Materializing Technologies

Surfacing Focal Things and Practices with Design

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Holly Robbins

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Dissertation

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by

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born in New York City, United States of America

For my parents.

"The way to solve the conflict between human values and technological needs is not to run away from the technology. That's impossible. The way to resolve the conflict is to break down the barriers of dualistic thought that prevent a real understanding of what technology is—not an exploitation of nature, but a fusion of nature and the human spirit into a new kind of creation that transcends both. When this transcendence occurs in such events as the first airplane flight across the ocean or the first footsteps on the moon, a kind of public recognition of the transcendent nature of technology occurs. But this transcendence should occur at the individual level, on a personal basis, in one's own life, in a less dramatic way."

Robert Pirsig
Zen and the Art of Motorcycle Maintenance
1974 p.274

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INTRODUCTION

Today, the world is populated with what we colloquially refer to as "black boxes."[1] These are technologies that perform sophisticated operations, but mask these complex operations, providing us with little context to what they do, how they work, and the role they play in our lives. I use this term "black box" not just to refer to the physical encasements containing mysterious electronics, but in its broadest conceptual terms: a technology that conceals its operation from its users and thus limits our modes of engagement with it. With this limited mode of engagement, we lack an ability to understand the larger context in which a technology is situated. How does this "box" reflect and contribute to the environment it is in, what does it draw on to function, how does it impact the social relations that develop around it, and what is the broader web of relations that it enables?

Black boxes manifest in a number of ways. They can be technology that automates something that was once mechanized, such as water flowing from a sink that is activated by a proximity sensor in place of water being physically pumped from a well. Black boxes may not be physically bound in a single "box." For example a network of computers, servers, and lines of code together constitute the Internet, it isn't bound to a single "box." What is consistent though is that in light of increasing technological complexity, certain design choices are being made to disburden us from that complexity by obfuscating it. These design choices can come with problematic societal implications (Borgmann 1984; Fallman 2009; Fallman 2011). For example, we can become over-reliant on a certain technology, or find ourselves more likely to over-consume it; and with technologies that act on their own, this also introduces questions of accountability and ethics.

In simple terms, this thesis seeks to find ways that design can support making consumer technologies more legible and relatable to people. It does so by exploring the nature of our relations with the materials that constitute a technology, and it argues that our capability to relate lies in how the design of these technologies surface such relations. These materials range from metal and plastics to code and Internet connectivity.

To set the scope immediately, this thesis does not advocate for a complete rejection of black boxes, nor does it make the argument that we need to be actively engaged in all the functionings of every technology, nor that they should be fully transparent (metaphorically or literally speaking). Indeed, some things are better left masked. Life support technologies should remain automated for example. Users of consumer electronics should not be burdened with all of the inner workings of some of these technologies. Transparency in this regard can be without any affect, and perhaps even a hindrance. Seeing the circuits behind an encasement does not make them more legible, it may in fact create a bit of chaos. Black boxes can serve and important purpose.

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1   While the archetype of "black boxes" still persists, they may also be referred to as "shiny white boxes" (Rowland et al. 2015).

Instead, this thesis explores this notion of legibility behind focal things and practices. What aspects of the technology should be made legible and relatable to an audience of general users to support the technology as a focal thing and practice? What aspects of the technology should we be engaging with as users to develop a notion of the context behind them and to provide us with a sense of agency? What are important aspects of the technology to surface to support them as focal things and practices, and what can be put aside?

In this introductory chapter, I will briefly lay out the core concepts that this thesis is built upon, and how these were approached with design research. I will then address the methodological approach of this thesis. After that, I will offer readers an outline for how to read this thesis.

CORE CONCEPTS

In terms that are a little more specific, this thesis draws from theoretical work from philosophy of technology to scaffold an understanding of the dynamics of the relationship between people and black boxes. It makes inquiries into this particular philosophic critique with design research. In the process of making these inquires with design research, this thesis expands and interprets this original critique in light of contemporary consumer technologies. This section will briefly describe the core theoretical concepts that inform this thesis' research objective.

THE DEVICE PARADIGM
Albert Borgmann's work on the "device paradigm," from philosophy of technology, outlines this particular dynamic between people and these "black boxes" (Borgmann 1984). Borgmann suggests that as we create more complex technologies, we "mask" this complexity with designs that disburden us from the complicated task that the technology performs. This obfuscation of complex technologies can be recognized as a black box. In effect, we become unaware of the social and ecological context surrounding these technologies, rendering them what Borgmann terms as a "device." The design of devices separates the *ends* of the technology (e.g., the outcome of the technology's use) from its *means* (e.g., the aspects of the technology responsible for the way it works). We have very little insight into, or engagement with, the work that the technology does to deliver its outcome or to function. As we flip a switch of a light, we are not engaging with the circuits, electric grid, and wires (*means*) that enable for there to be light emitted from our table lamp (*ends*).

FOCAL THINGS AND PRACTICES (FT&P)
The counterpoint to the device paradigm are "focal things and practices" (or "FT&P" as they will be more often referred to in this thesis). Borgmann refers to focal things as something of ultimate concern and significance, which are preserved and supported by their intimate connection with practices, or the 'ways of doing' that people have with

these technologies. (Borgmann 1984). Focal things and practices invite ways for people to be engaged in the fullness of their capacities. For example, maintaining a fire as a source of heat illustrates how the relation between the *means* of how the logs are cut, laid, and burned is clearly associated with the *ends* of the fire, its heat, smell, and smoke. The fire also engages us on bodily, social, and environmental levels. On a bodily level we're engaged by the physical labor of cutting the wood and bringing it inside, the sweat of that labor, the smell of the fire's smoke and warmth of its heat. It organizes us socially, from being the focal point of the home, and something to cook upon or warm ourselves by. Environmentally it can be a marker of the time of day and season, demonstrate our proximity to resources such as wood, and fill a space with smoke and soot. These rich avenues for engagement provide us a degree of insight into the technology and channels to understand and relate to it.

SOCIOMATERIALITY

As a conceptualization, "focal things and practices" encourages us to consider how to problematize people's engagement with technology from a design perspective (Croon and Stolterman 2003; Verbeek 2002; Fallman 2011; Tatum 1994). It also invites us to consider though how the relation between the *ends* and the *means* of a technology are made legible to people. This thesis expounds upon Borgmann's original perspective on focal things and practices, engagement, and the relations between the *ends* and *means* with a body of work from sociomateriality. In doing so, this thesis takes the position that when we engage with the *means* of a technology, we are actually engaging not so much with machinery of the technology, as in the gears or hardware necessary for the operation of the technology; but instead we engage with the various *materials* that make it possible for this machinery to exist. Therefore the question becomes how to conceptualize our relations with the materials of the technology in order to surface focal things and practices. A body of research in sociomateriality suggests that people and materials are co-constitutive, mutually defining one another (Orlikowski 2007; Mazmanian, Cohn, and Dourish 2014; Dourish and Mazmanian 2011). This presents a unique opportunity for this thesis, if we are already actively engaged in this exchange with the materials of a technology and thus already a part of its *means*, how can design surface such an exchange?

SURFACING TECHNOLOGIES AS FOCAL THINGS AND PRACTICES
With design research, this thesis offers a contemporary conceptualization of "focal things and practices" and inquires into how design can surface, or *trace,* the too often obfuscated relation that people have with the *means* of a technology.

Traces are a design approach that communicate things that are not apparent, persistent, or perceivable (Robbins, Giaccardi, and Karana 2016; Giaccardi et al. 2014; Robbins et al. 2015). This thesis describes a design research process where traces are applied as a design approach to explore how to make legible the sociomateriality of technologies, in an effort to surface them as focal things and practices. Traces become a way to identify the materials that make up a technology, the role of these materials as the technology's *means*, and our relation with them. In doing so, it becomes possible to build an

understanding towards surfacing these technologies as focal things and practices with design.

This thesis maps the design space around these questions, offering designers a "frame" with which to understand the complicated and unstable concept of focal things and practices, so that they can develop their own "designerly judgment" as to how to navigate this complexity in their practice

(Dorst 2010; Stolterman 2008). This thesis does not claim to be a guide to *make* focal things and practices. Such a complex and context-specific concept does not lend itself to a single solution (Stolterman and Wiberg 2010). The research artifacts presented in this thesis help to illustrate and demonstrate this framing, but are not "solutions" in and of themselves; nor were they evaluated in the context of people's lives to see if they indeed surfaced themselves as focal things and practices. Instead, the contribution of this thesis is in developing and articulating a conceptualization of focal things and practices that can be applied to conventional design practice.

METHODOLOGY

A bridge between Borgmann's device paradigm and conventional design practice is being built in this thesis with research through design (which will primarily be referred to as "RtD") and design anthropology. More pointedly, a series of design journeys are conducted with research through design, which are framed and interpreted with a lens from design anthropology.

I worked with student and professional design practitioners in iterative research-through-design cycles. Over the course of six research-through-design cycles, the research topic was translated into design briefs that interpreted these philosophical concepts into units of design. In each of these cycles, the research topic was framed, and then reframed after interpreting the design process and the resulting research artifact (Stappers and Giaccardi 2017). Ten research artifacts were yielded in these six cycles.

Design anthropology also was critical in conducting this research. Design anthropology is a hybrid discipline that blends theorizing the way things are (anthropology), with theorizing how things could be (design) (Smith 2013). This methodological approach was employed in these cycles of research through design, in addition to two additional field studies. As a design anthropologist my site of fieldwork was the design process itself, which served to develop an understanding in how to navigate between philosophy of technology and design practice. How were concepts and values from one resonating with the other, what about this exchange between philosophy and design practice was successful or not, what were the obstacles, where were the opportunities? Not only was I studying how philosophy of technology could support design practice, but also what could design practice contribute to this body of theoretical work from philosophy of technology.

OUTLINE OF THE THESIS

This thesis presents my research into how design can surface focal things and practices. This thesis speaks to an audience from design research and philosophy of technology, as well as to design practitioners who would like to develop a deeper understanding of how to make black boxes more relatable and situated in their context. This manuscript was written with the intention that it would be read straight through, however it was also written to support readers who read the chapters in isolation of one another. To allow for this flexibility, there is some repetition among chapters of certain theoretical concepts, as well as short descriptions of design concepts that illustrate the discussion at hand.

This thesis is divided into four parts. **Part I** describes the theoretical foundations of this work. *Chapter 1* addresses the body of work from philosophy of technology on the device paradigm and focal things and practices, as well as theoretical work on sociomateriality. This is then complimented in *chapter 2* with work in design research that informed the decision to use traces as a design approach to make the relations and dynamics that we have with black boxes legible.

Part II stages the methodological approach of this thesis, where design journeys into surfacing focal things and practices are pursued with research through design, the analysis of which is framed and interpreted with design anthropology. In c*hapter 3*, this thesis' approach to three key methodological components of research through design are positioned: the role of the research artifact; how the cycles of research-through-design relate to one another; and lastly the form of knowledge offered by this thesis as a map of the design space. In this thesis, research through design is supported with design anthropology, which is detailed in *chapter 4*. This chapter explains how design anthropology became a critical lens to carry out research through design, where the design processes behind creating research artifacts was the site of fieldwork, so to speak, that contributed to reframing the research topic. In addition, design anthropology was an important lens to support three field studies that did not yield a final design concept, but are still considered to be apart of this RtD process.

Part III then turns to the specifics of the research conducted. An anthropological account is offered in *chapter 5* describing four particular cycles of research through design. It dissects the processes of framing and reframing of the research topic through each cycle, and how the processes of creating the research artifacts and the artifacts themselves contributed to this. For the reader's reference, *chapter 6* offers an index describing each of the ten design concepts that this thesis' analysis draws from. This index will be a helpful reference in light of the next chapter, *chapter 7,* which constructs the design space surrounding the surfacing of focal things and practices with design. This chapter identifies patterns in different forms of these technology's materiality and how design can support the surfacing of focal things and practices accordingly.

The thesis concludes with **Part IV** which reflects on the various forms of "traversing" undertaken in the course of this design research. *Chapter 8* firstly discusses this in terms of the traversing within the particular design space that emerged, navigating across the different forms of materialities of technologies and possible engagements with those materialities. *Chapter 9* considers the traversing across academia and professional design practice, and how this contributed to a knowledge exchange loop between the two. This form of collaboration lead to opportunities to not only inform research, but also to directly disseminate and experiment provisional outcomes in practice. It reflects on how approaching this research endeavor as a design anthropologist made this possible. Finally, *chapter 10* reflects on navigating between the disciplines of philosophy of technology and industrial design practice and the different tensions that unfolded in working at this crossroads.

In the conclusion chapter, the arguments presented in each chapter are summarized. There is also a reflection on reframing the concept focal things and practices in light of the insights that this thesis provides. In addition, there my suggestions for future research, and a discussion on the implications of this research for its various audiences.

part I
Theoretical Foundations

CHAPTER 1.
THEORIZING THE BLACK BOX

As technologies become more complex, their complexity is obfuscated from the people and the context that they are situated in. Conventional interaction design practices seek to disburden people from the complexity of the technology by concealing it. The concept of "usability" within interaction design is dedicated to this objective. Using design to support usability is motivated to promote accessibility and provide for smoother interactions with the technology. However, as some within philosophy of technology would argue, in this effort to enhance usability our modes of engagement with the technology are obfuscated. We lack cues for how the device works, and how we work with it. While there are circumstances and contexts where obfuscating this complexity is appropriate, this thesis is concerned with exploring avenues exist for making that complexity legible, and also what aspects of that complexity should be made legible. This thesis is not an argument for a complete rejection of black boxes, but instead explores the boundaries of the ways that they are expressed. The obfuscation that characterizes black boxes can have some problematic nefarious implications, which this chapter will address.

1.1 REINTERPRETING THE DEVICE PARADIGM IN THE AGE OF DATA TECHNOLOGIES

The philosopher of technology Albert Borgmann outlines this problematic dynamic behind masking complexity of technologies as the "device paradigm" (1984). In this paradigm, he claims that technology becomes a "device" when it separates the *ends* from the *means*. To translate: the outcome of the technology's use (*ends*) are separated from the aspects of the technology responsible for the way it works (*means*). Without a mode of engagement with the technology that positions the *ends* and the *means* together, Borgmann argues that we are more likely to over-use these technologies, or become over-reliant on them. Further, this makes it difficult to position the role that the technology plays in our lives.

Borgmann's argument can be demonstrated with heating technologies. Early technologies such as the fireplace, for example, both situate and are situated within a specific context that deeply draws on our modes of engagement with the technology (fire, in this case). First there are our bodily senses, such as the physical skills developed and sensorial experiences related to chopping and handling the wood and keeping the fire going. As a technology, the fireplace also engages us socially; within a household people are assigned to different roles in maintaining the fire, which becomes the focal point of a home. We become familiar with its materiality, from the way that different woods burn and cut, to what makes good kindling, and how to build a base of the fire to promotes access to oxygen. It's also reflective of its environment as it marks the time of day or the season. We can see in this simple example how the technology of the fire is situated

among these different modes of human engagement, as well as the environment at large.

The device paradigm can be illustrated with the fire's contemporary counterpart, a household thermostat. A slight turn of the wrist adjusts a thermostat's dial and warms the house relatively quickly, without revealing how the ends and the means are related to one another. We are not engaged with the heating of the furnace, or how it delivers heat. Today, heat is delivered to individual rooms, it does not engage us socially as gathering around the fireplace all together once did. Borgmann warns us that under the device paradigm, this lack of engagement with the components of the technology that makes it work, makes it easier to over-use this technology, and become unaware of the role that this technology plays in our lives. Without being engaged in the task of the technology, it can be easy to forget to turn down the thermostat when you head out for work, making it easier to over-consume and over-use this technology than it is in the case of a fire.

Borgmann presents a compelling critique of how we design for advancing technologies, and the implications of this model of design. Yet, he was writing in the 1980s, before dig-ital and networked technologies became widespread. Even in light of these unanticipated technological advancements, the tenents of the device paradigm still ring true.

Keeping in the theme of heating technologies, we see the relevance of the device para-digm within the context of contemporary technologies such as the Nest thermostat. The Nest relies on automated learning algorithms and sleek interfaces that rarely ever need to be touched or manually set. The Nest's design may be motivated by promoting ease of use and accessibility, however as the device paradigm outlines, such a lack of engage-ment can comes with some consequences. For example, we can see that a person's ability to engage with and control these technologies in their daily life can become lim-ited. We may find ourselves at the mercy of, or without a sense of agency or autonomy with, our smart home systems. We can be at the whims of Nest's software updates and an inevitable bug that may lock us out of our own home's systems (Kuijer and Giaccardi 2018; Bilton 2016; Helbing et al. 2017). Or one party may lack agency as another party uses these systems as tools to assert their power or abuse over others, such as partners who make home environments hostel to those in them by manipulating thermostats, con-trolling speakers, and setting off house alarms; a disturbing phenomenon that is appar-ently becoming more prevalent (Bowles 2018). And what happens to the troves of data that is collected by these devices about our behavior and preferences? Who has access to it, what is their function outside of the operation of our own personal device? The Nest performs even more advanced functions than its predecessors, and still obfuscates this complexity behind this technology, being designed to fade into the background.

The device paradigm is being cultivated by conventional design practices that seek to make use of contemporary technologies and techniques to promote design that au-tomates functions, learn and react to our behavior, and further disburden us from the complex work of the technologies. The consequences of these design objectives leads to disengaged modes of consumption of that technology.

In Borgmann's framing, the separation of the *ends* and the *means* is an attempt to mask the complexity behind the technology (Borgmann 1984). His term "masking" strongly implies the physical blinding of complexity, such as with a physical "black box." As has been demonstrated (Introduction), black boxes may not always be physical boxes, but instead that which conceals its operation from its users and thus limits our modes of engagement with it; such as the code that is necessary to run a software, or the connectivity that one computer has to a remote server. Thus, this thesis instead conceptualizes the device paradigm in terms of "obfuscation," a word that more generally refers to obscuring that can be done with design to separate the *ends* from the *means*. This can accommodate other forms of materialities and complexities that are not necessarily enclosed within a physical box. For example, the light switch that obfuscates the complex network of circuits, wires, and electric grid that ultimately illuminate the lamp.

The device paradigm can be critiqued as appearing to argue for a rejection of contemporary technologies. This thesis does not adopt the position that the problem is with the fact that technologies are becoming increasingly complex. The resolution to this paradigm isn't in rejecting technological advancement in favor of archaic ones. Rather it's more of a question of how the design of these contemporary technologies can engage us in ways that can make them more legible. When the relation between the *ends* and the *means* are more relatable to us, we can have more agency in how we use these technologies.

Striving towards this legibility requires some nuance. Making complex technologies more legible necessarily come in the form of "transparency." A clear encasement over electronics or a terms and services agreement that explicitly details the particularities of a technology does not contribute to making them more legible to the general user. These are gestures towards promoting modes of engagement and contextualization, but still leave much to be understood. These explicit and literal attempts to show people the parts that comprise the technology do not demonstrate or contextualize how our engagement with these technologies shape the way the technology functions. The task for design then is not to "show" everything, but to determine what needs to be shown to contribute to creating opportunities for these technologies to be legible.

The device paradigm is becoming increasingly problematic in the context of our contemporary technologies, which we imbue with even more autonomy such as with artificial intelligence. The implications behind the illegibility of behind how technologies work become more significant, such as with algorithms that tailor news items to what it deems to be relevant to you, but perhaps not reflective of reality (Bowles 2016; Granados 2016). **The contribution that this thesis offers to the device paradigm is twofold. First it seeks to reinterpret the device paradigm for contemporary technologies. Secondly, it inquires into how design can reveal, engage, and situate us with these complex technologies.** Borgmann helps us to conceptualize what the characteristics of what the alternatives to the device paradigm may look like, which he refers to as "focal things and practices."

1.2 OPPORTUNITY FOR DESIGN RESEARCH IN FOCAL THINGS AND PRACTICES (FT&P)

Borgmann presents focal things and practices as the counterpoint to, and the key to reforming, the device paradigm (1984). **Focal things and practices, or FT&P as they will be referred to throughout this thesis, invite ways for people to be engaged in the fullness of their capacities. It's a way for the technology to encourage us to be present, or engaged on mental, social, bodily, material, and environmental levels.** Borgmann is clear that this engagement must be bolstered by practices. FT&Ps are epitomized with the example of the fireplace in the previous section. Focal things are "inseparable from its context, namely, its world, and from our commerce with the thing and its world, namely engagement. The experience of a thing is always and also a bodily and social engagement with the thing's world" (Borgmann 1984, 41).

Borgmann lays out a compelling case of what is the problem with the device paradigm. In FT&P, he identifies some of the qualities of the antithesis to this problem. But how to transition from one to the other, or how to utilize design to support and surface technologies as FT&P remains unclear. Some philosophers of technology specifically examining Borgmann's device paradigm suggest that "traditional philosophical approaches may not be capable of questioning and challenging technology in a sufficiently radical manner" (Higgs, Light, and Strong 2000, 7). This is where design can make a contribution.

It is almost as if Borgmann invites design researchers by pointing out where the opportunities lie to question the device paradigm: "If we are to challenge *the rule of technology,* we can do so only through *the practice of engagement"* (1984, 207).[2] **To support design processes that can ultimately support surfacing these technologies as FT&P we need to identify those parts of the technology that demand our engagement. What exactly are the obfuscated complexities of these technologies, or black boxes, that constitute their *means*? What are the illegible things that make it work, and how can design surface our relationship and engagement with those parts?**

How can we harness sophisticated technologies to engage people and lay the groundwork for a dynamic with the object that's closer to a FT&P? Again, this not to reject complex technologies or to completely disavow all forms of automation in favor of an extremist's interpretation of "engagement." There are also cases where obfuscation of a technology's complexity and limited modes of engagement are appropriate. For example, we should not have to manually charge a defibrillator. We should instead be engaging in other forms of critical care and leave the defibrillator to charge itself automatically. This thesis does not make an absolute rejection of obfuscation. In fact as later chapters will demonstrate (chapter 7, 8), the research described here points to only particular aspects of the technology where obfuscation should be re-problemtized.

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2 Emphasis original.

The research described here does not to uphold a totalitarian approach. Not everything should be made legible, some complexity should remain obfuscated. Not everything should demand our engagement.

The objective of the design research presented here is to explore and imagine what are the possible alternatives outside the device paradigm that make legible the complexity behind these technologies and our relations with them. Rather than making everything legible and engage-able, this thesis explores what about the technology should be made legible, what are the different aspects of the technology to be engaging with, and how to support both of these endeavors. The specific answers to these questions will vary depending on the specific socio-political contexts behind these technologies.

In doing so, this thesis seeks ways to use design to support the surfacing of FT&P. This thesis focuses its attention to the moment in a technology's life when it is being designed, so to surface these qualities of FT&P while it is in use. In this positioning, the design process can be simplified as that which precedes the moment when ownership of an artifact is transferred from the designer to the people or person who will ultimately engage with the designed artifact. This transfer of ownership translates to the "design time" and "use time" (Fischer and Giaccardi 2006). What is more interesting is the fluid, dynamic, and political relationship that exists between design and use time (Fischer and Giaccardi 2006; Giaccardi and Fischer 2008). This relationship can represent one where a stance is made in design time to leave the design "open" so to speak, for the people in "use time" to adapt and reflect their own design intention upon the artifact (Giaccardi and Fischer 2008; Fischer and Giaccardi 2006). Another take is where design time never actually finishes, and is instead an on-going, incomplete process by nature that seeps into use time. This is the case with today's data technologies for example (Redström and Wiltse 2015; Speed and Oberlander 2016). To support the surfacing of FT&P, this thesis takes the stance that the relation between design time and use time must be open. In this thesis, attention is narrowed to how to frame and conceptualize FT&P within the design processes of these technologies, so that in use time they can be supported in surfacing as FT&P.

1.3 CONCEPTUALIZING FT&P AS SOCIOMATERIAL EXCHANGE

To support surfacing FT&P, we must carefully consider what are the aspects of the technology itself that need to draw our social, bodily, material, and environmental engagement. FT&P are also characterized by the fact that the *ends* (the outcome of the technology's use) are joined with the *means* (the aspects of the technology responsible for the way it works). Therein lies an entry point for design to support our relationship with the technology, through our engagement with the *means*, which are conventionally obfuscated as black boxes. **As design researchers, we need to take a closer look at that the aspects of the technology that are responsible for the way it works. This thesis reconceptualizes the *means* of Borgmann's device paradigm as the "materials" that**

constitute the technology. In situating our relation with the materials, this theoretically can support surfacing the technology that they are a part of as FT&P. To be clear, when discussing "materials" of a technology, this thesis is referring to the parts that comprise the artifact. This can range from the metal and plastics that make the encasements, surfaces, electronics boards, and gears of that artifact, but in the case of contemporary technologies; but it can also exist in forms that are not necessarily physical, such as code or Internet connectivity that also play a role in defining the artifact and its operation.

The body of work on sociomateriality undertaken by scholars of several disciplines considers the ways that we already engage with materials, and how people and materials mutually shape one another. Within the social sciences, it is considered as the exchange or "correspondence" between people and materials, where people are vital in the process of "drawing out or bringing forth" the character of the material (Ingold 2013, 31). Coming from science and technology studies (STS), the argument is that breaking people and machines into distinct categories overlooks that technology is enacted through people's practices of using them (Suchman 2007). Others challenge the framing of materials themselves, and consider how things that are often framed as intangible digital materials indeed have very physical properties. Our practices with the physical properties of these materials likewise shape their digital properties (Mazmanian, Cohn, and Dourish 2014; Dourish and Mazmanian 2011; Dourish 2016). Similarly, approaches within design look at the entanglements among people, materials, and practices as a resource to shape the experience of a particular artifact (Karana et al. 2016). Another thread of work informed by a sociomaterialist perspective specifically turns its attention to the relationships that exist not just between a person and an artifact, but to a more global scale. This work considers how the relationships and practices between people and materials and artifacts impact organizations or systems (Bjørn and Østerlund 2014; Mazmanian, Cohn, and Dourish 2014; Orlikowski 2007).

A strong undercurrent among these sociomaterialist concepts is the principle that people and materials are entangled with one another, mutually defining and co-constituting one another (Orlikowski 2007; Dourish 2014; Bjørn and Østerlund 2014), they are a single entity with a shared agency (Orlikowski 2007). To illustrate this dynamic, organizational theorist Wanda Orlikowski describes a Google search that scans troves of web content instantaneously to provide us with the best result. It is assumed in this dynamic that the technology is the slave to the human master, a dynamic not unlike the one that Borgmann ascribes to the device paradigm (Borgmann 1984). The locus of control is assumed to be with the human making the search, delegating the material of Google's code and content to the passive, subservient role. However, this assessment fails to consider the active exchange between people and the materials of the algorithms in shaping one another. The materials of Google's algorithms favors some content over others by indexing, ranking, and prioritizing some pages over others (Orlikowski 2007). The algorithms consider the location of the person making the web search, their search history, makes some demographic assumptions, in addition to looking at page and ad rankings. Here we see the materials and the people constitutively entangled with one

another and mutually defining one another. Those search results shape our perception of reality.

This introduces a unique positioning for this thesis. If we are already actively engaging materials by shaping them, how do we surface and support this existing exchange? This sociomaterial exchange appears to be also a critical component to shaping the ends of the technology itself. In the case of the Google search: the results.

To surface our modes of engagement with the technology as FT&P, we have to recognize that we are already implicitly a part of that technology's materials. We are already engaging with the materials that constitute the *means* of the technology, perhaps without our realization. Utilizing design to surface this dynamic appears to hold great promise for supporting FT&P. But, not all technologies are the same, nor are the materials or the exchanges that we have with them. As later chapters will address (chapters 5 and 7), different technologies obfuscated their functioning in unique ways and will likewise demand our engagement in distinct ways. These later chapters contribute to a reinterpretation of Borgmann's device paradigm by developing nuance to his original concept of "masking" of technologies in favor instead of "surfacing" the existing yet illegible sociomaterial exchange people already engage with contemporary technologies.

The next chapter of this thesis (chapter 2) turns to design research to identify design techniques and approaches that are concerned with making socio-material exchanges legible. Specifically, the next chapter considers how traces are used to communicate and express such exchanges.

CHAPTER 2.
TRACES AS A DESIGN APPROACH TO SUPPORT LEGIBILITY

The device paradigm identifies certain problematic patterns about how technologies are designed. FT&P offers a reform of this paradigm by identifying the qualities that the technology should display. To summarize, these qualities of FT&P should be supported by modes of human engagement, and should also surface how the *ends* (the outcome of the technology's use) and the *means* (the aspects of the technology responsible for the way it works) of the technology are related to one another. With black boxes that characterize the device paradigm, the complexity of the technology and the relation between the *ends* and the *means* are obfuscated, thereby also limiting modes of engagement. This becomes even more problematic in light of data-intensive and Internet-connected technologies.

The design objective becomes how to support joining the *ends* and the *means* together, and in doing so how to support modes of engagement. This becomes a question of how to make something that is conventionally designed to be illegible, legible. By making engagement with the technology legible, it is also an approach to help surface the technology as a FT&P.

This thesis utilizes traces as a design approach to help discover ways to make these aspects of technologies legible. Traces are an emerging approach within the academic communities of design research and human and computer interaction (HCI) which seeks to make legible that which is not apparent. Therefore traces become a technique to identify and surface our engagement with the materials that comprise an artifact, which likewise holds promise for surfacing FT&P. This chapter provides an overview of previous work on traces as a design approach, and describes its motivation for applying traces to this thesis' objective of surfacing FT&P.

2.1 DEFINING TRACES

Traces communicate things that may not be apparent, persistent, or perceivable to us. This can be the passage of time, which we recognize through traces of decay or change of certain material qualities (e.g. fading of color); or exposure to the elements, for example through traces of chemical reactions (e.g. oxidation); or through an interaction or occurrence of use (e.g. we see the gradual wearing of stone stairs that become polished or indented from frequently being stepped upon). **Traces are directly tied with materials.** They are made in them, on them, or with them. By seeking approaches to make traces of our engagement with a technology, we are looking for opportunities to surface those very materialities themselves.

Traces make that which is illegible, legible. This is an intriguing design element to consider in relation to black boxes. Firstly, it offers a provocation to traditional under-

standings of black boxes which conventionally are made of encasements whose surfaces are often made from strong metals and glasses chosen deliberately for their ability to resist traces in them. But, **traces can extend beyond the surfaces of encasements.** Traces can also be a means to express our engagement with other types of materialities, such as those that don't necessarily have a physical representation that we can hold in our hands. Traces can also be a means to demonstrate our engagement with networks or the algorithms behind a Google search query (as described in chapter 1). Traces can become our entry point for our pursuit of FT&P, to explore and make legible how the *ends* and the *means* of the technology are related to one another, and our engagement with that dynamic.

2.2 PREVIOUS WORK ON TRACES

Within human-computer interaction (HCI), work on traces has sought to make sense of and explore the various sources of traces (time/ skill/ use) (Rosner et al. 2013; Hill et al. 1992). The physical qualities of traces and how these are entangled with behavior and temporal qualities have also been explored through design explorations (Rosner et al. 2013; Rosner 2014; Bergström et al. 2010). Traces, both tangible and intangible, have also been considered as markers of experience or behaviors that have been cultivated over time, such as those that are evidence of craftsmanship (Rosner and Taylor 2013; O'Connor 2006). Anthropologist Tim Ingold looks at traces in terms of the people's social experience of engaging with materials. In this perspective, the trace becomes a dynamic flow of interaction with the materials from which meaningful relationships emerge organically (Ingold 2013).

Traces are also of interest within product design research. These can range from concerns around aesthetics, perception, and function of these traces. This line of query falls under questions of aging (Rognoli and Karana 2014), patina (Saito 2008) and maturation of materials (Candy et al. 2004). Questions of the "acceptability" of the aesthetic qualities of the trace also are relevant in this field of inquiry (Fisher 2004; Robbins et al. 2015; Giaccardi et al. 2014). This work suggests that such aesthetic quality of traces can be harnessed to support (or not) meaningful experiences with the object that can relate to supporting attachment and/or promoting product longevity (Manzini 1989; van Hinte 2004; Robbins et al. 2015; Giaccardi et al. 2014; Chapman 2013; Ostuzzi:2011ih; Karana, Giaccardi, and Rognoli 2017). Two other notable practices of interest that have a strong philosophical stance towards traces are the Japanese wabi sabi and kintsugi traditions of imperfection and repair. These practices accept and aesthetically highlight the imperfection of the 'wear and tear' of use and breakage. In the context of ceramics for example, cracks and chips are mended with some kind of adhesion filler and are put to use again and emphasize the beauty of that imperfection (Rognoli and Karana 2014; Tsaknaki and Fernaeus 2016).

In each of these approaches, traces are recognized as having a formidable communicative capacity. To summarize the approaches to traces of previous research: some consider traces as markers of the relations that people have with materials. Other work here acknowledges that traces may conventionally be seen as undesirable and therefore potentially shorten a product's life span, and therefore take this as an ambitious opportunity to re-appropriate traces to extend a product's lifespan (Bridgens and Lilley 2017). In each of these lines of research, traces are being considered for the role that they play in reflecting and shaping the relationship that we have with the artifacts that they are a part of, and in some cases how this role can be reconfigured through the use of traces themselves.

Another relevant line of work on traces considers them in light of digital contexts. Such as how to take data from digital devices, such as personal activity trackers, and manifest it in a physical form such as traces on physical surfaces, again to promote product attachment (Lee, Cha, and Nam 2015; Lee, Son, and Nam 2016). Within science and technology studies (STS), Heather Wiltse builds on the notion of traces as not only being bound to changes in the physical surfaces of artifacts, but expands this notion to digital materials. Wiltse develops language to interpret the material and interactional aspects of traces, especially as they concern digital materials and spaces. In this context, traces are defined as a perceptual change in the substrate of the thing that's brought about by an action (Wiltse 2014). Her work is especially concerned with how digital traces are disassociated from activities that we have with digital objects. This critique echoes that of the device paradigm, but within a digital context.

This vein of work on traces resonates with work on sociomateriality, highlighting the mutual exchange between people and materials that are entangled in constituting one another but that is often deliberately being in joining the *ends* with the *means*. Three particular patterns emerged in this process, each with their own range of design techniques related to surfacing FT&P (chapter 7).

2.3 POINT OF DEPARTURE: SOCIOMATERIALITY OF TRACES

Building on this previous work on traces' expressive and communicative potential, as well as how it provokes our understanding of materials themselves, this thesis explores how traces can be applied to surfacing FT&P. As described in chapter 1, FT&P are characterized for their ability to engage people in the fullest of their capacities, and for making legible how a technology's *ends* (the outcome of the technology's use) and *means* (the aspects of the technology responsible for the way it works) are related to one another.

Drawing upon these definitions laid out in section 2.1, traces become an excellent design approach to surface our sociomaterial relations with the complexities of contemporary 'black boxes' precisely for their ability to communicate that what is

not apparent, persistent or perceivable in a legible way. By using traces as a design approach, we first are given an opportunity to reconceptualize our notion of *what* are the materials that constitute black boxes. This then opens up the possibility to make legible our sociomaterial relations with those materials. Traces become markers of those active, engaging, and co-constitutive exchanges between people and the materials. By illuminating this exchange that exists between us and the materials that is typically obfuscated, we also make legible how people are engaging in joining and relating the *ends* (the outcome of the technology's use) with the *means* (the aspects of the technology responsible for the way it works). In attempting to make this dynamic legible, we are attempting to support an avenue for design to surface FT&P. Part III will detail how designing with traces provided a richer understanding of FT&P (chapters 5 and 7). Chapter 7 identifies three particular patterns that emerged in using traces as a design approach that point to different materialities of technologies. Within each of these patterns, there were a spectrum of techniques towards surfacing FT&P.

part II
Methodology

CHAPTER 3.
RESEARCH THROUGH DESIGN

This thesis builds on theories from philosophy of technology to inform a line of design inquiry, namely to understand the design space surrounding surfacing FT&P. A tailored methodological approach is necessary to accommodate the pedigree of this particular inquiry spanning between the humanities and design research. In this particular case, it comes in a form of bespoke research through design (RtD), which this chapter details, and design anthropology, which the following chapter details (chapter 4). In essence, series of design journeys that are undertaken with a RtD approach are interpreted with a framing from design anthropology. This chapter will first position RtD within the context of the research conducted for this thesis.

This type of research inquiry blends the philosophy of technology from the humanities with design to make a disciplined critique to inspect normative assumptions of human computer interactions (HCI) and design. The intention behind this is to stimulate innovation and challenge us to "think deeply about new paradigms of computing" (J. Bardzell and Bardzell 2016; J. Bardzell 2009, 2362). Implicit in this humanistic line of research inquires is an interpretive, and dissatisfied, stance towards the predominate trends that we see of how design is done today and adopts an outlook that some kind of emancipation from this observed standard that is the subject of the critique.

Examining the device paradigm and FT&P represents what is referred to within design research as a "wicked problem" (Rittel and Webber 1973; W. Gaver 2012; Buchanan 1992) The complex and enigmatic phenomenon of FT&P as a wicked problem does not lend itself to a simple straight forward answer, guideline, or designed artifact that resolves the question in and of itself. Instead this research begs an "exploratory investigation of established theories with the overall aim of improving and widening the range of theory and knowledge" (Stolterman and Wiberg 2010, 102). RtD is well suited to exploring wicked problems (Zimmerman, Forlizzi, and Evenson 2007; Stolterman and Wiberg 2010). The ultimate knowledge output of this methodology can vary greatly, depending on the topic and the researcher's aims. In this case, RtD provides a route to expound upon the theoretical questions and constructs around the research topic. RtD offers a method to reconceptualize the device paradigm in light of contemporary technologies, and to support its reformation in the surfacing of FT&P. The knowledge output of this particular RtD process is a design space. The rationale for this type of knowledge output is described in section 3.3, and the details of this particular space will be described later in chapter 7.

This kind of theoretical and conceptual line of research requires a methodology that supports an exploratory inquiry, to which RtD is well suited (Stappers and Giaccardi 2017). Simply put, RtD examines a particular research topic through the act of creating a research artifact, and reflecting on the resulting research artifact and design process (figure 1). This becomes a route to frame and reframe the research topic and inform

another cycle of design. These cycles of reframing research topics and design continue iteratively (Stappers and Giaccardi 2017; Zimmerman, Forlizzi, and Evenson 2007). RtD is a methodology that can come in many forms, this chapter is dedicated to describing the shape it takes in this thesis.

RESEARCH
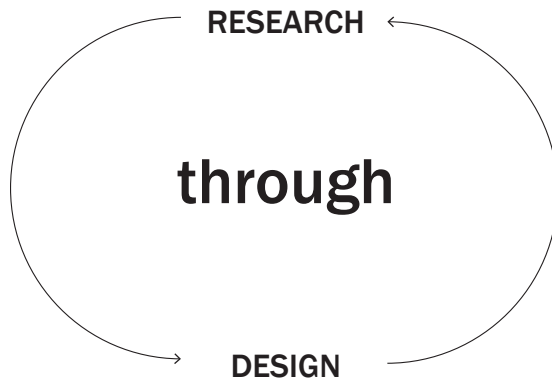
through

DESIGN

Figure 1. A simplified diagram of the structure of a research through design (RtD) process, where research is conducted through creating design, which is reflected upon to further reframe the researcher's understanding of the topic. This is repeated in a recurrent manner.

This chapter will go into detail describing how this thesis approached three particular pillars of design research (Stappers and Giaccardi 2017). Firstly it will discuss the interpretation and role of the research artifact in this RtD process (section 3.1). The following section will discuss the nature of how the cycles of this RtD process related to one another (section 3.2). Lastly, this chapter will conclude with a discussion detailing the specific form of knowledge output that this research sought to produce (section 3.3). Discussions about the RtD process will continue in the following chapter (chapter 4), which is dedicated to the "through" portion of this thesis, and how this was carried out with design anthropology.

3.1 DEFINING RESEARCH ARTIFACTS

A research artifact can be defined as something that gives form to, or is the embodiment of, an idea to be shared and communicated. It is a representation of decisions that had been made to interpret that idea. Research artifacts also offer the utility of clarifying and organizing thoughts for the purpose of being exchanged among others and reflected upon. In the case of RtD, a research artifact is a tool in which design researchers can

reflect upon, as well as frame and reframe the research topic.

In the RtD process for this thesis, the definition of a research artifact came to apply to more than just the design concept that was the culmination of the design process that followed a design brief. Additionally, the design brief itself that triggered the creation of the design concept also represented a research artifact as it has been defined in the previous paragraph. This expansion of the notion of "artifacts" provides us with a more holistic framing of what aspects of a design process help to provide moments or touch-points to reflect, communicate, and refine our ideas around the phenomenon being researched.

This section will first specify the role of a research artifact in this RtD process. The subsequent sections will elaborate on the distinction between research artifacts that are design concepts and those that are design briefs.

ROLE OF THE RESEARCH ARTIFACT
In this RtD process, the role of a research artifact is to probe the phenomenon of re-search. Research artifacts are like the satellites that we send out in a general direction of something that we want to explore in outer space. They help us collect blurry images for us to interpret and analyze which help us construct the boundaries of our universe.

As a probe, the research artifact is a touchstone upon which reflections, interpretations, and analysis of the topic of research are developed upon (Koskinen et al. 2011; W. Gaver 2012; Zimmerman, Forlizzi, and Evenson 2007). As a vehicle to investigate the topic of research, the research artifact first identifies that which needs to be articulated, and then develops a form in which it can be shared and understood by others. In the case of this thesis, the research artifact helps us understand and theorize a design space around the phenomenon being researched, surfacing FT&P in contemporary technologies (Stolterman and Wiberg 2010). Research artifacts help to tease out what are the considerations of the design of that technology that we need to problematize and surface to encourage its future as a FT&P.

Indeed, as this thesis proposes to explore a "wicked problem," it seeks to consider an ill-defined and nuanced topic from which there can not be a clear or singular "solution" (Rittel and Webber 1973). As such, it is important that research artifacts are considered in relation to other research artifacts, which will be discussed in section 3.2. The following sub-sections will discuss the forms that the research artifacts from this RtD process came in: as design concepts and design briefs.

