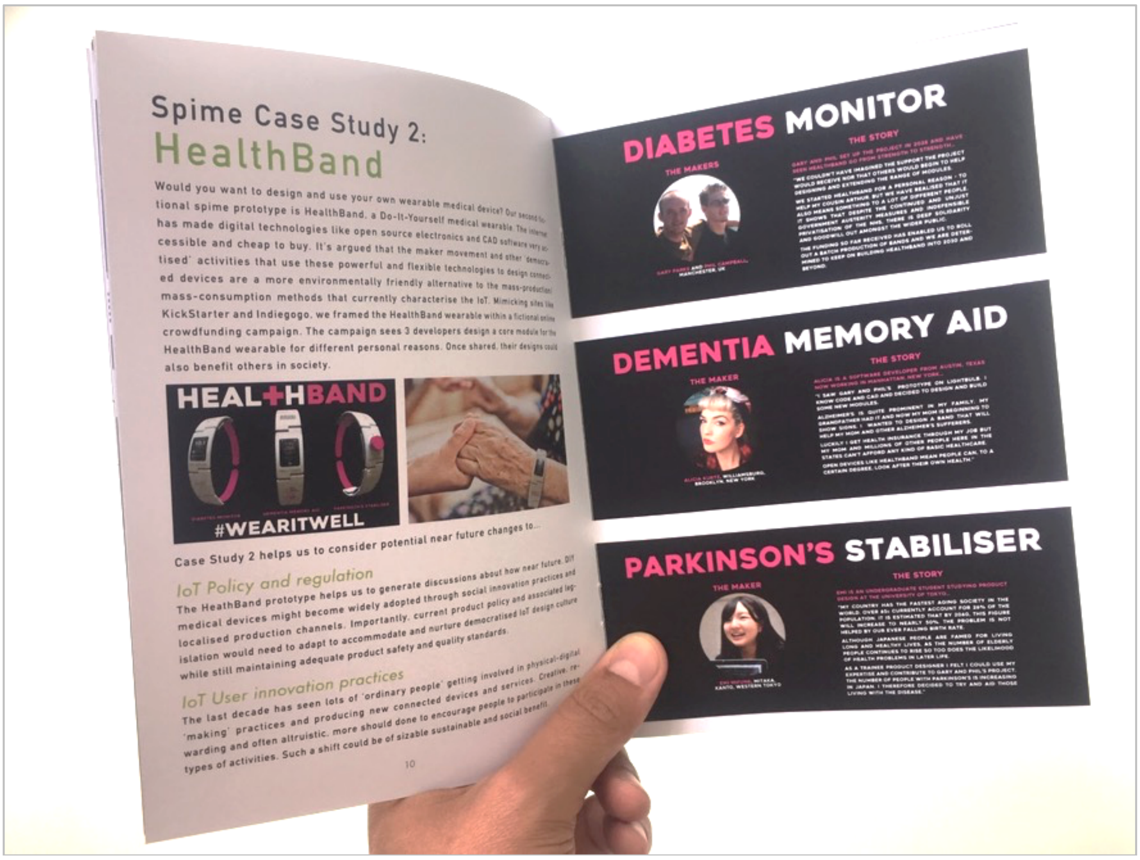
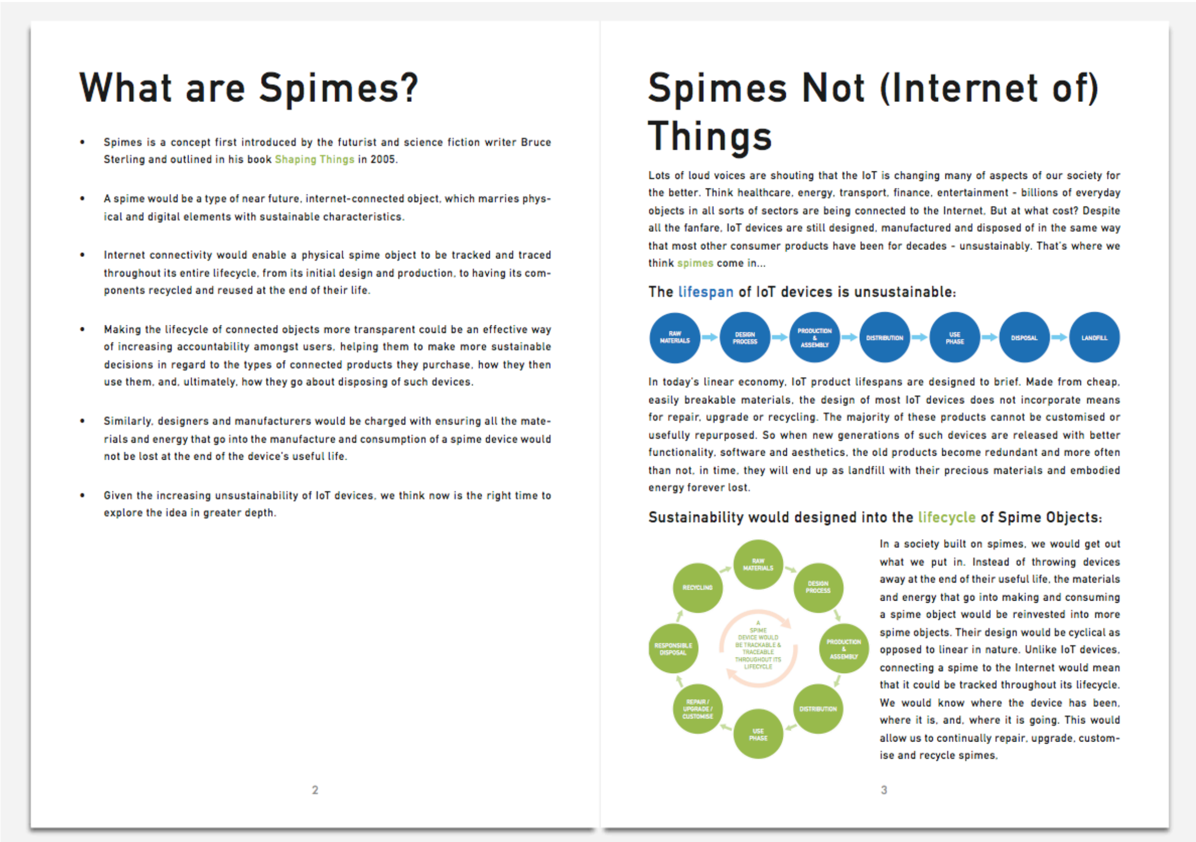


Figure 120: The *HealthBand* case study as presented in the printed manifesto. Source: Author.

Within the disciplines of art and design, the use of manifestos as a technique for presenting new methodological and ideological perspectives has a long and varied history. For example, *Dadaists* were highly critical of how technological advances were being harnessed to maximise the death toll and destruction during the First World War. Consequently, key exponents like Tristan Tzara (2003) were disheartened and pessimistic about what may come next and called for the 'abolition of the future' in their manifesto writings. Leader of the *Italian Futurism* movement F. T Marinetti and writer of the 'The Founding and Manifesto of Futurism' (1909) argued that manifestos must *take no prisoners* (Apollonio, 2009). As such, Marinetti (2006) stressed that manifestos were a means to present new ideas that sit 'contrary to established practice [and] disregard the example and cautiousness of tradition so that, at all costs, we can invent something new'. In this vein, my manifesto uses the spime case studies as a way to frame and critique the unsustainable design culture that pervades the IoT, while also envisioning potential, plausible alternatives to current products and practices. The document seeks to galvanise product designers, interaction designers, creative technologists and makers into action – the people who have the skills and know how to use materials and technologies to design future sustainable connected products. The manifesto is also written with environmentalists, connected product manufacturers, tech firms, politicians and legislators in mind – those who campaign for sustainable change and those who have the power to deliver it. Ultimately, like the *multidimensional lens for spimes*, I see the manifesto as tool that can be used to reframe design practices that will contribute to a more sustainable IoT product paradigm.

8.4.2 Dissemination

I have included key aspects of my spime research throughout the manifesto but have sought to convey such ideas in a manner with which non-academic audiences like commercial designers, technologists, environmentalists and politicians, might more effectively engage with (Figures 121 and 122). The manifesto is therefore reasonably short in length and easy to read. In addition to Gaver's validation regards manifestos as an effective RtD technique, I feel that disseminating my research in this way is also very much in keeping with *Design Fiction's* adoption of 'new media'. In 2019, I was the lead author for the peer-reviewed paper *Spimes Not Things: Creating A Design Manifesto for A Sustainable Internet of Things* which was published at the *European Academy of Design* (EAD) conference and later in *The Design Journal.* To quote an anonymous reviewer of this paper – *'by including a manifesto designed to be consumed by a non-academic audience [the research] answers the question 'How might we bridge the divide between academic research and real-world practice? ... having the manifesto as an output is a master stroke. It lifts the paper beyond the abstract world of academia and gives it real world relevance.*' Alongside the printed hard copies which I have dispersed at academic conferences like EAD and industry events, I have also created a Twitter feed – @SpimesNotThings – onto which I have posted the manifesto. My hope is that as I continue to explore spime-based design futures post-thesis, I can also share existing and new work online with the aim of engaging with audiences beyond academic peer review (Figure 123). By sharing my practice-led case studies, it is my hope that my research can begin to help others to consider how they might design spime-like devices and why a refocussing of their design practices in this way could start to build a more sustainable IoT. Crucially, I take pains to stress that the spime prototypes contained within the document are intended to be viewed as *examplars*, and not as 'end products' for production, nor as solutions to the specific unsustainable characteristics of the IoT that each case study critiques. Similarly, I argue that the prototypes should not be seen as archetypes of how spime objects *should* be designed, but rather, as three examples of the many ways in which a spimes *could* possibly manifest in the near future. As I have previously discussed with regards to *Design Fiction* and RtD, although they may appear convincing, my prototypes serve foremost as *provocations* and as embodiments of theory.


What are Spimes?

- Spimes is a concept first introduced by the futurist and science fiction writer Bruce Sterling and outlined in his book Shaping Things in 2005.
- A spime would be a type of near future, internet-connected object, which marries physical and digital elements with sustainable characteristics.
- Internet connectivity would enable a physical spime object to be tracked and traced throughout its entire lifecycle, from its initial design and production, to having its components recycled and reused at the end of their life.
- Making the lifecycle of connected objects more transparent could be an effective way of increasing accountability amongst users, helping them to make more sustainable decisions in regard to the types of connected products they purchase, how they then use them, and, ultimately, how they go about disposing of such devices.
- Similarly, designers and manufacturers would be charged with ensuring all the materials and energy that go into the manufacture and consumption of a spime device would not be lost at the end of the device's useful life.
- Given the increasing unsustainability of IoT devices, we think now is the right time to explore the idea in greater depth.

2

Spimes Not (Internet of) Things

Lots of loud voices are shouting that the IoT is changing many of aspects of our society for the better. Think healthcare, energy, transport, finance, entertainment - billions of everyday objects in all sorts of sectors are being connected to the Internet. But at what cost? Despite all the fanfare, IoT devices are still designed, manufactured and disposed of in the same way that most other consumer products have been for decades - unsustainably. That's where we think spimes come in...

The lifespan of IoT devices is unsustainable:

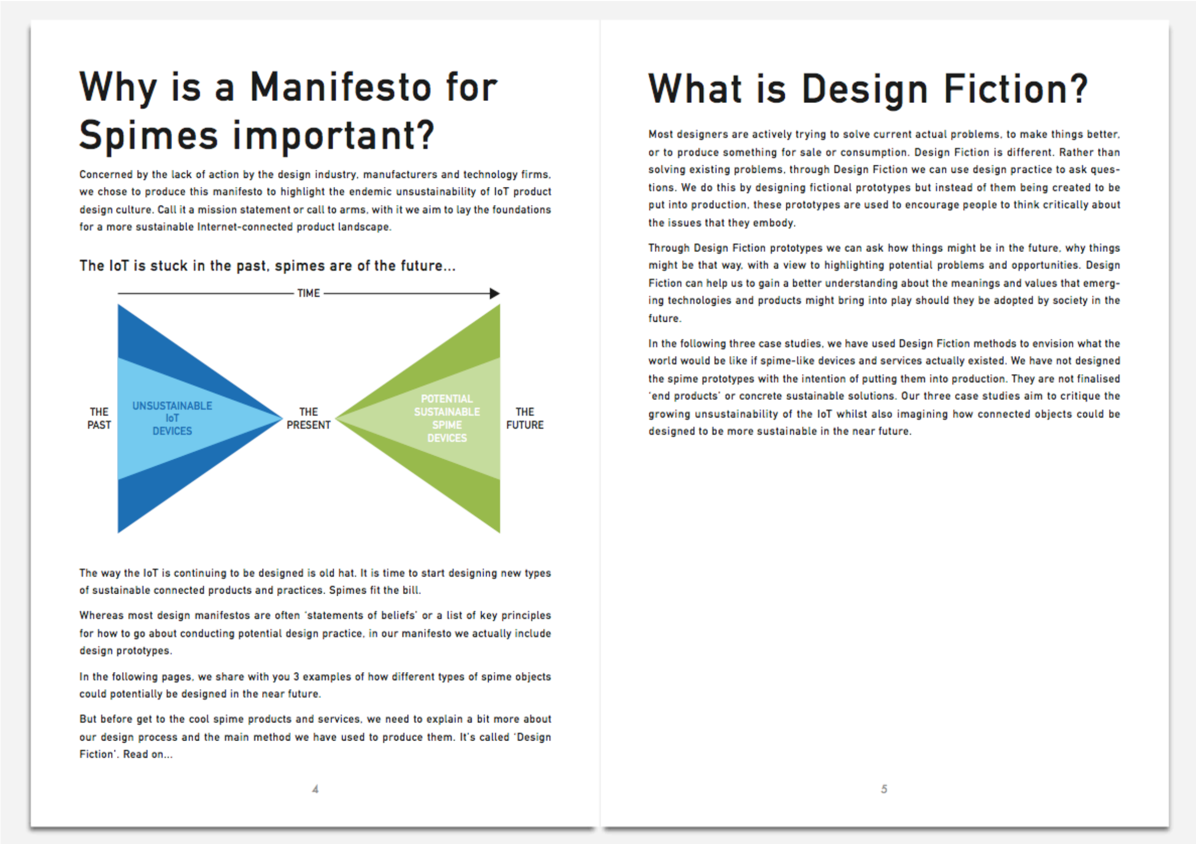
In today's linear economy, IoT product lifespans are designed to brief. Made from cheap, easily breakable materials, the design of most IoT devices does not incorporate means for repair, upgrade or recycling. The majority of these products cannot be customised or usefully repurposed. So when new generations of such devices are released with better functionality, software and aesthetics, the old products become redundant and more often than not, in time, they will end up as landfill with their precious materials and embodied energy forever lost.

Sustainability would designed into the lifecycle of Spime Objects:

In a society built on spimes, we would get out what we put in. Instead of throwing devices away at the end of their useful life, the materials and energy that go into making and consuming a spime object would be reinvested into more spime objects. Their design would be cyclical as opposed to linear in nature. Unlike IoT devices, connecting a spime to the Internet would mean that it could be tracked throughout its lifecycle. We would know where the device has been, where it is, and, where it is going. This would allow us to continually repair, upgrade, customise and recycle spimes.

3

Figure 121: Key aspects of my research are included in the manifesto in a manner that broader, non-academic audiences will potentially easily engage with should the manifesto be presented to them post-thesis. Source: Author.



Why is a Manifesto for Spimes important?

Concerned by the lack of action by the design industry, manufacturers and technology firms, we chose to produce this manifesto to highlight the endemic unsustainability of IoT product design culture. Call it a mission statement or call to arms, with it we aim to lay the foundations for a more sustainable Internet-connected product landscape.

The IoT is stuck in the past, spimes are of the future...

The way the IoT is continuing to be designed is old hat. It is time to start designing new types of sustainable connected products and practices. Spimes fit the bill.

Whereas most design manifestos are often 'statements of beliefs' or a list of key principles for how to go about conducting potential design practice, in our manifesto we actually include design prototypes.

In the following pages, we share with you 3 examples of how different types of spime objects could potentially be designed in the near future.

But before get to the cool spime products and services, we need to explain a bit more about our design process and the main method we have used to produce them. It's called 'Design Fiction'. Read on...

4

What is Design Fiction?

Most designers are actively trying to solve current actual problems, to make things better, or to produce something for sale or consumption. Design Fiction is different. Rather than solving existing problems, through Design Fiction we can use design practice to ask questions. We do this by designing fictional prototypes but instead of them being created to be put into production, these prototypes are used to encourage people to think critically about the issues that they embody.

Through Design Fiction prototypes we can ask how things might be in the future, why things might be that way, with a view to highlighting potential problems and opportunities. Design Fiction can help us to gain a better understanding about the meanings and values that emerging technologies and products might bring into play should they be adopted by society in the future.

In the following three case studies, we have used Design Fiction methods to envision what the world would be like if spime-like devices and services actually existed. We have not designed the spime prototypes with the intention of putting them into production. They are not finalised 'end products' or concrete sustainable solutions. Our three case studies aim to critique the growing unsustainability of the IoT whilst also imagining how connected objects could be designed to be more sustainable in the near future.

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Figure 122: The manifesto outlines the significance of the research. Source: Author.

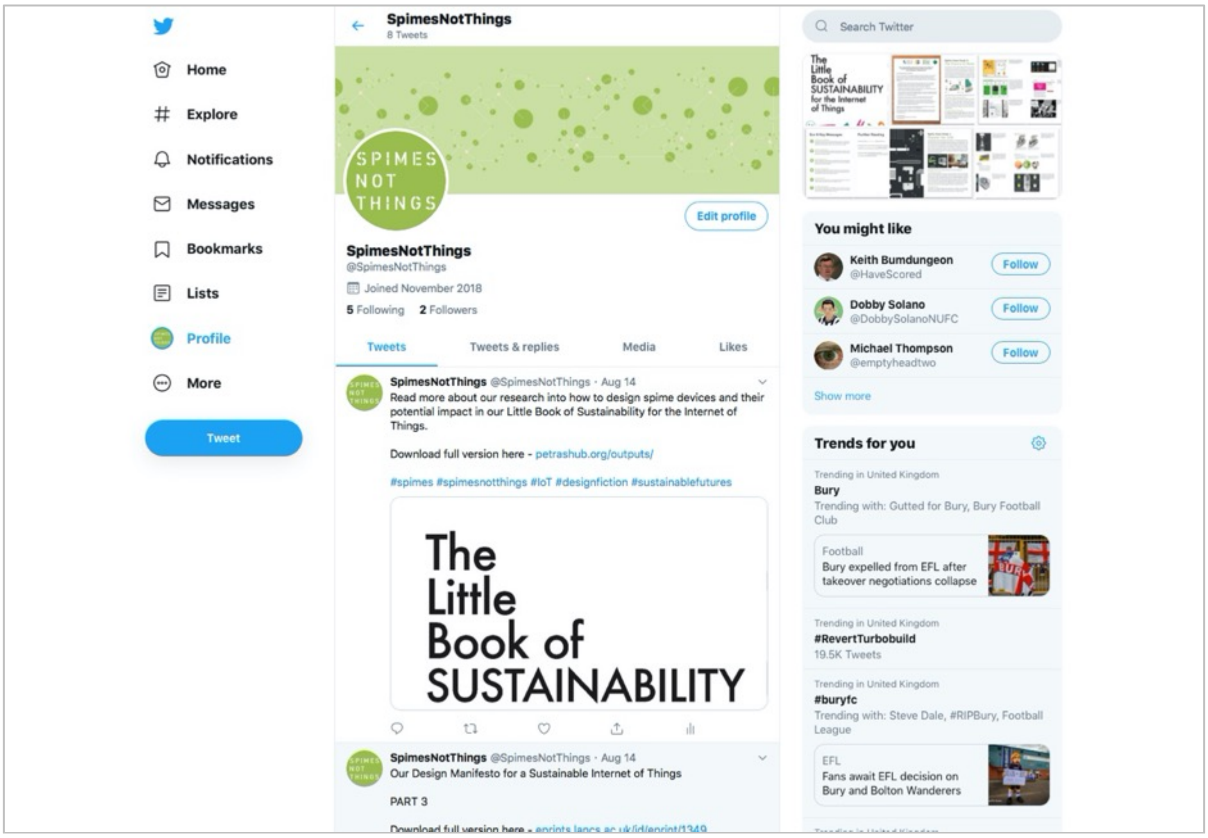

Figure 123: The *Spimes Not Things* Twitter profile. Further non-academic engagement and dissemination of my research is planned post-thesis. Source: Author.

8.4.3 Key Messages

Other design manifestos can be very prescriptive, in that, they often present a list of dogmatic commandments which readers are advised to follow in order to generate the 'perfect' design outcome, or even to ascertain a greater philosophical perspective with regards to the nature of design praxis. Although they can sometimes inspire creative outcomes, I argue that famous design tenets, such as Dieter Rams' *Ten Principles of Good Design* (Rams, cited in Klemp and Ueki-Polet, 2010) and Donald Norman's *Principles Of Design* (Norman, 1988), could be described as 'heavy handed' and advocate design requirements that are, more often than not, unobtainable in practice. While they similarly hold value, I argue that other technologically focussed examples, such as the *21st Century Robot Manifesto* (Johnson, 2014), the *Maker Movement* focused *The Maker's Bill of Rights* (Jalopy, Torrone & Hill, 2006) (these first two examples are both featured below in Figure 124), the *IoT Design Manifesto 1.0* (Van der Vleuten et al, 2015) (pictured in Figure 125) and the *Reconstrained Design Manifesto* (Hanna, Auger & Encinas, 2017) are again, all decidedly broad in scope and merely list firm edicts with limited contextualisation amongst design practice.

Figure 124: Examples of other technology orientated text-based manifestos. Source: Johnson (2014) and Jalopy, Torrone & Hill (2006).

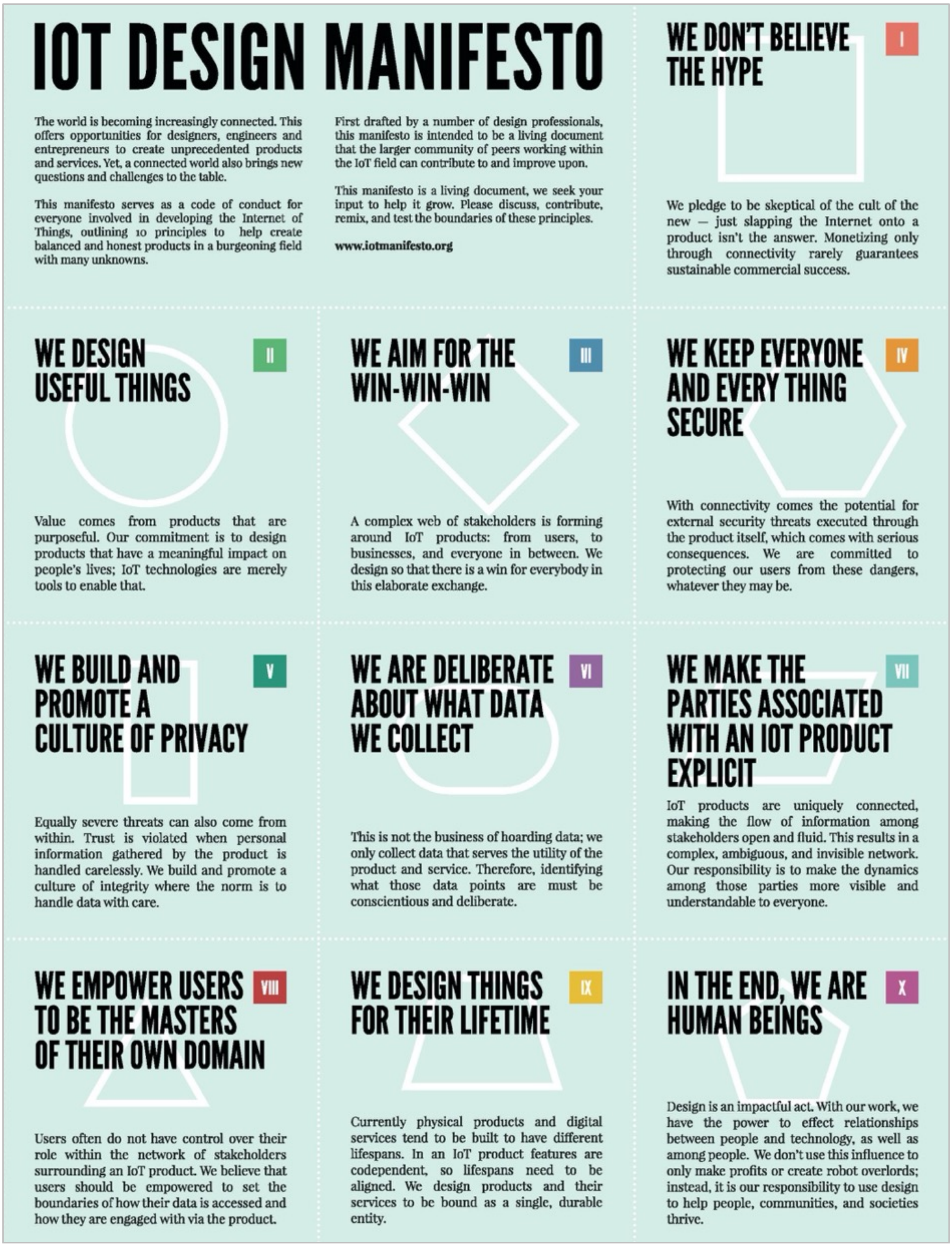

Figure 125: The *IoT Design Manifesto 1.0* does not contextualise its list of edicts in relation to any IoT design praxis. Source: Van der Vleuten et al (2015).