DESIGN CONCEPTS AS RESEARCH ARTIFACTS
In this thesis, a "design concept" refers to a research artifact that is created in a design process in response to a design brief. These research artifacts represent an idea, which is an interpretation of the design brief, communicating and sharing that idea in the form of a design concept. The process of creating a design concept as well as the design concept

itself served as a critical avenue to theorize the topic of research. Chapter 5 provides a detailed reflection of those design processes and how this contributed to reframing the research topic and the next design cycle.

These design concepts did not go into the field to be embedded into peoples lives. The purpose of these design concepts was not to provoke particular patterns of behaviors or user experiences. Rather, they were intended to strengthen the theorization and articulation of a concept (Stolterman and Wiberg 2010). In doing so, this analysis seeks to map a conceptual and theoretical space that these design artifacts helped to articulate and discover its boundaries (section 3.3). These design concepts develop knowledge by identifying avenues with which design can challenge the predominate design trends that facilitate the device paradigm.

There are 10 design concepts discussed in this thesis. They were the outcome of design processes that lasted between one and nine months and were crafted in response to a brief that I either authored or collaborated in authorship of. This is true with the exception of one design artifact where the brief was authored by a company sponsoring the project. For the reader's reference, chapter 6 provides an index of all of these design concepts. This index describes the design concept, the involved designers, the brief it was made in response to, when it was designed, and my role in the design process.

DESIGN BRIEF AS RESEARCH ARTIFACT

In this RtD research process, the design brief itself became a critical research artifact that also probed the boundaries of the design space that this thesis seeks to map. Reflecting back on our definition of a research artifact, the design brief satisfies each of its criteria. It communicates an idea, and is the representation of decisions made in interpreting an idea. According to an RtD process, this also makes it a critical lens to analyze and reframe the topic of research.

Interpreting and translating theorizations of the black box (chapter 1) into the form of a design brief was itself an act of design, or result of decisions made to interpreting an original idea in a designerly way (Cross 1982). Critiques and theoretical framings of the device paradigm, FT&P, and sociomateriality were reinterpreted into units of design: ways of doing, practices, interactions, and materials for the design brief. This required an act of design to create a research artifact that represents the organization and clarification of thoughts in the form of the design brief. The design brief became an expression of an idea to be shared and communicated, in this case with design researchers and design practitioners. It also became an important lens by which to frame and reframe the topic of research itself. Thus the design brief performs the role of a research artifact: it is a conduit for research findings to clearly communicate the research contributions (Stappers and Giaccardi 2017).

The design brief is a research artifact that similarly was iterated upon in cycles, a way of working that is archetypal within RtD. Firstly, as is often the case with design concepts,

there were many iterations or drafts of the brief that lead to the "final" version of a deign brief for a single RtD cycle. Also, the design brief becomes a point of reflection back directly upon the research topic to reframe it for another RtD cycle. Yet it also feeds into the design process of the design concept as well, an exchange that is also fruitful to reframing the research topic. A detailed account of how these iterations of reflection of how the design brief reframed the topic of research is provided in chapter 5. A collection of all the design briefs I authored for this thesis can be found in the appendices (appendix 1,3,4, and 5).

In light of this construction of the RtD process, our simplified diagram from earlier in this chapter (figure 1), needs to be slightly modified. As figure 2 demonstrates, the design brief becomes a distinct research artifact resulting from a design process. As a distinct research artifact, the brief also directly provides perspective into reframing the research topic itself in addition it shapes the design process of its companion research artifact, the design concept.
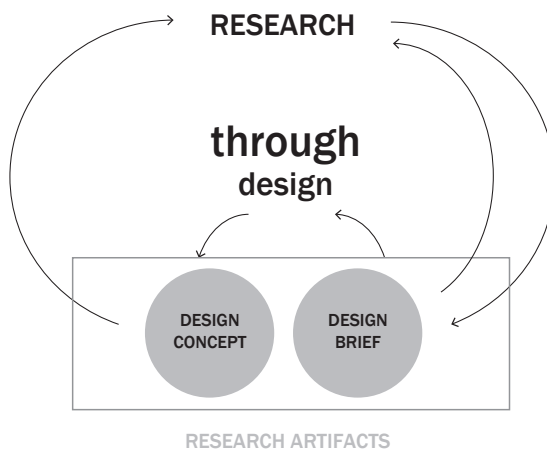
Figure 2. An elaborated diagram on research through design (RtD), building upon figure 1, illustrating this thesis' particular methodological approach. Research is explored through design process, which in this case results in two distinct research artifacts: the design brief and the design concept. Both research artifacts offer perspective to reframe the research topic to inform another cycle of design.

Interestingly, the briefs did not always yield a particular result. The initial intention behind the briefs may have been to guide the subsequent design process towards a particular goal or outcome. However these briefs did not have such a linear trajectory, instead the resulting design concepts would sometimes echo insights from previous briefs, or highlight entirely new insights. This non-hearichal and non-linear impact that the briefs had on the ensuing design processes will be discussed in the following section (3.2).

The design brief can serve as a snap shot, charting the development of the thinking around the research topic at the time. The briefs reveal and communicate (to design researchers and practitioners) the evolution in the thinking approaching the phenomenon of research. They reflect the problematic assumptions in the approach to the research topic, and also help surface new lines of questioning that needed to be pursued. The brief becomes a point of convergence to exchange thoughts on the topic that the RtD process was attempting to illuminate. As already mentioned, chapter 5 clearly demonstrates this convergence and communication that is triggered by the design brief, section 5.4 especially testifies to this dialogue that the design briefs provoke with designers. It accounts the actual conversation that took place between myself, the author of the design brief, and professional designers who were tasked with interpreting the design brief for a design process.

3.2 RHIZOMATIC RTD CYCLES

A distinctive quality of RtD's programmatic approach is that it is composed of cycles, which rotate between periods of designing, and periods of reflecting on how those design processes and research artifacts reframe the research topic, which later informs another period of design (Stappers and Giaccardi 2017). This section will discuss how these RtD cycles related to one another in the context of this thesis.

The relation among RtD cycles can take a variety of forms, such as a linear trajectory (Hermans 2015), or a spiraling approach (Eriksen and Bang 2013). The cycles of this particular thesis however resembled a rhizome, it was neither linear nor hierarchal. Within botany, rhizomes refer to an underground, horizontal root systems that branch out in various directions, radiating from a stalk. Interestingly, sections of rhizomes are capable of producing their own shoots, to generate a new root system of a new plant (figure 3). Some philosophers use it, or its variant "rhizomatic," to refer to theory or research that a non-hierarchical relation for various representations of data (Deleuze and Guattari 1980). It is a non-binary approach that can establish vertical and horizontal connections. Rather than offering a chronological narrative, it is a mode of mapping that accounts for a wide selection of events and influencers without a specific origin or end, and instead considers the relations and influences that exist among these occurrences.
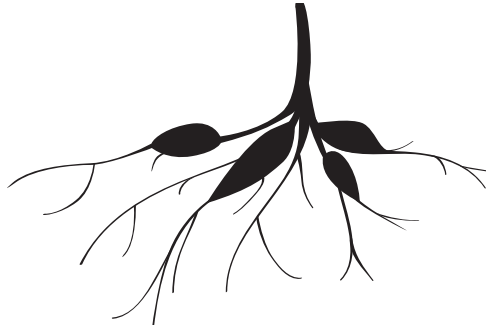
Figure 3. Diagram of an organic rhizome root structure. The stalk of the plant emerges from short rhizome root system. Rhizome root system radiates out from stem.

RHIZOMATIC DEFINED BY RELATIONS

This rhizomatic approach also is unique for the relations that exist among these various RtD threads to construct a greater meaning all together. We will return to the metaphor of space exploration from earlier in this chapter to describe this relationality among RtD cycles. The research artifacts of these RtD cycles are like satellites, being launched from earth to probe the edges of the universe that surrounds us. Part of what makes their mission successful is how these various forms of data collected by each satellite correspond to each other. A particular satellite may study Saturn, providing us with troves of data about its properties. But the things that we can learn from Saturn is different when it's considered not just as a solitary planet, but in the context of our solar system. We can begin to build an understanding of how Saturn relates to other planets, and build a map of our solar system—not just of the positions of things in it, but also of the set of relations among the various parts that constitute it. When discussing research artifacts and a RtD cycle in relation to others, the knowledge that can be derived at the level of a single research artifact will be distinct from the knowledge that is derived from the constellation of other research artifacts and RtD cycles. It is less about what knowledge came first, but more about the relations that emerge among the different forms of knowledge.

Considering artifacts and forms of knowledge in relation to one another is a well established tradition within design research. An individual artifact, represents a particular framing of the problem; however when it is considered in terms of the other constellation of artifacts, new opportunities to frame or reframe the artifact or the research topic emerges (Zimmerman, Forlizzi, and Evenson 2007; B. Gaver and Bowers 2012). Two artifacts put in conversation together will surface knowledge, themes, or patterns in relation to one another on a particular topic. But when another is added to this group, the conversation and the knowledge that will be surfaced could be entirely different (B. Gaver and Bowers 2012).This is a nice acknowledgement of the fluidity of knowledge and how it is constituted in relation to the artifacts being considered.

We are reminded by Ferri et al. that considering a collection of artifacts offers us an

epistemological benefit rather than considering an artifact in isolation (Ferri et al. 2014). Two artifacts put in conversation together will surface knowledge, themes, or patterns in relation to one another on a particular topic. The authors advocate however for widening of this collection beyond the work of an individual designer's project or program of artifacts to include a wide inventory of artifacts dedicated to the concept at hand.

As Erik Stolterman and Mikael Wiberg explain, when seeking to develop knowledge on a conceptual project, the manifestation of an artifact is merely a carrier of that knowledge, but the artifact on its own is not necessarily important, instead it is the knowledge that is derived from it (Stolterman and Wiberg 2010). This is especially the case when artifacts are considered in terms of their relations to other artifacts, a dynamic which will be detailed in depth in chapter 7. This thesis would like to contribute building upon this existing work to suggest that what distinguishes a rhizomatic RtD approach is the explicit distinction that these relations are not hierarchal or linear.

BUILDING THE RHIZOME
Ultimately, the rhizome comes to represent the design space that is constructed through this design research inquiry into FT&P (see section 3.3). This is an elegant reference to philosopher Gilles Deleuze's formulation of the rhizome as an "image of thought," which in this thesis is represented as a mapping of the conceptual design space surrounding surfacing FT&P (Deleuze and Guattari 1980). Chapter 7 visualizes and maps this design space.

In keeping with the botany metaphor of the rhizome, each portion of this root system represents different stages and components of an RtD cycle (figure 4). Branching out from the central stalk is the research phenomenon, the conceptual space of surfacing FT&P with design. This is translated, in an act of design, into a design brief. In two cases, this was also a field study (chapter 4 and section 7.3 will position and elaborate on these field studies respectively). These research briefs and field studies represent the thicker origin point of the root system. Design briefs yielded design concepts. These design concepts could yield a particular insight about the research phenomenon, sometimes two distinct insights. These insights represented as the wiry roots that fan out from its thicker origin point. The direction that these roots move towards represents the insights that emerged from analysis of these particular design concepts. These roots sometimes would split in two, moving in different directions. This demonstrates that a single design brief could yield a design concept that illuminate more than one insight. In the case of case of the field studies, the root system that emits from them similarly points to the specific insights it revealed about the research phenomenon. While these design briefs were written sequentially, this did not necessarily impact the design concepts or insights that they yielded in a directed, linear, or sequential way. Ultimately this root system comes to form and discover the boundaries of the conceptual design space of surfacing FT&P, which will be positioned in section 3.3, with the specifics of that space are built and detailed in chapter 7.
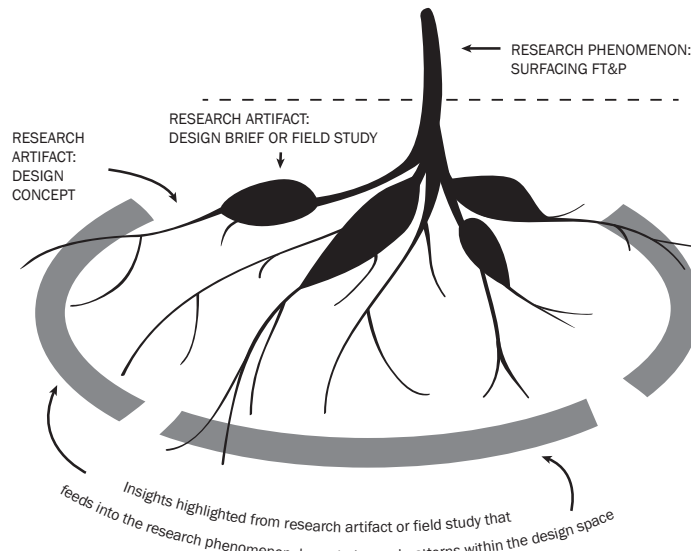
Figure 4. A metaphoric illustration of how the various parts of the RtD process map onto a botanical rhizome. This will be mapped out with specifics in chapter 7.

RHIZOMES GROW

This rhizomatic approach also illustrates another beautiful aspect of design research and RtD processes, which is that the research itself is never complete. There will still be much room to grow, and in all sorts of directions, anticipated and otherwise.

Returning again to our original metaphor of space exploration, there are parts of the universe are not mapped and remain unknown. Up to this point, I have primarily focused the discussion on the process behind how we engage with the satellite itself (research artifacts), the blurry picture it transmits back for us Earthlings to interpret, and how these pictures relate to one another. The reality is that there will always be much out there that we don't know. We sometimes have an awareness of the things that we don't yet know, such as that there are galaxies beyond the ones we have observed. As we advance our knowledge of the universe, our framing of what is the universe changes. We saw the sun and thought it revolved around us. Then we gained tools to see and understand that we were part of a solar system that revolves around the sun. In the process of making these tools we developed new areas of science, which begat new tools. With these new tools we were able to see and understand that there were many suns and that we were in just a tiny solar system among many, and that we're within a single galaxy among many.

Thus in chapter 7, where a map of the design space is presented which is representative of the boundaries uncovered in this rhizomatic RtD approach, it should not be assumed to be complete. While its circular appearance may appear to suggest completeness, it is

actually a representation of the work completed as a part of this PhD's studies. Indeed, even the representation of this rhizome, the mapping of the design space, has undergone several iterations itself. This diagram represents what has been completed, and serves as the basis for future work.

3.3 DESIGN SPACE AS INTERMEDIARY KNOWLEDGE

Lastly this section addresses the form that the knowledge, produced in this particular RtD process, takes. Borrowing from Stappers and Giaccardi's definition, "knowledge" both refers to the understanding about the world, but equally important is that it can be shared (2017). This definition draws our attention to not just the content of the knowledge, but also the form and implicitly, its audience. This section details the form of that knowledge, and also the ways that it is adapted to reach several different audiences. The content of the knowledge itself is detailed in chapter 7, and its implications for design processes are discussed in chapter 8.

The knowledge that comes out of an RtD process can come in a variety of forms, and the form of that knowledge output will suggest particular modes of communication and audiences. The output can come in the form of an artifact, guideline, or toolkits for example. In earlier stages of this process in fact, it appeared that the knowledge being developed was in the form of a set of design guidelines (Robbins, Giaccardi, and Karana 2016; Giaccardi et al. 2014; Robbins et al. 2015). However, traveling deeper into this research illuminated that mapping the design space around surfacing technologies as FT&P would be the most appropriate form of knowledge output.

This map represents a strategy to articulate this conceptual space, and also to aid the development of *designerly sensibilities* towards approaching and navigating the complexities of this space (chapter 8) (Stolterman 2008). Further, the knowledge that is mapped in this design space can also be represented in other forms, which are intended to reach other audiences.

DESIGN SPACES AS A LANDSCAPE

This thesis adopts Dove, Hansen, and Halskov's definition of design spaces as a "dynamic conceptual space that bounds the possible or probable designs, and which is constructed and explored through design activities" (Dove, Hansen, and Halskov 2016). As their extensive review of scholarly work point out, there is no cannon as to what constitutes a design space. However, this work aligns with and builds upon the work of Gaver, to suggest that it is constituted by a curated collection of ideas and concepts that work towards illustrating the metaphorical landscape of design opportunities — not possible ideas (W. Gaver 2011; B. Gaver and Bowers 2012). A map of this metaphoric landscape offers an approach by which the inquiries that this design research process makes into the theoretical and conceptual subject of FT&P can be understood within the context of one another (which had been discussed in the previous section, 3.2).

The map is an approach to make the conceptual whole more understandable. Presenting the knowledge generated from this design research process as a map of the conceptual whole is an acknowledgement that large and ambiguous conceptual topics of research are not those that should solicit a single answer to "solve" the problem; nor should there be the expectation that a single design concept or design artifact can encapsulate the knowledge that's produced from the study (Stolterman and Wiberg 2010; W. Gaver 2011). Prescriptive guidelines or toolkits would have a difficult time trying to address the situatedness and nuances of this particular design space (Stolterman and Wiberg 2010; W. Gaver 2011). As argued earlier in this chapter, the research artifact itself isn't the ultimate knowledge output (section 3.2). Dalsgaard echoes these sentiments that an isolated design concept is ill equipped to provide clear answers to complex theoretical inquiries. He instead advocates for less emphasis on the artifact itself, and a more meta perspective of what it represents. He argues instead that instead of generating answers we should seek to use these inquires as vehicles for materializing questions (Dalsgaard 2016).

A design space represents the accumulation of design inquiries that helps bring meaning to that much larger question. As described in the previous section (3.2), these inquires come in the form of various research artifacts and field studies (section 4.2). Taken together, these inquires help to identify the "boundaries" of this design space so to speak. Comprising these boundaries, we can identify "patterns" which attempt to identify an issue at hand, and offer some perspectives on how design can support that issue (Alexander, Ishikawa, and Silverstein 1977). In this case, these patterns offer different conceptualizations of FT&P, and some design approaches to support surfacing that conceptualization. This mapping of this design space serves to communicate the conceptual space to others.

This thesis dedicates its attention to what the collection of research artifacts represent as a whole, and how they help us theorize FT&P, and how to support surfacing them (Stolterman and Wiberg 2010). In setting its scope beyond individual instances of design, this thesis seeks to develop intermediary knowledge. As Höök and Löwgren explain, this type of knowledge is more abstracted than specific instances, but not yet generalizable like a theory (2012). Design spaces as a form of intermediary knowledge represent an effort to bridge the gap between "practical, straightforward guideline approaches and 'how-to' checklists, on one hand and, on the other, grand theories, usually 'imported' from disciplines in the social and behavioral sciences" (Stolterman and Wiberg 2010, 112).

SHARING KNOWLEDGE AND AUDIENCE

Maps of design spaces represent a rather open-ended form of knowledge, or tool, which encourages designers—practitioners and researchers—to develop their own skills in engaging with the complex ideas it seeks to represent. This design space is an attempt to support designers in approaching such a complexity, specifically in support of developing their "tools for reflection," or their individual "designerly judgment" in

navigating this complexity in their practice (Schön 1983; Stolterman 2008). Mapping this design space offers designers a "frame" with which to understand the complicated and unstable concept of FT&P (Dorst 2010). With such an understanding, designers are supported in building "a *heightened sensibility of quality and composition*, all with the purpose to *prepare-for-action*" (Stolterman 2008).[3]

In its present form, the map of the design space that this thesis presents (chapter 7) is most appropriate for an academic context, specifically for the design research, human computer interaction, and the science and technology studies communities (Robbins, Giaccardi, and Karana 2016; Robbins et al. 2015; Robbins 2017). But, the findings from this design space can be adapted into different forms, in order to reach and be shared among other audiences.

Communication with Research Artifacts

As addressed in section 3.1, the research artifacts that identify the boundaries of this design space also represent a technique to share and communicate knowledge about what this space represents. More accurately, a research artifact communicates *part* of what this space represents. These research artifacts can potentially reach a diverse audience. In the case of the design briefs, this was a research artifact intended specifically for design practitioners, to share and communicate an initial impression of the design space upon which they could develop further.

Conversely, design concepts are research artifacts that typically reached a much broader audience who may or may not necessarily be specialized in design. This was especially true while they were on display at exhibitions, events, and in public spaces. Design concepts that come in a physical form can offer have a kinesthetic experience which serves as a window into the conceptual space that it seeks to explore. These can be very impactful, especially with high fidelity design concepts where there was very little imagination required to engage with the artifact, which was the case with a couple of the design concepts discussed in this thesis: Mizu and the Transparent Charging Station (chapter 6). These were on display at national and international conventions, government and industry events, and were used in audiences with diverse expertise to communicate information that is relevant to this design space (figure 5).

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3   Emphasis original.

Figure 5. Mizu, a deisgn concept from this thesis, on display for a general audience at Dutch Design Week 2015. Image: Holly Robbins

Design concepts not only express and communicate an idea, but in some cases could also inspire action, as was the case with Thingformation (chapter 6). Thingformation started as an effort to explore approaches to surface FT&P in consumer electronics and was developed with governmental funds especially for a national design exhibition, Dutch Design Week 2016. Thingformation was well received, and the organization that provided the grant for the project expressing interested in the feasibility of scaling up the project. It was also used as a case study for another international industry-lead initiative that shared the very same goal as Thingformation, to promote consumer awareness of the invisible actors behind Internet connected objects (Bihr 2017).

Essays for General Audiences

Yet another approach to extend the reach of the knowledge mapped in the design space was carried out with essays written for communities of design practitioners. The intention behind these essays were fourfold: first to speak to audience outside academia about the knowledge related to this design space; secondly to present an argumentation to audiences outside of academia regarding the insights of this design research; to try to create opportunities for this design research to have an impact among design practitioners; and lastly to create opportunities for dialogue and exchange with design practitioners on this subject to benefit from their insights. These essays were invited, the invitation of which was made possible through close collaborations with design practitioners. The impact of this collaboration, as well as a discussion of how this collaboration supported dissemination of knowledge of the design space, will be discussed in chapter 9.

There were three essays authored in collaboration with practitioners that promulgated knowledge from this design space. First was a populist manifesto identifying 10

principles for responsible design for internet connected technologies: "The Internet of Things (IoT) Design Manifesto" (appendix 6) (Afdeling Buitengewone Zaken et al. 2015). This Manifesto was circulated widely among practitioners, impacted the agenda of ThingsCon, a European professional organization of professionals working in the IoT sector (ThingsCon 2017), and was covered in international media (Vanhemert 2015). The second essay, "The Fisherman's IoT," was the outcome of a design sprint sponsored by the Open IoT Studio, an affiliate of the Mozilla Foundation[4]. This essay contemplates what turn of the century fisherman's vessels could teach us about how to design an open IoT. The subject of this essay was a result of a short field study which will be discussed in detail (chapter 7.3, 9). This essay was later published in the Open IoT Studio's annual report (Thorne, Rogers, and Skelly 2016) and can be found in appendix 7. The final essay was invited by ThingsCon, on the state of responsible IoT. This essay uses Thingformation (chapter 6) as a lens to address the importance behind the design space that this thesis addresses: "The Path for Transparency for IoT Technologies" (Robbins on behalf of Just Things Foundation 2017, Robbins on behalf of Just Things Foundation 2018).

Each of these essays attempt to develop, share, and communicate the ideas behind the design space of surfacing FT&P with a wider audience. These essays would not exist had it not been for our collaboration with design practitioners. Similarly these collaborations represented opportunities to develop the design space itself. This will be discussed in greater detail in chapter 9. These essays served as an opening up of the research so that it could exist outside of the academic context; by doing so, new life is being breathed into it by other communities of design practitioners as it becomes appropriated for their own contexts (ThingsCon 2017; Bihr 2017; Thorne, Rogers, and Skelly 2016). Interestingly, next to a general audience, this work proved to be relevant to some academic communities. In these cases, these essays were consulted as being representative of the narrative within industrial design practice (Fritsch, Shklovski, and Douglas-Jones 2018; Wakkary et al. 2017).

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4   The Mozilla Foundation also are responsible for the Firefox web browser.

CHAPTER 4.
RESEARCH *THROUGH* DESIGN ANTHROPOLOGY

The methodological foundation of thesis is built upon research *through* design (RtD), as the previous chapter (3) has described. With RtD, the research artifacts and the design processes behind them feeds into reframing the research topic itself (Stappers and Giaccardi 2017). Typically, with RtD the expectation is that the designer herself is both the researcher and the designer in this process. Through the act of *doing* design, the research topic is being reframed. However, as this chapter will describe, the manner in which I "did" design drew more upon my role as an anthropologist, than as a designer.

This thesis proposes a methodological approach of research *through* design anthropology. In this case, design anthropology became a critical tool to carry out RtD. The design processes behind creating research artifacts, design briefs and design concepts, was the site of fieldwork so to speak that contributed to reframing the research topic. In addition, there are a handful of field studies of design practices and communities that did not yield design concepts that instead resembled anthropological fieldwork. These case studies also contribute to reframing the research as well as shaping the design space that this thesis maps.

This chapter will first position design anthropology in relation to research through design (section 4.1). It will then elaborate on design anthropology's contribution as a mode of understanding, contextualizing, and theorizing of design processes; specifically the *through* portion of RtD and how this worked towards reframing the topic of research. Additionally, I will detail and position my own approach as a design anthropologist (section 4.2). This chapter sets the stage for the following chapter (5) which is an anthropological account depicting four cycles of research *through* design anthropology, detailing each cycle's design processes and research artifacts and how they were contextualized and theorized to ultimately reframe another cycle of design and the topic of research, surfacing FT&P.

4.1 POSITIONING DESIGN ANTHROPOLOGY IN RESEARCH THROUGH DESIGN

Anthropology and its related methods are no strangers to design research. Ethnography for example, a technique traditionally associated with anthropology, has been used as a tool within design practice since the late 1970s to develop an understanding of the context that artifacts inhabit, and the social lives and needs of the people in those contexts. This technique has had such an impact that even abridged versions of have been developed for design processes, appropriately labeled as being "quick and dirty" (Hughes et al. 1994; Hughes et al. 1995; Millen 2000). Later, emerging from Scandinavia, ethnographers took on the role of mediators and facilitators of co-design sessions (Sanders and Stappers 2008), serving as liaisons to minimize the stance between

the context of use and the design process itself. This technique falls under the larger umbrella of "participatory design" (Schuler and Namioka 2017; Ehn 2008; Bjögvinsson, Ehn, and Hillgren 2012; Sanders and Stappers 2008). The application of anthropology to the RtD process discussed in this thesis however takes a different approach.

The emphasis in the methodological framing of RtD is distinguished for its consideration of what emerges through the processes of making and "doing" design. It implies that the researcher has his or her "hands," so to speak, directly in the design process. In doing so, RtD expands the focus of design research activities to include making as a mode of inquiry, thus moving the role of a design researcher beyond that of a critic (Zimmerman, Forlizzi, and Evenson 2007). The approach taken in this thesis studies design processes to consider and how they frame and reframe the topic of research, but with an anthropological lens.

To position myself, I do not have expertise in creating design concepts, or in fabricating prorotypes. Apart from authoring the design briefs (section 3.1), my "hands" were only very occasionally in the design process itself. Instead, I engaged with these RtD cycles as a design anthropologist rather than as a designer (Smith and Kjærsgaard 2015; Smith 2013; Smith et al. 2016). I still considered the modes of making or designing in these RtD cycles as the site of inquiry; but as a design anthropologist I sought to understand, contextualize, and theorize these modes of making and what they can tell us about surfacing FT&P. My inquiry into these design processes considered: how does design come into being; what are the factors, constraints, and opportunities that help form and shape it? As a design anthropologist, the design process was my site of fieldwork (figure 6). This fieldwork, so to speak, was a tool in understanding how to frame and reframe the topic of research: what are the design considerations that need to be taken into account to surface FT&P?
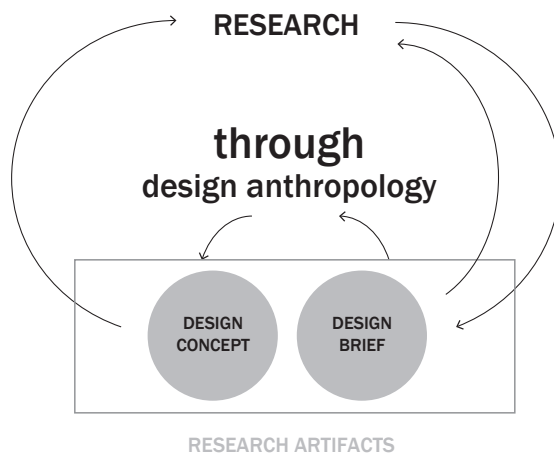
Figure 6. A revision to figure 2 to demonstrate the positioning of design anthropology within the RtD cycle. The design processes to create the research artifacts of the design brief and the design concept become the site of the anthropological fieldwork so to speak.

INTRODUCTION TO DESIGN ANTHROPOLOGY

Design anthropology is a hybrid practice that closely parallels much of the style of work that RtD proposes. At first glance, design anthropology may seem like an oxymoron. Design is about transforming the world whereas anthropology seeks to describe and contextualize the world. Design anthropology instead is a balance of understanding and contextualizing the way things are with theorizing and exploring how they could be.

Ton Otto and Rachel Charlotte Smith summarize the qualities of design and anthropology that contribute to defining this blended field. They list some of the qualities from the field of design that shape design anthropology: seeking to develop tools and practices of collaborative future making; an orientation towards intervention and transformation of social realties; and working in multi-disciplinary teams. The field draws on its anthropological heritage with: integrating pedagogical traditions of contextualization and interpretation into the design tasks, while emphasizing "the generative role of theory in developing design concepts and critically examining existing and conceptual frameworks" (Otto and Smith 2013, 4); incorporating investigations into the past to understand the present and envision the future; and are characterized by a unique sensitivity to the values of groups of people that are affected by design. This of course leaves much room for design anthropologists to interpret how to exercise these methodological tenets in their own work. A flavor of this diversity can be found in the edited volumes that are pioneering this methodological landscape of design anthropology (Smith et al. 2016; Gunn, Otto, and Smith 2013).

Based upon this framing of design anthropology, it is apparent that it is well suited for the inquiry of this thesis. Firstly, this thesis inherently represents a multidisciplinary approach in its incorporation of philosophy of technology and anthropological modes of inquiry with design research. This research is motivated by a critical stance towards existing conventions that facilitate the device paradigm, and relies on design to explore how to transform that reality by developing the theoretical concept of FT&P, and how to surface technologies as such. Developing this theoretical space around FT&P demands historicization as Borgmann considered the device paradigm to be an affliction of contemporary technologies and not their predecessors (section 5.3 specifically addresses this subject) (Borgmann 1984). To pursue this research agenda, this thesis heavily relies on design anthropology to interpret and contextualize the design processes, and the design artifacts themselves. These processes and outcomes of design are being used in an effort to generate a theorization of a design space that supports surfacing FT&P.

4.2 THEORIZING DESIGN PROCESSES WITH DESIGN ANTHROPOLOGY

In the contemporary context of design anthropology, we start to see some deviations from the previous appropriations of anthropological methodologies mentioned in the earlier section. First, we see that ethnography, a way of documenting the world, is being distinguished from anthropology, which is a way of understanding and theorizing the

world. Anthropologist Tim Ingold argues that ethnography is methodological, whereas anthropology is the application of the methodology to develop knowledge, or ways of understanding (2013). Computer scientist and social theorist Paul Dourish also makes a similar point that the impact that an anthropological approach can offer to design comes not just from descriptions of what is happening, but rather by developing an understanding of why things happen and understanding how members of the culture being investigated experienced those things (Dourish 2006).[5] This thesis adopts a stance in line with Ingold's that an "anthropological perspective" is one that is more oriented towards interpreting the way things are and why rather than just describing them. This distinction is a helpful step towards establishing the impact that an anthropological perspective can contribute to this thesis' RtD process. Specifically in its ability to understand, contextualize and theorize design processes and interpret the opportunities it presents for surfacing FT&P with design.

Ingold's framing of anthropology's purpose aligns with Otto and Smith's characterization of design anthropology's twofold objective of both theorizing the world and envisioning how to transform it. This can only be possible, Ingold argues, when we develop a deep understanding of why things are they way they are. In his words, the purpose of anthropology is to:

> *open up a space for generous, opened, comparative yet critical inquiry into the conditions and potentials of human life. It is to join with people in their speculations about what life might or could be like, in ways nevertheless grounded in a profound understanding of what life is like in particular times and places. (Ingold 2013, 4)[6]*

In the context of this thesis and RtD process, design anthropology is a critical lens to theorizing and contextualizing how designers engaged with not only the ideas of FT&P within their design processes, but what had informed or triggered their thought processes, why certain choices were arising, certain decisions being made, and obstacles being encountered.

As Daniel Fallman has argued, our exploration into FT&P provokes conventional attitudes and assumptions of what constitutes "good" design (2011). Thus, surfacing FT&P lies outside conventional ways of designing. Being able to contextualize and interpret the tensions that emerge in a design process around designing for FT&P helps the design anthropologist theorize FT&P themselves, and how to surface them with design. These tensions that exist within the design process between FT&P and the conventions of

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5   In his article, Dourish refers to this as "ethnographic" research and insights (Dourish 2006). However his description of this research is very much in line with the definition and framing that Ingold and this thesis adopts as being "anthropological" in nature (Ingold 2013). Therefore for the sake of consistency and clarity, I have elected to use "anthropological" instead of Dourish's original word selection.

6   Emphasis original.

"good" design are fertile grounds for discerning what are the opportunities for surfacing FT&P.

In being able to contextualize and interpret these tensions in the design process, we can theorize opportunities to transform the design of contemporary technologies to surface FT&P, as is described in chapter 5. Design anthropology becomes a tool to develop an awareness of the deeper context surrounding the observed events and patterns of these design processes that take root in the RtD cycles; making it possible to develop a theorization of how to reframe the research topic and thus subsequent design process to occur in the next RtD cycle. These distinct ways of understanding is well captured with Smith and Mette Gislev Kjærsgaard's framing of design anthropology's approach:

> …*we see design anthropology as being as much about contextualising these 'things', framing and re-framing the objects and practices of design, using different theoretical positionings and critical approaches to explore possible and alternative futures. This approach to design anthropology…emphasis[es] the theoretical or cultural frameworks and the socio-political contexts within which both field studies and design collaborations are conducted and understood within the design process, and by focusing on and challenging how these affect the intertwined processes of knowledge production and design.[7] (Smith and Kjærsgaard 2015, 75)*

This idea of a deeper understanding is also well captured by the notion of "thick description" as one of the patriarchs anthropology, Clifford Geertz, coined it (Geertz 1973). Thick descriptions do not just explain behavior, but also the context surrounding it so that these behaviors can become meaningful to those outside of the community that practices that behavior. Smith and Kjærsgaard also elaborate that the understanding that design anthropology seeks to establish depends on a theoretically informed distance from which the design anthropologist can perceive and reflect upon the situated relations among people, technology, and design (Smith and Kjærsgaard 2014). Which is exactly what this thesis examines in the RtD cycles in chapter 5.

CONTEXTUALIZATION THROUGH INVOLVEMENT IN DESIGN PROCESSES
Ingold explains that in doing anthropology "we go to study with people. And then we hope to learn from them" (2013, 2). This element of working *with* people is a key component to developing this grounded contextualization. Ingold elaborates that participant observation is not a sufficient method to "know from the inside," as an anthropological approach can afford. Instead, the anthropologist has to be a part of the process being researched herself. Ingold specifies that this comes through working with the materials directly, having your hand the clay that she is wielding or developing the code for a software. This resonates with Zimmerman's positioning of RtD's stance that

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7 Emphasis original.

making is a mode of research inquiry in and of itself.

Yet, this isn't necessarily the exclusive route to knowing from the inside. Involvement in design processes can come in many forms, as is demonstrated by the fact that design teams are increasingly being comprised of members with diverse competencies and expertise (Otto and Smith 2013). Psychologists and engineers are invited to the same design team precisely because of the unique and divergent ways that they can engage with the processes of design. Therefore, hands do not have to be directly in the clay or the code itself to be engaged with the design process.

As a design anthropologist working within the design processes depicted in this thesis, my involvement was varied. I had the opportunity for my hands to be directly engaging with the manufacturing and materials of a design concept. This was the case with one design concept, Mizu, as it underwent a second iteration for exhibition at Dutch Design Week 2016 (chapter 6). Typically when working with student groups however, the students led the design process, although I was still actively engaged in their design processes. This involved extensive discussions with the student designs in clarifying, interpreting, and problematizing the brief I had authored; as well as active involvement in regular team meetings and at critical decision points in the design process. In these sessions, we were concerned with identifying and considering the obstacles or realizations these teams were encountering in their design process. The specifics of how these student groups were assembled, the contexts surrounding their organization and work-flow are detailed in the beginning of sections 5.1, 5.2, and 5.3. Likewise when working with professional design practitioners there were similar discussions interpreting, problematizing, and conceptualizing the brief that I had authored. How these collaborations came about and the shape they took is extensively detailed in section 5.4 and chapter 9.

I treated my involvement in these design processes like conventional fieldwork, carefully documenting what occurred in order to inform how I interpreted it. This came in the form of extensive personal fieldnotes that I took regarding conversations, or general observations. Events and timelines in these design processes were carefully recorded, such as the progression of developments, hurdles, or advancements. The audio of some meetings and exchanges were recorded. My own personal thought processes and evolution of thinking were also documented, often in the form of short memos for myself and my supervisory team. These memos and fieldnotes became points of reflection that I would return to map my own progress and return to particular events of threads of thinking as I would reframe and theorize the subject matter that they were about.

DESIGN ANTHROPOLOGY'S IMPACT TO DESIGN PROCESSES
The previous sections have unraveled the first component of design anthropology's twofold objective: understanding, contextualizing, and theorizing the world. In this section the complimentary objective, transforming the world, will be discussed. Smith and Kjærsgaard discuss how it is precisely anthropology's mode of reflection,

contextualization, historization, and theorization that can inform and transform design processes:

> *Due to the orientation towards transformation and change, attention in design anthropology is on scaffolding contexts for emergence and assemblage of co-created reflections of present and future realities. It is about reimagining the possible through socio-material interventions that both create and transform knowledge and perspectives of the people involved (including the design anthropologists themselves)... (Smith and Kjærsgaard 2015, 76)*

It isn't just a question of how an anthropological perspective can enable "knowing from within" a design process, but how this perspective can ultimately lead to "transforming" that design process from within. It does not have to be from having our hands in the clay or the code alone that have the capacity transform the design process based on the research being conducted. Transformation of design processes can come from our understandings of that design process, which is built from being apart of it.

It is a matter of interpreting descriptive knowledge of design processes to identify underlying assumptions and cultural framings so that points of discourse can be identified, and ultimately reframed (Smith and Kjærsgaard 2015). Transforming and reframeing through reflecting on design processes is exactly the objective of RtD cycles. In the following chapter (5), an anthropological account is provided of four RtD cycles, where the design processes of creating research artifacts, both the design brief and design concept, are theorized and contextualized to reframe and transform future design processes[8] as well as our theorization of the research topic itself.

Dourish makes a similar argument to Smith and Kjærsgaard for why these ways of understanding, contextualizing, and theorizing design processes should be incorporated into design processes themselves. Dourish identifies the trend within HCI where the contribution of anthropological research is typically relegated to offer "implications for design," often in the form of a bullet list of suggestions of what designers should or should not do with their design. He argues that this current formulation suggests that design is the natural end-point for research with designers being the gatekeepers of that research. Thus, the anthropologists remain outside the design process (Dourish 2006). The anthropologist's suggestions for design become a list of prescriptive, and superficial, guideline for designers. As discussed in chapter 3, it would be difficult, or impossible, for such prescriptive tools to address the nuance and situated nature of such a conceptual design space as that surrounding surfacing FT&P (Stolterman and Wiberg 2010).

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8 Interestingly, while engaging as a design anthropologist in the design processes of the first RtD cycle, it was already possible to develop the contextualization and theorization of what was happening in the design process in order to reframe and transform the design process that was already underway. However, I elected to withhold from transforming and reframing the design process that was currently underway and wait until the following RtD cycle. This is explained in depth in section 5.1.

Dourish sees that the transformational potential of anthropological knowledge comes in its ability to provide designers with models for thinking about those communities being studied and what happens there. This is not unlike Stolterman's argument that designers need to be supported in developing their own judgement to navigate complexity (Stolterman 2008). Dourish likewise advocates that the output of anthropological thinking can not just be a list of design implications, but instead the a means for designers to understand why these suggestions were arrived at, what kind of intellectual, moral, and political commitment they embody (Dourish 2006).