In line with both the provocative nature of my *Design Fiction* case studies and generative RtD methodology, I chose to not include a list of 'static' commandments as part of my manifesto. As one can see in Figure 126, after outlining my three practice-led case studies, I conclude the document with *6 Key Messages*:

- **IoT Business Models**
  IoT businesses should start to think about designing out built in obsolescence strategies, putting long-term product after-care services in place and revising product warranties to allow for user customisation and repair.

- **IoT User Behaviour**
  Users of IoT devices should think more about accountability in regard to how they use their connected devices and how they go about disposing of them when they are no longer needed.

- **IoT Design Policy**
  Policy and legislation should adapt to accommodate and nurture democratised IoT design culture, allowing for localised production while maintaining adequate product safety and quality standards.

- **IoT User Innovation**
  Open source technologies and domestic fabrication tools are becoming ever-more affordable and accessible. Creative and rewarding, people should be encouraged to get involved in these types of practices.

- **IoT Data Ethics**
  Platforms and service providers should start making their data processes and infrastructures less complex and more transparent to users.

- **IoT Data Ownership**
  As it's difficult to keep track of what happens to your IoT data, you could do more to protect it by reconsidering your current online practices including how you interact online and what information you share.

The three lenses provide the basis for these messages, but I once again chose to convey such theory in a more digestible format so that future audiences beyond academic peer review might also more readily consider them. Fritsch, Shklovski & Douglas-Jones (2018) argue that the recent increase in the number of IoT-centred manifestos is a reflection of the growing societal and cultural anxieties people have about the accelerated and disruptive nature of this type of technological change. I have indeed created my manifesto in response to the increasing unsustainability of the IoT which, as I have explained, is primarily due to its culture of exploitation of novel technologies which culminates in the production of superfluous *gizmo* devices. I argue however, by having focussed on exploring mundane, plausible spime near futures through robust design fiction practice and peer reviewed case studies, my manifesto is not based upon hyperbole or empty rhetoric. With its aim to both highlight the said growing issues surrounding the IoT and to also act as a provocation, it would be fair to describe the manifesto as a 'call to arms' or 'mission statement'. And while I have made the case that it is non-prescriptive and not an example of 'best' practice in regard to designing spime objects, my manifesto can be deemed to be representative of a pro-sustainability ideology.

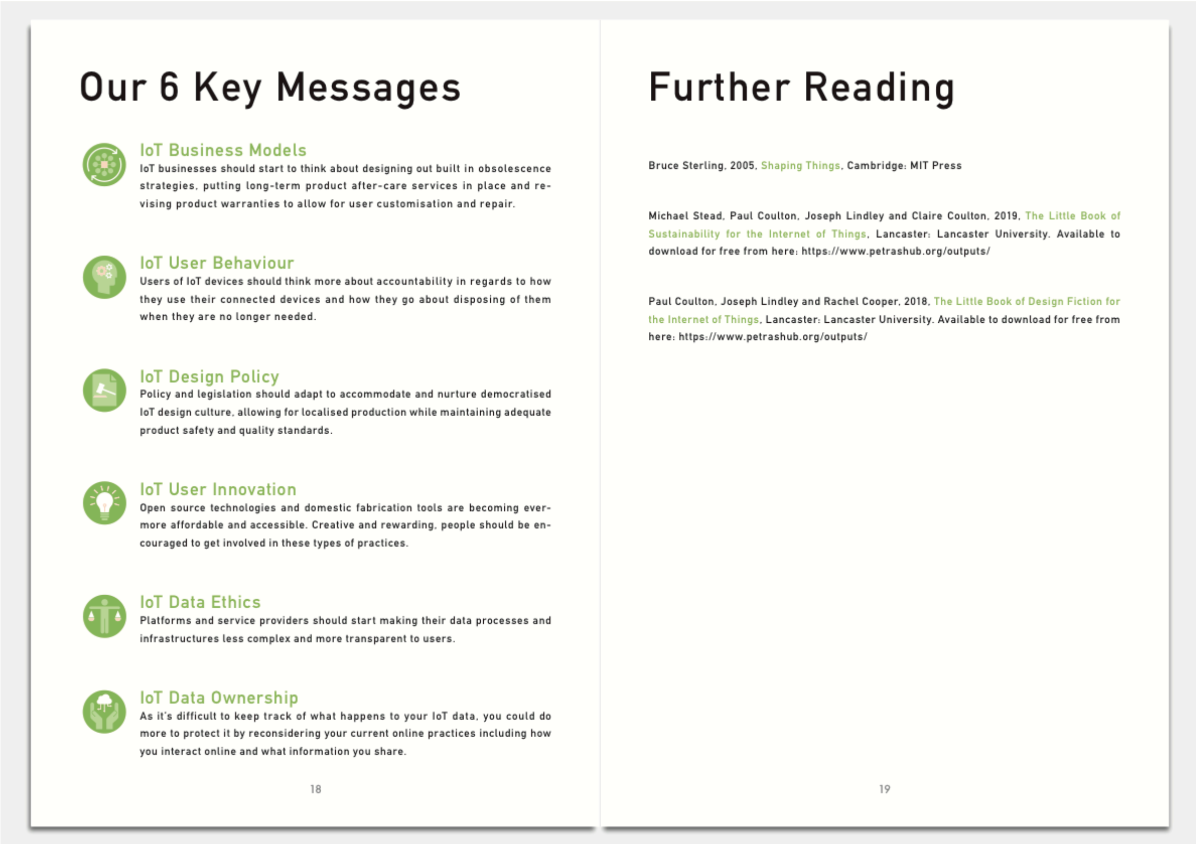

Figure 126: The '6 Key Messages' represent the three lenses that I elicited from each of the case studies, albeit in a more easily digestible form. Source: Author.

9 Conclusions

9.1 Introduction

> *People ask me to predict the future, when all I want to do is prevent it. Better yet, build it. Predicting the future is much too easy… you look at the people around you, the street you stand on, the visible air you breathe, and predict more of the same. To hell with more. I want better* (Ray Bradbury, 1979).

Throughout this thesis, I have sought to emphasise that the current rhetoric which surrounds the IoT across academia and industry is both persuasive and turgid. Many commentators posit that through its expanding array of networked artefacts, sensors and AI capabilities, the IoT will bring about *utopian transformative* change to all sectors of society, from healthcare and energy, to transport and finance (Government Office for Science, 2014; Fritsch, Shklovski & Douglas-Jones, 2018). I have also shown that the narratives that pervade sustainable design discourse can be equally bombastic. Often amplifying tropes found within classical philosophy of technology literature from the likes of Mumford (1934), Ellul (1964) and Borgmann (1984), some theorists put forth dystopian visions which predict human extinction, while others look backwards to rose tinted idylls for answers to the unsustainable nadir we now find ourselves in (Thackara, 2005; Walker, 2014). I contend that while such hyperbole is provocative, it is unhelpful for those attempting to envision more plausible implications arising from the widespread diffusion of the IoT, particularly in regard to the design of future *sustainable* IoT product-service systems.

Much fanfare is made of the IoT's potential utility for reducing energy usage through pervasive monitoring, yet as my research has shown, little discourse recognises the intrinsically unsustainable nature of IoT devices themselves. Under a façade of innovation, IoT product design culture displays a penchant for superfluous *gizmo* style devices, that is, devices that 'solve' problems that do not really exist. Exponents appear so preoccupied as to whether or not they can produce novelty 'enchanted objects', to use Rose's trite term (2014), that they do not stop to consider the lasting environmental damage resulting from such devices. My thesis keenly demonstrates that with IoT design cultures continuing to adhere to long established unsustainable modes of device manufacture, consumption and disposal, the time is right to explore Sterling's spimes concept in greater depth. Consequently, at the close of Chapter 4 (*4 Spimes: An Introduction – 4.6 Key Questions* – page 65), I formulated three key questions that I intended to explore through my spime-orientated practice-led research. In the following sections, I conclude how my work has, as practically is possible, 'answered' these questions.

9.2 What Are Spimes?

Based upon my research, in simple, practicable terms, I consider a spime to be *a type of near future, internet-connected, manufactured device which marries physical and digital elements with innate sustainable characteristics.* Unlike the disposable IoT devices that permeate our society today, a spime would always be designed so that it can be managed sustainably throughout its entire lifecycle, from its initial production process to having its components recycled and reused at the end of its life. To help us better understand the crucial distinction between the *lifespan* of a present day IoT device and the envisioned *lifecycle* of a potential near future spime object, I have generated Figure 127. One can see that an IoT device's lifespan is 'linear' and essentially 'cradle to grave' - it is limited, disposable and unsustainable. IoT product lifespans are designed to brief. Conversely, a spime's lifecycle would be designed to be 'cradle to cradle' – cyclical, ongoing and *sustainable*. Most other scholars who have written about spimes predominately overlook the concept's sustainable advantages and simply conflated the idea with the IoT, in other words, spimes are usually characterised merely as internet-connected devices with more advanced tracking and tracing capabilities. Through my research, I conclude that in a future spime-based paradigm, the prime reason for 'connectivity' would not be to 'hook up' any and every 'thing' to the internet just because it is possible to do so. Nor would it be a means to monitise people's personal data – both being the case with many current IoT *gizmo* devices. Optimising physical-digital connectivity to enable spimes to be trackable and traceable throughout their lifecycle would have a different value proposition entirely – *sustainable change*.

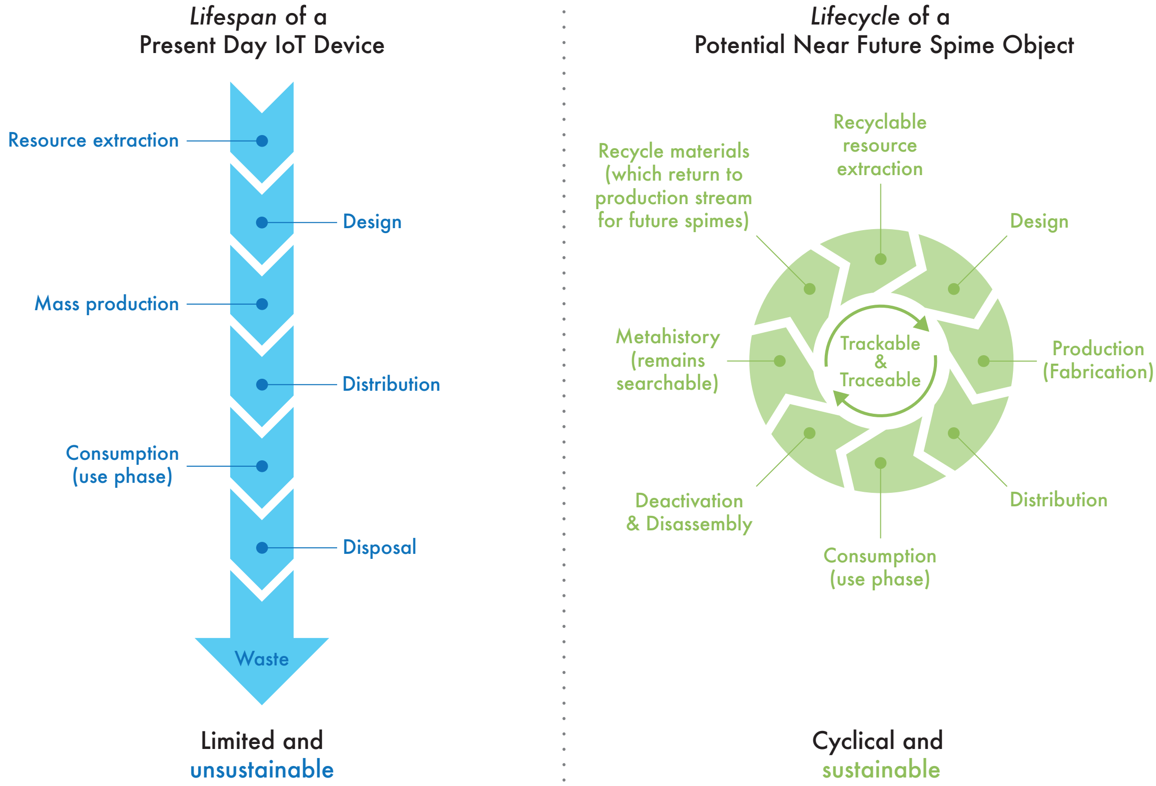

Figure 127: The contrast between the lifespan of an IoT device and the envisioned lifecycle of a spime object. Source: left – after Weetman (2016), right – Author.

Whereas the 'material instantiation' (the physical, tangible component) of an IoT device is only visible to its user, both instantiations of a spime would be explicit and manageable by its potential users. An individual spime object would always be the sum of its 'parts' - its 'material instantiation' and its 'digital instantiation' (the data a spime object would generate, both while being operated by its user(s), and through its own accord as it senses, records and shares information about its operations and surrounding environment). Figure 128 helps to illustrate this second critical difference between spimes and IoT *gizmos*. A spime's *dual transparency* would help to make such devices a greater sustainable proposition than current IoT product-services which are designed to keep their data processes and digital infrastructures hidden from users primarily because developers and platforms want to make money from the data surreptitiously. Making both instantiations of spimes explicit could be an effective way of increasing accountability amongst users, helping them to make more responsible decisions in regard to the types of connected products they purchase, how they then use them, and, ultimately, how they go about disposing of such devices. Similarly, designers and manufacturers would be charged with ensuring all the materials and energy that go into the manufacture and consumption of a spime would not be lost at the end of the device's useful life. Returning to Figure 127, it shows that these resources would all be continually reinvested into the design, production and use phase of *further* spime objects. Enhanced trackability and traceability would aid these processes. So dual transparency, coupled with a focus on product disassembly, and recyclable parts and componentry, would be the principal aspects of a spime object's design specifications.

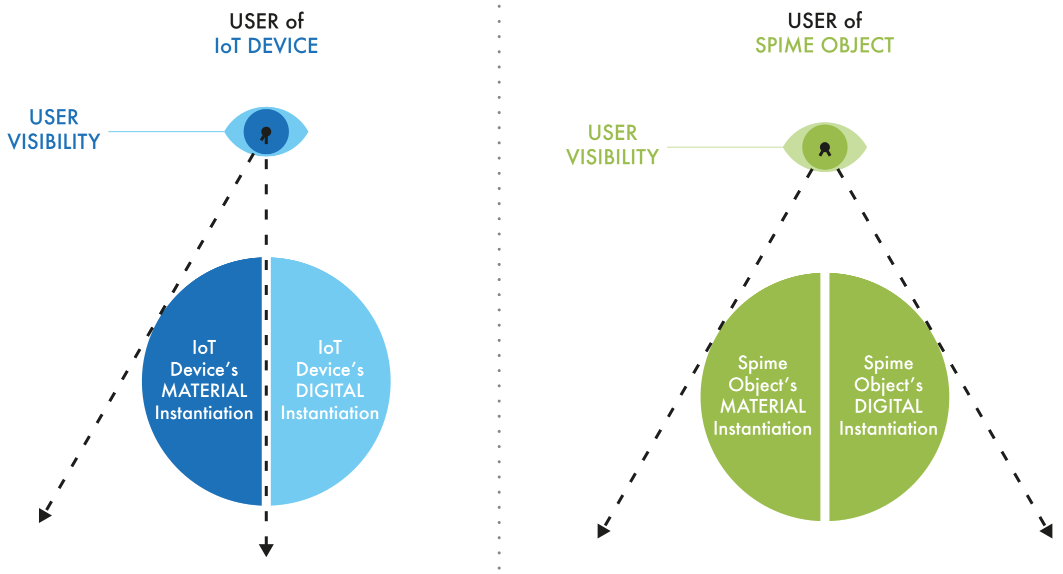

Figure 128: Unlike IoT devices, spimes would be designed so that both their material and digital instantiations would be made explicit to potential users. Source: Author.

In his original outline of the spimes concept, Sterling (2005) noted how the development of new technologies not only influences product design cultures but also has a profound impact upon societies at large. Building upon this outline, in Figure 129 I have depicted the most prominent shifts in societal *techno-cultures* throughout human history. This visualisation updates Figure 23 (in *4.2 What Do We Already Know About Spimes?* on page 54). As noted in this earlier chapter, *artefacts* included early technologies such as bespoke farmers tools and the environmental effects caused by the production, consumption and disposal of these early things was miniscule and more transparent than our experience with the today's man-made objects. Back then, people were much closer to the means of production and used natural materials which could eventually be repurposed or returned to the local ecosystem. Following *artefacts*, peoples' things, and the techno-cultures that they helped to shape, evolved through *machines* and *products* into the *gizmos* paradigm. Self-driving baby strollers (Smartbe.co, 2019), connected underwear (Skiin.com, 2019), smart dental floss (SmilePronto.com, 2019); I have shown that the IoT is a breeding ground for such *gizmo* products which are frequently promoted as solutions to real-world problems. In truth, such examples connect *atoms* (the physical) with *bits* (the digital) as a means for commercial gain. They offer little meaningful value for users, other than providing short-term novelty and superfluous functionality. In addition, devices like these continue to adhere to extremely complex, obscure and unsustainable modes of mass manufacture, consumption and disposal. Appropriately, in Figure 129, I have positioned today's IoT devices within the *gizmos* techno-culture and characterise such product-services as *unsustainable technological things designed to have short lifespans*.

Figure 129: I have positioned the IoT within the unsustainable *gizmos* techno-culture. Source: Author.

As well as a spime's practicable attributes, my thesis has also demonstrated that the concept is, in fact, much more valuable. Figure 130 helps to confirm how I have developed Sterling's concept from a 'think piece' on unsustainable technologies into a *multidimensional lens* that design researchers and practitioners can readily harness to envision potential sustainable connected product futures, whilst also critiquing the harmful IoT production and consumption practices that define our present. *What are spimes?* Spimes, in effect, are a *design mindset*, a progressive ideological stance for approaching sustainable connected product design in the unsustainable IoT era. I argue that my practice-led research has laid robust theoretical foundations for this argument.

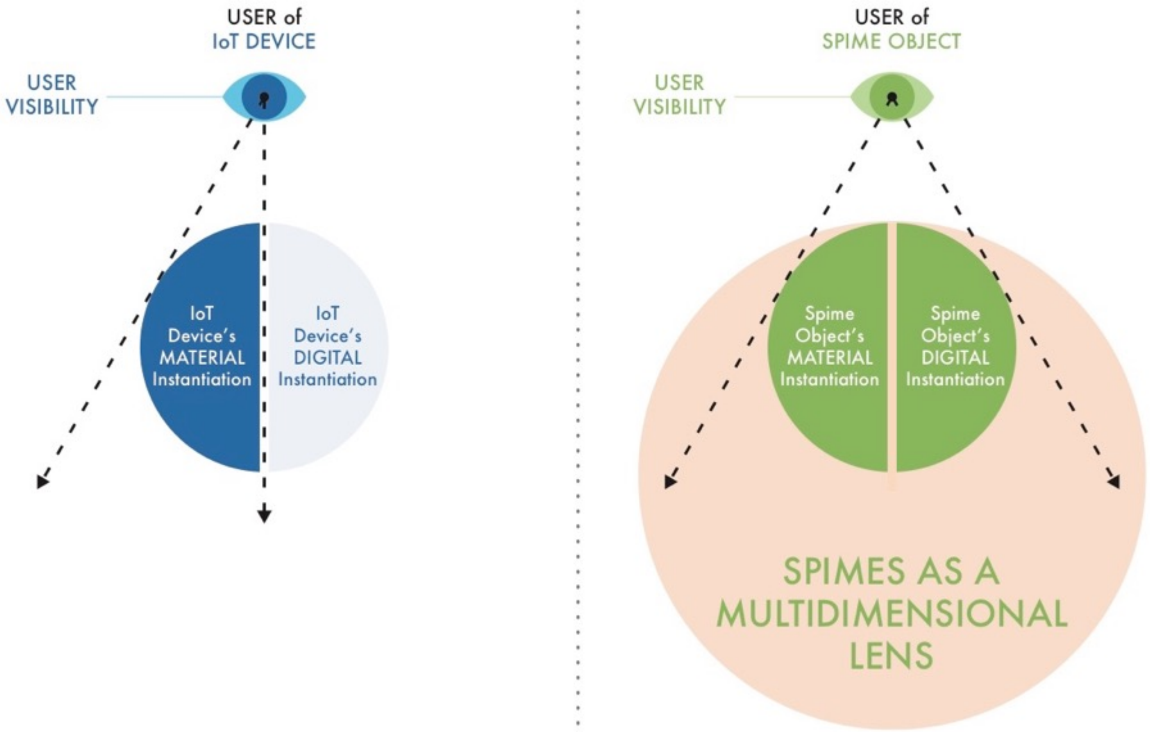

Figure 130: As a concept, spimes should actually be seen as a multidimensional lens. Source: Author.

9.3 Can We Begin To Design Spimes?

Whilst Sterling suggested some of their possible technological characteristics, he has never visualised potential spime devices nor explore the practicalities of incorporating such technologies into their design. This presented the challenge of how to effectively embody the critical thinking that spimes represent 'within' their design. I felt that the best way to resolve this was to utilise *Design Fiction* methods – specifically *Design Fiction as World Building* – to unpack and concretise the nature of spimes objects. Whereas commercial design practice typically centres on solving problems, *Design Fiction* practice focuses on using prototypes to embody theory, to ask questions and to encourage people to think critically about said prototypes. Accordingly, I applied *Design Fiction* techniques as a means to generate my three spime-orientated case studies. The goal of each case was threefold:

- to unpack and visualise key criteria for how spime objects might be designed in the near future;
- to critique different aspects of unsustainable IoT design culture, and,
- to explore possible implications arising as a result of these spime designs.

The progressive nature in which I have explored spimes using *Design Fiction* is in keeping with my overarching methodological approach, *Research through Design* (RtD). Originally outlined by Frayling in 1993, there remains no definite consensus regards how to pursue RtD. Despite this, I believe my RtD process follows Gaver's (2012) interpretation of the methodology, which he argues is 'a route to discovery [where] the synthetic nature of design allows for richer and more situated understandings than those produced through more analytic means'. My process has been a means for *sensemaking* – a way of creating, acquiring and understanding new knowledge regards spimes and the unsustainability of the IoT. As Figure 131 attests, my process has been agile and iterative, combining *cycles of design practice* with *cycles of reflective study*. Through this journey, which I characterised as *macro material engagements*, I have expanded upon the nature of spimes with each case study, subsequently developing the concept into a set of sub-lenses and the overarching *multidimensional lens*. This *reflective practice* corresponds with Schön's (1983) notion of *reflection on action*, where in order to gain actionable or some type of generalisable knowledge from my practice, I have had to appropriately reflect on the activity after the event.

The three case studies were also demonstrative of what I term *micro material engagements* – the implicit, nuanced and dynamic contextual details that 'make up' each individual case of my *Spime-based Design Fiction Practice* (SbDFP). Looking to Figure 132, we can see that knowledge regards spimes and its relationship to the unsustainability of the IoT can be constructed through SbDFP by negotiating: *direct and tangible making*; *proactive reflection* and *emergent knowledge*. As a result, the case studies correspond with what Schön (1983) described as *reflection-in-action* – thinking while doing. The fictional prototypes and artefacts produced via SbDFP build fictional spime-like worlds and such worlds aim to form a *discursive space* in which the implications, values and meanings inherent to the potential spime designs can be debated – both by the designers who envision said spime prototypes and amongst prospective audiences beyond academic contexts. In summary, I contend that my case studies demonstrate that, by carrying out SbDFP, it is possible for designers to envision how things might be in a future where spimes exist, why things might be like that, all with a view to highlighting potential opportunities and problems that might arise if societies were to adopt spime objects.