Ultimately, my involvement as a design anthropologist in these design processes led to a type of mutual exchange between myself and the design practitioners. There was a flow of ideas where their work influenced how I framed my process, and likewise research and contribution would permeate into their processes. This will be unpacked in chapter

FIELD STUDIES

In addition to examining the design processes in the RtD cycles through the lens of a design anthropologist, a similar anthropological perspective was adopted in three other case studies. In these circumstances, an existing community of practice related to design was examined in order to support theorization and contextualization to ultimately contributing to reframing the research phenomenon of FT&P. In these studies, the same methodology was followed as has already been mentioned in the first subsection of this section ("Contextualization through Involvement in Design Processes"): extensive personal fieldnotes were taken; events and timelines notated; exchanges recorded; and memos reflecting on the fieldnotes and developments were made. One critical exchange was transcribed, coded, and then analyzed in the spirit of grounded theory, and will be addressed in section 5.4 (Strauss and Corbin 1998). The context and details of these particular field studies are described in depth in section 5.4 and chapter 9.

part III
Investigations into Focal Things and Practices with Design

CHAPTER 5.
CYCLES OF RESEARCH *THROUGH* DESIGN ANTHROPOLOGY

This chapter provides an anthropological account of four research through design cycles (sections 5.1-.4). Each of these cycles are broken down into three different phases, which reflect the methodological framing of research *through* design anthropology that had been laid out in Part II (figure 7). The first phase addresses the act of designing the brief, where the topic of research was interpreted to create the research artifact of the design brief (as positioned in section 3.1). The following phase discusses what emerged in the design process that interpreted the design brief. This came both in the form of creating a design concept (sections 5.1-3) or conceptualizing the brief for a design process (section 5.4). The final phase discusses how these design process of creating the brief and the design concept contributed to reframing the topic of research to inform another cycle of design. In considering these four research through design (RtD) cycles, this section will demonstrates how this RtD process progressively built upon itself, and how the reframing of the research phenomenon evolved. This chapter will conclude with a reflection on these cycles as a whole (section 5.5).
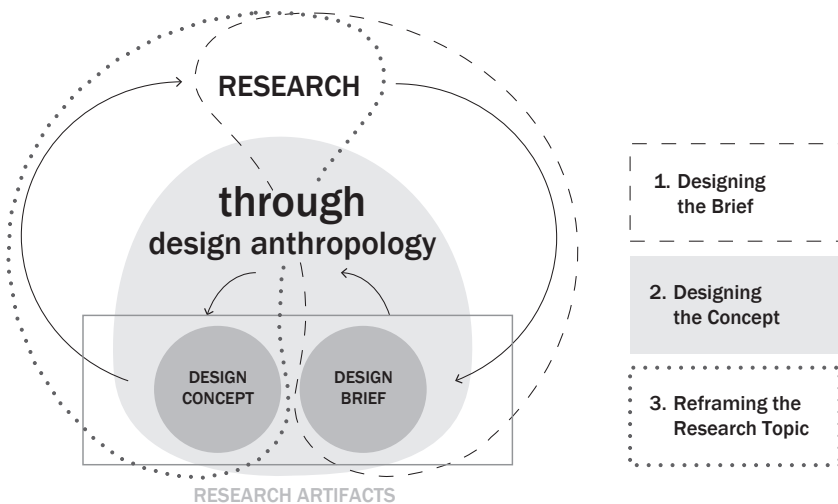
Figure 7. The analysis of this section will be structured around three unique phases of four different RtD cycles. This is first how the brief is designed based upon the research topic, secondly what emerged in the design process following that brief, and lastly a reflection of how these different design acts of creating the brief and the design concept reframed the research topic.

This chapter describes four RtD cycles chronologically that span two years (figure 8). Each of these cycles were initiated by a design brief I had authored, and was followed by a design process that interpreted that brief. An image of the design brief of that cycle will be at the start of each section, the design concepts of these cycles are described in detail in an index in chapter 6. Later, chapter 7 takes a wholistic look at these RtD cycles, among others, to map the design space of this thesis.

Each of the cycles described in this chapter chart the evolution conceptualization of this thesis' core concepts (as described in Part 1): FT&P, traces, and materials and the relations amongst these concepts. This development takes a distinct form in each of the phases of the RtD cycle: from designing the brief, to designing the design concept, and reflecting on the cycle as a whole to reframe the next cycle. The following sections take the voice of the design anthropologist, using these moments of reframing and design processes as sites of fieldwork, traversing between science and technology studies (STS) and design practice (chapter 4 and 10). What transpires in each of these phases will be described, contextualized, and theorized, demonstrating how one cycle informed subsequent ones.

Throughout these cycles, extensive fieldnotes were kept describing both the formal and informal encounters and communications that transpired during the design process. In the case of the fourth cycle (section 5.4), these communications were recorded, transcribed, coded and analyzed (section 4.2).

Cycle 1
Defining Traces as a Design Approach

February 2015 - June 2015

Cycle 3
Drawing from Historical References

February 2016 - June 2016

June 2015 - June 2016

February 2017

Cycle 2
Co-performing with Technologies

Cycle 4
Grappling with Materiality of Networks

Figure 8. Four design cycles are discussed in this chapter. Some of these briefs were being worked on in synchrony with another brief, others directly followed another. The start of the block indicates when the brief was delivered to designers, not when it was originally being drafted.

5.1 CYCLE 1: DEFINING TRACES AS A DESIGN APPROACH

This first design brief is a first attempt to approach something that is deeply unknown to map future directions for this research (figure 9). This particular cycle took place in a course for master's students pursuing a degree in Interaction Design at Delft University of Technology. Students were provided with a selection of design briefs, such as this one, and selected which projects they would like to be apart of accordingly. Fortunately, for the majority of the students that participated in this project, working on this brief was their first choice.

Four groups of master's students were assigned this version of the brief to complete over the five month semester period. Students worked on this brief iteratively and met once a week for a full day. The primary learning objective of the course is to familiarize students with the different stages of designing interactive products. In this course, stude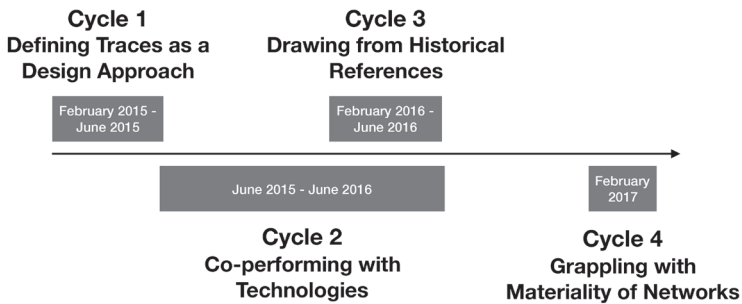nts design in five distinct progressive iterative cycles on the single design brief. Each of these progressive cycles culminates with the presentation of a design concept which is evaluated by instructors, invited experts, and the author of the brief. These iterative cycles involved rapid user testing, coaching from design and technology instructors and experts, and building the embodiment of the concept. The course's philosophy is oriented towards design through making (Aprile and van der Helm 2011). Students are evaluated on their ability to address the objective of the brief with their design, the team's process, and implementation of their concept. Each team is composed of five students with unique multidisciplinary roles (engineer / maker, conceptor, manager, reporter/communicator) working in parallel and collaboratively with one another within their domain of responsibility. Students came up with four design concepts: Zodiac, an alarm clock; Phonos, an interactive speaker; Animal's Tale, a physical audio book; and Mizu, a sink. You can find a description of these design concepts in chapter 6.

DESIGNING THE BRIEF

This first design brief followed previous work from our research group that considered traces as a design approach to communicate use of artifacts (Robbins et al. 2015; Giaccardi et al. 2014). In this brief, the notion of traces were framed as a design approach to communicate the ways that we use computational and physical components of a technology. This design brief addresses a particular argument of the device paradigm which critiques how the design of contemporary technologies separates of form and content from one another (Borgmann 1984). This brief builds upon this theme to target how that separation manifests in contemporary connected, networked, data-intensive technologies which became prevalent after Borgmann's authored his critique in the 1980s.

In the context of these technologies, this separation of the form and the content could be interpreted along the lines of the colloquial "digital-physical divide." Designers are asked to bridge this divide by using traces to illustrate our use of each of these divided elements, the digital or the physical. In effect, traces become a vehicle to join the form

Traces of Use, ITD 2015, Design Brief

Meta Design Brief:

Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. Within this section, there are 3 sub-briefs. Each sub-brief asks for designers to make it possible for physical traces as a means to communicate different aspects of the connected object. In each case it communicates different things about the object and its user(s):
  1. communicate how the connected object is manually used
  2. communicate the digital content of the connected object
  3. enable the user to make use of the digital aspect of the connected object
These physical traces can not be screen-based. In each case, traces are used to serve as a manifestation of different types of data or interactions with the connected object; all in an attempt to help bridge the digital and physical use of the object.

Sub-Briefs

Variable 1: Traces to demonstrate manual use of connected object
Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. **Your design should utilize material traces as a means to manifest how the connected object is manually used. This trace is intended to serve as a manifestation of the interactions with the connected product.** Consider a leather shoe as an analog example of this. We "break in" a leather shoe to fit our feet perfectly and create material traces (the wearing and stretching of the leather) in this process. These material traces of breaking the leather in demonstrate how the object was used. Apply this process of traces to a connected object so that it communicates how it has been used.

Variable 2: Traces to demonstrate digital use
place two groups on this brief
Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. **Your design should link how the digital content of the connected object with a material trace. In other words, enable the object to use physical traces to manifest data from the connected object.** This manifestation of data can not be a screen-based interactions or traces, it must be physical and on the object itself.

Variable 3: Trace making to use digital
Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. **Your design should utilize physical traces as a means to use or uncover the digital aspect of the connected object. Here, physical traces are to be created by the user to interact with the "connected" dimension of the connected object.** As much as it is possible, avoid screen-based interactions.

Figure 9. The design brief of the first RtD cycle, delivered to students at the beginning of the course Interactive Technology Design in February 2015. (Also appendix 1)

and the content together. By doing so, it provides an opportunity for the design process to investigate how to conceptualize how to create a union between the form and the content, and also how traces can conceptualize FT&P as bridging that divide.

This form/ content or digital-physical divide is parsed out in the design brief in a systemic way. A "meta" brief describes the general circumstances motivating this design cycle and was given to all four student groups. There were additional sub-briefs honing in on specific dimensions of this divide for each of the four groups of designers to consider. The sub-briefs direct designers to consider different approaches to make with traces towards deciphering this divide. A visual summary of these three different approaches can be found in figure 10. One group was asked to design with traces in such a way that reflected the use of the object as a whole (A). This sub-brief did not parse the digital and physical divide of the technology, but instead dealt in terms where the object which happened to also encapsulate both digital and physical qualities. Two groups were asked to use traces as a means to somehow convey the use of the computational (digital) layer of the technology onto the object itself (B). This is an attempt to disambiguate the invisible computational materials or functionality upon the object itself. The remaining group's brief instructed for a trace to trigger the computational machinery or functionality of the object (C).
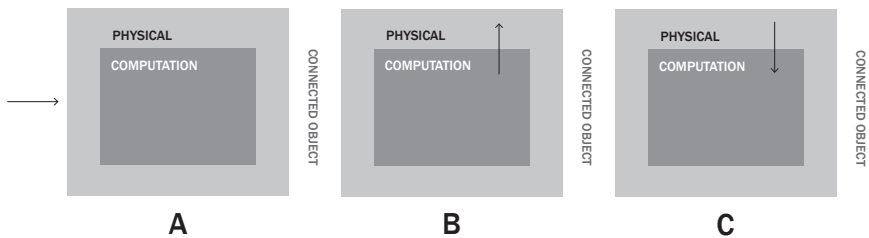
Figure 10. A visualization that accompanied the design brief of the first RtD cycle illustrating the distinctions among the three sub-briefs. Each block represents the connected object, which contains both a "physical" and "computational" aspect to it. Each sub-brief illustrates the unique role that traces should have in respect to these aspects. A. Use traces to reflect how object as a whole was used; B. Traces to convey how computational aspect was used on the physical body; and C. Traces upon the physical layer utilized to trigger the computational aspect of the object.

Therefore this brief scaffolds the design process to be about surfacing "traces of use" of the specific parts of a technology, be it of it's computational material (content) or its physical material (form). The brief specified that traces cannot be on a screen, a constraint that was intended to build upon previous work design approaches to traces

that consider them as physical markings on the surfaces of artifacts (Giaccardi et al. 2014; Robbins et al. 2015).

The brief was designed to consider how bridging the form and the content of a computational technology with traces could possibly frame it as a FT&P. Can a trace join the form and the content together? Does a trace give a form to the technology's content, or to the use of its content? Can we conceptualize computational content as having a form? How are traces of our engagement with the form and content conceptualized by designers? What could we learn from how these designers use traces as a design approach? How can traces be utilized to make the obfuscated aspects of the technology legible? Can the traces serve as a record that provides context of the modes of engagement that people had with the object (social, physical, sensorial, environmental)? Do traces enrich the relation between the form and the content, or are they just another feature? There are many competing notions of traces and how they could possibly relate to FT&P here that this first brief attempts to tackle.

EMERGED IN PROCESS OF CREATING A DESIGN CONCEPT
In the ensuing design process to interpret the design brief, the designer students brought to light some important questions about conceptualizing traces, and also some insight into how to develop the communication between STS and design practice.

Framing Traces

In this first RtD cycle, most of the concepts this design brief sought to address were in their formative stages. This is especially true for traces themselves, how should we frame the concept of traces itself (Dorst 2010). There were many questions raised regarding exactly what their purpose is.

The design brief did not make many specifications regarding the trace. It explained that traces were intended to represent some record of use of specific parts of the technology. (Via the sub-briefs) Apart from specifying that traces not be made on a screen, there was much room for interpretation regarding its form. My intention in writing the brief had been that the traces would be physical and enduring on the object itself, as projects previous to this one that I had been involved with were investigating (Giaccardi et al. 2014; Robbins et al. 2015). However students also related traces to smell, light, taste, etc. apart from physical manifestations. The design students also interrogated the temporality of these traces: should they be permanent, or can they be ephemeral? And what is the significance of the physical location of these traces? Does it have to be where we handle the object, or can it be made remotely somewhere else upon the object? All of these questions that emerged in the design process were ones that had not been problematized in the brief itself, which the design process brought to light. These other sensorial experiences can still serve the general goal of traces, which is to make a record of use perceivable (section 2.1). These questions raised in this design process encourage us to consider what is the form of a trace, and how does its form relate to the material

that it's communicating. Later briefs will take a specific position on some of these questions, as later sections of this chapter will describe (sections 5.2-4).

A more fundamental question that the brief raised for the designers was the question of why traces at all. The design students took a while to come to terms with the notion of traces, and tended to think of traces as something to prevent the appearance of, or alternatively that could potentially personalize an object that it was on, or as something that could possibly be used to persuade certain behaviors. Uncertain how to assimilate the concept of traces into their design practice, the student groups first had to confront their aversion to traces. The student designers were more familiar with circumstances where traces are *not* desirable, either aesthetically or for its ability to degrade an object's function or value. Great care is often taken to limit the appearance of traces. Special ware-resistant materials are selected in design processes. Various measures are taken by the owners to protect their prized possessions from evidence of ware, such as the rare comic books that we keep in plastic sheaths in order to help them retain their value.

The student designers then considered traces as a form of personalization. This is the sticker that you put on your laptop to distinguish your product from your neighbor's identical product. The brief suggests that traces be record of our processes of bridging aspects of these object's complexities (here framed as the digital-physical divide), which is inherently a somewhat personal record. Yet, this is different from using the object as a canvas to project aspects of your personality upon. This became a proposition that was difficult to analyze for how it relate to FT&P.

The student designers then turned towards asking what should traces persuade people to "do." This is a motivation that returns throughout most of the cycles described here (sections 5.2 and 5.4). When this brief was initially delivered to the students, it was accompanied by an explanation of Borgmann's critique that people should develop a deeper understanding of the role that technologies plays in our lives. In particular, traces were intended to communicate the social role of these technologies, not necessarily encourage a particular type of behavior or action. Yet, in this design process, the students strongly associated communication as having a particular objective behind it, specifically to shape behavior. Students suggested that perhaps traces should be used to encourage people to create their objects with respect: if you treat the object well, it will look beautiful (playing on the themes of aversion to traces). Or perhaps traces were a way to confront someone who wakes up poorly in the morning with a motivation to wake up in a more orderly way (Zodiac, chapter 6), or to encourage others to use less water when using a sink (Mizu, chapter 6).

Experimenting with Formats

This first RtD cycle was also my first attempt to write a design brief, and thus in experimenting with how to communicate between these concepts from STS directly to a design process. This design brief generated a lot of confusion among the designers, and

as a result delaying their progress in the course compared to their peers working with other briefs. It was too open-ended, leaving too many choices and interpretations to be made in the design process. One group prioritized pursuing the concept of the digital-physical divide, and tried to find contexts of that divide, rather than devoting their energy to attempting iterate in bridging one particular divide. As a result they radically changed the technology they were working with four times, significantly delaying them in the course.

Halfway through the course, the other instructors recommended that my brief be accompanied by a list of more specific design requirements. Through engaging with the designer's process (or struggle) in interpreting certain concepts of my initial brief, such as traces, I started to develop some of my own opinions of what may be fruitful ways to narrow some of these concepts. So I made checklist as a means to keep track of the priorities of the brief and the design process at large in response to what I perceived to be the designer's needs (appendix 2). Ultimately, I did not share this check list with designers as I had intended. I realized that the real utility of this first RtD cycle was in it's explorative capacity. It was too premature to take a position on some of these questions. Instead, I used this checklist as a personal annotation of where my expectations and assumptions were in the process.

REFRAMING THE RESEARCH TOPIC
On a logistical level regarding the briefs, it became apparent through this process that using sub-briefs as variables were not particularly constructive. The design concepts ultimately did not map onto these variables, and the concepts were still too ambiguous to parse out into particular variables. Therefore later RtD cycles would adopt a single brief that would be shared with multiple groups. Additionally, it appeared from this RtD cycle that design briefs would benefit from being more specific about the design requirements, to address the delay that was experienced in this particular cycle. Future briefs would include a bullet list to hopefully clarify some of the design expectations.

The primary concern of this cycle was in developing a design vocabulary for traces as representations of use. This related to FT&P as traces were being framed as a way to articulate the practices that we have with the technology. The reasoning was the activities that would make these traces would have to involve a form of engagement, or practice, that would support the focal-ness of the thing. The intention was also that the focal-ness of the thing would also be supported by articulating those practices in an enduring way through traces.

Ultimately the design concepts of this first RtD cycle were analyzed for the insights they surface regarding using traces to surface conceptualizations of FT&P, which were summarized and written up in a form resembling design guidelines (Robbins, Giaccardi, and Karana 2016). These insights also built upon some of these observations developed in the design process, such as that undelivered check list (appendix 2). These guidelines and paper developed its theoretical approach to help make sense of this particular RtD

cycle, while also taking a position on some of the questions that students surfaced in their design process. These guidelines were the first step in interpreting the potential of the relation between traces and FT&P, and further to attempt to make this interpretation actionable in a design process. These guidelines served as the basis for each of the later briefs that I authored (section 5.2-4).

Another theme from the design concepts that I had been struck by, but unsure of how to interpret, is how traces were utilized by designers to echo the traces that would occur on historic technologies. Such as the scratches on a record (Phonos), the softening of pages in a loved children's book (Animal's Tale), and the polishing of the metal parts that deliver water (Mizu). These design concepts did less to bridge the digital-physical divide, as had been the instruction, but more to illuminate and contextualize our engagement with these technologies, as their historical predecessors had. In doing so, traces served more to bridge another severed relation that Borgmann addresses with the device paradigm: the relation between the *ends* (e.g., the outcome of the technology's use) and the *means* (e.g., the aspects of the technology responsible for the way it works) (1984). Later cycles adopt this severed relation between the *ends* and the *means* instead of continuing with the one between *form* and *content* that framed this cycle (upon which the proxy of digital-physical divide was derived from). Later, research into sociomateriality would endorse this decision with theoretical reasoning (sections 1.3, 2.3, 5.4).

5.2 CYCLE 2: CO-PERFORMING WITH TECHNOLOGIES

Exactly as the first RtD cycle was coming to a close and design concepts were being presented (section 5.1), a master's student approached me to become involved in her personal project that would conclude her degree, which we refer to as the "graduation project." The student, Jaqueline van 't Hof, had arranged for her project to be done in collaboration with a company that manufactures and installs solar panels, Sungevity. For this graduation project then, the question was how to think about how to surface solar energy as FT&P with traces. For details on her final design concept, Aila, please see chapter 6.

DESIGNING THE BRIEF
This project followed closely on the tails of the last RtD cycle (section 5.1). In many ways, this project began in a similar way to the brief of the first cycle, but with some refinement of the ideas. The major contributions from the previous cycle came in terms of reframing the device paradigm as it relates to FT&P, as well as providing some specifications regarding traces.

Since this project was undertaken across two institutions, Delft University of Technology and Sungevity Nederland, the final design brief for this project was one that negotiated the briefs from each institution. For this final version, the graduation student combined the design brief that I had authored with that from the company. Sungevity's contribution

Graduation Project Design Brief
Conceptualizing and Changing Energy Usage with Material Traces
29 June 2015

Smart, or connected objects, continue to proliferate our technological landscape. This comes with great advantages, such as technologies that are more efficient, and respond to the people using them and their environment more effectively. However, a consequence is that the people using them lack a reciprocal knowledge of that technology. Philosophers of technology argue that when the ends and the means become segregated from one another, the only mode of engagement that people can have with technologies is to consume them, and further, they become replaceable or disposable commodities.

In contrast, consider how other material objects reflect the way that they're used and demonstrate a reciprocal knowledge of the people using them and their environment. Leather shoes for example stretch and change shape to fit the wearer's foot perfectly. The scratches and the watermarks reveal the environments that the shoe lives in. This material form of communication that show traces of use are critical to our relationship with the object.

This project will attempt to help people understand their usage of solar energy by utilizing material traces as a design approach. As it has been suggested, not understanding how the technology functions and the role that it has in our lives leads to unmindful consumption. With a design that utilizes material traces, this project will attempt to make people more conscientious, and ideally more careful with what they consume. This project will produce a designed connected object that communicates how the technology functions and utilizes material traces to communicate usage as a means to help reduce energy consumption.

Requirements in detail:
- Physical, connected object is designed that represents solar energy usage
- Traces and are not screen-based. Ideally limited screen based interactions
- Traces are permanent and cumulative
- Traces reflects how the technology works and is used

Figure 11. The design brief of the second RtD cycle, the basis for a master's student graduation project. (Also appendix 3)

largely pertains to the context to the solar economy of the Netherlands, while my contribution pertained to traces and FT&P. Considering the division of the domains that these two contributions to the ultimate brief, this section will restrict itself to the brief I authored that relates to traces and FT&P (figure 11).

In an attempt to address some of the questions raised in the previous cycle (section 5.1) regarding what this attention to traces and FT&P should encourage people to *do,* this brief uses one of the consequences Borgmann details of the device paradigm as an entry point. His argument is that the device paradigm leads to technologies being over consumed, therefore this brief is motivated by seeking ways that traces could offer alternatives to this consequence (Borgmann 1984). Thus this brief contextualizes the device paradigm by arguing that utilizing traces as a means to surface FT&P can potentially reduce overconsumption.

Borgmann address two important relations that are severed in the device paradigm. That between *form* and the *content*, which the previous cycle had been focused on (section 5.1), and also between the *ends* and the *means* (section 1.1 and 1.2), which this cycle focuses on. Automated technologies demonstrate the latter, where the outcome of the technology's use (*ends*), is not clearly related to the aspects of the technology that are responsible for the way it works (*means*). Thus with automation, the work of the technology demands little engagement from people and is obfuscated from the general user. This lack of engagement and obfuscation lowers barriers to overconsumption.

This brief is seeking ways to communicate the occurrence of that invisible and illegible work (automation) that follows our use of that technology. That illegible work, in the context of this brief, is that of the solar panels and the infrastructure behind generating and consuming energy. Further, this brief seeks to use traces to record and make legible the occurrences of how the *means* are triggered through use. The intention is that by demonstrating the ways we use technology, we will become more conscious of our use, therefore less likely to over consume it. In effect, this design brief attempts to reverse engineer FT&P by starting with a symptom of the device paradigm. It then attempts to mitigate the occurrence of this symptom by creating a definition of FT&P relating to making the practices of use of the technology legible through traces.

This brief also includes a list of requirements that first specifies that the output of the design concept be a connected object with a physical form that demonstrates solar energy use. In addition, this list of requirements offers some specifications regarding traces, which builds upon the checklist developed during the previous RtD cycle (section 5.1, appendix 2). The brief specifies that: traces cannot be screen based, with a general limitation of any screen based interactions for this design concept; traces are permanent and cumulative; and finally that traces reflect how the technology works and is used.

EMERGED IN PROCESS OF CREATING A DESIGN CONCEPT
Our graduation student, van 't Hof, was fortunate to do most of her work at Sungevity's

headquarters where she was supported by their openminded, curious, and enthusiastic colleagues. The design process following this brief ran for about a year, and followed a structure unique to graduation projects. This structure had dedicated times for literature review, user studies, and prototyping. Thus this section will also address some of the insights that relate to how her theoretical research also reframed aspects of the original brief, and thus the research topic itself. This project was lead by the student, but we met at regular biweekly intervals to develop some of the theoretical work, and make important design decisions.

Solar Panels as Existing FT&P

Van 't Hof conducted a study of existing solar panel users and found them to be a uniquely enthusiastic population about this particular technology. I would argue that their enthusiasm represents a mode of engagement with solar panels that resembles FT&P. It was a self-selecting and especially eager early adopters of solar panels that who made themselves available for the van 't Hof's user study. She confirmed Sungevity's market and user research, which indicates that their customers are already quite conscientious and engaged with their solar panels: from almost obsessively monitoring informational panels that indicate how much energy has been consumed and produced, to determining how the weather of the day will impact their house chores (van 't Hof 2016). For example, if it is an overcast day today, and thus less solar energy available to run a load of laundry, some users would wait to do their laundry on another day with more sun. Here both their practices surrounding the thing of the solar energy being generated by the panels were being made focal. This research demonstrated that these particular users were engaged with solar panels and energy on a social, bodily, and environmental level, like a FT&P.

This is where an interesting question surfaces, that will be revisited in later projects as well: where does focal-ness reside? In this particular case: *what* is the *thing* that the practices are supporting the focal-ness of? Is it the physical solar panels, or the solar energy itself? Or is it the larger system, network, or infrastructure that join the panel, the sun, energy, batteries, electric grid, people and their appliances together? In interpreting Borgmann's original framing of the concept FT&P, the case would have to be made for the focal-ness being of the system, network, or infrastructure at large (Borgmann 1984). Yet, his descriptions of FT&P draw on these social and somatic expressions: feeling the warm of the hearth, the sweat from the labor of cutting wood, having the hearth as the central gathering place of the household.

The challenge in this design cycle became how to support the focal-ness of the practices surrounding the network of things that comprise a technology. This was not a question we were fully prepared to address in this RtD cycle. It took several cycles to develop an approach to this question, and is discussed in section 7.4 and chapter 8. Additionally, we weren't prepared or equipped to problematize how to make the system behind solar energy focal, part of this was because we lacked the expertise to design with the solar

panel itself. As a result, the scope of this design process was focused to the processes of producing and consuming energy, and how to surface this as a FT&P. This is what gave way to Aila, the design concept from this RtD cycle, a living room lamp which we both generate the energy of and consume (chapter 6).

Benchmarking Matrix

After the student completed her literature review potion of her project, van 't Hof developed a matrix to further conceptualize FT&P that would inform the design concept's design process. The device paradigm was paired with social practice theory (Kuijer 2014; Shove, Pantzar, and Watson 2012), to offer an interactional and historical lens to examine energy practices with. The matrix is composed of two axises which loosely break down technologies on a spectrum of being focal things, and focal practices (figure 12). One axis pertained to how aware or unaware people were of the technology, referencing it as a focal thing. The second axis related to the practices of engagement that people had with the technology. Were people co-performing[9] the task with the technology, or was it an ambient technology, performing its task in the background without our involvement? This axis referenced it as a focal practice.

After narrowing the scope of the design process to be developing a design concept of a lamp, we then placed various historical and contemporary lighting technologies within this matrix. In doing so the matrix assisted in developing a designerly vocabulary to address how the interactions with a technology could impact its framing as a FT&P. With this matrix we are able to develop a sense of what the "the sweet spot" may be for how interaction design could support FT&P. The design had to fit within the quadrant of being "aware" and "co-performing."

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9   This use of the term "co-performing" does not reflect the recent scholarship and conceptualizations of the term as articulated in (Kuijer and Giaccardi 2018). This term was selected by the graduation student in the course of conducting her research in 2015. It is used in the title of this section and throughout this section's text to reflect the student's conceptualization at that time, which centered around an active engagement between the person and the technology in carrying our or fulfilling the task of the technology.

DIFFERENT TYPES OF LIGHT SOURCES, MAPPED ON THEORETICAL FRAMEWORK ————————
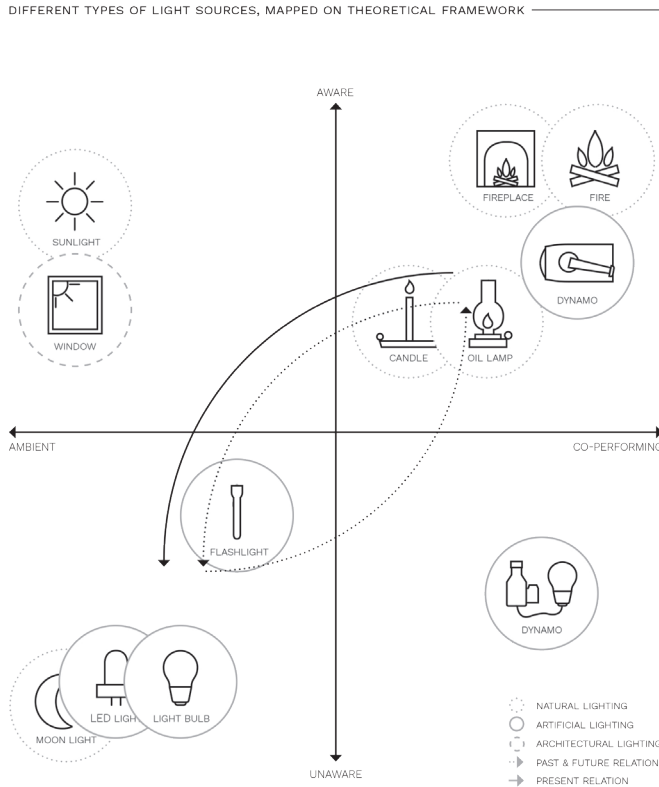
Figure 12. A diagram mapping contemporary and historic household lighting technologies according to variables interpreted from the device paradigm: aware and unaware on the y axis, and ambient and co-performing on the x axis. Adapted from master's thesis of Jacqueline van 't Hof (van 't Hof 2016 p.69).

With this matrix, a new orientation towards defining FT&P had emerged. While the brief outline how to keep people mindful of their usage of solar energy, now the direction had shifted towards engaging people in the practices of both consuming and generating energy. Now the design process would examine how to make the way the technology works (its *means*) legible to people through having them co-perform the *means* of that technology. Now this design process characterized FT&P as it relates to generating energy in terms of being either actively engaged in supporting the task of the technology (as with co-performance) or passively engaged in supporting the task of the technology (ambient, automated).

Problematizing Traces of Use

The focus of *what* was being design for changed throughout this process. The brief initially specified some kind of connected object, with the expectation that it would somehow be related to the solar panel use. It is after all a technology that converts light from the sun into energy to power a dishwasher in a manner that separates the *ends* from the *means* in ways that are not legible to us. Early in the design process it became apparent that it would not possible to design for the solar panels themselves, whose technology was far too specialized for the scope of this project.

Not only was the solar panel technology itself too advanced to design for in this particular cycle, but it is also a technology that sits on a roof, out of reach and touch from the person who utilizes its energy. We could not communicate our use of the technology itself by creating traces upon it. Typically people who buy this technology never actually interact directly with it, it's even installed by specialists. Even if the solar panel was a technology that we could design for and was something that people directly engaged or interacted with, what aspect of our interaction with it would we be trying to communicate? The solar panels are directly triggered by sunlight to convert it to energy for our households. What aspect of that exchange could we take part in?

This presents a fundamental challenge to the design brief, which frames the objective to be to use traces to communicate the use of the technology, upon the technology itself. This seems to suggest an interaction that is happening directly between person and technology, and that there is a trace that has to happen upon it as a result of that physical manipulation. This just wouldn't be possible between an energy user and a solar panel. But, as earlier user studies had demonstrated, solar panels could be framed as a FT&P in and of itself. This urged a reconceptualization of the notion of traces as physical markers existing only upon physical materials that we directly engage with. Apparently, engagement can happen in other ways, and could also take other shapes than those that would render physical etchings of traces. This reconceptualization did not come into fruition in this particular cycle, but did become pertinent in a later cycle (section 5.4).

The final design concept for this cycle however stayed close to the request of the design brief. To make this possible, the designer did not work with the solar panel. Instead she focused her design on how to communicate the relation between the *ends* and *means* in generating and consuming energy in the form of traces etched into surface materials of the technology. She did this with the creation of Aila, a stand alone lamp that was powered by people winding a a dynamo (chapter 6). The energy that produced was stored in reserves that people could directly manipulate to dim or strengthen the brilliance of the light. Both generating and consuming the lamp's energy were physical engagements with the surface materials of the lamp that left traces in those materials.

REFRAMING THE RESEARCH TOPIC
Two major contributions from this RtD cycle can be found in the use of historical

technologies as a frame of reference for the design process regarding FT&P, as well as its relation to the matrix to consider the device paradigm and FT&P in terms of referring to a spectrum whose axises run from aware-unaware and co-performance-ambience. These served as a common ground and language that demonstrated its resonance between design practitioners and my own interpretation of the body of work from STS. These two contributions came towards the middle of this year long cycle, and immediately could apply to the design brief of the third cycle which ran concurrently with this cycle (section 5.3), and were again referenced in the cycle following that (section 5.4).

In this cycle FT&P were being conceived on more conceptual terms, as the dynamic between "creating and consuming energy." Initially our research on solar panels seemed to resonate with our framing of the concept of FT&P; however we could not find an entry point to working and designing directly with the materials of the solar panel or the system that it is apart of. Because we could not embark on a design process with these materials, we redirected our scope to the dynamic of creating and consuming energy, an essential aspect behind solar panels. But this challenge helped to set the stage for questions that would be more explicitly grappled with in later RtD cycles and fieldwork, which is how to surface networks as FT&P, and how to make our engagement with them focal.

The other major contribution of this cycle in surfacing the tension between the brief's framing of traces as demonstrations of use, with the expectation that this would be physical markings and the use of only one thing (a single panel vs the grid that it relies upon). Indeed, as the solar panels demonstrated, we can engage, use, and interact with things that we do not physically manipulate. Additionally, the solar panel was a part of a network, which made it difficult in the design process to pinpoint what materials we were engaging with in order to make traces in them. This cycle demonstrated that the materials, the parts that constitute a technology, that we engaging with do not necessarily have a physical form for traces to be etched in. Our core notions of traces, materials, and use are provoked in this cycle. This engendered the investigation into sociomateriality (sections 1.3 and 2.3) that would become instrumental in the cycle that followed the completion of this cycle, the fourth (section 5.4).

5.3 CYCLE 3: DRAWING FROM HISTORICAL REFERENCES

This third cycle started in the middle of the previous cycle (section 5.2), and ran concurrently with the completion of its second half. This RtD cycle was similar to the first (section 5.1), in that it was entirely contained in the same semester-long course, just a year later. In this course, Interactive Technology Design (ITD), three groups of students were assigned to work on this brief over the course of the semester. The structure of the course was largely the same as it was the previous year, however there were slightly different roles that were assigned to students in their groups. Each team now consisted of five members who were assigned to the roles of either a concepter, engineer, manager, researcher, and communicator. The three student groups developed three design concepts: Concrete Time, a wall clock; Unwind, a wrist watch; and Rememory, a photo printer. A description of these design concepts can be found in chapter 6.

DESIGNING THE BRIEF

The framing of this brief borrowed heavily from the concepts and language of the matrix developed in the second brief (figure 12) that helped to identify the different interaction qualities that can frame a technology as a FT&P as one that we co-perform the task of the technology, and our awareness of the technology itself (section 5.2). Being both aware and "co-performing" with the technology appeared to be the most promising route to supporting that artifact as a FT&P. This RtD cycle attempts to explore that "sweet spot" highlighted in that matrix (the upper right hand quadrant, of being aware of and "co-performing" with the technology). Our engaged involvement with the task of the technology, or co-performance as it is referred to here, takes precedence in this brief, leaving the traces to be a somewhat secondary consideration. This marks a change of priorities.[10] Traces are relegated to being a residual form of communication of the fact that engagement had occurred.

Around the same time that this brief was being authored, so too was a paper interpreting the design brief and its design process of the first RtD cycle (section 5.1) (Robbins, Giaccardi, and Karana 2016). This paper outlines some criteria regarding the form of traces, which were provisionally being considered in the brief of the second RtD cycle (section 5.2). These criteria first establishes that the trace should be a form of "evidence" of the practices surrounding the forms of engagement when people contribute to the function of the technology. Traces should also represent how people engage with the technology in an understandable way. Additionally, the traces should be long-term and part of the technology itself and not temporary, disposable, nor could it be on a screen.

In light of the resonance that structuring the design process in respect to historical

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10   This change of priorities was also evidenced in the fact that the student groups assigned to this breif were referred to by the moniker "co-p." The previous year, the student groups assigned to my design brief were referred to as the "traces" groups (cycle 1, section 5.1). These seemingly superficial nick-names however do illustrate however the priorities of the design briefs. To reiterate from the previous section, this framing of "co-performance" does not reflect recent scholarship on the topic (Kuijer and Giaccardi 2018).

co-performing with technology
design brief

There was once a time when we used technologies and there was a trace of the ways we used it. A leather shoe is an example of this: we understood that through our use we broke it in, and traces of this was that it fit our foot perfectly. However, this is not the case with more contemporary technologies where, for the sake of usability, the way the technology works and the job it does is not communicated back to us.

This does not happen with contemporary technologies. Instead of co-performing with it, we expect it to be at our service. How we work with it is made invisible to us. We favor a Nest thermostat (which is intended to be invisible and doesn't require our engagement) to a fireplace (which requires co-performance in making and maintaining and tending to leaves traces of skill and is the focal point of a home).

Your group will be given a technology that you will have to redesign the interaction for so that the technology requires people to be engaged in and participate in the task the technology performs. **Note:** This does not mean that the interaction has to be labor-intensive or inconvenient. Additionally, your design must use traces as a means to show this interaction occurred.

Design criteria:

- People should help in co-performing the task of the technology. Evidence of this co-performance should be in the form of a trace.

- Traces should represent how people engage with the with the technology in an understandable way

- Traces should be long-term and a part of the technology itself, and not temporary or disposable.

- Traces can not be screen based.

Figure 13. The design brief of the third cycle, delivered to students at the beginning of the course Interactive Technology Design in February 2016. (Also appendix 4)

technologies had in the previous cycle (section 5.2), this brief instructed student designers to select a historical technology to redesign. The brief was accompanied by a handout with a number of historical technologies that have dramatically changed over the course of the years (figure 14). The handout had pictures of industrial and and pre-industrial era technologies that were labeled as general categories of technologies such as: lighting, messaging, time keeping, lock and keys, duplication, image capture, etc. The objective of the design process became to surface a contemporary technologies as FT&P, as its historical predecessor was; but to spare it from being particularly arduous or labor intensive, as the historical predecessor would be considered in our contemporary context.
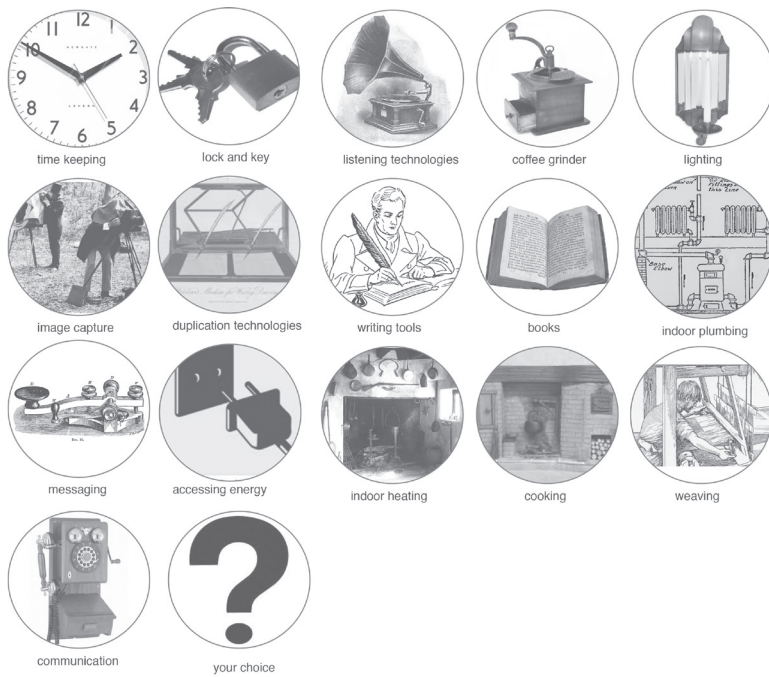
Figure 14. The supplementary material delivered to students along with the design brief. Students were instructed to select one of these general categories of technologies, or practices supported by technologies, to redesign.

This brief's instruction to designers to consider historical technologies as a starting point for their design process echos some of the framing of the device paradigm, which uses historical technologies as a point of comparison to critique what is problematic about contemporary design. With the device paradigm, Borgmann critiques the present through the lens of the past and how they do not embody qualities of their historical

predecessors, which were FT&P. Centralized heating cannot be focal in the same way as a fireplace.

In this brief, designers are asked to create a technology for our future, but to look to historical technologies for inspiration rather than their contemporary counterparts. Such a historical perspective to redesigning contemporary technologies has also been explored by designers attempting to envision sustainable energy practices (Kuijer 2014). In this RtD cycle, students were drawing from the past to design for the future, but utilizing contemporary materials such as the micro-controllers, sensors, and other mechanics.

EMERGED IN THE PROCESS OF CREATING A DESIGN CONCEPT
The brief's framing of this particular RtD cycle around historical technologies and active engagement offered a lot of structure to the ensuing design process. It also offered room in the design process for designers to consider what their position on the way that this technology shapes our lives have changed. Specifically, their designs take a stance not just on way that the technology itself has changed, but also on the context that the technology enables and how it has changed as a result of our relationship through that technology. As our relation to time has changed historically, as time keeping technologies become more precise and widespread.

Historical Perspective

One conflict that had been experienced in the previous RtD cycles was with the lack of examples to demonstrate FT&P. Part of the problem is that I was seeking contemporary examples of technologies that could be framed as FT&P, which this research presents as an underdeveloped area of design, thus there are a dearth of examples. This brief's instruction to students to draw from historical technologies as models of FT&P to be updated was a constructive way to frame their design process.