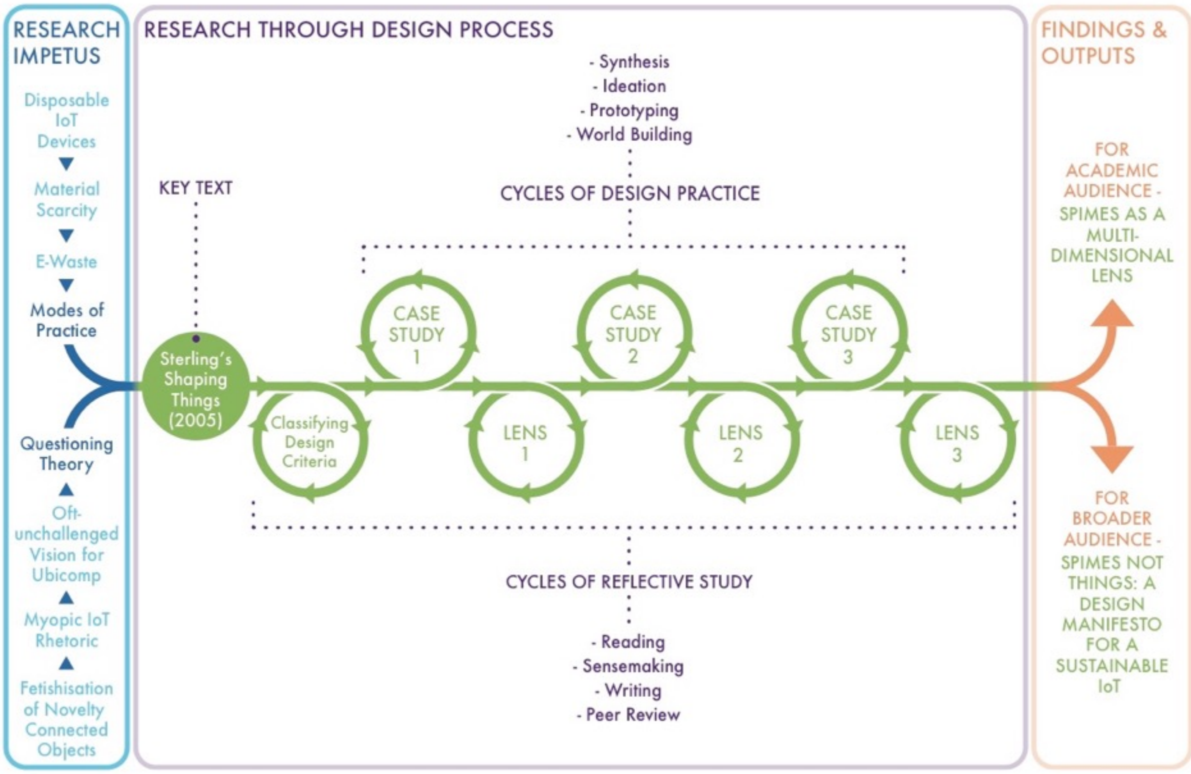

Figure 131: The diagram illustrates the interdependence between the 'cycles of design practice' and 'cycles of reflective study' that characterised my *Research through Design* (RtD) process. Source: Author.

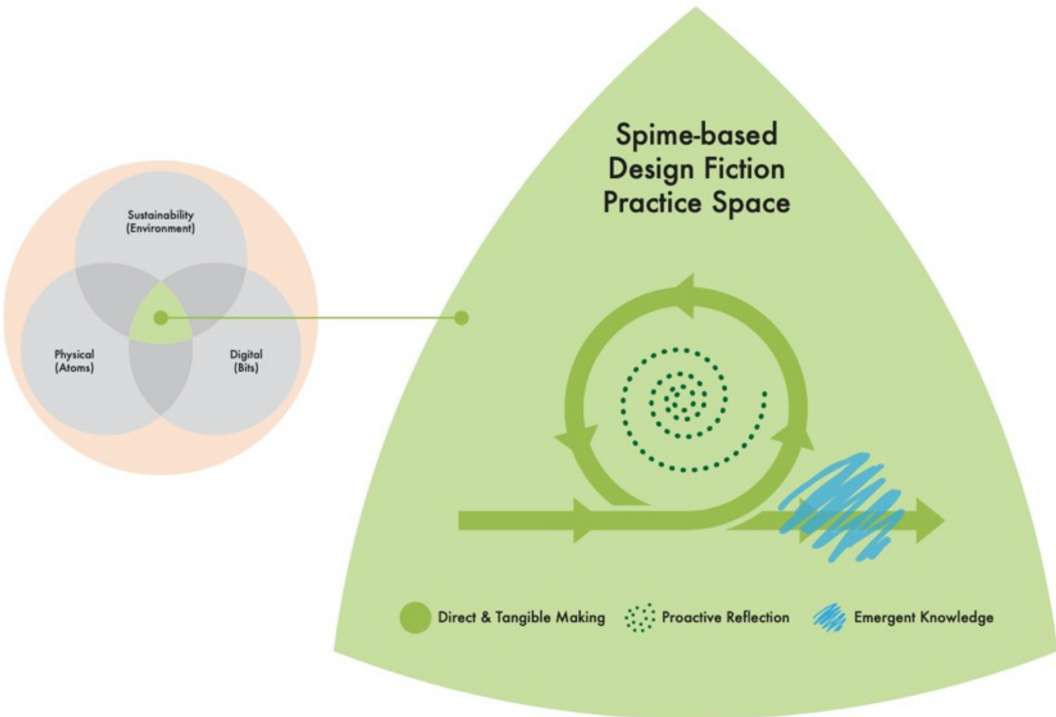

Figure 132: *Spime-based Design Fiction Practice* in focus. Source: Author.

9.4 What does Spime-orientated Research mean for Unsustainable Internet-connected Device Design Practice?

I noted early on in my thesis that a credible strategy for the sustainable design of physical *and* digital objects has yet to be developed. While established sustainable design theory and practice has greatly informed my research, the majority of such approaches have been concerned with inanimate, non-connected devices. It is therefore the right time to develop the spimes concept to address this void. When it comes to designing sustainable devices, I believe it is often easy to fall into a vicious circle of wanting to design something but then not wanting to design anything at all because you are acutely aware of the environmental damage that your product will inflict if placed into production. Consequently, I believe that my research demonstrates that designing spimes using *Design Fiction* methods is a compelling route forward for sustainable connected product design practice. Sustainability should be a fundamental constituent of any connected product design process and *Design Fiction* methods allow us to prototype spime-like devices and consider the potential sustainable impacts and value of these designs without having to put them into production to only then discover their negative environmental implications.

When introducing spimes (*4.2 What Do We Already Know About Spimes?* – page 54), I presented a graph based on Sterling's text (Figure 24) which depicts how the shift to each new pervading techno-culture has led to an exponential increase in the number of physical devices being produced. I have revised and augmented the graph (Figure 133) to illustrate that each of these shifts has resulted in the creation of ever-greater amounts of unrecyclable physical product waste. I have also included the recent emergence of the IoT within the *gizmos* techno-culture, and show how, unless sufficiently challenged, IoT *gizmos* will continue unabated on their unsustainable upwards trajectory (blue). A second trajectory (green) denotes a spime-based paradigm emerging from today's IoT *gizmo* landscape (yellow). I contend that a transition to a spime culture in the near future could potentially reduce the numbers of disposable connected devices being created and subsequently redirect connected product design cultures onto a more environmentally sustainable path.

I concur with Buchanan's (1985) notion that all design practice embodies the rhetorical stance of the designer(s). My application of RtD methodology and thus my spime-orientated research is underpinned by my ontological and epistemic position, this being an *Interpretivist* stance whereby I have constructed knowledge regards spimes through *reflective practice*. This has led me to present spimes as more or less a positive lens – an optimistic and progressive step towards sustainable connected product futures. Despite displaying a pro-sustainability bias, I maintain that the three spime case studies do not provide *preferable solutions*, nor are they visions of a *sustainable utopia*. Furthermore, *Spime-based Design Fiction Practice* has enabled me to unpack and concretise Sterling's concept in a manner in which I would not have been able to do through theory alone. By focussing on relatable and plausible spime-based futures, I contend that both the *multidimensional lens* and *design manifesto for spimes* act as valuable jumping off points for others to begin designing for the sustainability that the IoT, and the planet, desperately needs.

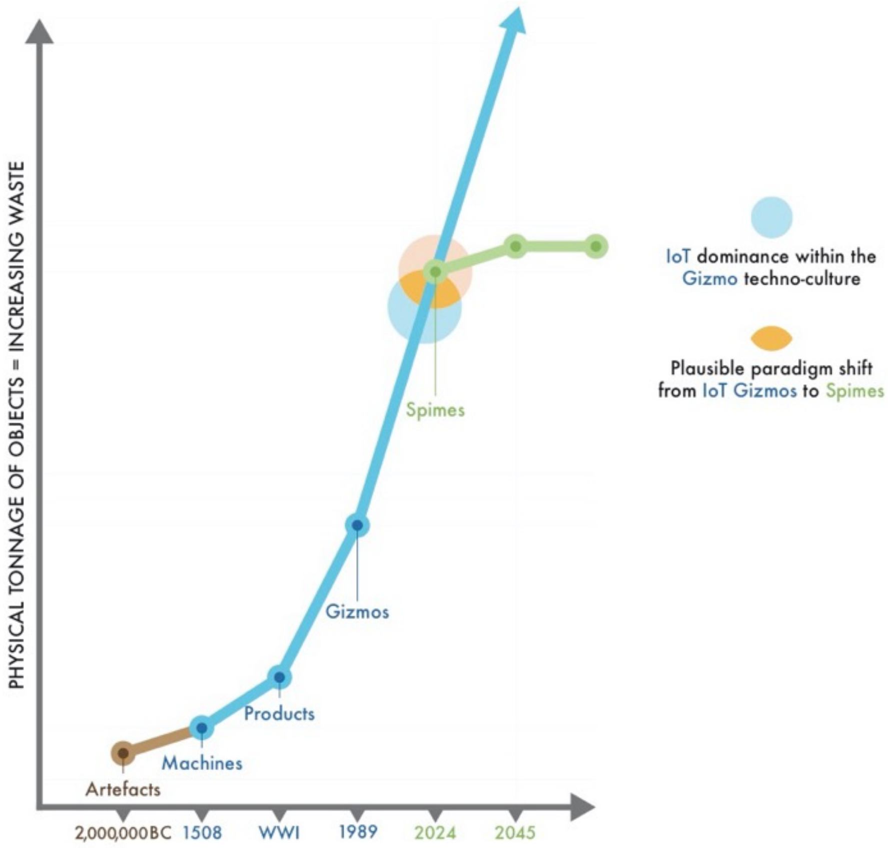

Figure 133: I contend that unless challenged, the design culture of the IoT will continue to increase product waste. Through the application of *spimes as a multidimensional lens*, I posit that design researchers and practitioners could begin to instigate a shift from unsustainable IoT *gizmos* to spimes. Source: Author, after Sterling (2005).

10 Future Work

I view my doctoral research as only the first step within a larger body of work which explores the potential advantages, and indeed disadvantages, of designing the necessary transition from today's unsustainable IoT design culture to a future sustainable connected product paradigm. Thus, in this final chapter, I outline how my spime-orientated research might be built upon and developed further in the future:

- **Further Case Studies**
  When outlining the *multidimensional lens for spimes*, I noted that there remains space on Figure 118 (*8 Contributions: 8.3.2 Macro Lens* – page 183) for further lenses to be developed and integrated should I and/or other researcher-practitioners wish to elicit them through *Spime-based Design Fiction Practice*. Whilst the three case studies have explored all of the six *classifying design criteria* for spime objects, I contend that there remain numerous opportunities for envisioning further worlds in which 'actually futuristic' spime products exist. In the final case study, *The Future Is Metahistory*, I outlined how the aim was to build a mundane, plausible and sometimes messy world – not a pristine, didactic nor unquestionably *preferable* future. Consequently, the world depicted within the metahistory fiction, and indeed the preceding two case studies, are just particular examples of *many* potential spime-based paradigms. Thus, as a means for producing further *Spime-based Design Fiction Practice*, other voices might frame or configure the six *classifying design criteria* in different ways or even develop entirely new criteria. Likewise, fresh case studies and their associated sub-lenses could focus upon a multitude of other implications that come with designing and potentially living with spime devices, services and systems. For example, one might start by considering where copious amounts of spime generated metahistory data could be stored? What are the wider environmental impacts of the ensuing spime server centres and data distribution infrastructures? Or might spime data be housed in silos close to its point of origin similar to the nascent theory of *Edge Computing*? Would this proximity reduce data-related energy emissions? Would the advances and growing autonomy of Artificial Intelligence mean that computers and machines could use harvested data to design and build their own spime devices without human intervention at all? How would this increase in non-human datafication impact upon the already contentious issues of connected data privacy, surveillance, malware and cyber-attacks? What happens when spime AI goes bad?

- **Evaluative Engagement**
  Given that it is my intention for this doctoral research to lay the *academic foundations* for future spime-based theory and practice – with the *multidimensional lens* and *manifesto* the fruits of this *academic endeavor* – I maintain that the present, brief dissemination of my research to *non-academic* audiences (for example, the diminutive number of followers of the *Spimes Not Things* Twitter account - Figure 123, page 188) does not undermine the work I have already published. Nor would I describe this as a limitation per se. I argue that further evaluation activity should be regarded as an additional stage of the research process, or perhaps even an alternate one should my thesis have taken an altogether different path. Nevertheless, my *Spimes Not Things* manifesto has been designed to convey my academic research in a digestible format which non-academic stakeholders can hopefully engage with. To paraphrase one of the reviewers of my EAD 2019 paper, the manifesto will

hopefully do much to take my research *beyond the abstract world of academia and give it real world relevance.*

In section *5.4 Evaluating RtD and Design Fiction* (page 97), I discussed methods that can be used to explore the 'discursive potential' of DF proposals with audiences beyond academia, and how these approaches can provide fruitful insights for further research. Of the evaluation activities outlined in section *5.4*, I foresee *co-design* workshops as potentially being the most valuable evaluation method going forward. Such workshops will not only offer a mechanism to present my spime case studies and manifesto to broader sets of stakeholders but will also likely provide a fertile route for the development and evaluation of new collaborative and meaningful spime-orientated fictions, insights and knowledge as produced directly by said stakeholders.

I will now provide a short overview of the next steps I plan to take to further evaluate my *Spime-based Design Fiction Practice* through engagement with non-academic audiences:

- *Website for Spimes* – Taking lead from Huusko et al's (2018) conclusion that DF proposals can be employed to *set the scene* for *co-design* workshops as well as provide a way to promote and get potential stakeholders interested such engagements, I intend to build a website which showcases my three case studies and their collective significance as part of the manifesto. As Huusko et al (2018) emphasise, such groundwork offers '*a chance to build a storyline to connect different workshop tasks into a whole with bigger goals.'* Thus, using the narrative and theory already contained in the manifesto, the website will also contextualise my doctoral research in relation to the increasing unsustainability of the IoT, e-waste and importance of speculating and designing for sustainable technological futures. Importantly, I also envisage using the website as a mechanism for gathering evaluative feedback regards the manifesto and case studies.

- *Evaluation Workshops – Co-design* workshops could present a means to put the notion of the *Spime-based Design Fiction Practice Space* 'to the test' so to speak. Is it possible to 'transplant' the underlying theory behind the SbDFS to collaborative design contexts? How will I facilitate others to work together to effectively navigate the design space and generate innovative spime-like outputs that reflect both the unsustainability of contemporary connected devices and envision potential environmentally conscious alternatives? I am currently in the process of generating a proposal for a funded research project that will both build upon the theory and praxis that I have developed through my thesis and advance it further through *co-design* workshops with non-academic audiences. To this end, *evaluate engagement* through *co-design* workshops will be critical to providing a *pathway to impact* for the proposed project's research outputs. While the shape and form of these potential workshops is still in the development phase, I will be taking inspiration from Tsekleves et al (2017) regards possible workshop scope and structure. As a means to stimulate debate, it is my objective to have a range of different types of stakeholders attend the workshops. This diversity will hopefully include 'ordinary citizens' (those who use IoT devices in their daily lives); IoT designers and technologists (those who develop IoT devices) and representatives from tech firms (those who manufacture and operate IoT devices and platforms). I will also strive to attract environmentalists and policy makers as further participants. The sessions would likely begin with participants considering and sharing their current knowledge and relationship to technologies like the IoT and smartness alongside their level of understanding of the impacts of the technologies in relation to environmental sustainability. To then initiate collaborative DF ideation amongst the participants, existing and emerging environmental policy and legislation would be discussed and debated in conjunction with exemplars of unsustainable IoT design practice and the fictive sustainable designs and artefacts that compose my three spime DF case studies. These discussions would ideally lead to participants evaluating current responses to the outlined environmental issues including my case studies. Following this, it is hoped participants would collaboratively produce several lo-fi prototypes which embody their own ideas for possible future sustainable IoT solutions as well as situating these prototypes within plausible *contexts of use*. The fundamental aim of the proposed workshops is to empower participants with personal and collective agency to drive the sustainable IoT discourse, prototyping tasks and future scenario development forward by themselves. This is the form of *evaluative engagement* that I intend to be the focus of my *Spime-based Design Fiction Practice* post-thesis.

- *Collaborative Sustainable IoT Research* – As I write this section, I am in collaboration with research colleagues from the *University of Edinburgh* regards the organisation of a design workshop for the *Designing Interactive Systems 2020* conference. The workshop will focus on generating insights for better design practice in relation to the disposal and reuse of IoT devices. The workshop and its related paper will grant me opportunities to outline/discuss my spime oriented research and gain some participant feedback. I hope that this collaboration will also lead to further research, for example, a co-authored journal paper and/or a more substantial research project.

- **Policy and Legislation**
As part of the *Engineering and Physical Sciences Research Council* funded *PETRAS Internet of Things* research project, I had the opportunity to co-author a short book in early 2019 based upon on my doctoral research – *The Little Book of Sustainability for the Internet of Things* (Stead, Coulton, Lindley & Coulton, 2019). The *Little Book* was presented alongside a range of *PETRAS* research outputs to policymakers, technologists and thought leaders at the House of Lords, London in February 2019 as a means to showcase the economic, societal, technological, environmental and political significance of the 3 year project's research into the development of the IoT. Like the manifesto, the production and positive reception of the book highlights my research's value beyond this thesis and indeed the traditional channels of academia. Whether my research inspires policymakers, politicians, tech firms and indeed designers to take credible action remains to seen.

With the reach and implications of the IoT, AI, Machine Learning and datafication continuing to rapidly embed itself within all aspects of everyday life, the impacts that these technological advances have on environmental sustainability are only likely to profoundly deepen. Thus, it is my hope that work will continue within this field, whether by myself with colleagues or by other design researchers and practitioners. The *HealthBand* and *The Future Is Metahistory* case studies both touched upon how revising present day policy and legislation to facilitate the design of future spime-like devices is critical to bringing about radical and systemic environmental change. Reflecting upon my body of research, I would argue that this is as important as evolving the design of the devices themselves. To reiterate, it is essential that we start to find new more sustainable ways of creating, consuming and disposing of future technological devices *today*. In this respect, the heedful words of the environmental economist E.F. Schumacher (1973) once again spring to mind – 'to talk about the future is useful only if it leads to action *now*.'

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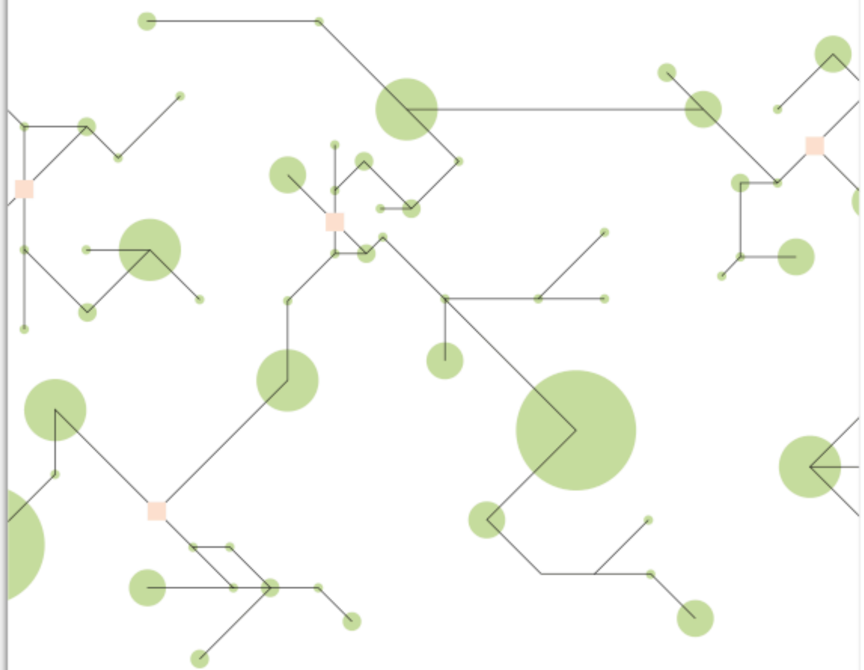
12 Appendix

12.1 The Manifesto

This section presents the *Spimes Not Things* manifesto in its entirety.



Who is this Manifesto for?

- The manifesto focuses on strategies for incorporating sustainability into the design of Internet of Things (IoT) devices.
- We hope it helps to galvanise product designers, interaction designers, creative technologists and makers into action - the people who have the skills and know how to use materials and technologies to design future sustainable connected products.
- The IoT is rapidly expanding and it is beginning to have both advantages and disadvantages for our society and our planet. The manifesto might therefore also be of interest to environmentalists, connected product manufacturers, tech firms, politicians and legislators - those who campaign for sustainable change and those who have the power to deliver it.

What are Spimes?

- Spimes is a concept first introduced by the futurist and science fiction writer Bruce Sterling and outlined in his book Shaping Things in 2005.

- A spime would be a type of near future, internet-connected object, which marries physical and digital elements with sustainable characteristics.

- Internet connectivity would enable a physical spime object to be tracked and traced throughout its entire lifecycle, from its initial design and production, to having its components recycled and reused at the end of their life.

- Making the lifecycle of connected objects more transparent could be an effective way of increasing accountability amongst users, helping them to make more sustainable decisions in regard to the types of connected products they purchase, how they then use them, and, ultimately, how they go about disposing of such devices.

- Similarly, designers and manufacturers would be charged with ensuring all the materials and energy that go into the manufacture and consumption of a spime device would not be lost at the end of the device's useful life.

- Given the increasing unsustainability of IoT devices, we think now is the right time to explore the idea in greater depth.

2

Spimes Not (Internet of) Things

Lots of loud voices are shouting that the IoT is changing many of aspects of our society for the better. Think healthcare, energy, transport, finance, entertainment - billions of everyday objects in all sorts of sectors are being connected to the Internet. But at what cost? Despite all the fanfare, IoT devices are still designed, manufactured and disposed of in the same way that most other consumer products have been for decades - unsustainably. That's where we think spimes come in...

The lifespan of IoT devices is unsustainable:

In today's linear economy, IoT product lifespans are designed to brief. Made from cheap, easily breakable materials, the design of most IoT devices does not incorporate means for repair, upgrade or recycling. The majority of these products cannot be customised or usefully repurposed. So when new generations of such devices are released with better functionality, software and aesthetics, the old products become redundant and more often than not, in time, they will end up as landfill with their precious materials and embodied energy forever lost.

Sustainability would designed into the lifecycle of Spime Objects:

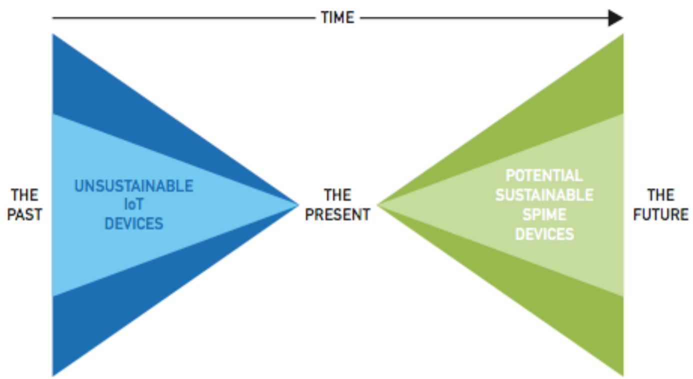
In a society built on spimes, we would get out what we put in. Instead of throwing devices away at the end of their useful life, the materials and energy that go into making and consuming a spime object would be reinvested into more spime objects. Their design would be cyclical as opposed to linear in nature. Unlike IoT devices, connecting a spime to the Internet would mean that it could be tracked throughout its lifecycle. We would know where the device has been, where it is, and, where it is going. This would allow us to continually repair, upgrade, customise and recycle spimes.