Students dedicated time in their design process to looking at how these technologies have historically evolved to consider how to mirror some of their qualities in their own novel designs. For example, the group exploring duplication technologies uncovered archival footage of a "Mimeograph Machine," presumably from the 1950s, that uses pressure from a master image affixed to a roller to transfer images onto blank pages by operating a hand crank (figure 15). This group later rapidly prototyped possible interactions for their own design that could utilize this cranking mechanics by propping a chair on a cabinet, spinning it's wheels and feeding paper through the legs (figure 16). Other mechanics behind duplication were also explored, such as the sweeping motion of distributing ink over a screen print, etching, photo transferring.

Figure 15. Archival footage of a Mimeograph Machine, duplication
technology presumably from the 1950s, that the student designers used to
inform their design process. Image is a screen grab from archival footage (Film
Archives NYC 2014).

Figure 16. Student designer group rapidly prototyping an interaction based
on the archival footage they uncovered about the Mimograph Machine of
figure 15. Here a chair was propped up on a cabinet, and it's wheels were
spun as if it where a crank, and another student illustrates how paper could be
fed in this interaction. Image courtesy of Myrthe Buskens, Marijke de Geus,
Eunyoung Go, Garry Lasamahu, and Miro Virta.

Through this period of examining historical technological approaches to duplication, the
student designers decided the general vision for their design concept. This group decided
that their ultimate design concept, Rememory, would be a wall mounted printer and the
interaction with it would mimic screen printing (chapter 6). A photo from a phone would
be sent to the printer, and people would co-perform the printing process with gestures
that would add one layer of color ink upon one another to achieve the coloration of the
photograph (figure 17). The group used a printer specialized in small photographs, the
Cannon Selphy, which prints one layer of ink at a time in the cyan, magenta, yellow and
black (CMYK) color model.
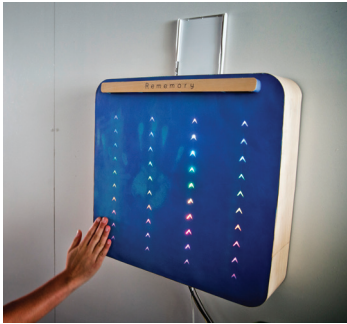
Figure 17. The printer that models its interactions based on screen printing techniques, where peoeple co-perform the task of the printer as they add another layer of colored ink upon the final image.
Image: Guus Schonewille

This team had continued to do more background research on historical duplication processes and came across an encyclopedia entry from 1902 visualizing how the CMYK color model was utilized as a printing technique (figure 18). The student designer who came across this discovery posted this image from the encyclopedia on the team's blog with the comment: "This is cool. And also how the technology behind our printer works." These designers were looking through historical technologies to contextualize and inspire their design process. This team's final design concept, Rememory, utilizes an interaction pattern reminiscent of historical technologies upon which to build their design. This gave them a framing for how to think about interactions and materials in their own design. This is not a question of re-inventing the wheel, but rather starting at the past to design for the future.

Figure 18. In the course of researching their materials that make the technology operate that their design was modeled after, the student group shared this image of historical duplication methods to contextualize and inspire their design process (Dodd Mead and Company 1902).

Designer's Agenda in Engagement with Technology's Context

What also emerged in this cycle which was totally unexpected was how designers used this entry point of historical technologies to consider how relations with technologies have changed, and taking a strong political stance with their design concept about how the loss of FT&P have impacted us culturally. With this comparative and reflective outlook, two student groups used their design concepts to take a stance on what role contemporary technologies *should* play in our lives. Interestingly both groups were working with time keeping technologies. In particular, their concern was more with the changing relationship that the context that these technologies enable (our relationship with time) more so than just the technology itself.

One group spent most of their design process researching existential questions about time and how technological developments have changed the way we perceive time. Thus it was not such a surprise when their final design took strong stances to suggest what our particular relation with time should be. Both of these groups took the position with their design concepts that the more that we allow time keeping technologies to rule our lives, the more destructive it can be. In their design concepts (Concrete Time and Unwind, in chapter 6), traces were used to demonstrate our use of the technology, which followed interactions that incentives not using the technology itself.

In the case of both of these design concepts, designers take this interaction with the technology a step further as an opportunity to assert, through the way they design our interaction with the *means* of the technology, their attitude about the role that the *ends* of that technology should play in our lives. In the case of one of these time keeping design concepts, the time would not be displayed until you pulled a weight that resembled one of a grandfather clock. As you pulled this weight, it slowly eroded the clock itself until one day it would not exist at all (Concrete Time, chapter 6). The designers were sharing their belief that we have become too over reliant on a precise relation with time, and that we should free ourselves from its oppressive grasp. Here our engagement with the *means* of the technology renders a trace which is effect a commentary of the role that the *ends* of that technology (the display of time, and the relationship to time that thus engenders) should have in our lives.

REFRAMING THE RESEARCH TOPIC
It appeared that the historical frame of reference that grounded this RtD cycle offered more clarity to the designers than the previous briefs (sections 5.1 and 5.2) regarding the qualities of FT&P. There's no doubt that the rich archives of examples that the scope of historical technologies opens up also benefitted this RtD cycle. In this cycle, the designers seemed to more naturally engage with and grasp the concept of FT&P than in previous cycles, even to the extent of developing an opinion or stance on them.

In the design processes behind this cycle, FT&P were being considered through the lens of practices as interactions with the things. These interactions were intentionally referencing historical technologies to capitalize on the ways in which these were focal.

Ultimately, these practices and interactions came to resemble a form of labor to engage with the thing. Again, traces were being utilized as a way to communicate that these interactions had occurred in an enduring way.

The stance that the two student groups working with time technologies took with their design concepts raised some interesting questions as to what role should the designer's ideologies take in surfacing technologies as FT&P? We could argue that very objective of designing technologies in a way to surface them as FT&P is inherently an ideological one. Yet the way that designer's opinions on technologies as FT&P took root in these projects was different. In both projects on time keeping technologies, designers injected a judgment as to what our relationship with time should be in the future with how they designed the implications of the practices around the clocks. In other cycles, designers had asked the question about what traces should engage people to *do*. How should traces impact behavior of people? For example, the previous cycle asked how should traces make us more contentious about their energy usage in an effort to encourage us to consume less (section 5.2). These questions about what should traces make people *do* were also among the first asked in the first cycle as well (section 5.1). In this cycle however, this concern manifested in terms of how a designer's agenda on the technology as a FT&P should surface through its use.

These questions gets to the heart of the relation that FT&P should have across design time and use time, or: the boundary between when the ownership of an artifact is transferred from the designer, design time, to the people who will ultimately engage with the artifact, use time (section 1.2) (Fischer and Giaccardi 2006). While the question of this relation between design and use time had been toed in the previous cycles, it became obvious in this cycle that this was a dynamic that needed to be conceptualized in the next RtD cycle. Thus a taxonomy, which will be discussed in section 5.4, attempts to explore this dynamic and the possible forms that traces can take between these two times, and how these may relate to surfacing FT&P.

This cycle suggested to me though that the designer's personal agenda is not particularly appropriate for surfacing technologies as FT&P. Instead, a more open stance should be adopted, where idiosyncratic relations unfold between people and the technology, and that this openness between the person and the technology is essential to surface it as a FT&P. I am skeptical that these relatively prescriptive statements that the designers posit with their designs actually allow for FT&P to flourish and develop in ways that are unique between people and their technologies. Instead, the designers' stance can become prescriptive to the specifics of the relation that unfolds between people and the artifact. These came to represent a political statement from the designers to determine *what* is focal. This is yet another element of FT&P that we had not yet had an opportunity to ponder in previous RtD cycles.

These time keeping design concepts also raised another important issue that reframed the research topic. In these two designs, traces emerged as a result of our physical engagement of the *means* of the technology, the materials that contribute to its

operation. However, the designers intention is that these traces reflected something out our engagement with not just the literal *ends* of the technology, the outcome of the technology's use, which would be the time that is displayed upon the clock's face. Instead, the traces attempted to bring about focal-ness to the context that the technology enables, which is our relationship with time, and the role that it plays in our day to day lives. The FT&P wasn't as much these clocks themselves, but more accurately the context that they enable, the experience and role of time. This was a significant finding of this particular cycle that appeared to be its own pattern within the design space in and of itself, and will be described in more depth in the following chapter (section 7.2).

5.4 CYCLE 4: GRAPPLING WITH THE MATERIALITY OF NETWORKS

This RtD cycle is unique from the others described in this chapter because this design brief did not ultimately progress into a design process yielding a design concept. Additionally, it is unique for the fact that this cycle was done in collaboration with professional design practitioners instead of design students. In this cycle I worked with Harm and Marcel, the two founders and directors of The Incredible Machine, a small design agency based out of Rotterdam (Netherlands). The Incredible Machine specialize in physical computing and speculative design (The Incredible Machine 2017a). I have worked very closely with these designers in a number of different capacities throughout my PhD career (chapter 9). They were familiar with the topic of my ongoing research, but had never directly engaged with it prior to this cycle. These designers were chosen not only for our established close working relationship, but also for their demonstrated ability to think abstractly and deliver high quality work in the past. They were compensated for their time on this project.

This cycle followed the conclusion of the both the second and third cycles (sections 5.2 and 5.3). The intention of this cycle was to create a robust design concept that could be studied with users, however this cycle was instead dedicated to a qualitative analysis of how the design brief was conceptualized. Therefore this session is treated not just as an RtD cycle, but also as a field study (section 4.2).

DESIGNING THE BRIEF
The original intention had been for this cycle to iterate upon the design concept from the second cycle, Aila (section 5.2, chapter 6). The Incredible Machine were sought out to strengthen the concept behind Aila as well as to create a design concept robust enough to undergo long-term deployment in people's homes. However, in preliminary discussions with these designers, this particular concept did not resonate with them. Instead, this design brief is dedicated to reframing the research topic regarding the relation between design time and use time, a subject that the previous cycle had brought to light (section 5.3) (Fischer and Giaccardi 2006). The draft of this brief was iterated upon approximately 6 times, each with a different approach to framing the research topic. This brief also benefited from other experienced designers who offered

Design Brief
Tracing Sociomateriality

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Context:
By definition, the very materials that define many of our technological advances today
are ones that are not perceivable to us. These are the materials like code, the learning
algorithms, energy, and data that are that shape our world, similar to how wood, and
stone and plastics do. The very nature of our inability to perceive them means that we
are fundamentally separating the *ends* from the *means*. We don't have a sense of how
these materials work, or how we work with them. There is always a fluid relation
among how people, their ways of doing, and materials are entangled and constituting
one another. A Google search yields certain results because an algorithm ranks pages
in terms of what appears to be the most popular pages, and a physical server that sits
in a building that is constantly cooled stores that page which the algorithm ranks.

Consider this in the domain of energy. How energy is produced or delivered to our
homes is very removed from how we consume it. By turning a dial on our thermostat,
we have no concept of how technological devices are heating up a boiler in the
basement, or collecting stored energy from a battery cell. We have no notion of the
energy grid that we are a node in, or the systems that are in place to receive the
energy. As a result, the energy

Domain
Home. Design for a device or practice where an object consumes energy that people
use often, and regularly forget about it while it's consuming energy.

Problem
Find a way to bring the ends and the means of how energy is procured and consumed
closer together. Energy consumption through this device should not be something that is
automated or regulated to the background. Instead, people should be engaged in the
task of the technology. Use traces as a means to illustrate this process. Traces should
not be screen based.

Requirements
- Create a working prototype that can run continuously for 8 hours without
  needing to be maintained.
- Create a prototype that tells a story, and illustrates the problem described
- Prototype is not an art piece, but an object that could reasonably be in
  someone's home in the near future.
- Operating the technology should not be inconvenient

Comparable projects
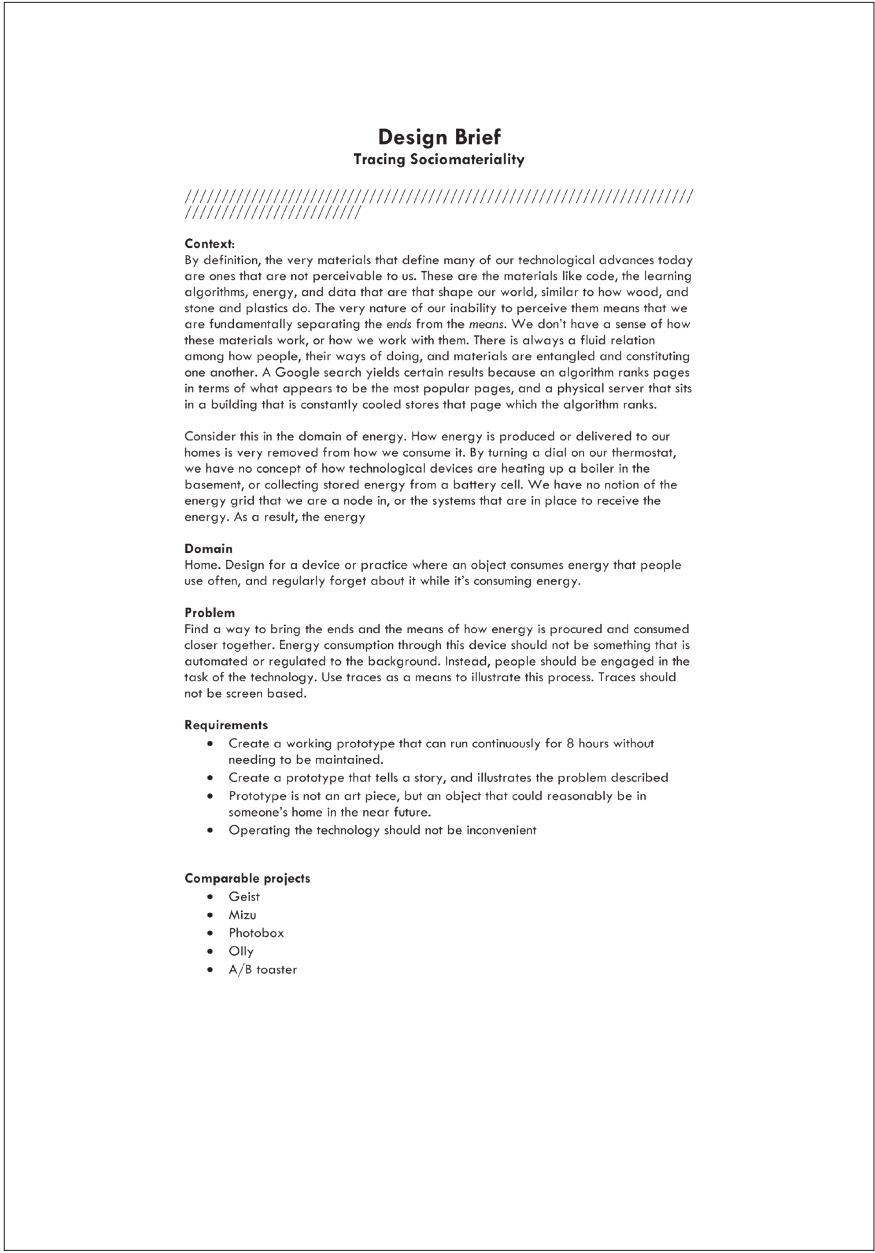- Geist
- Mizu
- Photobox
- Olly
- A/B toaster

Figure 19. The design brief of the fourth cycle, the basis for the
conceptualization discussion with professional designers. (Also appendix 5)

their editorial perspective specifically to aid in making abstract philosophical concepts relatable to design practitioners.

FT&P as Sociomaterial Exchanges

In an attempt to conceptualize this relation between design and use time, and the role that traces can play in communicating aspects of our relation with technologies across these times, a body of research in sociomateriality was consulted (section 1.3 and 2.3). This work specifically turns our attention towards the relations that we have with materials. Sociomateriality is an emerging approach within HCI and design that examines the complex ways that people and materials are constitutively entangled in everyday life, mutually defining and shaping one another (Latour 2005; Ingold 2013; Mazmanian, Cohn, and Dourish 2014; Suchman 2007; Bjørn and Østerlund 2014; Orlikowski 2007; Dourish 2016; Dourish 2014). Sociomateriality becomes a very constructive lens to consider relations with computational technologies, or those that are networked with other technologies, as the solar panels were in the second cycle (section 5.2).

This co-constitutive relation that we have with materials is well demonstrated by organizational theorist Wanda Orlikowski's example of Google search (Orlikowski 2007). A Google search provides troves of web content instantaneously to the fingers to all of us. This accessibility privileges locus of control with the human making the search, delegating the material of Google's code and content to the passive, subservient role. However, this fails to consider the active role that the materials behind the Google search engine has in shaping this exchange. The materials of Google's algorithms favors some content over others by indexing and ranking content, prioritizing some pages over others. Those search hits that are returned to us shape our perception of reality. Those hits are curated by Google's algorithms, which correlate information about where you are, your previous history, what other people in your area may be searching for, ad ranking, among other factors. He we see the materials and the people in constitutively entangled with one another, their agencies being mutually defined in one another. Our perception of reality, which are the search results, are shaped by the materials of the algorithms, which we in turn shape without realizing ourselves. People and materials are a single entity with a shared agency, working in collusion (Orlikowski 2007).

This cycle conceptualizes FT&P as being part of sociomaterial exchanges, and traces as a means to reflect this exchange. This premise being that the lack of awareness of this co-constitutive quality is very much comparable to the device paradigm. As demonstrated with the example of the Google search, the *ends* (the search results) and the *means* (the algorithms that shape the search results) are separated from one another leaving us with little to no insight into how a query's search results are determined. So while people are engaged in shaping the materials, and thereby implicitly also joining the *ends* and the *means* together, this exchange is not legible.

The consequence of this lack of legibility of this sociomaterial exchange or between the *ends* and the *means* now can be much more problematic than over consuming the technology as Borgmann had laid out. Although perhaps we do become reliant on Google to resolve any question we have, and also take for granted the things that we find on the Internet, leading to now infamous phenomenons of "filter bubbles" (Eslami et al. 2015; Hern 2017). The way that algorithms become loaded with biases to tailor certain content to particular people based upon evaluations of the data that they have produced can have significant societal impacts. This lack of awareness and legibility as to how the *ends* and the *means* of a Google search are related leads to a lack of awareness of how these technologies shape our sense of reality, an thus the role that these technologies play in our lives. The logic then follows that if this co-constitutive element of the technology was brought to light, perhaps this could help promote the focal aspect of the thing and the practices surrounding it.

This brief explores how, in design time, to support surfacing this co-constitutive nature of the relationship between people and technologies that would unfold in use time in an attempt to make them more "focal." Could design communicate how our practices engage with the materials of that technology, thereby surfacing the technology as a FT&P? To help frame this objective, this brief was accompanied by a taxonomy developed to specifically frame the relation between design and use time, and how traces can communicate across these times to reflect how people and the materials co-constitute one another.

Taxonomy Tracing Sociomateriality

The taxonomy included in the brief interprets the theoretical work on sociomateriality to examine how traces can play a role in surfacing how people and materials are co-constitutive of one another. Specifically it identifies various attitudes that can be adopted in design time, or the design process, to utilize traces to this ends, or not. One particular category within this taxonomy is identified as being the most promising to promoting FT&P, and designers are requested to explore this category.

In addition to creating these categories of different types of traces and positioning them in relation to one another, this taxonomy makes a departure from how traces have been conceptualized in the previous cycles. This particular brief suggests that traces can be either temporary or long term. This was a nod to the fact that the design concepts from previous cycles utilized traces in ways that were provocative and seemed to echo the sentiments of FT&P regardless of how long they stayed on the object (Mizu, Rememory, chapter 6).

This taxonomy was developed upon the experiences of previous RtD cycles (section 5.3 especially) and previous research conducted regarding traces as a design approach (Giaccardi et al. 2014; Robbins et al. 2015). The taxonomy defines its classifications on two basic principles (figure 20). First is a categorization of the posture taken in design

ANALOG CONTEXT	DEGREE OF OPENNESS FOR HOW TRACES EMERGE IN USE TIME	
	CONSTRAINED	FLEXIBLE

1. Coating often applied to kitchen appliances that advertise as being resistant to hand prints or smudges. 2. New furniture that is given the appearance of being used or aged. These are often then sealed with materials that prevent natural aging or sign of use to appear. 3. Newly produced jeans that are sold as being "worn in." More traces of wear will appear through use. 4. Tea cup that is not completely glazed. Through use, the unglazed parts become stained by the liquids that were in them, highlighting a pattern created by the designer Bethan Laura Wood. 5.Cast iron skillets become seasoned by the flavors that are cooked in them

Figure 20. Taxonomy on Sociomateriality of Traces developed for this design brief.
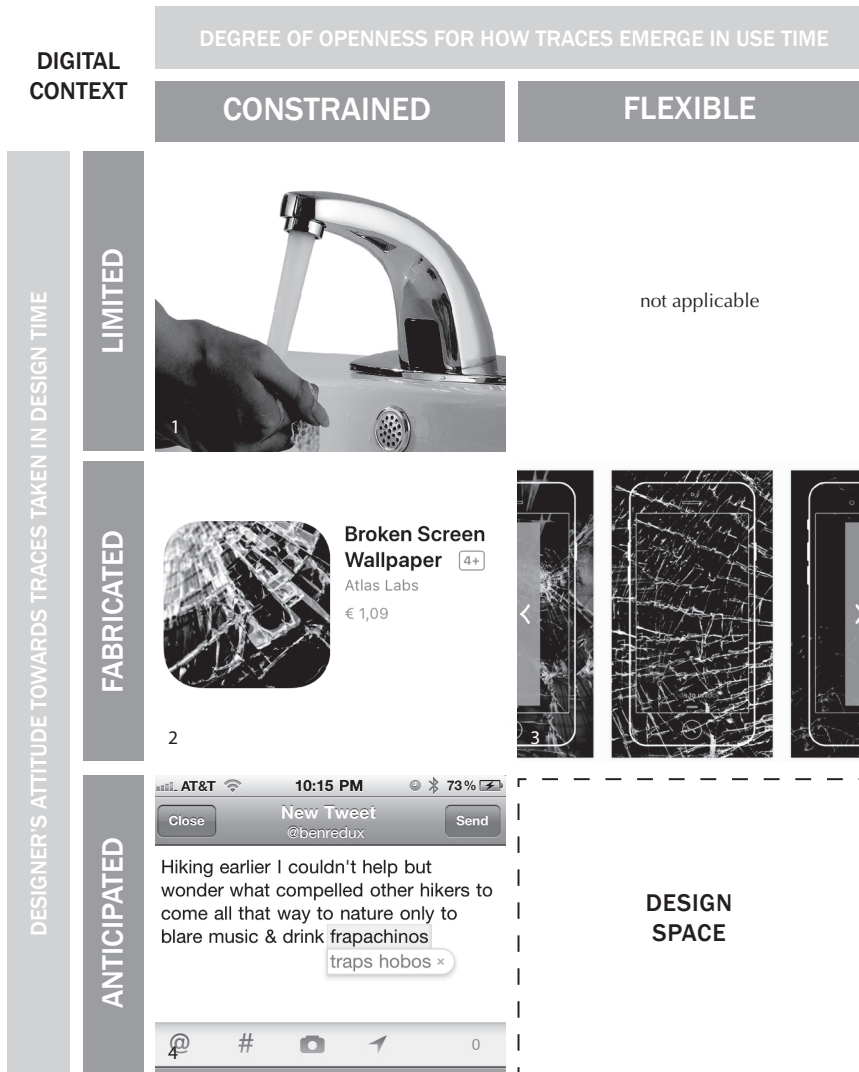
1. The possibility for traces to appear are limited completly by designer with sensors that do not requiere touching at all. 2. A downloadable smartphone wallpaper that is a static image of cracked glass. 3. A downloadable smartphone wallpaper that gives the pattern of cracked glass based on where you touch the screen. You can create your own "impact points." 4. Auto-correct algoritmes anticipate that there will be idiosyncraticwords of the user that will be adopted into the dictionary

Figure 20. Taxonomy on Sociomateriality of Traces developed for this design brief.

time towards the manifestation of traces that relate to use, and how these may emerge in use time (limitation, fabrication, and anticipation). The second principle adds another layer to these different postures to consider the degree of control exerted in design time as to how these traces will emerge in use time (constrained or flexible). Lastly, the taxonomy is illustrated with examples of commercial and conceptual products and services, both in the realm of analogue and data-enabled artifacts and services.

In this first principle, regarding the posture towards the existence of traces that is assumed in design time, the taxonomy identifies three general positions to be taken in design time towards traces:

- Traces can be limited. In this case, designers may opt to take measures in design time to prevent the appearance of traces on the artifact that may appear during use time. In these case, particular materials and interactions/ practices are being designed which limit or completely avoid indications of how people engage with these artifacts, and the sociomateriality at large. For example, smudge proof materials on kitchen appliances that prevent the appearance of fingerprints, or the use of sensors to completely limit any physical interactions with and resulting traces upon the artifact itself.

- Traces can be fabricated. Traces are created by designers in design time almost as if to give an indication of use time having already lapsed. Motifs of traces imitating how people, practices, and materials converge on the surface of the artifact are manufactured at design time. This is almost an "industrialization of experience" by creating the appearance of experiences with an artifact that have not occurred through interactions with the artifact itself. For example, jeans that are sold as "worn in," or a mobile phone wallpaper that gives the appearance that the screen has been shattered (Wax 2013).

- Traces can be anticipated. In design time, the surfacing of traces that will occur in use time are supported. These traces do not yet appear in design time. Such as a cast iron pan that is not seasoned when purchased, but later becomes so as it is used. Or the algorithm on your mobile phone's dictionary that eventually learns and adopts the words that you consistently spell in a way not initially recognized by the phone's original dictionary. Thus what was originally first seen as a misspelling eventually becomes adopted into the dictionary and recognized as the correct spelling.

There is an additional layer included in this taxonomy that considers the degree of control that may be placed upon the afore mentioned categories of traces. There may be a lot of constraints exerted in design time to prescriptively determine how these traces will emerge in use time. Conversely, there may be a flexible approach taken in design time, leaving a lot of spontaniety for how these traces will emerge in use time. This variable of constraints and flexibility of the taxonomy was added directly in response to

the previous cycle where designers brought our attention to the role that their voice can play in the emergence of traces (section 5.3).

This brief instructs designers towards a particular category of this taxonomy for this RtD cycle. Specifically, the brief instructs designers to work with data enabled technologies and to anticipate traces, but to take a flexible stance. In figure 20 this is labeled as the "design space". This is a much more specific framing of the "design space" that this brief attempts to access in this RtD cycle than previous ones had. In doing so, this cycle adopts a stance that to support FT&P, we need to anticipate the emergence of traces during design time, and that we should be flexible and receptive to the emergent relations that we have with the technology during use time. This leaves less space for designers to assert what they think your relationship with the artifact should be at the moment that the artifact is being created. Our individual agency with the technology should be supported and reflected back to us via traces.

THE DESIGN PROCESS OF CONCEPTUALIZING THE BRIEF
As mentioned at the beginning of this section, this particular brief was not followed by a design process resulting in a design concept as the previous cycles had. Instead, this cycle is dedicated to how the professional design practitioners, Harm and Marcel of The Incredible Machine, conceptualized the brief. This session with Harm and Marcel lasted approximately two and a half hours and was recorded and transcribed. The transcript was then approached in the spirit of grounded theory (Strauss and Corbin 1998). The coding process was assisted with the Atlas.ti software. The first stage of open coding identified units of meaning and process. These codes were then organized and put into relationships using axel coding, from which the following analysis is derived from. This session draws our attention that some materials are able to communicate more complex exchanges than others, and advances the conceptualization of traces away from what they make people do to the ways that they can enable people.

Differences in Materials' Communicative Potential

Much of this discussion circled around what role the materials themselves could play in supporting traces to surface how the *ends* and the *means* of the technology were related. Without knowing what they would be designing, or with what materials they would be working with, the conversation prioritized what properties the materials would have to achieve the brief's objective of demonstrating traces. In prioritizing the materials and their ability to communicate, this revealed that some materials are more adept at communicating particular types of exchanges over others. By framing this particular cycle around using traces to pinpoint our use of materials, it forces us to consider *what* materials we are engaging with when we engage with a technology. What we discover is that the design concepts that had thus far been developed in previous RtD cycles can not communicate on the scale of a network.

Learning from the second and third RtD cycles and the potency of historical examples

(sections 5.2 and 5.3), I brought up in our discussion the example of water tables to illustrate the communicative potential of traces in helping to illustrate how the *ends* and the *means* are linked together. Looking at the edges of a body of water provides cues about water levels, the levels may be relatively low indicating a drought for example. In this case, I argue that traces help illuminate how the *ends* (low water table) and the *means* (dry spell) are connected. Yet Harm demonstrates that such traces can only communicate so much as to the context surrounding that water level:

> **Harm:** *[Water tables] not enough to understand to understand the whole system. The farm where I grew up was in an area in Holland that gets flooded a lot of the time. My Dad was always checking the water level. But he didn't even walk to the river to look at the thing where there was a meter stick under the bridge, he doesn't care about that. He went onto Teletext, the TV text thingy, and checked all the levels all the way up to the Alps where the river was starting. Then can analyze how much snow was there last month and what's the temperature now, and what's the level at Lobith, and what's the level in Germany, because then he knows really what's going on. The material trace of the water level there is only one thing.*
> **Holly:** *yeah. We're talking about a much bigger system*
> **Harm:** *It's a bigger system, and he needed the Teletext, the information, to make a more informed decision on what he would do. Would he, you know, would he mow the grass and then that pasture that might be flooded... those kinds of things. So—I think there is a good reason why all those complex systems have screens and are designed in a certain way.*
> *(The Incredible Machine 2017b)*

As Harm clarifies, a water table conveys a rather limited set of information: the level of water in that one particular location in relation to other levels that have also existed in that location. This information, as he points out, isn't as useful when the system in question becomes more complex. In this case, a screen is necessary to accommodate all the different data points that his father needed to understand how the water levels related to his farm. The traces surrounding that water's edge cannot offer perspective into the larger network that contributes to those particular water levels, such as the rainfall at the source of the river.

These traces around the water's edge perform a similar function to those that had been on the design concepts from previous cycles, in that they convey information about a relatively limited context. Harm and Marcel recognize that the traces in the previous design concepts all require physical interactions, which demonstrate something about the use of the artifact. They point out that all these design concepts happen to require rubbing in order to use, and that the traces of this rubbing communicate the use and

depletion of the particular resource that that design concept dispenses: water, ink, and energy (Mizu, Rememory, and Aila respectively; chapter 6). Harm comments that it was the "most obvious" kind of interaction—rub the artifact to get it to work and to illustrate that use of that artifact's resources. Further, this limits the types of materials that could possibly be used in the design to certain metals, like bronze, copper, or brass (Mizu, Aila, and Unwind) and textiles such as leather or Tyvek (Rememory, Animal's Tale).

We see the designers taking a material-centric approach to not just exploring their ability to manifest traces, but also what those traces would represent in relation to that material. A water table tells you the water levels in one location relative to itself, verses the screen which can convey the complex information that can help you understand why the water at one place is at a particular level and how and why that level may change. Rubbing will only indicate that a very specific thing has been used has been used. Clearly materials and traces needed to be re conceptualized.

Tension Between Communicating and Persuading Through Traces

An important question that was asked explicitly as early as the first cycle (section 5.1) again emerged in this conversation: what should traces make people do? While the design brief frames the purpose of traces as something that surfaces and communicates an existing dynamic, the question in the designer's eyes was towards what outcome are traces intending to direct people towards. Harm and Marcel kept returning the question of what was the utility behind the trace itself: what are traces supposed to do, or perhaps more appropriately, what are traces supposed to make people do. There was a tension between how we framed our objectives that was difficult to harmonize:

> *Holly: In terms of what the PhD itself is about, and this perhaps very counter to how you solve problems and approach problems as designers, for me it's less about creating a behavior change. Instead, it's about illustrating this dynamic that is happening. That can be manipulated in design to have an impact for change to do this whatever. But what I have to first do is demonstrate that there are different ways that we can interact with materials and objects that surface this.*
>
> *Marcel: yeah sure, but whatever you do has an impact. Whatever you do — if you create an object, or design something: it has an impact. Unless people are totally ignoring it or it's invisible, it effects people's behavior. I mean, of course, we can argue whether we want to aim for a behavior change, or maybe create something and observe what is happening [when people use it], but then still, you kind of assume a positive contribution… we need to create something that's obvious enough that when people look at it, they can relate from personal experience, or at least have the impression how this might, you know affect their awareness or, effect their behavior, or*

effect... effect something. I mean that's what design is about. I mean, that's
not something that we can change. Even if you talk to David[11] about him
creating a beautiful lamp or a beautiful chair… it has everything to do with
[effecting] behavior.
(The Incredible Machine 2017b)

With this understanding, every design decision is about creating some kind of predetermined impact or effect in terms of how the artifact is used. This is similar to the question that arouse in the previous cycle between design time and use time (section 5.3). This cycle attempted to frame itself in such a way explicitly to navigate around design time being an opportunity to assert a designer's particular stance to be projected into use time, as this did not seem consistent with FT&P. Yet, here again the argument is that traces should be a way to encourage people to interact with the artifact in some kind of "correct" way. Merely communicating an existing exchange with traces, as had been my intention in the design brief, wasn't sufficient for the designers. Traces had to have a purpose, it had to instruct. I am explicitly reminded in the conversation that every design decision "has to have a purpose," but this purpose again and again appears to be about somehow directing people to do the purposeful thing that has been determined by the designer.

Traces to Engender Agency

Nearly at the end of our conversation, Marcel arrives at another conceptualization of the purpose of traces. The conversation had been framed in terms of how to design technologies that carried out the designer's intention, for example to encourage people to use less energy. Instead, the objective is reconceptualized to be about traces as a sophisticated mode to explain what is happening behind the technology in order to better inform the way we interact with that technology. Traces would therefore be providing people with the opportunity to have some agency of their own domains.

Marcel pointed out that in the previous design concepts developed for this research thus far, traces only serve as a record of events that had happened. What if they were instead not just to inform about a record of use, but somehow inform about the context that the object is existing in— in order to help shape our behavior?

__Marcel:__ The traces help people to, [think differently about the product] the
next time they're using it. But the product is pretty quote unquote "dumb,"
it still does the same thing. But it's YOU [that] change over time… But what
I'm more fascinated about, and I think, you know that also goes for us at
The Incredible Machine, we're fascinated about algorithms and how quote
unquote "smart" products that adapt to your behavior—or, based on data,

11   David is a mutual friend who is a furniture designer and had come up earlier in the discussion.

they decide to function slightly different than before. An ideal outcome for me, or a good outcome for me in this project would be that we demonstrate a product that adapts its behavior to the user. But through the material traces, a user can kind of comprehend, or kinda of understand how this happened or why this is happening.

Holly: *yeah. That sounds like a nice way to put it.*

Marcel: *It's a very simple way of putting it. It's not really solving moral problems here…So, a product that adapts its behavior based on what it learned about you, that's one thing. The other thing is that these [other design concepts] are very centered around [a single] object. The printer, the tap, the energy crank- it's a very individual experience. You first said something about social context…where there is more people involved and where you better understand how you do things.*

(The Incredible Machine 2017b)

This demonstrates a turn towards the more "flexible" stance that the taxonomy of this brief attempts to strike. We're also closer to a conceptualization of FT&P that is about the dynamic and individualistic exchange between people and the technology. Not only is it about people seeing how the technology works in terms of making legible how the *ends* and the *means* both reside within the technology. But also to put the people in the position of being directly responsible for impacting how the technology works. They can become a factor that works within the *means* of the object to shape the *ends*.

Now we're also able to circumvent the confusion we were having about the "purpose" of traces. It's not about the technology or traces as the method to instruct a particular behavior. Now we're talking about a mode of dialogue between person and technology, which is coming about by seeking to transform the illegible things about the technology into a form that is legible: the algorithms or materials function to create a certain output of the technology. This is truly capturing the essence of the sociomaterialists, that there is a co-constitutive exchange where people and the materials are shaping one another.

REFRAMING THE RESEARCH TOPIC

This fourth RtD cycle offers two main contributions to reframing the research topic. The first is a more meta perspective pertaining how to navigate between STS and design practice. The second contribution is more specific to the topic itself, which is the reconceptualization of materials and traces to accommodate networked technologies.

Reflecting Between STS and Design Practice

Studying the transcripts of the session of conceptualizing the design brief provided more nuanced and granular perspective into how design practitioners navigate how the design brief framed these topics from STS. Harm and Marcel came to this particular

research cycle with more than 20 years experience between them as design practitioners. One immediate observation is that the brief and its accompanying taxonomy was hardly consulted at all. The designers spent no more than two minutes reading it at the beginning of the session, but it was not referred to in the conversation, nor were some of the more specific concepts or examples that were offered in it.

Initially the intention behind this cycle had been to develop a design concept, or at the very least a concept for a design concept for this cycle. Yet, the majority of the conversation in this session was focused on exploring the tension with the concepts in the brief itself. This is in stark contrast to the previous cycle where a design concept concept was already being developed within the first half hour of being assigned to a group and receiving the brief (section 5.3). Therefore, instead of dedicating this cycle to the development of a particular design concept, this cycle was dedicated to the careful analysis of reflecting on how the design practitioners conceptualized the brief itself. Ultimately, I believe this brief was written too broadly and was too conceptual to really resonate with the designers. This will be reflected on in further detail in chapter 10, which will specifically address some of the insights about this transdisciplinary space of navigating between STS and design practice.

Reconceptualizing Materials and Traces for Networks

This RtD cycle had a radical impact in reconceptualizing materials, traces, and practices in light of technologies that are a part of a network. This discussion about differences in materials' communicative potential in this cycle brought to light that previous RtD cycles had been examining how traces can communicate exchanges that occur on a small scale. People touching an object, people consuming a resource, and traces as a log of the fact that these events had happened. Thus also, notions of practices that support focal-ness were limited to there being just one thing or material that we are engaging with when we engage with a technology. This can only work for a limited context, between a single person and an isolated artifact or material. It also only can support limited interactions with the technology, those that are mechanical or utilize friction. It doesn't help us think in terms of how FT&P can relate to networked technologies.

With the previous briefs, designers were encouraged to think in terms of connected, networked, or data intensive technologies and are instructed to work with traces to reveal how these technologies work (sections 5.1 and 5.2). Those briefs further prescribed certain physical attributes that these traces should have on the technology: it should be cumulative and long lasting, be on the object itself, not on a screen, and reveal how the technology works (an interactional attribute) (sections 5.2 and 5.3). These parameters in combination with one another naturally led to some consistency among the design concepts where traces were a log of a limited range of interactions with the technology: those that are mechanical or utilize friction. This framing only really permits for a one to one dynamic. It is like the water tables only being able to indicate the water level in one particular place, not provide us with the context to help us understand how or why.

But as we move into this realm of technologies that are comprised of materials such as network connectivity, we need to also expand how we can express and make legible these networked capabilities. This thesis is motivated by the observation of how Borgmann's device paradigm carries into this relatively new field of networked technologies, and thus the importance of finding ways to support FT&P in this realm of technologies (section 1.1, 2.3). Some of these materials behind these technologies, such as networked connectivity, are illegible to us, traces should be problematized to make these materials, and our relations to them legible (section 2.3).

The Teletext from Harm's example attempts to literally make the various nodes of the network legible. It provides textual information to inform us what are the water levels at Lobith and the rainfall in the Alps. With traces, we seek alternative, non-explicit, approaches to making the networked capacity of technologies legible.

Our understanding of traces has to be expanded if we want to understand how to navigate these networked technologies to support them as FT&P. A trace can no longer be an etching or discoloration from the friction between a hand and a surface. Traces can still be a manifestation of things that are no longer, or never were, perceivable (section 2.1). It's no longer just the passage of time, repetitive actions, or events from the past. We need to also instead consider the universe of other imperceivable things, such materials that we cannot handle such as networked connectivity.

Interestingly, this cycle was a prelude to another project that I joined with these same designers that yielded the design concept of the Transparent Charging Station which builds upon how this brief was conceptualized (chapter 6 and section 7.3). This project expands how we consider traces of networks, as well as the potential impact that making these materials legible with traces can have to our own agency with these technologies.

5.5 REFLECTION

Throughout the design processes in these RtD cycles, we can see a steady progression of how core concepts behind this research are problematized. It was through these design processes of tinkering with the materials and design approaches towards traces that notions of focal-ness, practices, and things were shaped and evolved. We should also take a moment to acknowledge how the context behind how each RtD cycle also made a unique contribution to the evolution of this research topic.

Internet access protocols at the Delft University of Technology presented a significant obstacle to our original objective of prototyping for Internet-connected technologies, as the first briefs had specified (sections 5.1 and 5.2). The security protocol for access to the university's network required that requests for individual devices with the IP addresses be submitted daily through a centralized bureaucratic system. This was not a feasible process for rapid prototyping, thus early design concepts for the first three cycles did

not ultimately engage with networked technologies. Without being able to problematize these notions of networked connectivity through prototyping, these cycles conducted at the university considered types of automation related to FT&P that could be prototyped with the micro-controllers and sensors that were available to designers (sections 5.1-3). By working with these kinds of sensors, interactions that were designed for were much more physical, thereby highlighting conceptualizations of traces that resided in the surfaces of materials. It wasn't until working with professional designers who shared 20 years experience between them specifically in prototyping Internet connected technologies that traces were problematized in terms of their relation to networks (section 5.4).

Additionally, through these RtD cycles, I too was developing my skills as a design anthropologist engaging with these design processes. This was especially apparent to me between the first and third cycle, which were both set in the same course at the university. The delays and confusions that occurred in the first cycle did not present themselves in the third. I was becoming more sophisticated in how to navigate this particular research context.

This chapter charts the evolution of the conceptualizations of some of the core concepts of this research, with particular attention to FT&P, traces, and materials. The development and problematization of these concepts are reflected and analyzed with the mapping of the design space, which is laid out in chapter 7 and 8. This chapter also demonstrates the steady progression of how the ideas developed upon each other, with one RtD cycle reframing another. This anthropological perspective on the design process also lead to some observations about navigating between STS and design practice, which will be addressed in chapter 10.