3

Why is a Manifesto for Spimes important?

Concerned by the lack of action by the design industry, manufacturers and technology firms, we chose to produce this manifesto to highlight the endemic unsustainability of IoT product design culture. Call it a mission statement or call to arms, with it we aim to lay the foundations for a more sustainable Internet-connected product landscape.

The IoT is stuck in the past, spimes are of the future...



The way the IoT is continuing to be designed is old hat. It is time to start designing new types of sustainable connected products and practices. Spimes fit the bill.

Whereas most design manifestos are often 'statements of beliefs' or a list of key principles for how to go about conducting potential design practice, in our manifesto we actually include design prototypes.

In the following pages, we share with you 3 examples of how different types of spime objects could potentially be designed in the near future.

But before get to the cool spime products and services, we need to explain a bit more about our design process and the main method we have used to produce them. It's called 'Design Fiction'. Read on...

4

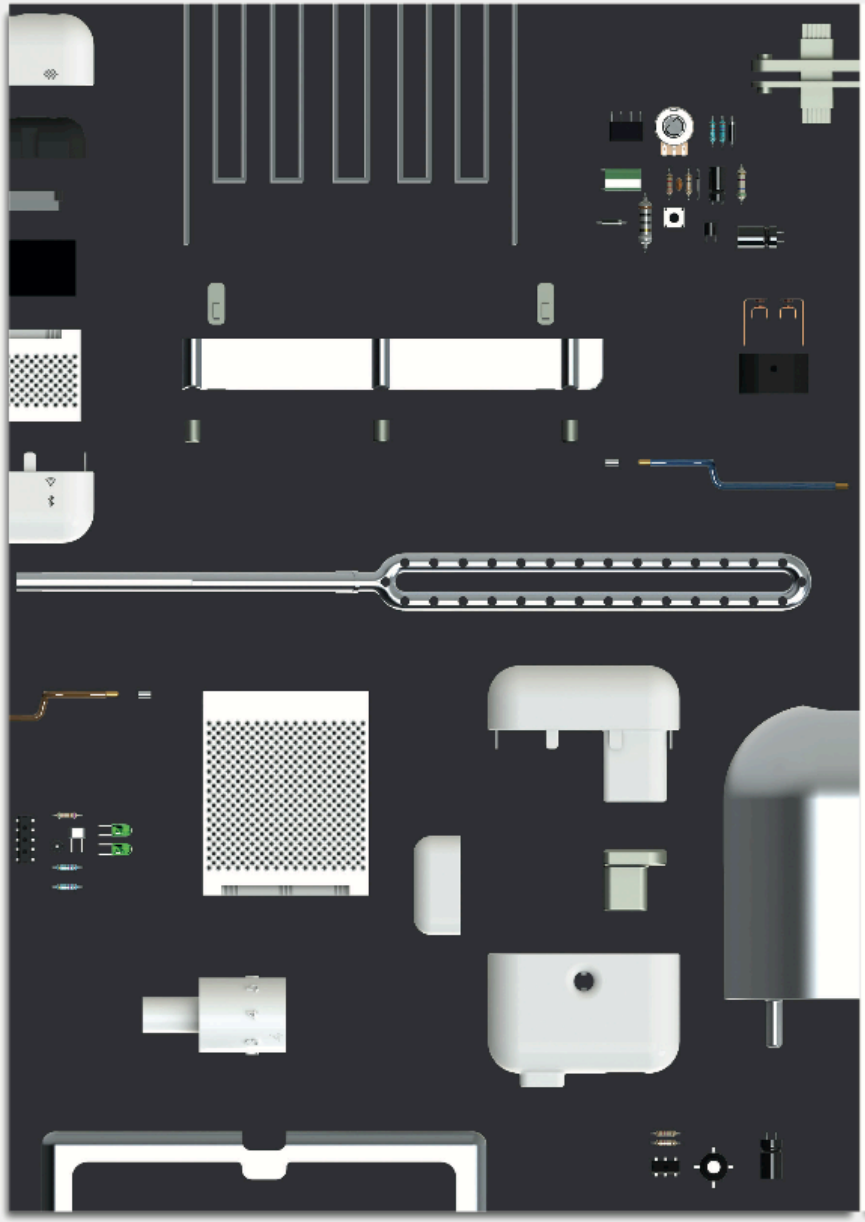
What is Design Fiction?

Most designers are actively trying to solve current actual problems, to make things better, or to produce something for sale or consumption. Design Fiction is different. Rather than solving existing problems, through Design Fiction we can use design practice to ask questions. We do this by designing fictional prototypes but instead of them being created to be put into production, these prototypes are used to encourage people to think critically about the issues that they embody.

Through Design Fiction prototypes we can ask how things might be in the future, why things might be that way, with a view to highlighting potential problems and opportunities. Design Fiction can help us to gain a better understanding about the meanings and values that emerging technologies and products might bring into play should they be adopted by society in the future.

In the following three case studies, we have used Design Fiction methods to envision what the world would be like if spime-like devices and services actually existed. We have not designed the spime prototypes with the intention of putting them into production. They are not finalised 'end products' or concrete sustainable solutions. Our three case studies aim to critique the growing unsustainability of the IoT whilst also imagining how connected objects could be designed to be more sustainable in the near future.

5



Spime Case Study 1: Toaster for Life

Our first Design Fiction spime prototype is the Toaster for Life. We wanted to take a boring household product that everybody's knows well and turn it into a spime object. To do this, we focussed on incorporating features and technologies that would make a near future toaster repairable, upgradeable, customisable, recyclable, and most importantly for a spime, all of its individual parts and components are trackable and traceable. Always. This would mean that the toaster's owner and/or its manufacturer, could keep tabs on the device at all times. So when it comes to replacing broken parts or it is time to get rid the whole thing completely, these practices can always be managed sustainably by the user/manufacturer.

Case Study 1 helps us to consider potential near future changes to...

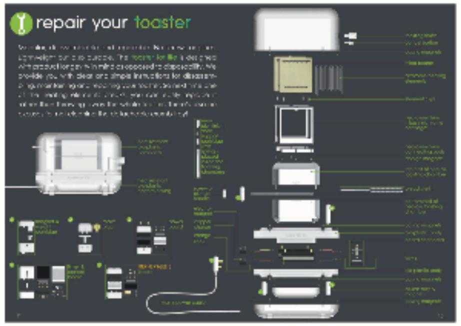
IoT Business models

Current IoT business models would have to radically change in order to accommodate a device like the Toaster for Life. People cannot simply repair, customise or upgrade IoT devices due to their complicated design, their use of disposable materials, and the fact that doing so would void product warranties. Our toaster is modular in design so that new parts can easily be replaced and augmented using 3D printed recyclable materials. And with all its componentry RFID tagged, GPS can pick them up at all times. As a result, manufacturers would have to reconsider built in obsolescence strategies, improve their after-care services and change the nature of product warranties.

User behaviour

The Toaster for Life would actively involve its owner in its lifecycle. This would make people more accountable in regards to how they use their connected devices and how they go about responsibly disposing of them when they are no longer needed.

7



In order for it to be repairable, we decided to make the fictional toaster 'modular' in design. This means that if a particular part was to break or fatigue it could easily be switched out and replaced with a new one.

Many existing internet connected devices are rendered useless as their built-in functionality becomes out of step with advances in computing. The toaster's modularity therefore also enables computing components to be continually upgraded and reconfigured.

Want an extra slot? Prefer it in pink? Should users' tastes or needs change, new parts and features can be incorporated into the device through fabrication technologies like domestic 3D printing.

8

Mostly composed of 'bio-plastic' and 'neo-aluminium', the toaster is 90% recyclable. These materials can be infinitely recycled and used in the production of additional devices if returned to the manufacturer.

Almost every part of the device is fitted with a 'nano-RFID' tag. This means that each part can be collectively/individually tracked and traced throughout their lifecycle using GPS.

The Toaster for Life would change the nature of the relationship between manufacturers and users. Things like product safety, product warranty and customer support would have to evolve to accommodate the device's five sustainable attributes.

9

Spime Case Study 2:
HealthBand

Would you want to design and use your own wearable medical device? Our second fictional spime prototype is HealthBand, a Do-It-Yourself medical wearable. The internet has made digital technologies like open source electronics and CAD software very accessible and cheap to buy. It's argued that the maker movement and other 'democratised' activities that use these powerful and flexible technologies to design connected devices are a more environmentally friendly alternative to the mass-production/mass-consumption methods that currently characterise the IoT. Mimicking sites like KickStarter and Indiegogo, we framed the HealthBand wearable within a fictional online crowdfunding campaign. The campaign sees 3 developers design a core module for the HealthBand wearable for different personal reasons. Once shared, their designs could also benefit others in society.

Case Study 2 helps us to consider potential near future changes to...

IoT Policy and regulation

The HeathBand prototype helps us to generate discussions about how near future, DIY medical devices might become widely adopted through social innovation practices and localised production channels. Importantly, current product policy and associated legislation would need to adapt to accommodate and nurture democratised IoT design culture while still maintaining adequate product safety and quality standards.

IoT User innovation practices

The last decade has seen lots of 'ordinary people' getting involved in physical-digital 'making' practices and producing new connected devices and services. Creative, rewarding and often altruistic, more should done to encourage people to participate in these types of activities. Such a shift could be of sizable sustainable and social benefit.

10

DIABETES MONITOR

THE MAKERS

GARY PARKS AND PHIL CAMPBALL, MANCHESTER, UK

THE STORY

GARY AND PHIL SET UP THE PROJECT IN 2028 AND HAVE SEEN HEALTHBAND GO FROM STRENGTH TO STRENGTH...

"WE COULDN'T HAVE IMAGINED THE SUPPORT THE PROJECT WOULD RECEIVE NOR THAT OTHERS WOULD BEGIN TO HELP DESIGNING AND EXTENDING THE RANGE OF MODULES.

WE STARTED HEALTHBAND FOR A PERSONAL REASON - TO HELP MY COUSIN ARTHUR. BUT WE HAVE REALISED THAT IT ALSO MEANS SOMETHING TO A LOT OF DIFFERENT PEOPLE. IT SHOWS THAT DESPITE THE CONTINUED AND UNJUST GOVERNMENT AUSTERITY MEASURES AND INDEFENSIBLE PRIVATISATION OF THE NHS. THERE IS DEEP SOLIDARITY AND GOODWILL OUT AMONGST THE WIDER PUBLIC.

THE FUNDING SO FAR RECEIVED HAS ENABLED US TO ROLL OUT A BATCH PRODUCTION OF BANDS AND WE ARE DETERMINED TO KEEP ON BUILDING HEALTHBAND INTO 2030 AND BEYOND.

DEMENTIA MEMORY AID

THE MAKER

ALICIA KURTZ, WILLIAMSBURG, BROOKLYN, NEW YORK

THE STORY

ALICIA IS A SOFTWARE DEVELOPER FROM AUSTIN, TEXAS NOW WORKING IN MANHATTAN, NEW YORK...

"I SAW GARY AND PHIL'S PROTOTYPE ON LIGHTBULB. I KNOW CODE AND CAD AND DECIDED TO DESIGN AND BUILD SOME NEW MODULES.

ALZHEIMER'S IS QUITE PROMINENT IN MY FAMILY. MY GRANDFATHER HAD IT AND NOW MY MOM IS BEGINNING TO SHOW SIGNS. I WANTED TO DESIGN A BAND THAT WILL HELP MY MOM AND OTHER ALZHEIMER'S SUFFERERS.

LUCKILY I GET HEALTH INSURANCE THROUGH MY JOB BUT MY MOM AND MILLIONS OF OTHER PEOPLE HERE IN THE STATES CAN'T AFFORD ANY KIND OF BASIC HEALTHCARE.