CHAPTER 6.
INDEX OF DESIGN CONCEPTS

This chapter serves as an interlude and reference for this thesis, providing an index of each of the 10 design concepts that that this thesis' analysis draws from. The idea behind these design concepts are described, as well as details about the context in which they were created in. As design concepts, these research artifacts give form to, or are the embodiment of, an idea to be shared and communicated. It is a representation of decisions that had been made to interpret an idea, in this case the research topic as it is represented by the design brief (section 3.1). These concepts are tools to make inquires into the design space surrounding surfacing FT&P, and help us to determine its boundaries.

The design concepts are listed in alphabetical order. All images are credited to the designers unless otherwise noted.

AILA
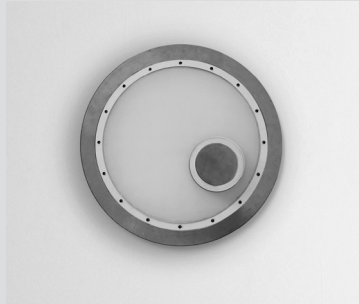
Alia is a lamp for your home, which invites people to be engaged in generating and consuming energy. Today's conventional lamps limit our modes of engagement with the task the technology performs. With a mere flip of a switch, the lamp is turned on. Aila is operated with an interaction that mimics the mechanics of dynamo lights often found on bikes. By rotating the outer ring of the lamp, the battery that powers the lamp becomes charged. The energy generated is represented back to the person with a series of lights that are illuminated along Aila's outer rim. The more lights illuminated, the fuller the charge. The strength of the light cast by the lamp can also be adjusted to be made more bright or dim by rubbing or tapping on the smaller bronze dial within the lamp's inner circle. When the light is made stronger, the demand on the energy store is higher, thus fewer lights along the rim will be illuminated demonstrating a drain on Aila's energy store. Conversely, if the light is dimmed, more lights along the side will be illuminated, as the demand on the charge is less and the energy store will last longer. The points of contact where people physically engage with the technology itself, the rotating dial and the knob to increase or decrease the lamp's brilliance, are plated in bronze. The patterns of it being touched polishes the material, reflecting usage back to people, while other parts develop a patina.

Designer: Jaqueline van 't Hof; master's graduation project co-sponsored with Jasper Hörmann at Sungevity Nederland

Brief: Appendix 3; RtD cycle 2 (section 5.2).

Author's Role: I acted as a mentor to this project, which was also chaired by Dr. Arnold Vermeeren. In my capacity as mentor I would meet with Jaqueline on biweekly basis to develop the research behind this project as well as to contribute to critical design decisions.

Date: June 2015 - June 2016

ANIMAL'S TALE

As we transition to audiobooks certain qualities are lost, such as the way that pages of loved books become worn. With Animal's Tale, designers attempted to bring some of these qualities back, but for audiobooks. A form resembling a book sits on a table, when it's opened, the audio file reading of a children's story begins and a small fan inflates the form of a creature relevant to the story. This creature is made from Tyvek®, a plasticized-fabric-like material that's durable but supple. The controls for the audiobook (volume, fast forward, rewind, skip chapter, pause, etc) are embedded in the material of the inflated creature. Thus, interacting with the audio recording also means interacting with the material form of the creature. Handling this controller results in the material aging, becoming softer and discolored where it is touched, much like a traditional page of a book would be.

Designers: Student group: Loriana Daggers, Assmae El Coudi El Amrani, Laura Koot, Anouk Vergunst, and Sergej Schetselaar.

Brief: Appendix 1; RtD cycle 1 (section 5.1).

Author's Role: I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it.

Date: February 2015 - June 2015

CONCRTE TIME
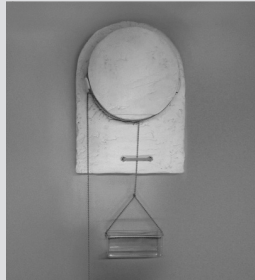
Time keeping technologies are ones that are often consumed in mindless ways. Clocks always remain on, always displaying the time in the background. Concrete Time is a wall clock that doesn't display the time until the chord, which resembles the weight of a grandfather clock, is pulled. By doing so, the face of the clock illuminates to display the time. However pulling this chord to display the time also chips away at the form of the clock itself, which is made from concrete. Therefore each time the time is checked, a small part of the clock deteriorates, wearing away. This metaphorical linkage between use of the clock to engage with time and the decay of the clock itself is an attempt to show traces of the passage of time, and the destructive nature of how we engage with time.

Designers: Student group: Daniel Aguirre Broca, Ziran Chin-On, Linxi Li, Sylvia Machgeels, and Heidi Mao

Brief: Appendix 4; RtD cycle 3 (section 5.3).

Author's Role: I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it.

Date: February 2016 - June 2016

MIZU

Image: Marcel Krijger

Mizu is a sink that uses gestures that are metaphorically related to the tasks the sink performs, as opposed to turning a knob, which is an abstraction of the task the technology performs. Hot water is procured by rubbing a portion of the basin rapidly, similar to how one would warm his own hands. Tapping on the side of the basin, similar to how one touches a surface that's too hot, cools the temperature of the water. The force of the stream is made stronger with a long stroke that travels the length of the basin, almost as if to beckon more water from the sink. These interactions are made possible by sensors embedded in bronze tiles along the basin. These bronze tiles also respond to these gestures by wearing in ways that reveal traces of how the sink has been used. Where the sink is touched, as well as the frequency, is reflected with traces of polished bronze.

Designer(s): Original concept by a student group as a part of coursework. Student team members include: Shen Kao Cheng, Beatrice Chichiarelli Maxe Van Heeswijk, Lennaert Kempers and Olivier van Nieuwmegen.
Later, another iteration of the sink was made for a national exhibition (Dutch Design Week 2016). The second iteration of Mizu was made in collaboration with the student team as well as with the assistance of university technical staff member Martin Havranek and fabrication assistance from Joost van Bemmelen of Houtwerk BV and Sotiris De Wit of S.T.R.S.. The second iteration, described and pictured here, was made possible with a grant from Design United.

Brief: Appendix 1; RtD cycle 1 (section 5.1).

Author's Role: This project originally was a student project, during which I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it. Later, in another iteration of the project, I was involved in a more direct way in the design and fabrication of the sink itself. This was primarily as a project manager— but also in terms of having my hands in the process of making the sink: from developing the specifications to manufacturing and installing parts.

Date: February 2015 - October 2015

PHONOS

Phonos is an interactive speaker that plays mp3s. The body of the speaker itself also acts as a controller to adjust the music. For example, by tilting the speaker in one direction, you can skip to the next track, and by tipping it upwards the volume can be adjusted. In adjusting the speaker, and thus its physical orientation, a small LED that's pointed towards the surface of the speaker also changes location. On the speaker's surface is a slip of photochromic paper that changes colors when the direct light of that LED hits it. Thus, the light traces lines in the speaker's paper reflecting how the speaker was used, similar to how a needle would scar a record in a player.

Designer(s): Student group: Aafke Croockewit, Jet Gispen, Luis Herrera, Sietse Taams, and Xi Xu

Brief: Appendix 1; RtD cycle 1(section 5.1).

Author's Role: I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it.

Date: February 2015 - June 2015

REMEMORY

Image: Guus Schonewille

Contemporary printers do not offer much insight into the process of how images are reproduced. In an attempt to surface histories of printing technologies and techniques, Rememory replicates screen printing techniques but is supported by contemporary printing, sensing, and photographic technologies. Rememory's encasing houses an ink jet printer which is programed to layer various colors of ink (cyan, magenta, yellow and black, or CMYK) over one another to achieve the coloration of the original digital image. However, with Rememory, people take part in layering that ink. A photograph is first sent over a bluetooth connection to Rememory. The four vertical lights on the body of Rememory each represent a layer of the CMYK ink, and light up in a slow upward motion to prompt the user to trace with their hands along that line to lay the particular layer of ink. This continues for each of the 4 lines, sequentially. There is a direct connection between how the person traces these lines in the printing process and how the ink layer will appear on the image. If the person skips a line, that layer of ink will be missing from the image. If the person stops tracing the line halfway way, only half the image will have the ink layer of that particular color. The surface of this printer is made with a special leather produced by Ecco which responds to the heat generated by people's hands by changing color. Like any leather product, it also wears and softens through repetitive friction.

Designer(s): Student group: Myrthe Buskens, Marijke de Geus, Eunyoung Go, Garry Lasamahu, and Miro Virta

Brief: Appendix 4; RtD cycle 3 (section 5.3).

Author's Role: I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it.

Date: February 2016 - June 2016

TRANSPARENT CHARGING STATION

The Transparent Charging Station is a speculative design developed in response to a future scenario where electric cars become more widespread. Due to some of the constraints behind electric infrastructure, the availability of a charging station's energy supply will fluctuate (see "brief" section below). Thus, future charging stations will have to decide how to prioritize fueling protocols, and also how to conceptualize to users the fluctuating availability of electric resources.

The Transparent Charging Station first utilizes a system of prioritization to determine which customer's cars need to be fueled, regardless of who else is requesting energy at that moment from that very station, or the general availability of energy on the grid as a whole at that moment. These customers who should have priority access are our emergency responders, on-call doctors, critical civic leaders, and the medically vulnerable such as those at the top of the organ recipient list. The system provides these customers with special privileges that make sure their access to energy is unencumbered.

Beyond this system of prioritization, the Transparent Charging Station features a system where people can negotiate with the algorithms behind the charging infrastructure to determine how much of their battery can be filled within a particular timeframe. The charging station they designed has a large interface that resembles a Tetris game. Each station has three ports from which energy is dispensed to three different vehicles. The board illuminates what resources are available, as well as illustrating the demands of the other ports, which are signified as outlines of shapes within those boarders. The person who has come to charge their car has two dials which they can rotate to indicate how much charge they will need (15%, 85%, 100%, etc.) and within what time frame (1 hour, 8 hours, 24 hours, etc.). The board will modify the Tetris-like configuration in accordance with these demands as they relate to what's available and what are the demands of the others currently utilizing that station. In this dynamic international exchange, one negotiates with the algorithmic constraints that govern this system. This provides the person with a sense of autonomy and also insight into how the system works and how to work with it.

The Transparent Charging Station was awarded the Dutch Design Award in 2018 in the "product" category (Dutch Design Awards 2018).

Designer(s): The Incredible Machine.

Brief: The speculative design was commissioned by Alliander, and Elaad, specifically for a national industry event.
A Dutch energy company (Alliander) and their subsidiary who produce electric car charging stations (Elaad), came to the realization that there will need to be a radically different approach to how energy is delivered to electric charging stations in the future. We are not far away from a future where electric cars become the norm. The problem will be in how to meet the spike in demand that these cars will create when they return from rush hour and plug into electric charging stations all at once. This isn't a question of developing a better technology for such a purpose. The problem isn't with the technology itself, but rather the infrastructure around electric grids. We have grown accustomed to rapidly fueling our cars on demand at central distribution points, like petrol stations. Instead electric charging stations have to account for the fact that charging a battery takes more time than simply transferring liquids from one location to another. Also the availability of energy will depend on a variety of factors, from what the battery of the station already has in store, to the availability of renewable energy such as solar or wind power, to other demands on the grid at that particular moment. Availability of resources will be inconsistent and ever-shifting in response to a different range of variables, unlike our petrol and gas reserves now.
In response to this future, Alliander and Elaad commissioned The Incredible Machine to create a speculative design to explore avenues for how this energy can be delivered in this future scenario. In particular, they were especially concerned with making sure however energy was distributed would be "transparent" and ethically responsible. Further, they wanted for this future delivery system to illustrate how it works and makes its decisions.

Author's Role: I was invited to contribute to this project by The Incredible Machine. The designers believed that the topic of my research was relevant to the client's requests, and also to what they envisioned as being a possible design approach that they would take. I joined a meeting with their clients, as well as in initial conceptualization brainstorming sessions.

Date: February 2015 - June 2015

THINGFORMATION

Internet of Things (IoT) products are made in such a way that obfuscates the networked complexity behind them. Beyond / IO created a conceptual design of a pictorial system to reveal this complexity in a care label for IoT products: Thingformation. Similar to a wash label one would find on clothing, their pictorial system reveals and communicate some of the intricacies of IoT products. With simple symbols, the Thingformation label conveys qualities of a specific IoT product that may not initially be apparent. The intention behind these symbols is to try to tell the story of the product before it's used. The label classifies a product on five distinct, although interrelated, qualities: type of encryption used with the product, the number of companies affiliated with the product, what body of laws regarding data protection is the product being held accountable to, the expiration date of the product, and lastly a graded evaluation of the trustworthiness of the company in terms of their use of customer's personal data. The designers of Thingformation envisioned that such a labeling system would be supported by regulatory bodies, to whom the companies that make these products would report to. Like the wash label, the Thingformation labeling system limits the qualities that have to be interpreted or evaluated, favoring qualities that are objective or purely factual (such as what type of encryption is used, the number of companies attached, what laws are followed, and the stated expiration date). The only quality that requires subjective evaluation is on the measure of "trustworthiness," which would be calculated by the regulatory body.

The designers of Thingformation recognize that IoT products are a part of a complex system, and this labeling system is a modest first step at making it more accessible to people. We see similar rating systems regarding environmental and energy efficiency having an impact on both product regulations and consumer behavior. Thingformation is offered as a means to not only help inform purchasing decisions, but will also hopefully motivate industry standards and support the development of our sensibilities in navigating and understanding these complex technologies. It would be an attempt to help close the knowledge gap between these intricate technologies and the layperson.

Designer(s): Beyond / IO

Brief: This speculative design was commissioned by the Just Things Foundation (Just Things Foundation 2016) to represent principle VII of the IoT Manifesto (appendix 6), for a national exhibition (Dutch Design Week 2016).

Author's Role: The particular principle of the Manifesto that served as the brief for this design concept is one that I championed, and is most closely related to this thesis' research. As a member of the Just Things Foundation, I was a part of a team that logistically made this design concept possible and organized the exhibition that it was designed for.

Date: June 2016 - October 2016

UNWIND

The first mechanized time pieces developed required regular and careful maintenance and calibration. Gears had to be wound, hands moved, clocks synchronized. There was an active exchange between the technology and the person to promote the functionality of the technology, so that the technology can perform its duty and provide reliable time telling services and, thus structure, to the community it serves. As time pieces become increasingly autonomous, that exchange between people and the technology is no longer so collaborative. Watches reliably provide time with little input from the people who utilize it, and also at the same time we see a culture emerging where time very much rules our day to day activities. Unwind is a personal wrist watch that re-introduces this exchange between person and technology back into the context of time keeping. Unwind does this by not having the watch be "ready at hand" so to speak. Instead of constantly displaying the time, time is communicated in rather ambiguous ways. Only the hour hand consistently shows what time it is. With a touch of the bronze trim along the bevel, the watch's face will illuminate a quarter of the face which corresponds to what quarter of the hour it currently is. With another touch to the bevel, the minute hand will appear, indicating exactly what minute it is. The watch provides another service upon the third touch, where a 15 minute break is initiated, where no time will be displayed at all. At the conclusion of this break, a small vibration on the wrist alerts the wearer that that period of time has lapsed. This series of interactions both supports an opportunity for exchange between person and technology, and also suggests that perhaps specificity isn't always entirely necessary in our relations with time. The body of the watch is made from wood and has bronze inlays. The bronze rims act as conductors and tigger the various prompts of the watch. Both materials will respond to the oils and friction of people's hands to leave traces of their use upon the watch.

Designer(s): Student group: Paula Besterman, Martijn Kerklaan, Pei-Chiang Lin, Maaike Nijholt, and Vincent Poppelaars

Brief: Appendix 4; RtD cycle 3 (section 5.3).

Author's Role: I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it.

Date: February 2016 - June 2016

ZODIAC

Zodiac is an alarm clock with a unique mechanism for snoozing and disabling. To turn off the alarm, one must rotate an orb to complete a "connect the dots" puzzle lit by LEDs within the sphere. The process of rotating the orb to complete the puzzle creates traces on the orb's surface, which persist and show how the alarm has been used over time. Here the traces are scratches in the paint of the orb that indicate the accuracy, or the alertness, with which the person rising was able to complete the puzzle and disable the alarm.

Designer(s): Student group: Edoardo Fusaro, Sofia Hnatiuk, Franke Kingma, Ewoud Offenberg, and Josien Verhoeckx

Brief: Appendix 1; RtD cycle 1(section 5.1).

Author's Role: I acted as a client and mentor to this group in their design process. My job was to clarify the brief and concepts, contribute to critical design decisions, as well as evaluate their final artifact and the process that went into making it.

Date: February 2015 - June 2015

CHAPTER 7.
SURFACING FOCAL THINGS AND PRACTICES WITH DESIGN

This chapter represents the culmination of the forms of knowledge gathered in this design research process, and puts them in relation to one another. What emerges from this dialogue among the research artifacts (design concepts and design briefs, section 3.1), reflections on the design processes (section 4.2, chapter 5), the field studies (sections 4.2, 7.3, chapter 9), and theoretical work (chapters 1-2) is a landscape of the design space of surfacing focal things and practices (FT&P) with design. **In mapping this landscape, three patterns emerged that identify distinct problematizations of FT&P and how to approach surfacing technologies as such. These three patterns call attention to unique forms of materialities, thereby framing what needs to be made legible in a design process to surface technologies as FT&P.** This chapter is dedicated to mapping and illustrating each of these. Chapter 8 will put these patterns in conversation and relation with one another, as well as opening up this design space to a general discussion about the opportunities that it may hold (section 8.1).

The concerns that are mapped in this design space represents the modes of engagement and design strategies that emerged in this particular design research process that helped to recognize these patterns. They do not represent an exhaustive list of all the possible framings, demonstrators, and strategies, but just what emerged in this particular RtD process. An editorial choice was made not to exclude any research artifacts (deign briefs or design concepts) or field studies from this analysis.[12]

THE FOUNDATIONS OF THIS DESIGN SPACE
This design space offers a map that articulates a conceptual space, surfacing FT&P with design, with the intention to support the development of designerly sensibilities towards navigating the situated nuances of this conceptual space (section 3.3)

(Stolterman 2008). While there is not a cannon as to what constitutes a design space, it is defined as the "dynamic conceptual space that bounds the possible or probable designs, and which is constructed and explored through design activities" (Dove, Hansen, and Halskov 2016). Aligning with Gaver, this chapter presents a curated collection of ideas and concepts that work towards illustrating the metaphorical landscape of design opportunities—not possible ideas (W. Gaver 2011). In this chapter, this curated collection is the body of design research done for this thesis. These are referred to as "demonstrators" later in this chapter for their function in highlighting particular regions within this conceptual space.

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12   This comes with one exception, which was an excursion to Shenzhen China in the spring of 2017. This field study was concerned with how to implement design approaches deemed unconventional in light of the device paradigm (section 1.1) in a manufacturing context. However this inquiry ultimately fell outside the scope of the narrative of this thesis and therefore has not been included.

In supporting the development of designerly sensibilities in surfacing FT&P, this design space seeks to understand how design processes can support the creation of technologies that are primed to engage people in the fullness of their capacities (section 1.1-2). As FT&P, these technologies would encourage us to be present or engaged, on mental, social, bodily, material, and environmental levels as we engage with them. These modes of engagement must be bolstered by practices, or ways of doing with these technologies, to make this focal-ness possible (Borgmann 1984). This type of engagement is not conventionally supported by, or even expected of, contemporary technologies. Instead we lose touch with FT&P with design conventions that obfuscate the relation between the technology's *ends* (outcome of the technology's use) and its *means* (the aspects of the technology responsible for the way it works). With this separation, the complexities behind the technology are rendered illegible, and so also our engagement with that technology. However illegible or limited our engagement with these technologies may seem, we *are* engaging with the technology's *means*, and the materials that constitute the parts of that technology. Likewise, this inevitable engagement contributes to defining and shaping the technology's *means* and materials as the sociomaterialists would argue (section 1.3).

Therefore, this chapter maps the different ways with which we engage with the obfuscated parts of various technologies, and presents the emergent design strategies that seek to surface these modes of engagement and make them more legible in order to bolster framing the technology as FT&P (section 2.3). This design process embarked on using traces as a design approach to pinpoint both the materials of these technologies that we engage with, and how this design approach could potentially make that engagement and their complexity legible (chapter 2).

LEGEND TO THE DESIGN SPACE
To pursue surfacing FT&P, this design space asks what are the unique aspects that contribute to the way the technology works that we don't even realize we're engaging with when we use it? How can those parts be made legible? In more technical terms, what aspect of the technology's materiality demands our engagement to make the relations between its *ends* and *means* legible to the general user of technological objects. Addressing this question comes in three stages, which are visualized as the rings that make the boundary of the design space itself (figure 21). The two outer rings represent layers of problematizing the notion of surfacing FT&P: the outermost ring attempts to theorize the black box, building upon the principles laid out by Borgmann (sections 1.1-.2); while the middle ring looks more specifically with a sociomaterialist lens towards framing how traces can surface engagement as an approach to contribute in surfacing the technology as a FT&P (section 1.3, chapter 2). The innermost ring divides itself into segments that identify the range of specific design strategies that emerged among the design concepts, design processes, and field studies that respond to the two proceeding rings it is nested under. Ultimately, there were three distinct ways in which the questions posed by the outer two rings were answered, each of which represents what is referred to in this chapter and thesis as a "pattern" (sections

3.3, 7.1-.3) (Alexander, Ishikawa, and Silverstein 1977). These patterns offer different conceptualizations of FT&P, and some design approaches to support surfacing that conceptualization. This mapping of this design space serves to communicate the conceptual space to others.
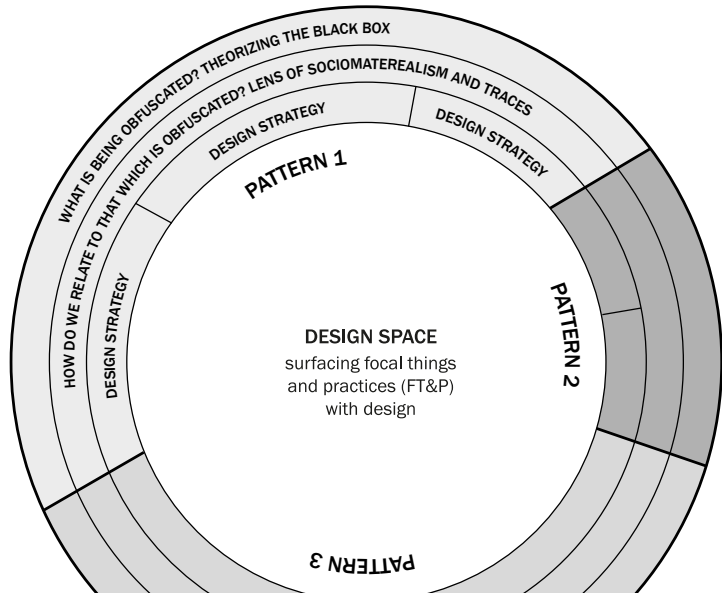

Figure 21. A legend to the design space that this chapter will build. The two outer rings ask distinct questions to frame the concept of FT&P, while the inner-most ring identifies the specific design strategies that emerged in this design research process to address this framing. Three distinct ways to answer and address the questions raised by these rings came to light through this research, they are identified as "patterns." Figures 22, 32, and 38 build upon the structure of this figure as it relates to each pattern to ultimately construct the design space as a whole.

The outermost layer theorizes the black box by asking what is obfuscated when we separate the ends from the means of the technology, pointing to what should be made legible. In Borgmann's framing, the separation of the *ends* and the *means* is an attempt to obfuscate the complexity behind the technology (Borgmann 1984). When the relation between the aspects of the technology responsible for the way it works (*means*) and the outcome of its use (*ends*) are obfuscated, they are made illegible to people because they are designed to be hidden from them. This obfuscation is at the root of the device paradigm. Borgmann argues that our engagement with a technology is limited because of this masking or obfuscation; and as a consequence so too is the role that the technology has in our lives, and that we're more prone to potentially overusing it (Borgmann 1984) (Introduction, chapter 1). Each pattern highlights a unique aspect of the technology that

is being obfuscated, which differs among various technologies and will be illustrated in the following sections (sections 7.1-.3).

The middle ring more specifically seeks to position the person in relation to that which is obfuscated. This is where traces are introduced into this design research process as an approach to both identify what is the obfuscated aspect of the technology that is being engaged with, as well as to attempt to make that engagement legible (chapter 2). The premise of this particular layer of the design space is built upon the work of the sociomaterialists who suggest that there is already an existing co-constitutive entanglement between people and the parts that constitute a technology (materials). Therefore turning to traces as a design approach provides an opportunity to problematizes both *what* are those obfuscated materials, and *how* are we engaging with them (section 2.3). This ring considers what about our engagement with that obfuscated material needs to be made legible to support surfacing the technology as a FT&P.

The innermost ring divides itself into sections, each of which detail specific design strategies that emerged in this design research process as it relates to the two questions posed by the preceding rings that it is nested under. Each of the sections of this innermost ring represent distinct design strategies that came to light among the design concepts (section 3.1, chapter 6), design processes (section 4.2, chapter 5), and field studies (sections 4.2, 7.3, chapter 9) referencing the questions posed by the prior two rings. If these prior rings conceptualize "what" of the technology needs to be surfaced with design, this ring offers the spectrum of "how" design can surface these concerns.

This chapter systematically build this map up, pattern by pattern (figures 22, 32, and 38) The following sections will be dedicated to a single pattern, firstly explaining their conceptualization of the questions posed in the outer rings. Then each of the design strategies nested in this pattern will be described, and illustrated with demonstrators that emerged in this design research which come in the form of design concepts, or field studies.

The non-hierarchal and rhizomatic quality of this design space will become apparent through this chapter as well (section 3.2). The central point of this map, or the stem of our rhizome, is the topic that motivated this design research: surfacing FT&P with design. Within the figure, the first phase of the RtD cycle, the design process that yields the design brief that interprets the topic of research into units of design, is represented as circles within the boundaries of the design space (section 3.1, chapter 5). Additionally, field studies are represented as diamonds surrounding within the confines of the design space (sections 4.2, 7.3, chapter 9). The lines that radiate from the design brief or field study, the origins of the root structure, represent the insights that came from this source. For the design brief, each line represents a particular design concept that emerged from the design process interpreting the brief and are labeled accordingly. In some cases, a single design concept yields insights that relate to more than one pattern, and thus split branching out towards each of the particular findings, similar to how root structures

grow in the direction of their source of nourishment. This is the case for three particular demonstrators that touch upon both the first and second patterns (sections 7.1-.2). In the case of field studies, the line branching from it points to the particular finding that an analysis of the field studies reveal (section 7.3).

7.1 PATTERN 1: TRACING PHYSICAL USE

The first step to accessing this design space of surfacing FT&P (outermost ring) is to examine what is being obfuscated. *This first pattern points to the fact that the physical materials that contribute to the operation of the technology, from the raw materials that make up the encasements to the components that comprise the electronics, are being obfuscated.* This pattern seeks to draw our attention to the ways that we engage with that which is concealed behind the physical encasement, or the "black box." This pattern looks at the materials that contribute to the obfuscation of the technology in broad terms: from the raw materials of these encasements, but also the sensors and physical components that contribute to the way the technology works that are concealed behind that encasement. This framing attempts to account for the obfuscated role that these materials play in supporting the function of the technology (*means*), making the technology's outcome of use possible (*ends*).

The second step to bring us closer to surfacing the technology as a FT&P (middle ring) is to make legible our relation and engagement with these materials that contribute to the technology's function (*means*). Not only is the existence of these particular materials being obfuscated, but so too is our engagement with them. Sensors detect our presence and respond accordingly, so that we don't even have to directly engage with the technology: a sink turns on when we are near it, not because we engage with the mechanical parts that enable it to function. Even our physical engagement with the physical materials that encase the technology are often obfuscated. Indeed these materials are often selected precisely for their ability to resist evidence the effects of being handled by people (Lilley et al. 2016; Baxter, Aurisicchio, and Childs 2016), or for not even being needed to be handled at all.

In response, this pattern seeks to position people in relation to these obfuscated physical materials by demonstrating our use of them. Physical traces on the bodies of these technologies[13] are utilized as a design approach to demonstrate our use of these technologies and thus how we collaborate in their operation. As the sociomaterialist would frame it, we are inherently collaborating with the materials of these technologies as we and materials are entangled in a relation where we co-constitute one another (section 1.3). Even a sensor needs to sense a person to operate as a sensor. The gears of a wristwatch are wound and calibrated by the motions we make with our arms as we walk. We are engaging with these materials—the sensors, the gears—whether or not we realize it.

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13   In the case of two demonstrators, these physical traces are instead made upon the physical byproduct of these technology's use (Phonos and Rememmory).

This pattern seeks to make that co-constitutive entanglement that people and materials are engaged with legible by using traces as a design approach to draw our attention to it (section 2.3). *Specifically, in this pattern traces make legible our use of the particular materials of the technology*. Traces became the perceptible, enduring marks that are brought about through people's engagement with the physical materials of the technology that contribute to its operation; or contribution to carrying out the technology's *means*. Traces serve as legible remnant of our use of and engagement these materials.

In the framing of this first pattern, FT&P are conceived in terms of the ways that we engage with technologies or things that have mechanical properties. Here, focal-ness is in considering the mechanical properties that comprise a technology, or a thing, and how we engage with those properties as engage with the technology. **The focal-ness is being directed to these mechanical parts and our relations and practices with them, in order to bring focal-ness to the thing.** In this pattern, what varies is the nature of how these practices with the mechanical parts of the thing are designed. Thus traces are intended to make legible the relations and practices between people and the thing and its mechanical parts.

DESIGN STRATEGIES AND DEMONSTRATORS: CORRELATION BETWEEN INTERACTION AND MATERIAL TRACES

The design strategies for this pattern (innermost ring) offer a spectrum of how closely the traces of the interaction with the technology are referenced by the materials. What varies within these strategies is how closely traces represent the interaction or engagement that people have in using the materials of the technology, and how these episodes of use are reflected through traces in these materials. If we were to translate between interaction design terminology and the conceptual language of FT&P, the question becomes about how interactions are a type of engagement that supports the focal-ness of the practice, and how that is reflected upon the materials to surface the focal-ness of the thing (chapter 1). Thus the spectrum of design strategies here chart how closely the interaction supports the focal-ness of the practice, and how that is then reflected upon the thing. These different arrangements that interactions can have towards materials can be characterized as falling into three unique approaches within this pattern: collaborate, chronicle, and trigger (figure 2).

This pattern demonstrates a spectrum of ways to engage people in physical materials that contribute to the operation of the technology, and to communicate that engagement through technology's interaction design as well as the materials themselves. This spectrum of design strategies chart how closely the interactions surrounding our use of the technology's various materials can be reflected by those very materials themselves. People can be deeply engaged in collaborating with these materials, colluding with them in determining how the technology will operate (design strategy: collaborate); or engagement with the technology may be with materials that are perhaps not integral to the technology's operation, but record our use with the technology nevertheless (design

strategy: chronicle); or lastly may utilize materials as a way to reflect our use of triggering the technology to perform its function, as with a button whose materials age according to frequency of use (design strategy: trigger)
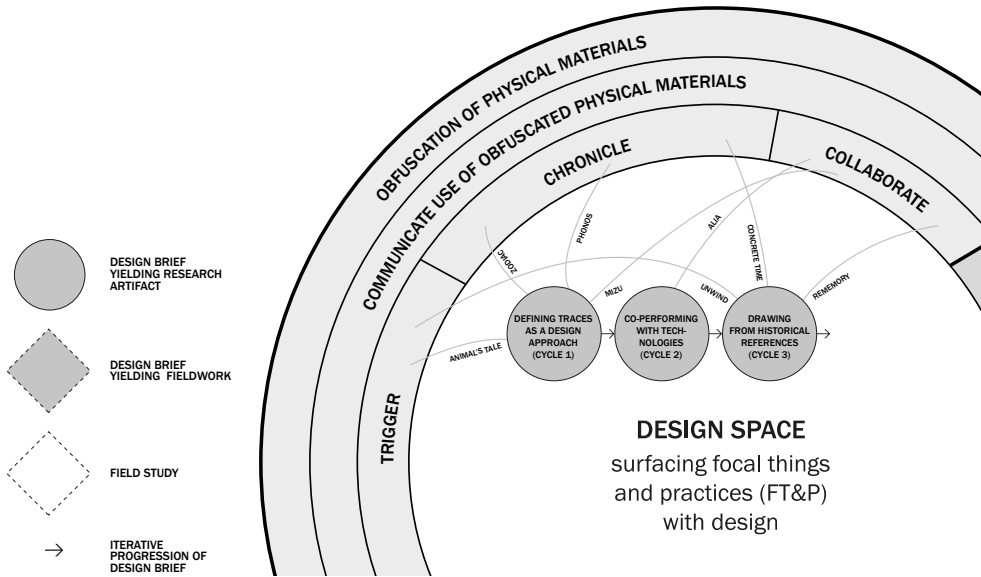

Figure 22. Diagram of the design space highlighting the first pattern. Here the black box is problematized in terms of the physical materials being obfuscated with design. Thus the challenge becomes how to communicate people's use of those physical materials with traces of our engagement with them. The design strategies that emerged represented degrees of how closely people's interactions with those materials were reflected by the materials.

Collaborate

In this design strategy, our engagement or interactions with physical materials that collaborate in the operation of the technology is directly reflected upon or through these materials themselves through traces. This extends both to the raw materials that comprise of the physical encasement, as well as the physical components that comprise the parts that contribute to the technology's function, such as sensors. These materials are directly being engaged by people in an interaction where they collaborate with these materials to operate the technology. There is a direct correspondence between how people engage with these materials, and the particular performance of the technology itself. These interactions demand some kind of physical engagement, and this engagement is reflected as a trace directly upon the technology. These forms of engagement are then being reflected back directly onto the materials themselves with traces. **Here, focal-ness is**

being framed with a strong correlation between the practices surrounding making use of the technology, and the particular performance of the technology.

The gestures and interactions that activate the sink Mizu reference the tasks the sink perform (figure 23). As opposed to turning a knob, which is an abstraction of the task the technology performs, hot water is procured by rubbing a portion of the basin rapidly, similar to how you would warm your own hands. The temperature of the water is cooled by tapping the side of the basin, similar to how one touches a surface that's too hot. The stream's force is made stronger with a long stroke that travels the length of the basin, almost as if to beckon more water from the sink. These interactions are made possible by sensors embedded in bronze tiles along the basin. These bronze tiles perform two functions. Firstly, they are capacitive sensors, so touch changes the charge of the material, thus activating its electronics. The various ways of touching these sensors (rubbing the tiles or the trailing gesture along the side) will change the function of the sink itself, making it possible to collaborate with the technology through use to determine the particular outcome of that use. Unlike proximity sensors often found on sinks that merely activate the technology based on your presence, we collaborate with Mizu's physical materials (capacitive sensors and the bronze tiles) with our gestures to work with the technology in operating it. Similarly these bronze tiles reflect these gestures with traces, becoming polished through touch, illustrating where it is touched and a relative degree of frequency; as well as developing patinas from the environmental humidity (figure 24). *What Mizu surfaces is the focal-ness of the practices surrounding the embodied interactions with the mechanics of the sink (the sensors, flow and heating of water) and the environment surrounding the technology, which is directly communicated upon the thing through patinas and polishing of its bronze surfaces.*

Figure 23. Mizu is a sink that while we engage with it, we collaborate with the materials to operate it. Image: Marcel Krijger
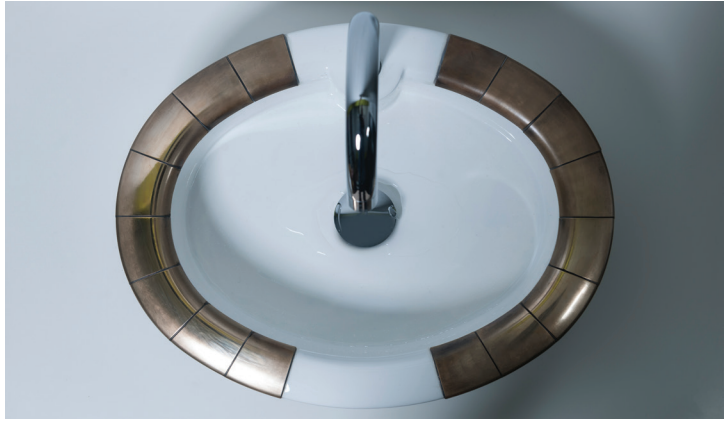
Figure 24. The bronze tiles on Mizu polish with touch and develops a patina as a result from environmental factors and the passage of time. Image: Marcel Krijger

Long gone are the days of manual duplication of texts and images once done by monks, today duplication technologies have migrated into the black box, such as with a Xerox photocopier. Rememory takes duplication out of black boxes and invites people to print by involving them as collaborators, directly in adding the layers of ink of the CMYK color model upon the image being duplicated. Their gestures on the printer serves as a proxy laying each color's layer of ink, thickly, sparingly, inconsistently, or not at all. This directly translates to how the image is printed (figure 25). Here, we engage with Rememory's sensors, which are being translated into traces of how the ink is being laid upon the photographic print. These traces communicate the particular collaboration that we have with the materials (the sensors) that we have when we engage with the technology. Additionally, the encasement of the printer that is being interacted with is made from an unusual thermochromic leather. As the printer is engaged with, the leather becomes progressively more supple, and its color changes temporarily indicating the transfer of heat from our hands onto the encasement through our engagement (figure 26). *The interactions directly correspond with how the technology operates, surfacing the practices with the thing's mechanical parts as focal. Further, these forms of engagement with the technology surface the focal-ness of the thing by drawing a strong correlation between the interactions with the technology and the outcome of its use (*ends*), surfacing the focal-ness of the thing itself.*
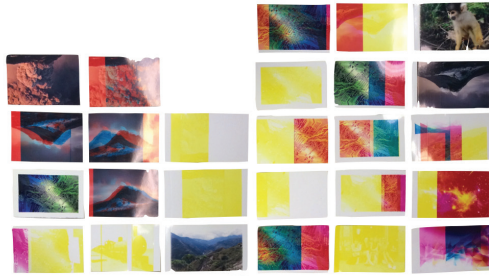
Figure 25. Samples of the various ways that the Rememory pinter lays the ink of the CMYK color model according to how the technology is used by people. Image: Myrthe Buskens, Marijke de Geus, Eunyoung Go, Garry Lasamahu, and Miro Virta
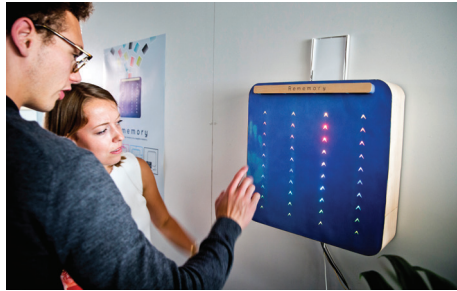

Figure 26. The thermochromic leather on the face of the Rememory printer changes color as it is touched. Image: Guus Schonewille

Aila similarly fluidly joins the interactions with the materials. Aila is a lamp which is powered through the interaction of being wound. Previously, homes would be lit with candles and fires that required constant tending (figure 12). Fires would have to be stoked and candles would have to be replaced after they had been depleted. Thus, these pre-technical lighting technologies' focal-ness is supported by the practices of tending to the lights and other context-sensitive aspects of its use or environment: was the log hard or soft wood; has the wood been brought indoors to dry; were the candles close to a heat source or a draft melting even faster than usual? Aila also requires tending to. It doesn't turn on with a flip of a switch, or automatically sense your presence in the room. Instead, it needs to be wound in order to accumulate an energy supply for the lamp, like a dynamo. This energy generated becomes a unit stored within the lamp which can be dispensed at a rate that the person decides: quickly as a bright light, or slowly with dim lights (figure 27). The materials of this lamp, wood and bronze, were selected for their abilities to develop traces of these physical interactions that people have with the technology. Like the bronze tiles of Mizu, Aila's bronze surface requires touch to activate

the micro controllers that adjust the light. In winding the outer ring of Aila to charge the dynamo, oils from our hands naturally become imparted onto the wood, demonstrating how it was handled. *The physical materials of the lamp need to be manipulated to operate the technology surfacing the focal-ness of the practices related to the* means *of the technology. These are again reflected upon the materials themselves surfacing the focal-ness of thing itself.*

Figure 27. The outer rim of the Aila lamp is wound to generate energy for the lamp. The outer ring of lights indicates how much energy has been stored, which can be dimmed or brightened by rubbing the inner circle as demonstrated in the picture above. The wood and bronze develops patinas referencing the occasions that we collaborated with the materials to operate the lamp. Image: Jaqueline van 't Hof

Chronicle

Similar to the previous strategy, materials reflect the use of the technology. However in this strategy, our collaboration with the materials are not integral to the operation of the technology. Instead, the materials that comprise the encasements chronicle episodes of use with traces. Thus the traces as well as the interactions do not closely reflect our collaboration with the materials in operating the technology, but instead reflect that we have used the technology. **In this strategy traces attempt to highlight the focal-ness of the thing by drawing attention to the way we use it; but this strategy demonstrates a less direct connection between the how the practices relate to joining the *ends* and the *means* together with the technology's materials.**

For example, the interactions to manipulate the operation of the Phonos speaker are relatively arbitrary, they do not closely reference a collaboration or engagement with the materials that assist with the technology's operation. There isn't much cooperating

with the materials in order to operate, or a joint activity between people and the materials to determine how the technology will function. Instead, we engage with Phonos in ways that are not specific to the materials that we are handling; but the impact of the episodes of these interactions are recorded poetically through traces that reference the technology's historical predecessor. The speaker features a piece of circular thermochromic paper over its surface, which develops a linear design as a result of the way we interact with the speaker to operate it (figure 28). To skip a track or to adjust the volume, the freestanding speaker must be tilted in a particular direction. With this engagement with the physical form of the technology, a laser positioned beneath the thermochromic paper is moved slightly, tracing a new line in the paper. Thus as we engage with the technology to adjust its operation, a trace is made reflecting this engagement had occurred. However, the trace does not reveal much about the how the materials of the technology contribute to its operation, or our specific engagement with them. The lines in the thermochromic papers can not be read in a way that deciphers the interactions themselves. These were random audio files that were listened to, the record of our listening sessions appear on the materials as more serendipitous than focal. However, it is poetic how the accumulation of these traces of the interaction come to resemble how a record may accumulate scars from the player's needle, tracing its use. While we physically participate in the technology's operation, there isn't much insight being offered into our collaboration with that operation apart from traces which demonstrate the fact that it happened. Our use of the technology is being made legible, but less so are the ways we work with the physical materials to collaborate with its function. *In this design concept, focal-ness of the thing is framed as the demonstration of its use, potentially in offering some indications of the social context of that use with as the etchings*. While these etchings are abstract, they reflect some of the circumstances surrounding the practices and the focal-ness of the thing (section 7.2). *However the practices with the thing are relatively arbitrary (the tilting and position of the speaker and how this relates to the mechanics), and focal-ness only is supported by recoding that they happened as demonstrated in the abstract etchings in the paper.*

Figure 28. Phonos is adjusted by changing the positioning of the speaker itself. Moving the speaker causes a laser underneath the surface to change location, thus etching a pattern into the removable thermochromic paper that covers the surface of the speaker. Image: Aafke Croockewit, Jet Gispen, Luis Herrera, Sietse Taams, and Xi Xu.

Concrete Time references grandfather, or longcase, clocks from the 17th century where weights and pendulums were used to calibrate the clock's gears. Pulling on the pendulum of Concrete Time is a bodily form of engagement to operate the technology. Time is displayed as a result of this interaction, which leaves a trace with the slow erosion of the concrete form material of the clock itself as an illustration of how much the clock has been consulted (figure 29). Contemporary clocks obfuscate all the physical components that are responsible for keeping the time. Concrete Time makes these legible by inviting people to pull on the pendulum show the time, and thereby rotate a gear that erodes the clock. But again, here the materials are not critical to the operation of the clock, instead they are critical to demonstrating that we used or consulted the clock. Additionally, the material's eroding response in light of the interaction also carries a particular agenda of the designers, which will be discussed in the next pattern (section 7.2). *The traces in the material form of the clock dramatically chronicles through morphing the form of the clock itself, and in doing so attempts to make focal occurrences of our practices of use of the thing.*

Figure 29. The pendulum of Concrete Time needed to be pulled to display the time its face. In doing so, some of the concrete would deteriorate, which was collected in the box that counterbalances the pendulum on the right. Image: Guus Schonewille

Zodiac, an alarm clock that requires small puzzles to be completed in order to deactivate, also falls under this pattern. These puzzles require rotating a globe to "connect the dots" between two lights that are illuminated from within (figure 30). If you are able to complete this puzzle, you are deemed to be awake enough, and the alarm ceases. By rotating the globe, lines are etched into the globe itself, representing your ability to complete the puzzle and deactivate the alarm, a trace of the device's usage and the success of your own morning aptitude tests. Again, the materials are not integral to the operation of the technology. An interaction engages people to be focused and physically engaged in operating a feature of the technology (deactivating the alarm). This does not however reveal the materials that contribute to the operation of the technology, but does make possible for traces to reveal that we were involved in operating it. *Zodic's approach to focal-ness is also in traces as etches that chronicle occurrences of practices of use, however these practices are less related to the mechanics and materials of the thing itself.*
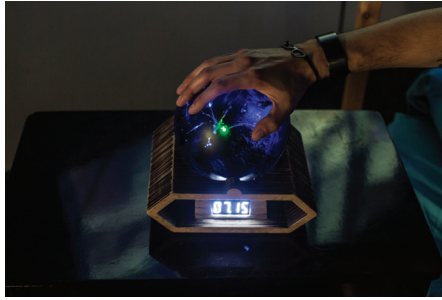
Figure 30. To deactivate the alarm of Zodiac, the globe had to be rotated to connect two lights illuminated from within the globe. The action would etch a line in the paint of the globe leaving a trace of the use. Image: Thierry Schut

Trigger

In this case, the interactions with the technologies do not demand much engagement from people, likewise the materials only minimally make legible how the *ends* and the *means* are related to one another. Yet, this strategy is consistent with the others in this pattern for its use of certain materials for their ability to make traces reflecting our engagement with the technology's mechanics. The interactions with the surfaces of these technologies are very much like the ones we have with buttons, we apply pressure or friction to a particular location in order to trigger the technology to perform its operation. Unlike with the collaborative design strategy, there is not a range of interactions that are possible with the materials to shape the particular function of the technology; and unlike with the chronicle strategy there is not much being made legible about the ways we use the technology. Instead, there is a very localized point of the technology for us to engage with (a button) and a limited scope of interactions, practices, and traces possible. Thus the range of communication here is around the wearing of the material of that tigger demonstrating that it has been utilized. **Here focal-ness may be framed as the cumulative wear and patina of the thing itself, but that there are is a limited scope of practices to support this focal-ness of the thing with the trigger strategy**.

Animal's Tale is a children's audio book that comes in the form of a creature that references the plot which inflates as the story begins (figure 31). Embedded in the materials of the form of the creature are the controls to manipulate the audio file: to pause, replay, skip, adjust the volume. The creature is made from Tyvek, a plasticine fiber. After frequent touching of this material to make use of the controls embedded in them, the material becomes worn and supple. This also echos technological predecessors, like how the pages of a well-loved children's book become soft from use. As the technology lives in people's lives, and is engaged with, the material properties of this form change over time to reflect that use. The interactions we have with these materials are very much like pushing buttons, and therefore do not reveal much about how the *ends* and the *means* of the technology are joined through our practices, or are the materials or physical

components of the technology. It is just that the materials of these particular buttons are specifically designed to illustrate that these buttons, and thus also the physical components and materials that they activate, have been used. *Here the focal-ness of the thing is not being supported through the practices of triggering a type of button, but the way the material encasement of the thing wears could perhaps reflect some of its focal qualities.*

Figure 31. Animal's Take is an audiobook, a character from which inflates as the story begins. The controls for the audio recording are embedded in the materials of the inflated character. On the right is a close up of the inflated character (a squirrel) being handled to operate the controls. Image: Loriana Daggers, Assmae El Coudi El Amrani, Laura Koot, Anouk Vergunst, and Sergej Schetselaar

The wristwatch Unwind is most interesting in terms of how designers communicate a particular agenda through the relation of the function of the watch and traces, and will therefore be discussed in greater detail for how it belongs to pattern 2 (section 7.2). Yet, we also see that Unwind utilizes the trigger design strategy within this pattern. Unwind's materials serve as buttons to trigger its particular services, and to develop a patina to demonstrate that the button has been used. Like Aila and Mizu in the first strategy, the areas that are touched on Unwind are made of bronze, and thus the sensors respond to that touch and develop a polishing patina from use. However, unlike the first strategy, there isn't a strong collaboration with the materials as there had been in the first strategy. As a button to trigger a specific reaction, there isn't much insight being given to the particular materials or physical components of the technology. It is just that the bronze surface of this so-called button reflects that it was used. *Again this triggering action does little to engage people with the mechanics of the technology itself; but the way the surfaces of the technology respond to these trigger interactions by wearing may perhaps offer some focal qualities of the thing, but less so through the practices themselves.*

OPENING UP OTHER PATTERNS: PROBLEMATIZING BEYOND PHYSICAL MATERIALS
This pattern is a first step towards challenging conventional design heuristics that presume that technologies should be designed in such a way to resist indications of use or limit modes of our engagement, such as interactions. In doing so it provokes conceptions of the black box as an impenetrable barrier between the person and the

materials that comprise the technology, as well as the idea that those materials are inert and do not require our engagement. In fact these conceptualization of the black box are misleading, we collaborate and engage with these materials, but perhaps in ways that we are not aware of (chapters 1 and 2).

This pattern was the first to emerge in the process of conducting this research, the demonstrators for which can be attributed to the work of master's design students at the university based off briefs I had authored (sections 5.1-.3). All of these design briefs explicitly ask designers to direct their process into examining how materials can support "traces of use," which was built upon previous work on this very topic (Robbins et al. 2015; Giaccardi et al. 2014; Rosner et al. 2013). This early research on traces resonated with the objective behind FT&P: to understand how design could surface modes of communication of the ways that artifacts are used and the richness of the lives they live with people.

What we see in this pattern in surfacing FT&P is that practices represent a form of engaged labor with the thing's materials to join the *ends* and the *means* in operating the technology. This practice of labor is a way to become engaged in a fuller capacity with the thing. This pattern is pertinent to making focal the mechanisms of the technology to be more engaged with its context. This isn't necessarily a strenuous form of labor of course. Drawing your hand upon the surface of Rememory doesn't require much effort as screen printing does with spreading the ink across the page. Borgmann even makes the case that walking can be a FT&P (Borgmann 1984, 200). But here we are becoming involved with mechanics that would otherwise be obfuscated or illegible in an engaged bodily way.

However, within this pattern we see that the design strategies to surface FT&P have a very specific scope. There is a limited range of materials and interactions possible in this pattern. As one colleague had pointed out (section 5.4), the predominate interaction featured in this pattern is some sort of friction or rubbing as can be observed with Aila, Animal's Tale, Concrete Time, Mizu, Rememory, Unwind, and Zodiac. As a result, the materials that respond to this kind of friction— to display traces or to somehow chance in a perceivable way— are somewhat limited. Wood becomes oiled from fingers (Aila, Unwind). Metals become polished and develop patinas from the environment (Aila, Mizu, Unwind). Surfaces are susceptible to some type of etching, either through temperature (Phonos, Rememory), sharp edges (Zodiac, Conccrete time), or fibers are slowly broken down (Animal's Tale, Rememory). This leaves FT&P with a narrow means of being surfaced: through friction and materials that respond to friction with wear and patina on the surfaces of these technologies.

Perhaps the more critical limitation is that this inherently implies a one to one exchange between the person and the technology itself. This supports reframing a limited scope of technologies as FT&P. There are aspects of technologies that we can not touch, but still fall prey to the device paradigm. The intention behind this research, even at its earliest

stages had always been to find a way to apply FT&P to networked and data intensive technologies (section 5.1). We can not touch, warm, or rub the "Internet of Things." There isn't a one to one dynamic at play there. None of the research artifacts in this pattern are networked or data intensive. We could not problematize how to "trace" the use of networks in an accessible way that demonstrated how they work. Nor could we problematize how to interact with networks. This first pattern conveying usage could be appropriate for some types of technologies, but not all. The third pattern (section 7.3) offers some perspective to this particular quandary.

7.2 PATTERN 2: MAKING ENGAGEMENT WITH CONTEXT LEGIBLE

The emergence of this second pattern was quite unexpected, and represents a departure from the first and third patterns in terms of how the back box is being conceptualized. Whereas the other two patterns seek to make legible our engagement with the technology and its various materials (sections 7.1, 7.3), *this pattern turns instead to make legible our engagement with the context that the technology enables*. This represents a shift in the interventions that we are making with design away from making the thing and the practices legible and focal, towards *making our engagement with the context that the technology enables as focal by surfacing the technology itself as a FT&P.* To frame the conceptualization of engaging with the "context the technology enables" this section will first build upon later work of Borgmann to discuss contexts accessible through technologies, and will then turn to Peter Paul Verbeek's argument of how engagement with these contexts can be focal.

This pattern requires that we stretch our conceptualization of the unique materialities of technologies and their relation to the outcome of the technology's use to include the context that they enable. The "context that the technology enables" refers to a particular classification of technologies who's materials need to be realized through technology to make it into a reality that we can engage with. Borgmann posits that these technologies contain materials or information that replaces reality, in effect offering a "hyperreality" in his terminology (Borgmann 1999). This is a recent technological development that specifically addresses information technology. This phenomenon of hyperrealities can span the gambit from virtual worlds to CDs, each of which contain a replacement of, or a unique, reality. A CD creates a hyperreality that is there on demand, and can capture qualities of reality that may not be actual (sound quality, remix, synthesizing, etc). The materials behind this hyperreality are the digital materials encoded onto the CD (Borgmann refers to these as "technical information" (Borgmann 1999)), the plastics and metals of the CD itself, and also implicitly the CD player and its parts that are necessary to realize the reality contained on the CD. The hyperreality it creates are the sounds it produces when it is played.

This layer of technological mediation to engage with the materials of the technology speaks the question of our outermost ring: what is obfuscated with this black box that

separates the parts that comprise it (*means*) and the outcome of its use (*ends*)? In the case of the hyperreality of the CD, this is the separation of the materials of digital data encoded into the physical CD, the CD itself, and the player (*means*) from the sound that is possible once the CD is played (*ends,* and the hyperreality that is the context that the technology enables us to engage with). *This pattern specifically addresses this obfuscation between the materials that enable the context that the technology enables and that context itself. In the case of the technologies that fall into this unique classification of Borgmann's, what needs to be made legible is the gap between these materials and context.*

As to the question that the second ring poses, how to position people in relation to this obfuscated gap, Peter Paul Verbeek argues that *it is our engagement with these contexts that should be made focal* (Verbeek 2002). Borgmann was skeptical that these technologies could be surfaced as FT&P, as our only mode of engagement with them is through the consumption of their content, or hyperrealities (Borgmann 1984; Borgmann 1999). In fact, one of Borgmann's definitional qualities of the device paradigm is when our mode of engagement with a technology is limited to merely consuming its content (Borgmann 1984). Yet, Verbeek argues that we can also strive for "focal engagement" with the artifact's content, which in the case of the CD are the sounds it is capable of producing (Verbeek 2002, 78).

Returning again to the context and hyperreality of the reproduction of sound, Verbeek argues that the radio itself may blend into the background, while the programs it broadcasts can be engaging and focal according to Borgmann's definition: inviting people's engagement and "ask people to be present in the fullness of their capacities" (Verbeek 2002, 71). These radio programs offer us a context to become engaged with that may not have not been possible without this technology, we are able to enjoy and become absorbed in a timely and critically relevant speech from a political leader that we may not have otherwise had the resources to engage with without the radio. Verbeek makes the case that our engagement with that radio program can be defined as focal: the sound of a speech that is modified in such a way that it can be broadcasted across the country, and if locally engaging as it cal leave those within earshot of the radio socially bonded with one another, frozen in silence hanging on every word. *This pattern seeks to make legible our engagement with the context that the technology enables with design that establishes the connection between that context and the technology that is necessary to realize it.* **Here the focal thing is that context enabled by the technology, which is being supported by our practices of engagement with that context.**

DESIGN STRATEGIES AND DEMONSTRATORS: TRACING ENGAGEMENT AND DESIGNER'S AGENDAS
As this pattern requires a bit of conceptual staging apart from the other patterns, this subsection will first elaborate how the demonstrators relate to this pattern and the particular rings of the design space (figure 32). Then it will discuss the particular strategies that emerged in this pattern, which represented a spectrum in terms of the role

that designers took in pointing our attention to what specifically about our relation to these contexts should be made focal.
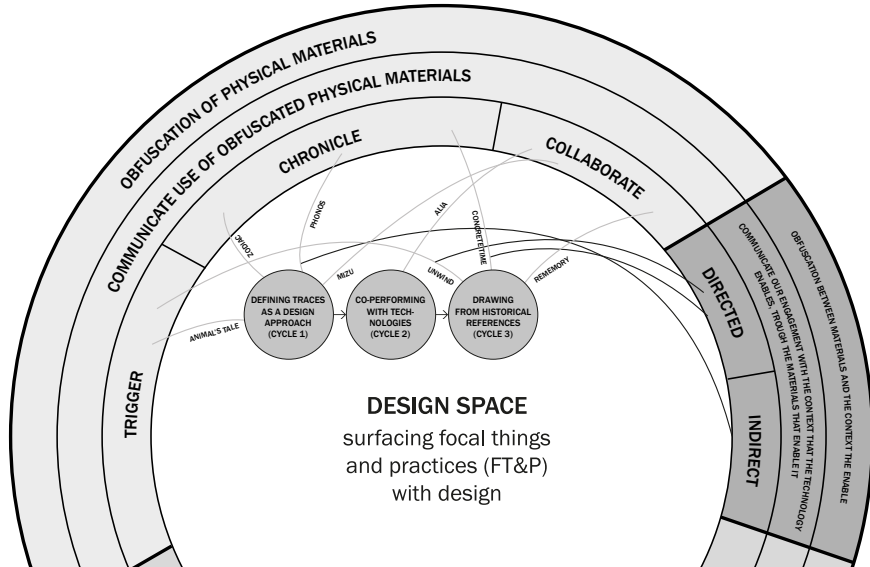

Figure 32. In the second pattern, attention is shifted to how the context enabled through the black box is engaged with. Specifically, how can design make legible the ways that we engage with the context that technology enables directly upon the materials of those technologies. The strategies that emerged reflected the role that the designer assumed to pointing out with their design decisions what should be made focal.

The technologies that enable contexts or hyperrealities for us to engage with is a specific category which Borgmann identifies as only possible with information technologies (Borgmann 1999). In this pattern, each of the three demonstrators are technologies whose materials produce content (*ends*) that create their own context, similar to the types of hyperrealities that Borgmann identifies: the digital standardization of time (Concrete Time, Unwind), and the reproduction of sound (Phonos).

We can get quite metaphysical when considering time, and if it exists without technological mediation, and how the technology of the clock shapes our experience of time (Ihde 1993). For the purposes of this section, we'll spare ourselves from that. What is very clear is that the standardization and synchronization of time is very much a byproduct of information technology. There are atomic clocks that are digitally being synchronized and use precise digital technologies to calculate and tabulate official units of minutes, seconds, and hours. In order to access the time that they record, we require a clock as an interface of these digital materials to make this digital information and

materials into a reality accessible to people. Time could be argued to be a hyperreality: how we perceive time may be different from how a clock would frame it. A day may fly by, but it is still comprised of 24 hours that have been precisely measured by the clock. To the question posed by the outermost ring, these time keeping demonstrators (Concrete Time, Unwind) seek to address the obfuscated relations between how the materials involved with keeping and making time accessible relate to our engagement with the context of time itself. Thus, these demonstrators seek to make legible our relation with time through the materials of the clock itself. How can we make traces in these clocks that represent the ways that we engage with time?

As for the other technology responsible for reproducing sound, this does not require much introduction as the previous subsection already went into great length describing this type of technology. Mp3 files are digital materials realized by the materials of the speaker (Phonos) to create the hyperreality and context of reproduced sound for us to engage with. In terms of this pattern, what is obfuscated is how the context that the technology enables of reproduced sound is related to the materials that create that sound. Thus the second ring uses design to make legible our engagement with the context of reproduced sound through the materials that make that context possible. How can we make traces on the speaker that represent our engagement with that context?

The spectrum of design strategies that emerged in this pattern related to how strongly the position or agenda of the designer was projected through their designs. On one end of the spectrum, traces and the technology's physical materials were designed to communicate a particular agenda of the designers regarding how we *should* engage with the contexts the technology enabled (design strategy: Directed). The opposite end of this spectrum was the lack of a particular agenda being communicated via the traces and materials about how we should engage with the context these technologies enabled (design strategy: Indirect). This pattern became especially apparent during the second third RtD cycle when it was clear that the way that the interactions were designed to utilize traces in a way to convey a particular message (section 5.3).

Directed

Both of the demonstrators in this strategy involve time keeping technologies, which the designers utilized the interactions and materials of to communicate a particular statement about what our relation to time should be. **In this case, the designers attempt to make focal a particular stance towards our engagement with time through the materials and practices surrounding the clock**.

Concrete Time mimics a grandfather clock in how it requires a pendulum to be pulled in order for it display the time. As previously described (section 7.1), each time the pendulum is pulled to trigger the time to be digitally displayed, the pendulum slowly erodes the concrete form of the clock itself. Ultimately, by activating the clock enough times, the clock itself will deteriorate to the point where it will no longer be

functional. These traces made with the eroding materials from operating the technology provocatively posit that the more closely that you watch the time, the less available it will be for you. Time is fleeting, and developing an excessive reliance on it can cause us harm. Thus the materials of the clock relay a message on behalf of the designers about how we should interact and use time itself. As discussed in the previous pattern (section 7.1), the clock is being made focal with practices that support turning it on, and with the powerful statement that is being made with its deteriorating edifice. *What's further, and relevant to this pattern, is that the designers are using this dynamic to make a statement, making focal our relations with time itself each time we enact the practices of accessing it.*

Making statements about time was a common approach as the wristwatch Unwind also demonstrates. The watch tells time, but it also obscures it from people. The hour hand always indicates the hour. To reveal the time more precisely, the bronze portion of the bezel of the watch must be touched. This will illuminate the quarter of the hour that you are currently in. Touch it a second time, and the minute hand will indicate the exact time (figure 33). Yet, there's another feature. After a fourth touch, the clock will be put to "sleep" for a quarter of an hour making its functionality unavailable to you during that time. With all these barriers to actually reflecting the time, traces come to represent a zealous interest in time. With each touch, oils are imparted to the wood and metals that make up the watch, thus tracing the way that we relate to our dependence on time. Through the interactions and the materials themselves, the designs seek to encourage people to not become too reliant on knowing the time, the context that this technology enables. *The designers are burying the function of the clock to tell precise time in layers of interactions to distance ourselves from an obsession with time. The way that the watch has been designed supports surfacing the focal-ness of our relationship with time by designing practices to distance ourselves from it.*

Figure 33. The exact time is not immediately apparent on Unwind. After touching the bronze bezel several times, the precise time reveals itself, while also imparting traces of our engagement with the watch and time itself onto Unwind's form. Image: Guus Schoonewille

Indirect

The ways that we engage with the particular sounds that the Phonos speaker makes is recorded with traces upon the surface of the speaker itself. Each time a track was paused or skipped or the volume was adjusted a laser within its encasement is moved, making a trace in the thermochromic paper placed on the speaker's surface (figure 34). Thus the traces make legible our engagement with the sound, or the context that outcome of using the technology's materials. With Phonos, the designers didn't define a particular statement about our particular relationship with music or the role in our lives through the interaction or quality of the traces. Instead, the traces left in the thermochromic papers are abstract testaments to the fact that we engaged with the speaker's sounds. These traces are not something that can necessarily be "read" to reveal something in particular about our usage of music, and instead come to resemble a Jackson Pollock painting with lines and blots that are relative to one another, and intriguing in their obtuseness. *Here, the focal-ness is directed towards our relationship with sound is being surfaced with manifestations of our practices with that sound (the paper etchings)*.
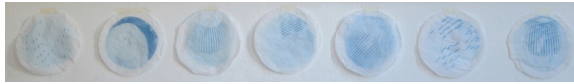

Figure 34. Phonos creates traces referencing how the audio file was manipulated during use, these resemble how records would become scratched by needles through use. Image: Aafke Croockewit, Jet Gispen, Luis Herrera, Sietse Taams, and Xi Xu.

OPENING UP OTHER PATTERNS: EXPANDING CONCEPTUALIZATIONS OF MEANS
It was surprising to stumble upon this pattern. The briefs that were used for these research artifacts (appendix 1, 3, and 5; sections 5.1-.3) were more pointed towards making legible the physical materials and components of technologies that we engage with and co-constitute. However, the exact same framing of these briefs also uncover this second pattern. In doing so the concept of "*ends*" is broadened to be not just about the outcome of use in terms of the technology's function, but expands this concept to be the context that the technology enables and how we engage with that context. This helps to account for the relations that we have with the types of hyperrealities or context that we can access through these technologies.

With the finding of this pattern, expanding our conceptualization of the ways we support the relation that we have with the *ends* of the technology, it becomes natural to also ask if perhaps the concept of *means* should be similarly be expanded. In the first pattern, FT&P were explicitly concerned with the physical object and the use of its physical materials and components. This pattern encourages us to think about the materials that we engage with that may not necessarily be as obvious. **How can we make legible, with traces, the materials and things that may not be what we hold directly in our hands?**

7.3 PATTERN 3: MATERIALIZING NETWORKS

This pattern considers the overarching question of this design space in terms of how to make legible the relation between the *ends* and the *means as it relates to technologies that are constituted by networks*. Thus networks become a specific form of materiality that this pattern problematizes as they relate to surfacing FT&P.

The outermost ring of the design space addresses how networks, as a material essential to constituting the technology, are obfuscated. This pattern considers how we make legible networks, the materials that are not physical and contribute to the way the technology functions. For example, our most immediate encounter with a car's GPS navigation system is with its screen as we enter an address, and to follow its instructions. However, for that navigation system to work, there are a lot more materials it draws from. Firstly, the GPS location from your car is sent to a satellite to share your position. That satellite collects data from other cars to identify where traffic is particularly dense to determine what route is best for you. This is then also coordinated with updated maps. These indicate what roads exist to get you to your destination, but is also updated regularly to inform as to where there may be road closures for construction work. Thus, when we activate the screen of the navigation system, we're really tapping into a comprehensive network of data and other connected devices. The navigation system draws on information collected from various nodes of a network to perform its operation. *Thus the network itself can be recognized as a material that contributes to the function of the technology.* The network becomes a material that constitutes the *means* of the technology, through using these materials it is possible for this system to offer accurate directions (*ends*).

If design materials are defined as the parts that can constitute an object, than the networks behind connected objects are a part of those materials. Networks are essential for that technology to perform its task. Yet they are not something that are typically made legible, and are obfuscated as we engage with these technologies. This pattern offers an opportunity to conceptualize networks as design materials.

The material turn in interaction design seeks to find ways to understand the tangibility of intangible things, such as that which is often referred to as the "digital" (Nansen et al. 2014; Wiberg and Robles 2010; Rosner et al. 2012; Dourish and Mazmanian 2011). This has two purposes. First this is to remind us that intangible things are rooted in material forms. Data is stored on servers and is connected with wires, which occupy physical space and require utilities such as electricity and air-conditioning to operate. This "intangible" thing of digital data actually has physical material properties, such as server farms (Dourish 2014).

Secondly, as Paul Dourish and Melissa Mazmanian point, these material properties of digital things shape our interactions with them as the interactions that they can have with other objects (Dourish and Mazmanian 2011). For example, if the air-conditioning fails

on a server farm, making a critical server crash, which can render a website temporarily unavailable. The network itself, this web of relations, is a material that shapes the way that we interact with technology. How can we communicate the role that these materials play in constituting the artifact, and our role as actors in that network influencing and reacting to materials?

This brings us to the question asked by the middle ring regarding surfacing our relation to that which is obfuscated and making it legible. *In the case of this pattern, we need to make legible that we, the general users, are actively co-constituting networks as nodes in these networks, the materials that are typically obfuscated in this pattern*. We do not merely benefit from this network, we also are a part of it. In the example of the navigation system, our own presence on the road becomes a data point to be tabulated with others to calculate traffic flows on that very road to share with other users of that navigation service. We play a role in constituting that material with our own interaction and engagement with the nodes itself. The design question becomes how can traces make networks as a material perceivable to us (section 2.1). In this case, it is not necessarily a question of traces as physical etches, but more as a design approach to make materials perceivable and legible. We can not necessarily hold a network in our hands, but we can use traces to surface their existence.

For this pattern, field studies (section 4.2) were also critical to shaping a perspective as to *how* to surface these relations with design along with demonstrators. In particular, the field studies supported a more nuanced framing of the relations to be surfaced that we have with networks as an obfuscated material. The demonstrators performed a similar role as they had in the previous sections (7.1-.2), and articulate specific design strategies that relate to *how* to surface these relations.

FIELD STUDIES: THE NATURE OF RELATIONS WITH NETWORKS

Two field studies in particular played a role in formulating a perspective on our relations with networks as obfuscated materials (section 4.2, chapter 9). These loosely came to represent two perspectives. The first was an industry perspective into the realities about what our relations with networks represent within a commercial setting and was supported by the collaboration with design practitioners for the IoT Design Manifesto and the Just Things Foundation (Just Things Foundation 2016; Afdeling Buitengewone Zaken et al. 2015). The second perspective represented a case study of analogues networked ecology which offered a pointed perspective into framing the relations that people have with a network (Thorne, Rogers, and Skelly 2016).

Industry Perspective

The importance of acknowledging that there are many parties entangled with a single connected object first emerged as a critical point to be contended with while working on the IoT Manifesto with design professionals (Afdeling Buitengewone Zaken et al. 2015). The intention behind the Manifesto was to identify principles to guide the responsible design of Internet-connected technologies. The contribution of the design research

related to this thesis on the device paradigm and FT&P is encapsulated in point VII of the Manifesto: "we make the parties associated with an IoT product explicit" (appendix 6) (Afdeling Buitengewone Zaken et al. 2015). This principle specifically relates to the fact that device paradigm is characterized for its predilection to obfuscate the parts that constitute a technology, such as the various vested corporate interests.

The inclusion of this principle offered a window to engage with design practitioners and industry partners on this topic of obfuscation, and to advocate and experiment with avenues to make legible the networked parts that constitute the technology (figure 35). When composing this principle with the co-authors, it was in the spirit of consumer protection. While drafting this point, we were concerned about forms of data that were being collected via connected devices, and the various commercial and governmental entities that may have access to it. This was very much based in the experiences of the professional designers working in this field.

Figure 35. Some of the co-authors of the Internet of Things Design Manifesto in a workshop with other professional designers discussing how the concepts of the Manifesto relates to their professional practice. Image: Holly Robbins

This Manifesto became a rallying call for design practitioners and educators in this field across Europe and beyond, and the manifesto became a critical discussion piece to some of their practices (Robbins and Giaccardi *forthcoming*). In communicating this point via the Manifesto, this idea about unveiling complexity reached critical audiences (ThingsCon 2017; Vanhemert 2015; Fritsch, Shklovski, and Douglas-Jones 2018) (chapter 9, 10). It also offered opportunities for design practitioners and industry partners to share the realities behind such an objective, such as the practical concerns regarding its implementation (Bihr 2017; Robbins, Just Things Foundation 2017).

Analogous Networks; Turn of the Century Fishing Vessel

Networked ecologies have existed before the dawn of the Internet, and urge us to ask how can we apply the principles behind them to designing the relatability of their

contemporaries. A study of a turn of the century fisherman's vessel, its crew, and restorers provided insight of the role that people play within networks (figure 36). The Reaper, a fishing boat from the 1902, demonstrated that networks don't necessarily require an Internet connection. It demonstrated that connected technologies need to be considered as ecologies of things that are defined by their relation to one another, and that humans play a critical role as a node contributing to the operation of that network as a whole (Thorne, Rogers, and Skelly 2016).[14]

Figure 36. A field study with fisherman and restorers of turn the century fishing vessels illustrate how the boat resembles a networked ecology. Images: Holly Robbins.

Ships of this era were designed to be autonomous units, to withstand the unique conditions of being out at sea, withstand inclement weather, or being far from a port for an indeterminate period of time. As a result, every item that was on that ship is a piece of technology that serves many different functions and lives many different lives in relation to each of the other objects there. Likewise, sailors needed to understand how to operate and be resourceful with those items. Rope may initially be used to hoist a sail. One sailor shared a story of a time when he was in crisis in a storm and needed to repurpose some rope to fix the rudder in order to steer the ship to safety. Later, when rope becomes weak, it's woven into a buoy that lines the boat to protect it from the dock (figure 37).

14   See appendix 6 for an essay reflecting on this field study. It was also published in: (Mozilla Open IoT 2016; Thorne, Rogers, and Skelly 2016)

Figure 37. Rope is repurposed when it is too weak to perform a vital function on the ship and woven into a buoy to line the edge of the ship to protect it from scratching the dock. Image: Peter Bihr

Through this example, we see the network for its relational qualities, and that we too are nodes in that network. People collaborate with the various other nodes (rope in this example) to make that node, and the ship as a whole, function. A growing body of work within design research also encourages us to consider the perspective of the networks that objects exist within, and the agency and social relationality that these objects possess (Giaccardi et al. 2016; Wakkary et al. 2017; Nansen et al. 2014). With objects as social agents, they have "specific properties, histories, affordances and relations" which impact humans as well as being defined by them (Nansen et al. 2014). This encourages us to take a step away from thinking about networks in terms of a human-centric, or use-centric approach where the objective of the network is to deliver services to the human. Instead, such a perspective prompts us to design networks of artifacts that "consider how objects already exist in established networks of relationships with people and how this sociality can be incorporated in insulated, engaging, shared and meaningful ways" (Nansen et al. 2014).

We see not only the relations that exist among different nodes in the network, but also the role that people have in that web of relations. The sailors were critical components of that network, defining the relationship between different artifacts by actively engaging with them: rope to human to sail; rope to human to rudder. This network is able to function *because* of the role that people play in it, collaborating with other nodes. By framing people more as nodes in the network rather than as consumers of the network, there are greater opportunities for design to make legible how nodes relate to one another and how that impacts the system as a whole. This echos the work of sociomaterialists who suggest that people and materials are engaged and entangled in co-constitutive relations, mutually defining one another (sections 0.1, 1.3). Here is when we turn to the demonstrators and design strategies for specifics as to how to make these relations that exist between people and networks as materials legible.

DESIGN STRATEGIES AND DEMONSTRATORS: DECIPHERING OUR ROLE IN THE NETWORK
This pattern features two particular design strategies that offer different modes for people to frame and relate to their engagement with networks. *Both strategies make the*
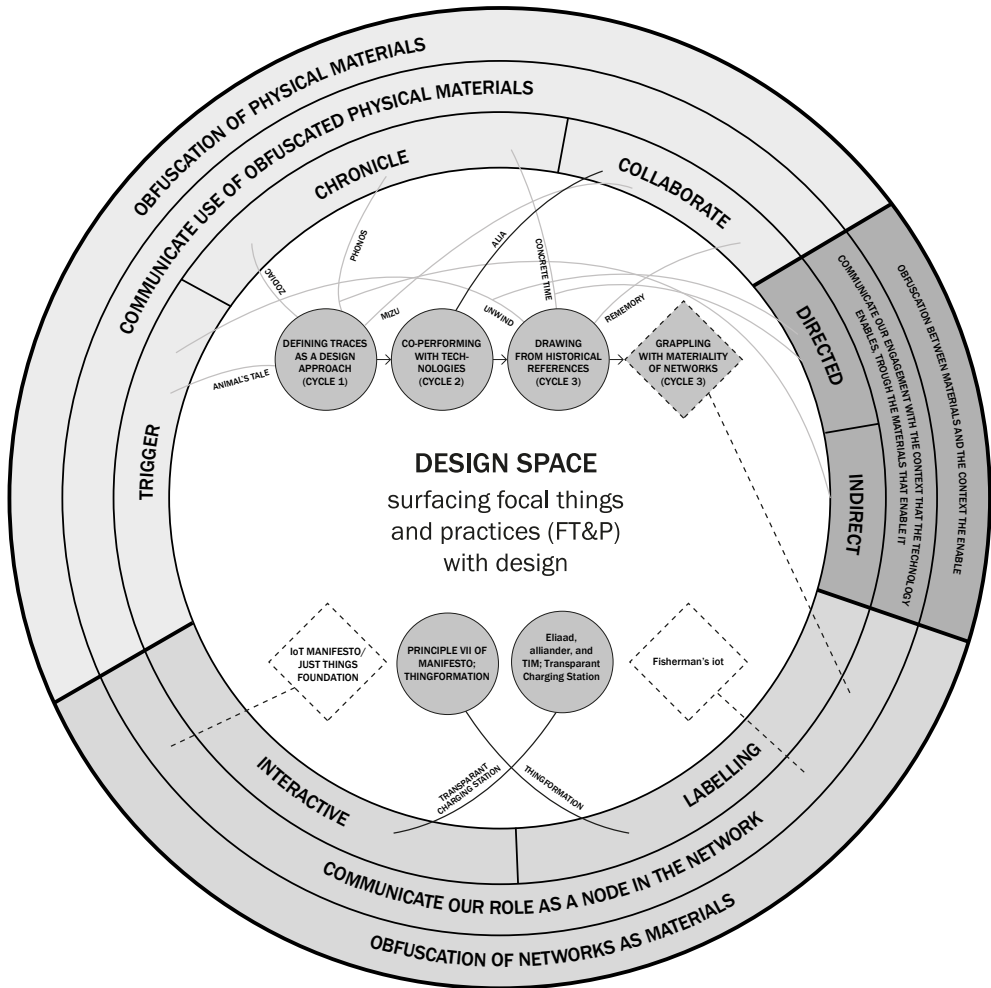
Figure 38. Diagram of the design space highlighting third pattern. Here the black box is problematized in terms of how networks, as materials, are obfuscated with design. Thus the challenge becomes how to communicate people's engagement with this network, as well as how we co-constitute the network itself. The design strategies that emerged in this pattern seek to surface our role in the network and make it legible through either labels, or dynamic interactions with the technology.

technology and its network relatable by putting people in an active role in deciphering that network, clarifying how we constitute that network itself. The first design approach does this by developing a labeling system to this effect, while the second design strategy conveys this positioning and relationality through dynamic interactions with the technology (figure 38). **In this pattern, opportunities for technologies to be surfaced as focal are supported with design strategies that make perceivable traces of the networks that they are comprised of in such a way as to promote the development of informed practices surrounding how we engage with this aspect of the technology's materiality. Practices for engaging with the network that comprises the technology serve to demonstrate that we are a small node of a much larger system, which serve to make the technology focal as a whole.**

Labeling

In this first approach, a symbolic language labels and describes the network, but more importantly serves as a resource for people to make decisions about how to conduct oneself within that network. This does not perhaps seem as a revolutionary or novel design strategy, this has been a technique that has been around for ages. In fact, the design concept that exemplifies this strategy (Thingformation) is even modeled after a specific labeling system that have been in place for more than half a century. However it is a novel strategy in the context of networked technologies, and does make an effort to make networks legible in a way that has not been attempted before (Bihr 2017).

Thingformation is design concept specifically commissioned from the Belgian design agency Beyond / IO to: "make the parties associated with an IoT product explicit" (Afdeling Buitengewone Zaken et al. 2015). This research artifact achieves this by creating a pictorial labeling system, similar to clothing wash labels, to communicate information that is not immediately apparent about networked technologies. The symbols of this pictorial system reveal the complexity of a connected product, and is displayed as a label on the packaging of the technology (figure 39). The label classifies a product on five distinct, although interrelated, qualities that refer the networked complexity behind the object: type of encryption used with the product; the number of companies affiliated with the product; what body of laws regarding data protection the product is held accountable to; the expiration date of the product; and lastly a graded evaluation of the trustworthiness of how reliable the company is with how they use their customer's data. This research artifact aims to reveal the complexities of a connected object in the spirit of consumer protection. Thingformation is offered as a means to not only help inform purchasing decisions, but will also hopefully motivate industry standards and support the development of our sensibilities in navigating and understanding these complex technologies (RobbinsJust Things Foundation 2017).

Figure 39. Thingformation: an Internet of Things (IoT) product packaging labeling system for consumer electronic. The label reveals the parties associated with the internet-connected product. Design and image: Beyond / IO (beyond.io 2017).

It may be easy to overlook Thingformation's contribution to our greater objective of supporting legibility, it seems rather explicit: it's literally a label to be read. However, with this labeling system, Thingformation attempts to provide people with the tools to close the knowledge gap between complex technologies and the layperson. This label is not prescriptive, they are not instructions. Instead it is a tool to help support the development of our own agency within this network and ability to decipher its complexity. We should turn our attention to Thingformation's predecessor to appreciate the potential of this labeling system: wash labels for clothing.

Our role in relation to clothing manufacturing and maintenance has changed dramatically over the last couple centuries. Previously there were limited textiles available to us, and we made and washed our own clothes by hand. But a knowledge gap developed as manufacturing of clothing was outsourced beyond the home and machines to wash clothing became more accessible. We knew less about the textiles and how they would respond to these machines. In light of this knowledge gap, a system of pictorial labels was developed to instruct how each item of clothing had to be cared for. These symbols, known as laundry, care, or wash symbols, have become an international convention (figure 40). The first laundry symbols emerged in the late 1950s, around the time when washing machines were becoming commonplace in homes and instruct us on things such as washing temperatures or how to best dry the item (GINETEX 2011; Cave 2016). From these recommendations, we develop sensibilities about how to care for certain materials. We can draw on the sensitivity we've developed over time

to determine what instructions we deem to be overzealous or necessary. Here when clothing and washing technology has become more complex and accessible, a simple symbolic labeling system brings harmony to making that complexity something that is accessible and relatable.
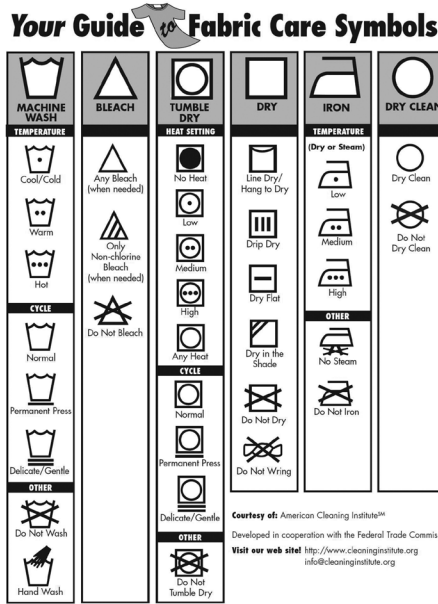
Figure 40. Guide to the Fabric care symbols on wash labels. Image: American Cleaning Institution (for distribution).

It is less the label itself, or the product it is on that makes it legible. Rather, its open-endedness and the skills that the label engender which is where legibility lies. The complexity is stated, but in a way where people are directly being addressed and held responsible for using this perspective to navigate the complexity behind the technology themselves. Thingformation enables people to develop the awareness and skill in understanding that they are now a part of a network. The hope is that with Thingformation, over time we too will develop skills to play our role in this network in an informed way. *The thing is made focal with the practices necessary to decipher the label, and having it likewise shape how we interact with that technology and all its various materials; making focal not just the thing, but the ecosystem that surrounds the thing.*

Interactive

In this design strategy, dynamic and responsive interactions are the mode through which our participation and role within a network are made legible. We are moving towards a future where most cars will be electric, which will radically challenge existing practices surrounding how we fuel cars. Car batteries require more time to recharge than it takes to fill a car with petrol at the station. We've also grown accustomed to the fact that, under normal circumstances, a petrol station will always have a reservoir of fuel available on demand. However, with an electric fueling infrastructure, the availability of electric energy at the "pump" will fluctuate in response to a number of factors: what is the demand on the electric grid at any particular moment; the availability of renewable resources; the weather; and what's already currently stored. There are a network of factors that will influence how and when the car can possibly be charged. To address this complexity in refueling electric cars on a mass scale, the Transparent Charging Station problematizes how to deliver this energy to cars, while conveying the network that is necessary to its functioning.