OPEN DEVICES LIKE HEALTHBAND MEAN PEOPLE CAN, TO A CERTAIN DEGREE, LOOK AFTER THEIR OWN HEALTH."

PARKINSON'S STABILISER

THE MAKER

EMI MIFUNE, MITAKA, KANTO, WESTERN TOKYO

THE STORY

EMI IS AN UNDERGRADUATE STUDENT STUDYING PRODUCT DESIGN AT THE UNIVERSITY OF TOKYO...

"MY COUNTRY HAS THE FASTEST AGING SOCIETY IN THE WORLD. OVER 65s CURRENTLY ACCOUNT FOR 26% OF THE POPULATION. IT IS ESTIMATED THAT BY 2060, THIS FIGURE WILL INCREASE TO NEARLY 50%. THE PROBLEM IS NOT HELPED BY OUR EVER FALLING BIRTH RATE.

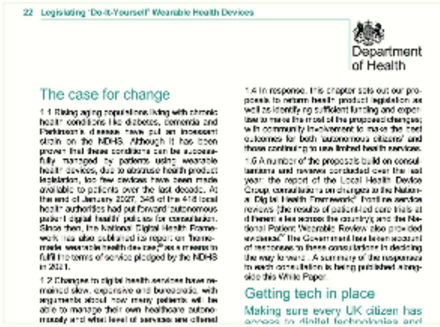
ALTHOUGH JAPANESE PEOPLE ARE FAMED FOR LIVING LONG AND HEALTHY LIVES. AS THE NUMBER OF ELDERLY PEOPLE CONTINUES TO RISE SO TOO DOES THE LIKELIHOOD OF HEALTH PROBLEMS IN LATER LIFE.

AS A TRAINEE PRODUCT DESIGNER I FELT I COULD USE MY EXPERTISE AND CONTRIBUTE TO GARY AND PHIL'S PROJECT. THE NUMBER OF PEOPLE WITH PARKINSON'S IS INCREASING IN JAPAN. I THEREFORE DECIDED TO TRY AND AID THOSE LIVING WITH THE DISEASE."

Inspired by sites like KickStarter, we created a fictional crowdfunding page for the HealthBand wearable to show how people could easily get involved with the device's development and production.

The fictional wearable's design is modular which means new modules with new functionality can easily be integrated as and when they are developed.

Personal health data captured by a HealthBand device could be viewed via an online app.



A fictional 'white paper' produced by the UK Government proposing legalising DIY medical wearable device production.

The UK's National Health Service might have to provide guidelines to patients to ensure they develop clinically safe devices.

To regulate DIY production, people might have to even apply for a permit.

COUNCIL FOR SCIENCE AND TECHNOLOGY

better IoT global

Alliance for Sustainable Blockchain Stewardship

The Council and BIG announce the formation of the *Alliance for Sustainable Blockchain Stewardship* and the creation of the *Secure Metahistory Certification Mark*

For Immediate Release: 23/02/2026

The Council for Science and Technology and Better IoT Global are pleased to announce the formation of the *Alliance for Sustainable Blockchain Stewardship* and the creation of the *Secure Metahistory Certification Mark*. The announcement comes after implementation strategies for both initiatives were approved by Government following a year of research and consultation:

- The Department for Science and Technology's white paper *The Future is Metahistory: Blockchain, Ecology and the Economy* was published 18/01/25 and outlined potential benefits and possible issues with regard to corporate and public adoption and acceptability of Blockchain and the optimisation of consumers' metahistories.

- Technology and consumer trials held across summer 2025 were successful and provided valuable insights for efficient and secure implementation.

- *Open Traceability Protocol* and knowledge exchange - the increased transparency granted by metahistory data regards physical and digital materials is deemed to hold transformative possibilities for environmental sustainability.

- Optimisation will also create new markets and generate opportunities for platform development and data mining jobs which in turn will boost the overall economy.

- Blockchain's inherent decentralisation is a proven secure and robust alternative to traditional centralised transaction systems. There has been growing mistrust amongst the wider public for conventional banking culture since the UK was again plunged into a recession by banking malpractice in spring 2023.

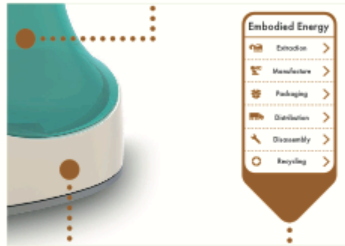
The alliance will work closely with product manufacturers, data platforms and sustainable bodies on advancing open traceability for sustainable benefit.

The certification mark will be used by stores, platforms and applications to denote a secure and sustainable transfer of consumer's personal metahistories using blockchain and smart contracting processes.

Dr Clement Benway,
Government Chief Scientific Adviser (GCSA),
c.benway@gov.uk

Spime Case Study 3:
The Future Is Metahistory

Your personal IoT data is really valuable. When you use connected products and their associated services like apps and websites, tech companies sneakily harvest and monitise your data. They mine it for any commercial intel and often also sell it on to other 'invisible' partners who do the same. But what if the value of connected product data was not money but sustainable change? Our final case study looks at an attribute of spimes called metahistory. A spime object would generate meta-data about itself at all times. We designed a series of prototypes and artefacts that help us to start thinking about how spime metahistories might be 'optimised' for sustainable gain.



Case Study 3 helps us to consider potential near future changes to...

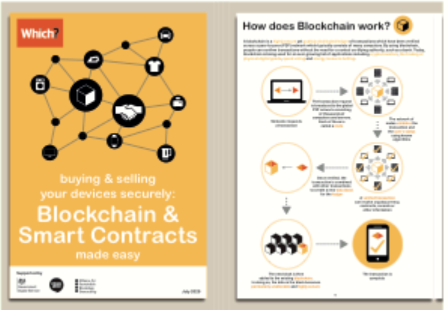
The ethics of IoT data practices

The way in which peoples' personal data is handled throughout the IoT today is incredibly complex, difficult to trace, almost invisible to users, and, is probably unlawful in many aspects. If society were adopt to spime metahistories as presented by our prototypes, technology platforms and services would be compelled to make all their data processes and digital infrastructures much more transparent to users. In light of recent data scandals and breaches, transparency of data is something tech firms need to consider in greater depth.

The ownership of IoT data

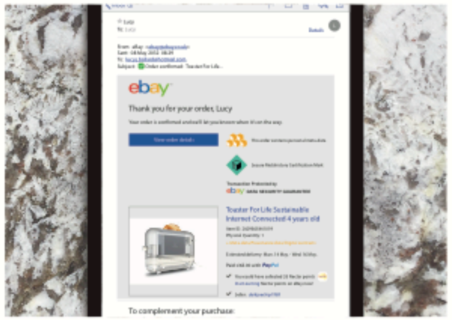
As it's difficult to keep track of what happens to our data, we should do more to protect it by reconsidering our current online practices. We mirror this in the spime based future we have designed. Everyone would have access to everyone else's metahistories. In this event, we are sure people would consider more carefully how they interact online and what information they share.

15

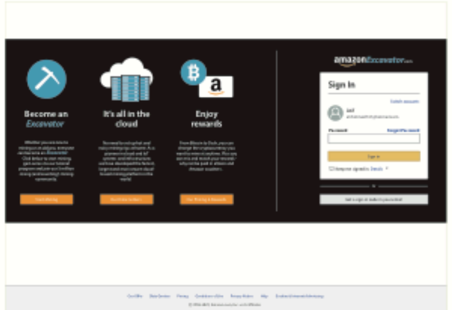


We created a near future Which? tech help guide to introduce audiences to the technology and explain its complexities and advantages in terms that can be easily understood.

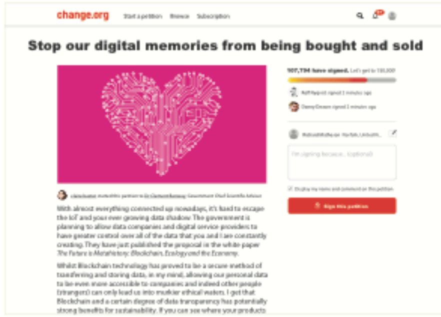
We created a fictional mobile app called Lazarus which utilises blockchain to facilitate greater 'asset transparency' by tracking the origins and histories of connected products, and verifying their provenance. We envisage an app like Lazarus might help to empower sustainable behaviour by helping people to securely recycle, reuse and repurpose data-rich spime objects when they are no longer wanted.



As per governmental protocol, eBay has included the Secure Metahistory Certification Mark on this receipt to denote that this transaction involves blockchain processes which ensures the safe transfer of the toaster's seller's personal metahistory data.



A web interface for a fictional cloud data-mining platform operated by the Internet giant Amazon. So called 'excavators' can sign up to mine the vast silos of spime product metahistories for crypto-rewards. In our fictional world, Amazon would accumulate membership fees and percentages from successfully mined metahistory blockchains.



This Change.org petition highlights concerns that some people might have regards future 'open traceability' and widespread adoption of metahistory data exchange.

Are the sustainable advantages of spime metahistories more important than users' privacy? A photo of protesters at the Make Metahistory HISTORY march through London, June 2028.

Our 6 Key Messages

IoT Business Models
IoT businesses should start to think about designing out built in obsolescence strategies, putting long-term product after-care services in place and re-vising product warranties to allow for user customisation and repair.

IoT User Behaviour
Users of IoT devices should think more about accountability in regards to how they use their connected devices and how they go about disposing of them when they are no longer needed.

IoT Design Policy
Policy and legislation should adapt to accommodate and nurture democratised IoT design culture, allowing for localised production while maintaining adequate product safety and quality standards.

IoT User Innovation
Open source technologies and domestic fabrication tools are becoming ever-more affordable and accessible. Creative and rewarding, people should be en-couraged to get involved in these types of practices.

IoT Data Ethics
Platforms and service providers should start making their data processes and infrastructures less complex and more transparent to users.

IoT Data Ownership
As it's difficult to keep track of what happens to your IoT data, you could do more to protect it by reconsidering your current online practices including how you interact online and what information you share.

18

Further Reading

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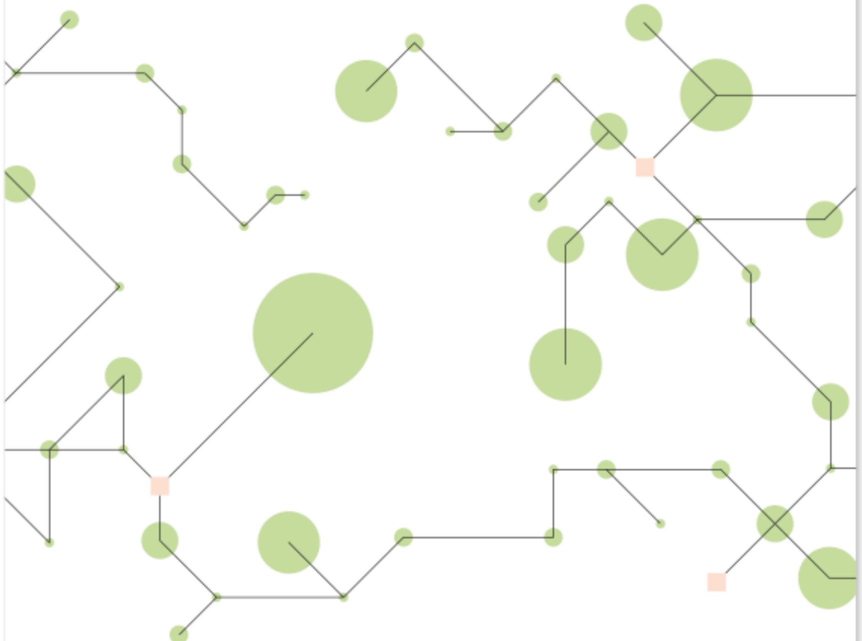
Michael Stead, Paul Coulton, Joseph Lindley and Claire Coulton, 2019, The Little Book of Sustainability for the Internet of Things, Lancaster: Lancaster University. Available to download for free from here: https://www.petrashub.org/outputs/

Paul Coulton, Joseph Lindley and Rachel Cooper, 2018, The Little Book of Design Fiction for the Internet of Things, Lancaster: Lancaster University. Available to download for free from here: https://www.petrashub.org/outputs/

19

This work was conducted for the PETRAS Internet of Things Research Hub. It has been supported by the HighWire Doctoral Training Centre and ImaginationLancaster Design Research Lab at Lancaster University. It was funded by the Engineering and Physical Sciences Research Council.

20




PETRAS
EPSRC