Each charging port of the station has two dials (figure 41, pictured in red, green or blue). By turning these dials, drivers set within what time frame they require a charge, and what percentage of their battery needs to be refilled. The station's interface responds to the turning of these dials by illustrating how the grid may or may not be able to satisfy the request being made. This interface resembles a Tetris matrix, which narrows and widens based on what resources are available on the electric grid (figure 41, close up of matrix grid on the right). The requests being made of that particular station is accommodated into that matrix, fitting within the electric grid's overall constraints. Your request has to be balanced with those also being made by that particular station's other patrons. As you turn the dials to select your percentage and timeframe, you are making a negotiation with the constraints of what other people have requested as well as what is available on the network as a whole. The interface changes in a fluid and dynamic way in response to the requests being made, and the constraints on it at that moment. In turning the dials you can broker an arrangement between yourself and the network, experimenting with different plans and compromises.
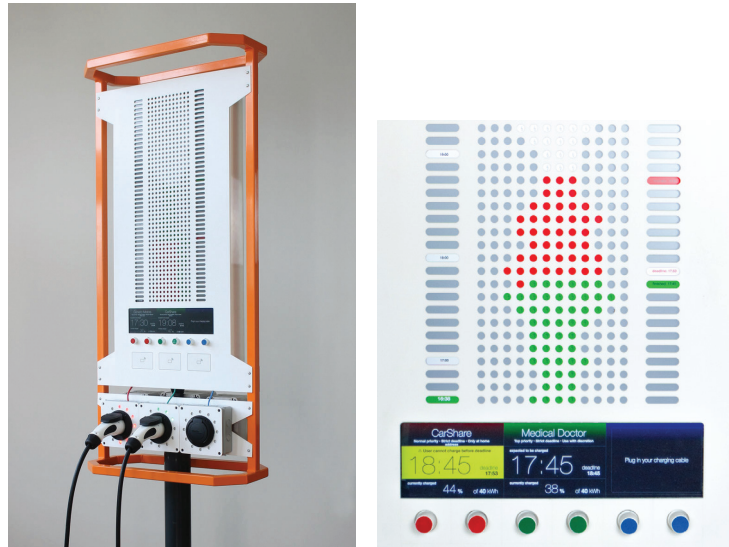
Figure 41. (Left) The Transparent Charging Station is an electric car charging station that allows people to negotiate how much of their battery is to be charged and within what time period according to the networked constraints of an electric energy grid. (Right) The interface of the Transparent Charging Station demonstrates the constraints and demands on the electric grid with a Tetris-like screen. The figure in the middle illustrate what energy is available on the grid over the course of the day. By turning the dials of your port (red, green, or blue), a driver can negotiate within the constraints of what is available on the grid, and the demands other patrons are making of that station. Design and images: The Incredible Machine (The Incredible Machine 2018).

In turning these dials, actively navigating, interacting, and negotiating with the algorithmic constraints, you are directly relating to the network itself. You can see the impact your request has on the other nodes of the network, such as the others who are charging at that very pump, as the interface's Tetris-like screen changes its shape and coloring accordingly. "Transparency," as the name of the design concept suggests, or legibility as this thesis suggests, is offered not to the extent where the algorithm is explicit. That would be too dense to be accessible to the layperson anyway, and therefore not legible. Instead, through these dynamic interactions, people begin to form an understanding of the complexity of the network, and their own role in it. *The focalness of the station and the network that it is apart of are being made legible through the practices of navigating and negotiating with that network by interactions with it.*

OPENING UP TO OTHER PATTERNS: OTHER FORMS OF INTANGIBLE MATERIALS

At the outset of this research, the objective was to understand how to support FT&P for networked technologies, specifically Internet-connected technologies (section 5.1). Yet it

wasn't until later in this design research process that networks were framed as materials, and design strategies to surface them as FT&P were conceptualized. As this was the last pattern to emerge in this research period, it could benefit from more RtD cycles to develop more nuance and research artifacts to further define these strategies. There is much more conceptual work to be done to frame networks as FT&P. Additionally, it opens the door for this design space to consider how to surface and problematize other forms of intangible materials as FT&P, such as learning algorithms, artificial intelligence, or mixed realities. This, is an area for future research (Conclusion section 0.2). In the following chapter puts these patterns in conversation with one another to more directly speak to how these insights can relate to design processes (chapter 8).

part IV
Discussion: Traversing Boundaries

CHAPTER 8.
LESSONS FOR TRAVERSING THE DESIGN SPACE OF FT&P

The design space described in chapter 7 on surfacing focal things and practices (FT&P) with design (illustrated in full in figure 38), is composed of three patterns that emerged in this design research process (Alexander, Ishikawa, and Silverstein 1977). Each pattern uniquely conceptualizes the black box and how design can surface the legibility of that black box. In each of these patterns, the technologies are characterized by their unique materials, each of which demand different modes of engagement from the users of the technologies. This thesis argues that encouraging these modes of engagement with technologies that are sensitive to their particular materialities and our relations with them offers a promising avenue by which technologies can be surfaced as FT&P (chapter 1, 2).

The intention with mapping this design space and the patterns contained within it is to help designers develop a sensitivity towards the materialities of these technologies (section 3.3). Equipped with this sensitivity, designers can develop sensibilities to exercise during design time in supporting people's modes of engagement with these technologies through their use of them (section 1.2). The design space offers designers a resource to reflect upon, to develop their own "designerly judgement" in navigating the complexity surrounding surfacing FT&P in their own practice (Schön 1983; Stolterman 2008). The map offers designers a "frame" to decipher the complicated and unstable concept of FT&P (Dorst 2010). Upon the framing provided by this design space, designers can develop their own "heightened sensibility of quality and composition" of surfacing FT&P to approach it within their own design practice (Stolterman 2008).

This chapter distills the patterns of the design space (chapter 7) and puts them in conversation with one another, effectively traversing the design space. In doing so, this chapter points to how designers can problematize various materialities of technologies with an eye towards encouraging modes of engagement that people can have with technology's materiality. **With design supporting modes of engagement and legibility that are particular to the specific materialities of a technology, this offers opportunities for people to be present with both the thing and the practices surrounding it in the fullness of their capacities, thus surfacing the technology as a FT&P. Additionally in doing so, we see the conceptualization of FT&P evolve as well in this process.** "FT&P" has different meanings in the contexts of different technologies, each pattern offers its own interpretation of what engaging with the "fullness of our capabilities" could mean, and the practices that support that engagement.

This chapter will briefly break down each pattern of this design space into three parts. First it will discuss how each pattern conceptualizes the black box is in terms of identifying what are the materials that characterize it and how these are obfuscated. Then it will turn to the opportunities for designers within this pattern to make these materials legible, in effect reconceptualizing the black box. Finally, the opportunities that these re-conceptualizations of the black box and its materials can offer in terms of encouraging

possible modes of engagement in use time, a way to encourage surfacing the technology as a FT&P, will be discussed. Lastly, this chapter will close (section 8.1) with a general discussion of opportunities that may lie in these patterns if these technologies are legible with rich modes of engagement.

PATTERN 1: TRACING PHYSICAL USE
In this first pattern the black box is being conceptualized for its physical materials that are obfuscated, our engagement with which are also illegible (section 7.1). These physical materials comprise the mechanisms of the technology and contribute to the operation of the technology, and our engagement with them are literally being masked or obfuscated. This comes in the form of physical barriers that hide away mechanical or electronic components, or encasements made with materials that resist indications of being handled.

The opportunities for designers thus is in making these materials and our engagement with them legible. In this case, with physical traces highlighting the materials of the technology itself as well as our use of them. What we can see from the demonstrators that emerged in this pattern is that design can support this objective with interactions that physically engage with the technology, sometimes even as if to collaborate with the tasks the technology is performing (design strategy: collaborate). These physical interactions, which generally involved some kind of friction or etching, are then logged by the materials themselves which are altered by these physical interactions. **The focal-ness is being directed to these mechanical parts and our relations and practices with them, in order to bring focal-ness to the thing. What we see in this pattern is that practices represent a form of engaged labor with the thing's materials to join the *ends* and the *means* in operating the technology.**

In doing so, the black box is no longer conceived as merely an encasement and barrier that obfuscates or deflects signs engagement. Instead the materials of that barrier, and what is concealed within that barrier, are directly engaged with; and that there are lingering traces of that engagement. These promote legibility of the materials by both directing our attention to the fact that they were engaged with, and making the correlation with how they relate to our engagement and the function to the technology.

PATTERN 2: MAKING LEGIBLE OUR ENGAGEMENT WITH THE CONTEXT THE TECHNOLOGY ENABLES
For the second pattern, the black box is not conceptualized so much as being about the technology as a physically bounded object. Instead, it is being conceptualized in terms of the *relation among* ourselves, the physically bound object, and the context that that technology enables (section 7.2). These technologies are characterized by their digital materials which are inaccessible to people but that have the ability to create a certain context, or what Borgmann refers to as a "hyperreality" (1999). However this context, or hyperreality, is only possible after the materials of these technologies are interpreted or brought to life by a mediating technology. This is the encoding on a CD that people

can't directly engage with; but when a CD player reads this encoding, it creates music which we can engage with. Thus what becomes obfuscated are how the materials of these particular technologies are related to the context that it enables. **In this pattern, the focal thing is conceptualized as the context enabled by the technology, which is being supported by our practices of engagement with that context. Thus our engagement with the context and the context itself being considered for their focal-ness.**

The opportunities for design is to make legible and focal the relation that exists among our engagement with these particular contexts that the technology enables, and the materials that enable that context. Whereas the context that the technology enables may typically be separate from the form of the technology itself, this pattern traced our engagement with that context upon the physical form of the technology.

This is an effort to surface and communicate what Peter Paul Verbeek terms "focal engagement" with the content of the technology (2002). He contends that we should also consider how we engage with what the technology enables, or its content, to be of equal import in considering that artifact's focal-ness as it as a thing or how it is supported by practices (Verbeek 2002). Our relationships with reproduced sound and time can be just as focal as the speaker or clock that delivers it. For example, the demonstrators of this pattern (Concrete Time, Unwind) offer opportunities for our relationship with time to be surfaced as focal in a way that can provoke introspection about the extent upon which we rely and obsess over it (design strategy: directed).

PATTERN 3: MATERIALIZING NETWORKS
This pattern addresses a type of technology whose materiality includes networked connectivity (section 7.3). We inherently engage with these networks when we engage with the physical artifacts of these technologies, whether or not we realize it. Further, what's also obfuscated is that we are nodes in that network. As nodes, we contribute to the functioning of the technology that we are directly engaging with, but also towards the functioning of the other nodes that that technology is networked with. **To surface these technologies as FT&P, we must consider the thing for all of its materials, including the network that it is comprised of. Practices must be oriented towards first conceptualizing the networks of these things and our role as a node in them, and finding ways to engage with them.**

The opportunity for design is to make this network, and our role in it, legible. However this becomes a challenge unique to those of the previous two patterns because these materials and our engagement with them are much more complex and multifaceted. The nature of a network is such that there isn't a single thing that is being used at a given moment, thus we need to frame how we understand our engagements with the black box as something beyond episodic use and instead in terms of the relations among things that constitutes its materiality. The opportunity is in making legible how we engage with many things at once, and therefore engagement must be directed to supporting people in developing the ability to decipher their role in that web of relations. Equipped with this,

people can develop their own agency to engage with that network.

Engaging people in making the complexity of this web of relations legible can not be explicit. For example, terms and services agreements provide extensive detail in impenetrable legalese informing us of the complexities behind Internet-connected devices. However if you manage to get through these agreements, which most of us don't, that information typically does not bear any relevance once we use the technology. Instead, our modes of engaging with the complexity of the technology must be open-ended, to support people in actively cultivating "ways of doing" with it. This creates opportunities for the technology and the network to be surfaced as focal in engaging people in the fullness of their capacities.

This can be with dynamic interactive exchanges (design strategy: interactive) which don't necessarily reveal the code behind the algorithms that make up the system, but shows us how it responds to us in ways that make legible our role as nodes in a fluid network. We see how our input interacts with the system's constraints, and how we impact others. This mode of engagement provides opportunities to find ways to make the most out of our relationship with that network. Similarly labeling systems (design strategy: labeling) don't necessarily have to be prescriptive, but can offer some parameters in which people can be engaged in determining how they would like to inhabit a network. There is a learning curve that comes with labels, we will have to learn and experiment with the reality behind what these symbols represent. This is not unlike how children or teenagers who do their own laundry for the first time learn how heat or turbulence in a wash cycle may impact their clothing, or when they can reasonably disregard the "hand wash only" label.

Both of these design strategies in this pattern offer people opportunities to identify the network behind the technology, and to render it legible to the extent that they can determine how they would like to engage with it. This can either come in the form of immediate interactive feedback (design strategy: interactive) or through a more experimental process of trial and error with the label (design strategy: labeling).

8.1 OPPORTUNITIES THROUGH LITERACY

In advocating for these forms of legibility, it is a call on design to create opportunities to empower people to develop a type of literacy of these complex technologies. Reading and coding literacy are generally promoted as critical components for building participation in, and for building a more robust society. Literacy is a gateway to accessibility, which can thus benefit from the massive resources of human creativity. Language is constantly being adapted, developed, and expanded through people's active engagement with it. With more people able to read and write we are able to record, share, reflect, transform, and delve deeper into the human experience.

One only has to look at the ingenuity around the practices of hacking mechanical technologies in Cuba to appreciate the profound creative force that can be obtainable when our literacy with the mechanical properties and physical materials of technologies are widespread (pattern 1, section 7.1) (Rognoli and Oroza 2015; Robbins 2015). With limited resources available to the island after severe sanctions from trading partners, and a fleet of well educated engineers, Cubans became creative about how to repurpose their limited resources to meet their daily technological needs. For example, rationed toothpaste tubes are redesigned as kerosene lanterns, or motors from washing machines become repurposed to power a coconut shredder (figure 42) (Marder 2015). This practice is so commonplace that even the military developed a manual ("Con Nuestros Propios Esfuerzos" or, "With Our Own Efforts") of crowd-sourced ideas on how to manipulate, repair, or reuse everyday objects for how to repurpose rationed items in other building projects (Marder 2015).

Figure 42 Some examples of various objects engineered from rationed items in Cuba, from kerosene lamps from jars and cans to fans made from records and rotary phones. Credit: Ernesto Oroza from exhibit "Technological Disobedience" at the Miami Science Museum 2014.

This legibility and engagement with relation between materials and the contexts that they enables (pattern 2, section 7.2) can also benefits from widespread literacy. Music remix culture for example allows people to appropriate the context that the technologies involved with reproducing sound enable to create new cultural references, with juxtapositions with other sounds to bring new meanings to these cultural resources. This can be an inherently political act that can add richness to our culture (Sinnreich 2010).

Lastly the opportunities that come with technological sensibilities for networked materialities remains largely unknown to us. I would argue that it holds the potential to imbue a type of agency with people that with nurture a more ethical and legible relationship between people and their technologies (RobbinsJust Things Foundation 2017; Afdeling Buitengewone Zaken et al. 2015; Fallman 2011). While reading the news, we can see a discomfort growing with the lack of legibility behind how networked

technologies shape our society. How do news items spread through digital networks and become credible, how do filter bubbles shape our realities, or how does our personal data on platforms become a resource for others (Leetaru 2018; Hern 2017; Eslami et al. 2015; Halpern 2018)? How do we build trust, credibility, and relations with others through blockchain technologies? Or how we decipher things like artificial intelligence when we cannot decipher the reasoning behind its decisions ourselves? There is a growing demand for literacy around networks which does not yet appear to be widely being supported with design.

CHAPTER 9.
LESSONS FOR GENERATING VALUE IN TRAVERSING PRACTICES
OF ACADEMIC AND PROFESSIONAL DESIGN[15]

This chapter addresses the relation between academic design (research) practice and professional design practice, how each can enrich and impart value onto one another, and how a methodological grounding in design anthropology is critical to enabling this exchange. This chapter suggests that this exchange can fruitfully occur through discourses of design practice, which develop across a sustained arch of mutual exchanges between these two communities and ultimately shape one another's programmatic ideals and intentions. This mutual informing of values and practices is coined as the *knowledge exchange loop* in this chapter. It is not only a question of learning from one another; but more crucially the emerging, growing, and consolidating of a set of shared design ideals and intentions. This chapter addresses the impact that the methodological grounding in design anthropology was crucial to this mutual informing and shaping of programmatic ideals and intentions.

To illustrate the dynamics of this exchange and the emergence of a set of shared ideals, this chapter offers an account of a collaboration that extended several years between myself as academic design researcher, and a small group of professional design practitioners and entrepreneurs. Through this collaboration, our design practices overlapped, converged, and impacted one another. In this chapter, this impact is considered in terms of its influence on one another's programmatic values. As an academic design researcher, I entered into this collaboration with the intention of making this research relevant to professional design practice. Yet this collaboration was more than just an opportunity to disseminate a design program. A shared program emerged, formed on design ideals and intentions mutually shaped by the encounter of our two communities. This enabled the original design research program to extend its relevancy within industry and professional designer's practices, while at the same time being nurtured by the collaboration. This is the essence of the *knowledge exchange loop*: through the manner in which our design practices converged in practice, we were imparting value on to one another's programs.

This chapter describes field studies and design processes that have already been addressed in this thesis, but with attention to the relations among these projects and the nature of the exchange with design practitioners and their related communities. Therefore some of these particular design concepts and field studies will be briefly described again to contextualize this chapter's analysis. To reiterate again, the value is not so much in the particular project, output, or design concept from this collaboration; but instead in the exchange that we encountered in these discourses of doing design, the *knowledge exchange loop*.

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15   The majority of this chapter is an excerpt from: Robbins, Holly, Elisa, Giaccardi. "Capturing Knowledge Exchange Loops in Research through Design." (Forthcoming) CoDesign International Journal of CoCreation in Design and the Arts.

When speaking of "value" in this chapter, we borrow from Erik Stolterman's argument that the value of design research is in its impact for design practice (Stolterman 2008). This value can come in many forms, such as guidelines or methodologies. This kind of standardization of output of a design research process can be easily disseminated and executed in other contexts. However, other forms of output can become more complicated to identify, measure, or evaluate; such as the mutual exchanges of knowledge that occur in collaboration. Not every form of knowledge comes with a standardized or quantifiable metric that renders itself immediately recognizable to others. This nuance is often under examined and will be parsed in this chapter, supported by examples from the my collaboration with design practitioners.

When referring to "values" instead, it is concerning the hard core of basic beliefs, ideals and intentions that made a design (research) program (Redström 2017). In this design research process, our collaboration both had an impact on shaping my research program, as well as impacting the design practice of my collaborators. **This mutual shaping of programmatic design ideals and intentions leads to identifying the phenomenon of the *knowledge exchange loop*.** This exchange of worldviews and knowledge took place 'through practice' with particular, repeated and sustained collaborations where the boundaries between the research experiment and the commercial product are difficult and somehow futile to draw.

My academic design research program sought to make inquiries into this theoretical concept of FT&P as well as the design space that surrounds it, in the attempt to make the concept meaningful for researchers as well as design practitioners (section 3.3). It is not an endeavor for a prescriptive solution or guideline to FT&P to instruct designers. Instead this research program contributes value to design practice by enmeshing itself in it and mutually developing ways of understanding and designing for FT&P that search for the "breaking points" of the FT&P definition rather than its "comfort zones" (Redström 2017). This meant also involving myself with broader communities of practice that surround the individual practitioners we had direct exchange with.

This chapter will examine how this *knowledge exchange loop* emerged through our collaboration and produced value on two scales. First, it will speak of the broadest scale, the shape this loop took on impacting a community of industry practitioners. In this circumstance, we will describe how the projects of each loop informed and led to another, thus advancing the research program among a community of practitioners and contributing value to the research program itself. Second, it will speak on a more granular level of two case studies that illustrate these direct exchanges of ideals and intentions between individual design practitioners and my own research program. Then it will discuss how to construct and asses value in these loops, and will ultimately close with a discussion of how this loop was made possible by approaching this exchange as a design anthropologist. This methodological orientation put me in the unique position to be able push the edges, and find the breaking points outside of the comfort zone of our design research as well as that of our collaborators' design practice (Redström 2017).

However, I will now provide some context to the nature of the collaboration with design practitioners will be offered before unpacking the *knowledge exchange loop*.

EXTENDED COLLABORATION WITH IOT DESIGN PRACTITIONERS

I am fortunate that my into FT&P included a collaboration spanning approximately three years with a group of young and upcoming designers particularly active in the growing field of internet-connected devices (section 4.2). Each of these designers were in their late-twenties to mid-thirties and had established their own companies within the last six years. There are three companies among them that are located in either Belgium or the Netherlands, and have between two to seven employees (Afdeling Buitengewone Zaken 2017; The Incredible Machine 2017a; beyond.io 2017). These companies handle diverse types of client work, from developing interactive exhibitions, conceptual projects, staging conceptual design interventions, to envisioning products within the field of Internet-connected devices; a short hand for which is the "Internet of Things" (IoT).

Our collaboration started somewhat serendipitously, but later grew to become a prominent project in all of our careers over this time. After an informal conversation with one of these designers one day, it became apparent that we shared similar concerns for the conduct and impact of design practices in the IoT space. He and his peers were being asked by clients to make IoT products and services that they felt were ethically fraught, mostly because its qualities as a black box were being exploited. In response, they decided to create a manifesto to frame discussions among designers to support the responsible design and development of IoT products and services. Their concern was that the users of these products and services were being taken advantage of through their connective properties, and that as designers they could potentially intervene to remedy this circumstance through the design process itself. I was invited to join them in writing the manifesto as it aligned with my research on the device paradigm and FT&P, which similarly seeks to unveil what's at work behind black boxes and establish more legible and responsible relationships with these technologies.

Together we made a succinct manifesto of 10 principles intended for our local community of design practitioners in north-western Europe (Afdeling Buitengewone Zaken et al. 2015). Later we extended our collaboration by establishing the Just Things Foundation (Just Things Foundation 2016) to develop and promote this work in various forms, which this chapter details. We developed this foundation in parallel to our own independent careers, be it in academia or running these agencies.

9.1 PROGRAMMATIC VALUE OF THE KNOWLEDGE EXCHANGE LOOP

The initiative of the IoT Design Manifesto launched us into an extended collaboration that would take on a string of experimental projects that contributed to unpacking and further developing the design ideals and intentions at the core of the IoT Design Manifesto, and FT&P additionally in the case of my design program, and help all those

involved grapple with its "poetics and politics" (Redström 2017). In each successive step that our collaboration took as a result of a project, our work reaches new communities, furthering it among them, benefitting from their input, and ultimately forging a new relevancy to this work that will advance it to yet another community, carrying our collaboration much further than we had ever anticipated.

The following section broadly describes some of these projects, their relation to one another, and thus their contribution in developing both the content of the research program and its impact on communities of practitioners. **It is the trajectory of these projects that represents the shared programmatic value generated by the *knowledge exchange loop*.** The way that this original research program on FT&P morphs into new projects that are relevant to different communities is a representation of the exchange, emergence, understanding, negotiation, and normalization of our research program among these communities of practitioners. Likewise, this trajectory also represents how my research program benefitted from this exchange: understanding, negotiating, and normalizing this research program in accordance to the needs of the communities of practitioners. This section offers an account, detailing how one project related to another, and later maps this programmatic impact.

IoT Manifesto

As mentioned previously, our collaboration began with the IoT Manifesto to guide the ethical and responsible development of IoT products and services. While drafting the Manifesto we shared industry case studies, anecdotes, experiences and perspectives, and our values, to identify the "dos" and "don'ts" of IoT design. For example: the weak security of baby monitors which have been hacked by burglars to observe houses they would like to target is a strong "don't"; clever IoT products such as bike sharing systems that use mobile phones to utilize their services is a strong "do." These were grouped and categorized by a principle that acknowledges a concept critical to shaping a "responsible" IoT product, which we primarily characterized as a commitment to consumer protection (figure 43) (Afdeling Buitengewone Zaken et al. 2015). The initiative of the Manifesto was to collect the myriad of themes and concerns concerning this relatively new design space around designing IoT technologies and organize them into a coherent format. The Manifesto was not intended to be revolutionary, contrary to what its name may suggest. Instead it was intended to offer some structure to frame discussions among professional designers and other stakeholders surrounding IoT technologies and their responsible development.

There is one particular point of the Manifesto that I posited that most closely echoes this thesis' design research program on the device paradigm and FT&P, which is point VII: "we make the parties associated with an IoT product explicit" (Afdeling Buitengewone Zaken et al. 2015). As our colleagues were collating their thoughts onto post-it notes, I grouped several of these and advocated for it to be characterized by this particular point (VII). My collaborator's perspectives closely tapped into how I have been interpreting

the problem space behind FT&P: that masking the complexities behind these products is problematic. My framing of this point was aligned with the perspective of our collaborators, and was adopted as a category that became principle VII.

The language and style of the Manifesto was deliberately chosen to promote readability and circulation among other designers, first in being complimentary to a poster format, as well with an online presence to collect digital signatures (appendix 6) (Afdeling Buitengewone Zaken et al. 2015). We have been nominated for awards for our work on the Manifesto (Creative Heroes Award 2017), invited to give talks and workshops internationally, and received grants to develop this work further. As authors, we don't claim ownership of this project and are happy to see others give talks on the Manifesto (Savič 2017). It's a form of dissemination that we greatly encourage. This transformative knowledge is spreading among international communities of design practitioners, but is also acknowledged within academia (Fritsch, Shklovski, and Douglas-Jones 2018; Wakkary et al. 2017).

Figure 43. Drafting the IoT Manifesto with co-authors on April 1, 2015; at The Incredible Machine's office in Rotterdam, the Netherlands. Case studies and thoughts regarding what constitutes the responsible design of IoT products and services are collected on post-it notes, discussed and grouped to arrive at what would become a principle of the IoT Manifesto (appendix 6). Image: Holly Robbins.

ThingsCon

The Manifesto was unveiled at ThingsCon, which identifies itself as "Europe's leading conference about the future of hardware, connected devices and Internet of Things (IoT)" (ThingsCon 2017). It is a community of practitioners of different expertises: from developers to designers, user experience professionals to product managers, owners to manufactures, and an increasing number of design academics. They come from all over the continent for annual conferences, and organize smaller events around the world.

In the 2015 annual meeting in Berlin, we presented our Manifesto. It was well received, and continued to generate interest beyond the conference. Influential participants of the conference promoted our work (Sterling 2015), and it was even covered by international media sources relevant to this community (Vanhemert 2015). The major critiques issued to the Manifesto was that it was not as "revolutionary" or radical as its title suggests.

The Manifesto had entered into this practitioner's community at the right time, and generated a lot of enthusiasm. The founders and organizers of the conference decided to incorporate the principles behind the Manifesto into the official stance of the organization: "[foster] the creation of a human-centric & responsible IoT" (ThingsCon 2017). The following year the theme of the conference presentations were orientated towards promoting a responsible IoT and members of our collaboration became active in the leadership of this community.

Just Things Foundation

Following the largely positive reception of the Manifesto among our community of practitioner peers at ThingCon, most of the authors decided to continue our collaboration and formalize it as a non-profit foundation: the Just Things Foundation (JTF) (Just Things Foundation 2016). As a foundation we develop the work related to the Manifesto through lectures and master classes for academic and professional contexts, exhibitions, commissioning speculative design projects, and consulting. The foundation supports its work through grants and appearance fees.

With our collaboration cemented as a single legal entity, we became a recognizable unit within our community, making us more accessible. As a single entity, it become easy to invite us to events or to give talks or workshops, and delegate to whomever is available at that time. We each have unique approaches to the topic based on our diverse backgrounds and expertise, which gets shared to broader audiences as a result of our association with one another. This again opened up opportunities for the knowledge exchange loop to reach communities which may have not been accessible to us design researchers, had it not been for the established exchange and relation with the members of our collaboration and foundation.

Dutch Design Week

As a foundation, the first grant we received was to prepare an exhibition for 2016 Dutch Design Week, the national design week in the Netherlands. The exhibition illustrated exiting products that successfully execute each of the points of the Manifesto and also featured some speculative products to this effect (see "Thingformation" below). This exhibition targeted a general audience and drew a crowd estimated at about 10,000 visitors of all ages (figure 44). We reached an even larger audience when we were featured in local media on the web, radio, and in TV interviews (Bright.nl 2016; BNR Radio 2016; Engle 2016). This again gave us opportunities to experiment with how to

craft our narrative and research program in ways that would be accessible to different audiences, and to similarly benefit from these audiences' input about our work. This exhibition later travelled to a few other venues.

Figure 44. Part of the Just Things Foundation's exhibit at Dutch Design Week 2016. Image: AfdelingBuitengewoneZaken

Thingformation

The Just Things Foundation commissioned a speculative design concept for our exhibition at Dutch Design Week in 2016 from the design agency Beyond.io. They were commissioned to design for point VII of the Manifesto, the principle that specifically addresses our research program on FT&P: to reveal some of the hidden elements behind IoT products (Afdeling Buitengewone Zaken et al. 2015). Their design was a pictorial label system, similar to clothing wash labels, which disclose product information that is typically not very obvious. This pictorial system is called "Thingformation" (chapter 6, 7.3).

Thingformation makes something that is abstract, the networks that comprise a product, suddenly seem tangible, relatable, and actionable. We were later invited by the ThingsCon community to write about this project for a report regarding the "State of Responsible IoT," which was made available on an online platforms for general and technical audiences (RobbinsJust Things Foundation 2017). Additionally, this project was a gateway to another design process, where we were invited to contribute to a report commissioned by Mozilla to explore how to establish trust with IoT products (Bihr 2017).

Fisherman's IoT

The foundation was fortunate to join a week-long design sprint organized by a branch of the Mozilla Foundation,[16] the Open IoT Initiative, to envision what an Open IoT could look like. We traveled to a remote fishing village in Scotland to provoke the orthodoxy of how technology is typically created by a relatively small demographic, of young white men in Silicon Valley, to explore alternate approaches to envisioning IoT technologies. After a tour of a local fishing vessel from 1902, it became apparent that we had more to learn from this ship and sailors about IoT systems than to offer them. The ship hosted a unique technological ecosystem or network that resembled an analogue predecessor to the IoT (section 7.3), which also resembled FT&P.

With two other participants of the sprint, we wrote an essay on the lessons we extracted, and how these can be applied to the vision of how to design an Open IoT (appendix 7). This field study and essay became an important case study in FT&P, and also ultimately a provocation that the Open IoT Initiative included in their internal annual report (Thorne, Rogers, and Skelly 2016).

Transparent Charging Station

One of our collaborators, The Incredible Machine, had a client project that they believed my design research program could contribute to. I was invited to join a client meeting and conceptualization session to offer an interpretation of the project through the lens of my design research program. Their clients make electric car charging stations and came to realize that the infrastructure will not be able to support a sudden influx in demand, such as after rush hour. The availability of a station's electric energy depends on a variety of factors: what the battery has in store, the availability of renewable energy at that particular moment, and demands on the grid. The clients commissioned a speculative design of a "transparent charging station" that would make the availability of those resources understandable to customers. The Incredible Machine's final design involves a system where people negotiate with the station itself how much energy will be delivered to their vehicle and when (chapter 6, 7.3).

The station debuted at industry conferences and is now the centerpiece of an academic initiative on the "Smart City" (De Ingenieur 2017; Amsterdam Institute for Advanced Metropolitan Solutions 2017). TIM and the Transparent Charging Station have also received national recognition with the award of the prestigious Dutch Design Award in the product category (Dutch Design Awards 2018).

MAPPING OUT THE PROGRAMMATIC IMPACT

The expectation of where the value resided in this collaboration shifted as this it unfolded. *The emphasis moved from considering the output of our collaboration as carrier of knowledge in and by itself, to examining the exchange that occurs through the discourse*

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of doing design and how its value (of design ideals, intentions, etc.) "carries" into future projects. In doing so, the design research program was able to transverse different sets of unstable and transitional world views (Redström 2017, 95). The impact isn't so much in the Manifesto itself; but the mutual exchange that comes from writing it, and the subsequent projects it engenders (figure 45). This ultimately is what defines the *knowledge exchange loop*.

In this *knowledge exchange loop*, the design research program is introduced to new communities of design practitioners, each of whom contribute to developing the program in the setting of a particular project, and in doing so part of our research program unfolds into their practice. We can see how figure 45 maps the shape that the impact trajectory takes. For example, the work impacted the course of an industry organization (ThingsCon), and also reached industry communities outside this organization (with the Transparent Charging Station project), speaks to general audiences through exhibitions and media (Dutch Design Week), and is sought out for consultation (Mozilla Sprint, Trust Mark Report, State of the IoT).

Here the value of the *knowledge exchange loop* is being demonstrated with each new community or project that is impacting, and likewise by encouraging us to expand our notions of the research topic by applying it to these new contexts. These projects and communities brought my design program to new and unexpected "breaking points" in how we constructed FT&P, while simultaneously shaping how it would be re-framed. At each loop, exchange of worldviews and knowledge takes place within a particular collaborative project, enabling to traverse 'through practices' of academic and professional design. The trajectory that this program takes illustrates that its themes are being interpreted, adapted, applied, understood, normalized, and negotiated within yet another context.

With each successive project and loop, we were developing and furthering our work at the invitation of our peers. But, as the next section will describe, part of what makes this advancement of the program possible is how knowledge is transformed and developed on the more granular scale within the collaboration itself.
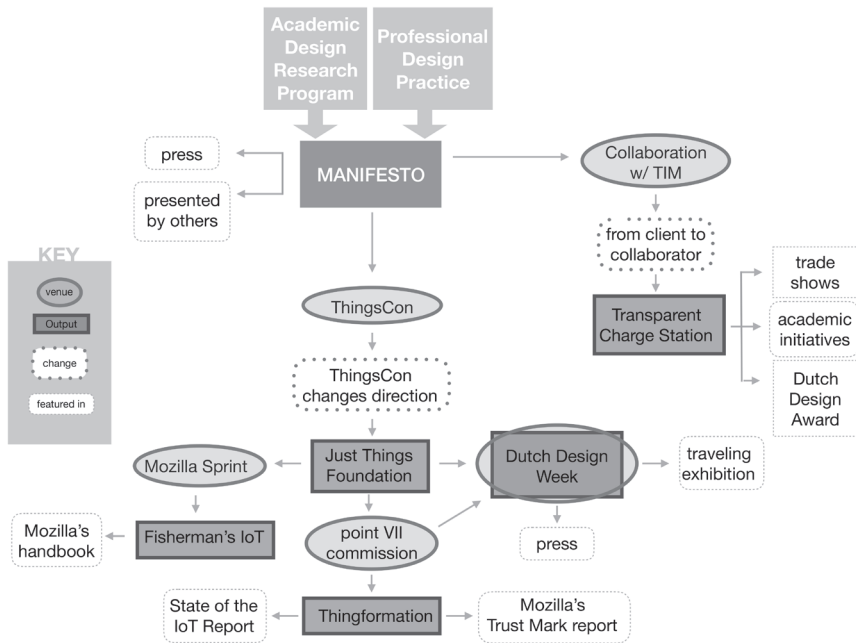
Figure 45. This map charts the trajectory of projects that our design research program was incorporated into. It demonstrates the progression and dissemination of the collaborative work that originated with our initial project of the IoT Manifesto.

9.2 THE KNOWLEDGE EXCHANGE LOOP'S VALUE TO INDIVIDUAL PRACTICE

Collaboration with design practitioners was instrumental in advancing the conceptualization of FT&P and relating it to design practice. Experimentation with what language, framing, and problematization of FT&P was necessary for it to resonate outside a purely theoretical and academic context. Attempts to synthesize and explain this idea through workshops, lectures, and design briefs had already been attempted within an academic context (Robbins, Giaccardi, and Karana 2016; Giaccardi, Speed, and Netten 2016). These projects were experimental in nature, but very much positioned in the real world of design practice.

As mentioned, upon entering into the collaboration, there was no expectation that this academic design program's impact would exceed it's own academic context. The intention was to develop a more informed and scholarly perspective on FT&P, and to assess the impact of that perspective within our academic community via peer-reviewed articles and conference work. Likewise, my collaborators were seeking to enrich their

own design practice with new ideas and perspectives. As they are all run their own small businesses, their primary concern is to invest time and resources into activities that can help advance their businesses and give them competitive advantage. *Yet, it was precisely the competition and conflict between competing worldviews that informed the development of a programmatic set of design ideals and intentions about how designers should concern themselves with constructing a more legible and ethical relationship with technology.*

At the scale of those that we worked directly with, the *knowledge exchange loop* would rotate around a project or a particular output. Both myself and my practitioner colleagues exchange the ways that we approach our design practice. I approached this with a body of theoretical work on FT&P, and my colleagues with their wealth of professional experience in the field. This functions as a form of exchange as we ultimately draw from the other's experience and practice to inform and shape our approach in later projects.

These mutual informing and instances of value exchange are difficult to quantify and measure. This will be discussed in more detail in the following section (9.3). In this section, I will provide an account illustrating two particular projects as exemplars and the nature of the exchange that transpired on a more granular level. One will pay more attention to our experience of loop (Case Study: Thingformation), and the other with more attention dedicated to the impact the loop had on the professional design practitioners (Case Study: Transparent Charging Station).

CASE STUDY: THINGFORMATION

As previously mentioned, Thingformation was commissioned to illustrate the point VII of the Manifesto, which most closely echoes this thesis' theoretical work on and FT&P (Afdeling Buitengewone Zaken et al. 2015) (chapter 6). Thus as a design researcher, I was especially invested in this particular project for which our research program on FT&P essentially served as its design brief. Thingformation attempts to reveal the invisible parts that constitute an IoT product with a labelling system.

Through the process of creating this speculative design, design practitioners surfaced two critical concerns regarding how to design for FT&P that had not been appreciated in our academic design research. Firstly, it demonstrated that we have to think of complexity as more than just hard/software sophistication—code, chips, and data. Instead we also need to think about how to frame the complex relationships that a person has with a network, its different nodes and their different functions. Secondly, Thingformation encouraged us to think on the scale of infrastructure. Its labelling system requires a centralized international regulatory body that would depend some coherency, or development, of relevant international standards.

Up to this point, as a design researcher my approach had primarily been concerned with how to express the idea of FT&P to convince designers of its merit. But this had not resonated with our colleagues. Instead the designers approached this project in practical

terms, illuminating that we have different understandings of the "what" of this project. We defined "what" the project should do as supporting FT&P in joining the ends and means together thereby situating our social and ecological context. As Thingformation's lead designer explained to us, he understood what the project was about as "communicating what's invisible in an IoT product to an end user before they use it, and on a tiny canvas" (Tiete 2017). Our "whats" implied different "hows." Theirs suggested tapping into infrastructure, whereas ours were built on different conceptualizations of social constructs.

As a design researcher, I had been struggling to figure out how to explain the importance of FT&P and how to make it relatable to design practitioners, yet through this project we understand that we had not been speaking a language was resonating. These designers needed to think about it in terms of what "materials" they were working with: the end user, the packaging, the infrastructure; these were not the terms I had been working with. In participating in the way they do design, we were able to understand what parts of our framing needed to be examined. We needed to think more broadly about what complexity means, and also the practical concerns, such as infrastructure and politics, that are necessary to support FT&P. Reflecting upon previous projects, we can see how this oversight had constrained previous projects. Missing practical concerns like these certainly made our theoretical work less convincing to the practitioners. What *was* compelling to these designers was identifying existing models and infrastructure could help with this principle, and try to maneuver and adapt their objective within that system (adapting clothing wash labels for IoT products).

With Thingformation we gained a new mode of thinking about FT&P, as well as the skills to approach it more fruitfully in subsequent projects. Thingformation breathes life into our research on FT&P, making it richer and easier to grasp, and also extending its resonance to a larger audience. Within my design research program, I started to think more concretely about networks, which is apparent in later work with the essay on Fisherman's IoT the Transparent Charging Station, and other projects we did outside of this collaboration. This was followed with an invitation to write an article for a general audience based on Thingformation to whom we could frame the nature of the design program on FT&P (RobbinsJust Things Foundation 2017). This article ultimately became one voice among others that was analyzed within academia for how it represented a growing "revolution" for ethical internet-connected technologies (Fritsch, Shklovski, and Douglas-Jones 2018), as well as the authors of a report being commissioned by an industry partner, for which we were consulted (Bihr 2017). The framing and approach to the academic design research behind point VII of the Manifesto clearly benefited from our colleague's practical approach in this loop to make our design research relevant and applicable to design practitioners in industry.

CASE STUDY: TRANSPARENT CHARGING STATION

One of our collaborating agencies, The Incredible Machine (TIM), had a client project that they thought my academic design program could contribute to. They were asked

to create a "transparent" charging station for electric cars, to reveal how the station determined which cars could be charged and within what timeframe. The client had made some specifications for the design that TIM associated with one of the early design approaches we had been exploring (traces of use) (Robbins, Giaccardi, and Karana 2016; Robbins et al. 2015), which they presumed was the focus of my research. Indeed, this was an approach that I had been exploring to support FT&P, but my primary concern was in inquiring after FT&P. It is telling that even after years of collaboration, I was still striving to make the very core of our research relevant and accessible to our colleagues. Regardless, I was thrilled to contribute, and more importantly see what we could learn from this next loop. I was invited to join a client meeting and ideation session. Indeed, the client's vision behind this charging station is very much in line with the design program on FT&P, albeit for reasons different than what TIM had presumed.

During the ideation session, I pressed upon TIM that the client's project brief is in line with our argumentation of FT&P. I attempted to make this point without the jargon of FT&P, and instead illustrate this with the historical metaphor of the tragedy of the commons, where limited resources have to be shared and distributed among a large community. In this case, the resource and the technologies surrounding its use becomes a FT&P because an awareness of its social and ecological context is vital. If the resource, such as water from a communal well, is consumed without an awareness of how the others may use it or how it is being supplied, the whole community could suffer from drought. Thus it is vital that contextual information regarding the availability of that resource, such as the demand from others and the availability of this natural resource, be apparent so that people can act accordingly with it. This awareness, and the ability to understand use and the context that makes that use possible, are essential to FT&P. This not the case at petrol stations, where the resource is available on demand a d the supply is hidden underground. There are some clues to the context surrounding this resource, such as price, but this impact is relatively nominal and the *ends* and the *means* are still separated in this context. However the charging station operates on an infrastructure that is more like the shared well. There is limited and fluid amount of energy on the electric grid that has to be distributed judiciously, it can not always available on demand to all. Its availability is also not currently made legible to the general user. Thus the opportunity for the "transparent" station, I argued, is in highlighting and making legible this fluid context behind the resource, and how our use of the station taps into that. This is the dynamic that frames the station as a FT&P.

Through examining the transcripts of our ideation session, it was apparent that our colleagues did not see the opportunity in the framing of energy resources as FT&P as our design research program had laid out. Instead it had been understood as an argument for the specific design approach that we had previously been experimenting with (traces of use). They had been clear with the first author that they had "tried traces, and they didn't work." They also informed us that they "tried to work with the tragedy of the commons metaphor, but it also didn't work." She had not been able to trigger them with her reasoning for FT&P.

Regardless of this apparent refusal, the final design concept of my colleagues beautifully captures the point being argued in the ideation session with FT&P as an approach to reframe how we interact and conceptualize the energy resource, the technology that delivers it, and the network we exist with it in. The final design of the charging station features a screen indicating the availability of electric energy based factors such as other demand from other cars charging, or how renewable energy was generated that day. Its interface shows the constraints of what energy is available on the network, and the user has the opportunity to negotiate their needs within those parameters with their turns of the dials. The station becomes a focal thing that people can interact with in their ways of doing thereby connecting the *ends* and the *means* together with their own engagement. It is sensitive to situating the social and ecological context behind the machine and the network it represents (section 7.3).

Based on the transcripts, punctuated by explicit moments of refusal, it is clear that our collaborators did not appreciate the academic design research program's framing in the ideation session; yet we can observe that their final design expresses the concept of FT&P and our academic design program's reasoning. The design of the station surfaces qualities in line with FT&P, having people directly engage with the technology in such a way that illuminates how it works, and the context of the infrastructure behind the services it provides.

Again, this cycle of the *knowledge exchange loop* provided us with an opportunity to develop our sensibilities of how to make this nascent research program relatable and accessible to designers. Based on the strong correlation between TIM's final design of the station, and the proposal that this design research program is attempting to put forth regarding the qualities of FT&P and how they relate to limited resources, we observe that this is an instance where this design research program was able to contribute value and impact our collaborator's practice. TIM's final design so beautifully captures the concept that had been advocated for, further helping in developing this very research program's framing itself. This project created the opportunity for this design research to contribute in broadening the scope of their design practice, whether acknowledged or not.

9.3 CONSTRUCTING AND ASSESSING VALUE IN KNOWLEDGE EXCHANGE LOOPS

This last case study brings us to an important point that we must contend with, which is the subjectivity behind constructing and assessing programmatic value in these *knowledge exchange loops*. As mentioned, such a mode of thinking or sets of values and beliefs don't lend themselves to quantifiable or easily defined metrics. This is especially true of collaborative design processes where the objective is not in parsing out individual contributions but supporting "unstable and provisional" design processes (Redström 2017).

As this chapter has described, we are very aware of how our research program has benefitted from these *knowledge exchange loops*. Through working with design practitioners, we are able to expand our own framing and relevance of FT&P in ways that are more applied or process-oriented. Working with these collaborators has enriched my design research practice not only by providing a rich array of design concepts and research artifacts that contribute to articulating the research program around FT&P, but also by giving us opportunities to understand how design processes impact how to conceptualize the idea of FT&P. For example with Thingformation our research program turned to also consider the infrastructure behind regulating IoT products and their legibility.

Based on an analysis of the fieldnotes of our ideation sessions and exchanges with designers that have been notated, coded, and in some cases transcribed, we also observe that their design practice too has been impacted by our involvement in the *knowledge exchange loop*. On more than one occasion, collaborators have tried to engage with our theoretical design research, and had been clear with that this research didn't seem relevant. However, as demonstrated with Thingformation and the Transparent Charging Station, we see how these research artifacts that they developed ultimately encapsulate the ideas we were proposing, and advance their maturation. This research program had a significant and observable impact in broadening the scope of their design practice. Yet, we can only speculate on how their work has benefitted from this design research.

Perhaps my colleagues cannot see the shape of this impact because there is an expectation that coming from an academic context our contribution should be more fully formed, quantifiable, or "provable." Thus when sharing an academic design program still being developed with our practitioner collaborators, if it doesn't immediately seem viable it is dismissed, as was the case with the ideation session for the Transparent Charging Station. Yet, in this very project, the line of thinking and metaphors offered during the ideation are then captured in the final design, whether or not designers explicitly are aware of it.

This becomes much more complicated when we try to parse out the programmatic value of our design research on the scale of a community of design practitioners. For example, what was our contribution to triggering ThingCon's program shift? How do we identify this research's contribution to this change, compared to that of the collaboration? Or was it an inevitable tidal change for the ThingsCon community? Part of what made it possible for the voice of a design program on FT&P to even reach this venue is the fact that it was strengthened by the collaboration with practitioners. What matters the most perhaps is that the voice of our research was somehow contributing to this mix, which made it possible for us to continue to further this design research program with and within this community (RobbinsJust Things Foundation 2017; Bihr 2017).

9.4 ENABLING EXCHANGE WITH DESIGN ANTHROPOLOGY

These loops created an impact and value both to the designers we collaborated with directly on projects, but also extended to a larger community of design practitioners. This exchange of worldviews and knowledge took place 'through practice' with particular, repeated and sustained collaborations where the boundaries between the research experiment and the commercial product are difficult and somehow futile to draw.

Through the notion of the *knowledge exchange loop* we encourage design researchers to seek value beyond the particular artifact itself and even beyond the particular means of fabricating a particular artifact. Instead, attention should be attuned also to the exchanges that transpire when different design practices engage with one another. Staying flexible and open to alternative design practices is not only an opportunity to expand and enrich our own programs as design researchers, but perhaps more importantly, an opportunity for such programs to create an impact on other diverse sets of design practices and communities.

I believe that part of what of what made the *knowledge exchange loop* possible was with a methodological grounding in design anthropology, with the design process itself as a field site. Otto and Smith suggest that design anthropology has a two fold objective of both theorizing the world and envisioning how to transform it (Otto and Smith 2013). It is exactly this perspective of blending modes of contextualization and theorization with a desire to make changes (chapter 4) that left me as a design researcher primed to make use of opportunities of mutual of shaping of design programs.

As a design anthropologist, I was concerned with developing a nuanced perspective into theorizing and contextualizing design processes in order to bring greater meaning to the subject of my research, surfacing FT&P with design; but also to seek opportunities to transform design practices to pursue this research topic. Equipped with a nuanced perspective on design processes and what make them unique within different contexts, it became possible to mold my research within these contexts in order to create more opportunities for it to permeate into another communities and be relevant within them. This engendered opportunities for mutual shaping of our design ideals and program to develop ways that abstract theoretical work such these critiques from philosophy of technology could speak to different communities of design practice.

This question traversing between academic and professional design practice was beautifully captured in a particular exchange after a grueling day of editing the Manifesto. As we were packing up, one of the co-authors turned to me and said that after a day like today I must be regretting joining the project. I seriously and enthusiastically responded: "Are you kidding? I'm so happy to be doing something so practical." Without missing a beat, the two collaborators stopped in their track and let out a bellowing laugh. They said that this is the most "theoretical" and least practical work they've done in their shared 20+ years of experience as professional designers. How we frame this exchange is in the eye of the beholder, yet its impact is certainly observable in both practices.

CHAPTER 10.
LESSONS FOR TRANS-DISCIPLINARIANISM

This thesis represents a design research process that navigates trans-disciplinarily between philosophy of technology and conventional industrial design practice, in an effort to make a contribution to enriching both. This chapter reflects on my own experience within this specific design research process described in this thesis to point to, and tease out, some of the tensions that emerged in working between philosophy of technology and industrial design practice. In developing a deeper understanding and an application of this particular conceptual work from philosophy of technology (surfacing FT&P) within industrial design practice, three tensions manifested throughout this trans-disciplinary exchange. These tensions reflected the different styles of working, values, and assumptions of the two fields. In particular, these tensions were between different levels of specificity and abstraction, reference points, and modes of evaluation that existed between these fields, and will be unpacked in this chapter.

Through the lens of the research conducted and presented in this thesis, we find insight into how these disciplines work together and what they have to offer one another. With a deeper appreciation of these tensions, this thesis hopes to contribute towards building a more productive marriage between the two fields. Such a marriage is particularly timely amidst calls for the design of technologies to be responsible for incorporating more cultural analysis, critical theory, philosophy and values, as we find evidenced in the emergence of the third wave in the field of human computer interactions (HCI) which focuses on promoting values on human and societal scales (Fallman 2011).

10.1 SPECIFICITY AND ABSTRACTION

Throughout the various cycles of research through design (RtD) undertaken in this design research process, designers found it difficult to engage with the critiques from philosophy of technology. These critiques were considered to be ambiguous, too conceptual, and not particularly constructive for their design process (chapters 5, 9). While designers may be able to relate to and find Borgmann's critique valid, it was still difficult to understand how to utilize this information in their design process. Similarly, presenting design concepts, the product of design research, to a philosophy community was also at times bewildering. For designers, the philosophy was too abstract, and for philosophers the designer's work was too specific.

There was a tension between how information is communicated within philosophy of technology communities, and in a design process. Demonstrating and communicating ideas through the use of examples is foundational to both designers and philosophers. But the nature and purpose of these examples, and what they explain, varies between these disciplines. The designers that contributed to the RtD cycles in this thesis sought examples of existing contemporary designs to inspire and model their novel designs from. Examples were used to establish a vocabulary within their design process of particular features, functions, or roles that a new design should have. Within philosophy

of technology, an example is often a critical lens with which to illustrate an argument or make a counter point. Examples are used to illuminate the boundaries of a particular idea or critique in order to refine the idea further. For design, examples are supporting the design process, which results in a new design. In philosophy the example is at the service of an argument, illustrating and supporting its point.

Over the course of various RtD cycles, different modes of piloting these disciplinary modes of communication were experimented with (chapter 5). A clear demonstration of the tension between these modes of communication and how it was navigated can be found in the evolving relationship with examples throughout this design research process. This came to represent iterations of what Kees Dorst refers to as "framing," where the unstable concept of surfacing FT&P were being problematized and reconfigured for these industrial designers (2010). Upon reflection, it was not just the topic of the research itself that was being reframed, reproblematized, and reconfigured, but also the approaches to navigating between philosophy of technology and industrial design practice which were also unstable.

CHECKLIST

This tension between how to use examples immediately became apparent in the first cycle of our RtD process (section 5.1). The first design brief (appendix 1) broadly characterized the essence of the device paradigm, and instructed that an internet-connected technology be designed to represent specific qualities that were theorized to be traits of FT&P. In this RtD cycle, the designers struggled to make sense of this and asked for clarification in the form of examples that they were to model their own work after. However such examples, by definition, don't exist. As Dorst would argue, designers can not frame the topic without any references to develop this frame upon (2015). This is a novel space we were seeking to explore through design. We can offer examples demonstrating the absence of these qualities, and also examples in totally different contexts (those that are not internet-connected). But there weren't yet examples that affirmed the qualities that we were seeking. This was was a significant challenge for the designers we were working with.

This left designers struggling to decipher a brief that they felt was too ambiguous, causing delays and confusion. In response over the remaining time of this particular RtD cycle, and later with other cycles, we experimented with potential forms of specificity and tools that we could offer to designers to disambiguate this particular body of work from philosophy of technology for their design process. The most extreme form of specificity, which was explicitly requested by designers, was a list of design requirements. Within conventional industrial design practice, this list of requirements often accompany a design brief and consists of a list of specifications that are typically deemed as the conditions necessary to satisfy the contract. These requirements often list specific features that the design should have, such as being able to run off a battery for eight hours. Such a checklist of requirements were created in response to the first RtD cycle (appendix 2), however it ultimately was not shared with students.

The intention behind withholding this checklist was have the opportunity to first study the tension itself, to inform our thoughts of what should even be on such a list. It was too premature to create and guide a design process with such a list. As design researchers, the motivation isn't only in answering the question of how to surface FT&P with design, but also to understand what were the obstacles between industrial design practice and philosophy of technology that need to be piloted.

GUIDELINES

The progressive step in disambiguating this philosophical construct came in the form of design guidelines. After the first RtD cycle, the resulting research artifacts were analyzed in terms of what appeared to be successful or unsuccessful about how they appeared to create opportunities for the technology to be surfaced as a FT&P. These were distilled as a list of guidelines for future RtD iterations that made a step in making the theoretical work of the philosophical critiques actionable within a design process (Robbins, Giaccardi, and Karana 2016). These guidelines are a collection of design principles and recommendations. They are not on the level of specific requirements, such as being able to run off a battery for eight hours. The guidelines are more interpretive while still being instructive: "People should co-perform with the functionality of the technology. Evidence of this co-performance should be in the form of a trace" (Robbins, Giaccardi, and Karana 2016). These guidelines served as the basis for later iterations of the design briefs (sections 5.2-.4, appendix 3-5), but appeared to set a particular scope to the ensuing design processes, which were perhaps not as constructive to surfacing other patterns (such as pattern 3, section 7.3). These guidelines construct a particular "answer" to a phenomenon that we were still trying to understand. In Erik Stolterman's terms, these guidelines, as the name indicates, attempts to "guide-in-action" by offering detailed prescriptive procedures (2008). Such an approach, as Stolterman argues and this research echos, limits designers in their ability to be prepared-for-action, or to handle complexity that arises from design circumstances as they arise.

MAPPING A DESIGN SPACE

Indeed, to support designers in approaching such a complexity, research has to support their "tools for reflection," or their individual ability to make judgements of have to handle complexity (Schön 1983; Stolterman 2008). Thus, another mode of navigating this tension between ambiguity and specificity was necessary. The goal then became to support designers with froms of intermediate knowledge about the topic, FT&P, for designers to develop their own judgement of those topics (Höök and Löwgren 2012). This is knowledge is more generalizable than a particular design instance, but isn't yet a theory. In other terms, it's not a single research artifact that personifies FT&P, or a prescriptive set of guidelines, but instead a broader approach to understanding of what surfacing FT&P can consist of. As Stolerman, Wiberg, and Gaver suggest, large and ambiguous conceptual topics of research are not those that should solicit a single answer to "solve" the problem, nor should there be the expectation that a single design concept or design artifact can encapsulate the knowledge that's produced from the study (Stolterman and Wiberg 2010; W. Gaver 2011).

In the case of this thesis this intermediary knowledge to support designer's ability to handle the situated complexities as they arise in a design process comes in the form of a map of the design space surrounding FT&P (section 3.3, chapter 7, 8) (Dove, Hansen, and Halskov 2016; W. Gaver 2011). A map of this space is less prescriptive than requirements or guidelines, and involves designers in interpreting and navigating this space. In making these interpretations, designers are developing certain sensibilities about the conceptual ideas behind the device paradigm and FT&P (chapter 8).

QUESTION OF FIT

Ultimately, through this process it appeared to be a question of fit between these two fields to identify the right framing, mode of communication, and form of knowledge output to support the relation between these two fields. Throughout this research process, there were a changing set of expectations about how design research can contribute to philosophy of technology, and vice versa. Initially, we had hoped that the design research could offer a list of directions as to how to encourage opportunities for technologies to be surfaced as FT&P, a resolution to the theoretical critique of the device paradigm. Instead, through this process we are able to build a map of the design space around the considerations to be taken into account to surface FT&P with design (chapter 5,7,8). Mapping this design space is an attempt to support "designerly ways of knowing" to synthesize questions of design within design practice (Cross 1982); as well as to point to the nuances of this space that can contribute to the formulation of the concept of FT&P in its very self, as chapters 7 and 8 do in addressing different materialities of technologies and our engagement with them. The design space struck the right balance between offering some points of reference to inform a design process, while also opening up the particular concept from philosophy of technology of FT&P.

10.2 DIFFERENT REFERENCE POINTS

Another tension emerged in this particular research process regarding how these fields address the point of criticism, and in framing the corresponding notion of the "change" in response. In this case, interpretations regarding "change" have very different reference points between these fields. One is characterized by noting the change that has happened and that results in this current predicament, whereas the other is interested in changing the future. These of course can be complimentary objectives, once we can recognize the effective approach to bridge them.

Broadly speaking, Borgmann's device paradigm critiques present technologies for what about historical technologies are lacking in them (1984). Conventional industrial design practice however is generally motivated to change the present in order to improve upon the future. To cope with this tension of conflicting reference points, a compromise between the two were arrived through this evolving design research process. Design briefs instead set the scope of the design process to be at looking at the past in order to inform the future. This was most clearly implemented in the third RtD cycle where

the brief instructed designers to start with a historical technology and redesign it with contemporary materials (such as micro controllers and sensors) to surface the aspects of the historical technologies that were FT&P in novel designs (section 5.3). These historical technologies already have relatives in our present, yet this brief did not start with these present-day technologies as the progenitor to the future. Instead, the present technologies were being bypassed, and design concept became a direct descendant of the (relatively) historical technology. For example, Rememory is a printer that more closely references screen printing techniques from the pre-mechanical era than it does the one that may sit on the desk of our home office today.

This blended temporality even organically arose in design processes without it being explicitly requested. Thingformation (chapter 6, section 7.3) references wash labels that emerged at the dawn of wide-spread accessibility of washing machines (GINETEX 2011; RobbinsJust Things Foundation 2017). Another occasion of this was with Phonos (chapter 6, section 7.1-.2), a bluetooth speaker that created etchings from its use that resembled those made in records by the needle of the player.

Understanding the different reference points that exist between disciplines, temporalities in this case, requires a type of open-mindedness and adaptation for these disciplines to thrive off one another. It isn't merely a question of speaking the same language, using the same logic, or methodologies. Instead it's a question of understanding ways of working.

10.3 MODES OF EVALUATION

Lastly, there is a question regarding how work is evaluated differently between philosophy and among industrial design practitioners. Firstly, it's a question of audience. Speaking in *very* general terms: philosophers speak of issues with far-reaching impacts touching upon broad ranges of populations; however their work often tends to specifically address specialized audiences, such as other philosophers, policy makers, or high level experts on a *very* general terms: an industrial designer practitioner's audience may also be specialized, however their work still often speaks to the general layperson. They are, after all, often the audience whom the design intends to benefit. In speaking to the layperson, their work must serve and be relatable to a broad population, and this typically comes in the form of design efforts that promote accessibility across these varying aptitudes. Serving a non-specialist public is what motivated the convention of design techniques surrounding such as automation, the black box, and the device paradigm in the first place (section 1.1).

Thus, each of these audiences' have different notions of how to evaluate what is "good design." On the one hand, conventional design trends represent "good design," which are the very conditions that support the continuation of the device paradigm (section 1.1). On the other is the suggestion that what constitutes "good design" is determined by its ability to relate to, incorporate, and promote human, social, political, ethical, and

moral values. These alternative mode of evaluating "good design" is being triumphed by third wave of HCI and philosophers alike (Fallman 2011).

It is not easy to make this transition to redefine "good design." Some of the qualities of technologies and engagement that Borgmann advocates for can be considered as archaic by conventional design standards. With each RtD cycle, designers would question "why" we would want challenge these particular design conventions, confident that people wouldn't want to use these technologies or that they would not be marketable technologies (chapter 5).

There were some provocative circumstances where these seemingly conflicting visions of "good design" were in harmony with one another. One research artifact, Mizu (chapter 6), could be argued to represent both visions of "good design." Mizu's design beautifully articulated the research objective of encouraging the technology to be surfaced as a FT&P with design. This research artifact was on display at several different design fairs where it generated a lot of interest. It was even well received by the press and we were in a position to explore producing the sink commercially (Visscher 2015; Steinhart 2017; Junte 2015). Here is a conceptual research artifact that both achieves this thesis' philosophic standards for "good design" in that it creates opportunities for the technology to be surfaced as a FT&P (section 7.1), as well as being well received by the general public, potentially even at a commercial level. But the question that comes to mind is *if* the general public appreciates this sink as a FT&P. They may be charmed by novelty of rubbing the bronze tiles of the sink to heat the water, but do they appreciate what it represents in terms of engaging people with the materials in joining the *ends* and the *means* of the technology together? Is awareness of this engagement a factor in determining its focal-ness? This particular question doesn't seem to have a straightforward answer for Borgmann either. He argues that FT&P should be both "inconspicuous and humble" (Borgmann 1984, 199). Yet, the same description could also apply to a product that can be characterized with the device paradigm: inconspicuous and humble because it does *not* demand your attention or demand focal-ness.

Who has the authority on evaluating what is "good design" or a FT&P, and by what standard? Borgmann again presents a challenge to his own theories suggesting that making a "case-by-case appraisal of technology['s focal-ness is] so inconclusive" (1984, 208). Does the general laymen have to appreciate the philosophical and conceptual aims behind the design for it to be successful? Borgamann instead argues "that the more clearly we understand the coherence and the character of the technology, the more evident it becomes to us that the technology must be [a FT&P]" (1984, 208).

Thus, if the question is of how we *experience* FT&P, this is a question best left to future research that can examine how people live lives with these artifacts (conclusion 0.2). However, this thesis has concerned itself with exploring this "coherence and character of the technology." With each pattern and mapping the design space, this thesis proposes different conceptualizations of the character and coherence of the technology,

and how these can be supported, or not, with design (chapter 7,8). With its foundation in research through design anthropology, this thesis develops ways to conceptualize the coherence and character of a technology in its design phases (chapter 5, 9).

10.4 TRAVERSING DISCIPLINARY AUDIENCES

This research attempts to speak to many audiences, and at different levels and venues. From academics in both philosophy and design, as well as design practitioners, consumer advocates, and the general public. Among all these audiences, the same subject is being broached, although with totally different narratives, and with different framings of the impact and significance. This is perhaps the contribution of this thesis that I value the most. Through this active trans-disciplinary collaboration, work from different fields are contributing to the development of others.

Redström observes that programmatic design research looks for structures (of practice) that "somehow cater to the need of a worldview, a hard core" but argues that these structures should be set up in a way that "enable us to work with a diverse set of inherently unstable and transitional worldviews" (2017, 95). Thus the activities of design research should unfold this worldview "searching for its breaking points rather than its comfort zones" (Redström 2017, 95). This thesis' design research program has sought to open up the design space for FT&P, using projects within the various disciplinary academic contexts and through collaborations with practitioners. These approaches have served to extend ourselves and conceptualizations of FT&P beyond the comfort zone of both academic frameworks and predominate commercial design trend of the device paradigm, to understand what were the breaking points of our own conceptualization of FT&P. This had value not only because it helped design research in FT&P, but also because it helped form a core set of design ideals and intentions among broader community of practitioners and academics.

CONCLUSIONS

In this thesis, design research is being blended with philosophy of technology in order to challenge and expand upon both disciplines. In particular, design research is used to make inquires into the notion of focal things and practices (FT&P) from philosophy of technology. This has been to develop an understanding of how industrial design practice can contribute to the advancement of these critiques, and how these critiques can advance academic and professional design practice. In doing so, this thesis makes three contributions, one regarding its unique methodological approach (chapter 9), the second regarding the content of the research itself and the design space supporting FT&P (chapter 7, 8), and lastly in a reflection of working between design and philosophy (chapter 10).

0.1 SUMMARY OF ARGUMENTS

THEORIZING THE BLACK BOX AND DESIGN APPROACHES

This thesis makes investigations into a critique articulated by philosopher of technology Albert Borgmann into how technologies can be surfaced as "focal things and practices" (FT&P) (Borgmann 1984). For technologies to be FT&P Borgmann argues, they must engage us in the fullest of our abilities. He argues that contemporary technologies are designed to limit our engagement with them, thus giving rise to what he refers to as the device paradigm. In the device paradigm technologies do their work in the background, requiring little to no involvement from us, they are automated and/ or obfuscate their complexity from the general layperson. This becomes especially true with contemporary technologies that are data-intensive or Internet connected (chapter 1). In this thesis, these contemporary technologies are problematized in terms of the materials that they are comprised of, with a careful eye towards the new modes of engaging that we have with these technologies, whether or not we realize it. Many of these materials we actively co-constitute, as exemplified in a Google search: as we search, the algorithms are drawing on data points such as the searches from people in our proximity and our previous search, in order to deliver tailored results. This single search we make then becomes a data point that will inform future searches, by ourselves and others (Orlikowski 2007).

This thesis seeks to make legible our engagement with these contemporary technologies, which are often obfuscated with design. Specifically, this design research turns to traces as a design approach to explore how to make our engagement with the varied materials of these technologies perceivable, but more importantly legible (chapter 2). *Traces become a vehicle with which to explore how design can create opportunities for these technologies to be surfaced as FT&P for their ability to assist in expanding our conceptualization of a technology's materiality, and our relations with that materiality.*

RESEARCH THROUGH DESIGN (ANTHROPOLOGY)

To navigate between design research and philosophy of technology, this thesis uses a

methodological cocktail of research through design (RtD) and design anthropology. With RtD, this thesis looks at cyclical design processes as a way to shed light on the topic of research (chapter 3). This thesis argues that it was not only the design process in creating the design concept that offers insight into the topic of research, but also the design process in creating the brief (section 3.1). Therefore both the brief and the design concept are considered research artifacts and are analyzed for how they help to reformulate the research topic for another RtD cycle. The knowledge produced through these RtD cycles did not necessarily sequentially build on itself. Instead the knowledge produced came to resemble a rhizome, in that it was not linear nor hierarchal (section 3.2). Together, this knowledge came to build a design space (section 3.2), which will be mapped out and detailed in chapter 7 and 8.

Design anthropology was an important lens with which these processes of design were interpreted (chapter 4). Design anthropology's mode of contextualization and theorization, but with the motivation to transform was essential to traversing this interdisciplinary work between industrial design practice and philosophy of technology. It also created opportunities for field studies of other design practices or ecologies of technologies to bring meaning the subject of our relations with technologies, or FT&P (sections 4.2, 9, 9.4).

MATERIALIZING TECHNOLOGIES AS FOCAL THINGS AND PRACTICES
Chapter 5 deconstructs four chronological RtD cycles, providing an anthropological account of each. This chapter demonstrates the fluid and cyclical nature of the RtD process by detailing how each cycle was framed, and subsequently would reframe the next. Each cycle is broken down and interpreted in respect to three distinct phases of a RtD cycle: first how the brief was designed and interprets the concepts from philosophy of technology into units of design; second what emerged in the design process itself, what were the concepts that designers struggled with, or knowledge generated; and lastly a reflection on the insights from this cycle and how it contributed to reframing the subsequent cycle.

Over the course of these four cycles, a deepening sophistication in navigating the concepts from philosophy of technology within a design context develops. In parallel, is an appreciation for how design can contribute to strengthening the nuance of these critiques from philosophy of technology. Through each cycle the concepts, role, and function of materiality, interactions, and traces are being framed in increasingly nuanced terms. Similarly intensifying is an understanding of how materiality, interactions, and traces can encourage opportunities for the technology to be surfaced as a FT&P. The first cycle represents initial attempts in defining traces as a concept and as a design approach (section 5.1). The second cycle turns its attention towards our ways of doing, or forms of engagement with the task of the technology, with traces as physical markers of that engagement (section 5.2). In the third cycle, the importance of drawing from historical technologies is highlighted (section 5.3). Lastly in the fourth cycle it becomes apparent that when considering FT&P in the context of networked technologies, design needs to

assume a unique framing of materialities, interactions, and traces that are distinct from the previous cycles (section 5.4).

Following the discussion analyzing the design processes in these RtD cycles, chapter 6 offers an index of the 10 design concepts whose creation is somehow related to this thesis. This index is intended as a reference for the reader. There is an image of each artifact, an attribution to the designers who created it, it original brief, the dates of its creation, and my role in its creation.

Building upon this foundation of how design was done (chapter 5) and the specific research artifacts it yielded (chapter 6), chapter 7 describes the design space that emerged in this design research process regarding surfacing technologies as FT&P. This design space consists of three patterns that point to different aspects of our relations with technologies that are obfuscated with design. Each pattern draws our attention to the different ways that we engage with technologies and their materialities, and the opportunities and design strategies within each of these patterns to surface technologies as FT&P.

In brief, these patterns represent different ways in which a technology's materiality can be conceptualized, thus too how the focal-ness of the thing and the practice can be conceptualized. The first pattern mainly addresses the physical components of technologies, in which case our relations with the physical parts and the technology's mechanisms are highlighted (section 7.1). The second pattern deals with technologies that enable people to be able to engage with a particular context (time, prerecorded music), thus in this pattern what's highlighted is how we engage with that particular context (section 7.2). In the third pattern the technologies are composed of networks, and the existence of this network and our participation and function in it is what needs to be featured in this pattern (section 7.3).

RECONCEPTUALIZING FOCAL-NESS OF THINGS AND PRACTICES
This thesis argues that the focal-ness of the thing and the practices with a technology resides in its materiality. Its materials are the parts that make up and comprise the technology and contribute to its functioning. As the sociomaterialists point, we co-constitute those materials, defining them as they define us (section 1.3). What this research as demonstrated is that the materiality varies with the technology, thus so too do the ways that we co-constitute these technologies, and the way that the focal-ness is conceptualized. For the purposes of this thesis, traces were a strategy to be able to tap into, discover, and problematize that materiality and our relations with it.

As demonstrated with the patterns (chapter 7 and 8), for defining technologies by their mechanical mechanisms, engagement takes a physical form, akin to a type of labor. For technologies defined by the context that they enable, focal-ness is directed towards that context and our engagement with it. And for defining technologies based upon the network that comprises them, focal-ness should be directed to that network and the

role that we play in that network as a node. These patterns are not necessarily mutually exclusive. As demonstrated in the rhizomatic design space, some design concepts pointed to more than one pattern. This is where designers can exercise their discretion.

This thesis does not argue a right way or a wrong way to conceptualize FT&P, but instead points to considerations to be made. Borgmann suggests that making a "case-by-case appraisal of technology['s focal-ness is] so inconclusive" (1984, 208). Instead he advocates "that the more clearly we understand the coherence and the character of the technology, the more evident it becomes to us that the technology must be [a FT&P]" (1984, 208). The patterns offered in this thesis explore this character and coherency, and the roles that design can play in supporting them (chapter 7,8). With this approach with research through design anthropology, this thesis develops ways to conceptualize the coherence and character of a technology in its design phases (chapter 5, 9).

CONTRIBUTIONS TO BE FOUND IN TRAVERSING BOUNDARIES
This thesis closes with three chapters discussing and reflecting on the lessons and contributions of this design research. The first of these discussions reflects on traversing the boundaries of this particular design space, and the sensibilities that designers can develop with the assistance of this mapping of the design space (chapter 8). Then the discussion turns to how this research traversed between academic and professional practices of design and reflects how approaching this research as a design anthropologist made this possible (chapter 9). Specially, how positioning this research between these two design practices enabled unique opportunities for professional practice to not only inform the research, but also enabled this research to reach various communities of practitioners in what's referred to in this thesis as the *knowledge exchange loop*. Lastly, there is a discussion about the observations of the tensions that emerged in this particular research process navigating between philosophy of technology and industrial design practice (chapter 10). This chapter reflects upon these tensions, and how they were problematized and piloted in the course of this research.

0.2 SUGGESTIONS FOR FUTURE RESEARCH

This thesis theorizes and makes inquires how design can encourage technologies to be surfaced as FT&P, concentrating on the design time of these technologies (section 1.2) (Fischer and Giaccardi 2006). Had this research continued another four years, the next logical step would be to examine how these technologies surface FT&P through their use, or the question of the *experience* of FT&P. What happens when technologies are designed with respect to the design space that laid out in this thesis (chapter 7)? How does mapping this design space impact professional industrial designer's practice? What is the best format to share this knowledge with them? Will the relationship that unfolds between people and the technology resemble that of the FT&P that this design space hopes to achieve?

Theorizing the role that an object will play in someone's life can only take us so far. As science, technology and society scholar Daniel R. Sarewitz reminds us, there is only so much we can understand about how a technology will shape our lives before it lives in our lives:

> When a new process or product emerges from the laboratory, it undergoes a profound transition— from well-behaved, insular idea or object to dynamic component of a complex interactive social system. Once imbedded in that social system, the new idea or innovation may produce edicts that are completely surprising. When a new television is turned on, a series of intrinsically predictable electromagnetic processes occurs inside the television that always leads to the generation of a visual image on the screen. But nothing else about the television is predicable or immediate because of all its other attributes derive not from the physical laws that allow it to operate but from the context in which it is used: when, where, and by whom is it turned on; what is being broadcast; how the viewer is affected by the program, what activities the viewer chose to forge in making the decision to watch… (Sarewitz 1996, 9)

This design space has theorized aspects of design that could support technologies to be surfaced as FT&P, but *how* or *if* these technologies will be surfaced as such is an unknown. I suggest that a longitudinal qualitative study where research artifacts designed for this purpose of surfacing FT&P are deployed in people's daily lives. Are there interactional aspects of our relations with technologies that have not been problematized in this design space? How is legibility experienced by the general user? Theorizing this design space can only take us so far, it can not always predict how these technologies may or may not fulfill this quality of a FT&P. An assumption that this design space is predictive of these technology's futures implies that this conceptual notion of FT&P has a single solution or framing, which is simply not the case (Stolterman and Wiberg 2010).

A lovely example of a case where the design was theorized to be problematic and perpetuate the device paradigm, but in practice actually presented the opportunity to surface the technology as a FT&P can be found in electric cars. In one argumentation, the device paradigm appears to extend to electric cars. They are so quiet that we are left without any clues that it is running or that its machinery is being engaged, they can have a seemingly endless supply of energy. One philosopher wrote prior to their wide spread availability that "the popular image of an electric car could hardly be more wrong as a design idea" precisely for how it encapsulates the device paradigm (Tatum 2000). However anyone who has had to take even a short road trip will a fully electric car, such as a Tesla, knows that couldn't be further from the truth. Indeed they are quiet, minimizing one avenue for us to engage on a sensorial level with the technology's function. However their energy supplies are not endless and require

significant engagement on behalf of the drivers and passengers. Personal plans have to accommodate recharging a car, which may be required several times in a single day trip, and can take hours. Not to mention that currently the location of these charging stations are few and far between. The driver and the car together calculate a route to maximize efficiency of the battery, taking into account dynamic contextual variables such as elevation in the route and possible traffic as these will impact how rapidly the battery is drained. I would argue that driving and maintaining these fully electric cars are a living example of modern technologies that is surfaced as a FT&P, at least for the time being.

The work of this thesis provides a foundation upon which such qualitative studies can be built upon. Indeed, the very philosophers that issue the critique of technologies also suggest that "traditional philosophical approaches may not be capable of questioning and challenging technology in a sufficiently radical manner" (Higgs, Light, and Strong 2000, 7). Tatum even specifically suggests that to challenge the device paradigm we must "reach into the design process itself" (Tatum 2000, 185). The research presented in this thesis offers nuance to understanding how the philosophical principles can align with design processes. But indeed, the next logical step is to have these technologies live with people to develop more of a nuanced understanding of how these relationships with people unfold, and how the framing of what needs to be supported to surface FT&P is aligned with that unfolding. T*his is a question of the experience of FT&P,* which was not empirically studied in this thesis (section 10.3).

Additionally, the mapping of the design space has illustrated that as new technologies develop, they invite a new framings of materialities and interactions. These new framings likewise invite new modes of problematizing how to support and surface FT&P. Rounding the design space we follow a history of technology: moving from mechanically operated technologies, to those that create a context for us to engage with (pattern 2, music and time), to networked connected technologies. Networks are burgeoning now, but different types of nascent technological realities which will also have to be problematized as it relates to FT&P. I think new patterns could be uncovered that problematize engagement with technologies such as learning algorithms, artificial intelligence, and mixed realities would be an interesting area to explore next. How can we make these technologies more legible to people? These emerging technologies again challenge our framing of materialities and interactions with those materialities, and our role with them in unique ways.

0.3 IMPLICATIONS

As someone who has traveled across many disciplines herself, and deeply values the impact of learning from a foreign perspective, this thesis has been motivated to make an impact on each of the disciplines it draws from. Firstly, to **philosophy of technology**, this design research offers that "radical" challenge to the device paradigm (Higgs, Light, and Strong 2000). Through its approach with research through design anthropology, this

thesis identifies that there are unique aspects of technologies that can be surfaced to promote their transition from contributing to the device paradigm to being surfaced as FT&P. This exercise in design research parses out what makes technologies, as devices and black boxes, unique from one another. And how these differences demand different problematization of materials and our engagement with them to encourage them to be surfaced as FT&P. In mapping this design space to parse out FT&P as a concept, this design research offers a rich and nuanced vocabulary demonstrating that FT&P isn't a one-size fits all category.

For **design researchers**, this work from philosophy of technology addresses mounting concern about the societal impact of design choices, which is typified by the third wave movement in the field of human computer interactions (HCI) (Fallman 2011). We should no longer evaluate technologies purely on the basis of their usability, but in consideration of the impact that they have on society, as well as the values and morals that they embody. This work from philosophy of technology on the device paradigm and FT&P an is avenue for such an exploration. This thesis responds to Daniel Fallman's provocation to this shifting basis of assessment in design, away from usability and towards encouraging us to question the metric that we evaluate what "good" design is (Fallman 2011). But there is no easy answer to what is "good" design when it comes to addressing how to support FT&P among diverse technologies and contexts. The nature of this assessment doesn't correspond to a quantifiable metric. Instead, this research draws on these concepts from philosophy of technology in order to contribute to developing a designer's ability to consider these questions in their processes of doing design.

With the mapping of the design space, **designers** are being offered a "frame," in the language of design researcher Kees Dorst, which is an attempt to address unstable, vague and changing problems full of contradictions and uncertainties (Dorst 2010). Dorst specifies that a frame is a "novel standpoint from which problematic situation can be tackled— this includes perceiving the situation in a certain way, adopting certain concepts to describe the situation, patterns of reasoning and problem solving" (Dorst 2010, 134). The mapping of the design space supporting surfacing technologies as FT&P contributes to providing designers with a viewpoint which they can navigate that concept, taking steps towards making it more stable, less vague, identifying the contradictions, and providing some clarifications. This thesis takes the position that a topic so ripe with complexity, as FT&P are, the most impact that this design research could have is in encouraging designers in developing their designedly judgment, which this thesis' design space supports. With this judgment, designers are being helped in building "a heightened sensibility of quality and composition, all with the purpose to prepare-for-action" (Stolterman 2008, 61).

Lastly, this thesis endeavors to make the academic work of philosophy of technology and design research accessible and relevant to **communities of design practitioners**. I found that industrial design practitioners were critical resources to not only grounding and deepening my perspective of how design is done outside of a research context, but

also in sharpening the sophistication and perspective of the concepts being researched themselves. By working in projects, collaborating in design projects together, the exchange was active and fluid between different research contexts and practice. The research from both the philosophy and design context intends to speak to and impact design outside its own research context, thus it incorporating that context outside of academia was vital to making that bridge (chapter 9) (Robbins and Giaccardi *forthcoming*). The beauty of bridges is not just in where we are now able to travel to, but that it is possible to travel in two directions upon them. This research was not only being shared with designer practitioners, but that design practitioners were also contributing to the formation of the research itself.

REFERENCES

Afdeling Buitengewone Zaken. 2017. "Ab/Z." *Afdeling Buitengewone Zaken*. Accessed November 30. http://afdelingbuitengewonezaken.nl.

Afdeling Buitengewone Zaken, beyond.io, FROLIC Studio, The Incredible Machine, and Holly Robbins. 2015. "The IoT Manifesto." *IoT Manifesto*. May. http://iotmanifesto.org.

Alexander, Christopher, Sara Ishikawa, and Murray Silverstein. 1977. *A Pattern Language*. Oxford University Press.

Amsterdam Institute for Advanced Metropolitan Solutions. 2017. "AMS Science for the City #5 – Democracy by Design – 22 Nov." *Ams*. November 20. http://www.ams-institute.org/news/ams-science-for-the-city-5-democracy-by-design-22-nov/.

Aprile, Walter, and Aadjan van der Helm. 2011. "Interactive Technology Design at Delft University of Technology – a Course About How to Design Interactive Products." In. London, UK.

Bardzell, Jeffrey. 2009. "Interaction Criticism and Aesthetics." In, 2357–66. New York, New York, USA: ACM. doi:10.1145/1518701.1519063.

Bardzell, Jeffrey, and Shaowen Bardzell. 2016. "Humanistic HCI." *Interactions* 23 (2). ACM: 20–29. doi:10.1145/2888576.

Baxter, Weston L, Marco Aurisicchio, and Peter R N Childs. 2016. "Materials, Use and Contaminated Interaction." *Materials & Design* 90 (January). Elsevier: 1218–27. doi:10.1016/j.matdes.2015.04.019.

Bergström, Jenny, Brendon Clark, Alberto Frigo, Ramia Mazé, Johan Redström, and Anna Vallgårda. 2010. "Becoming Materials: Material Forms and Forms of Practice." *Digital Creativity* 21 (3). Routledge: 155–72. doi:10.1080/14626268.2010.502235.

beyond.io. 2017. "Beyond.Io." *Beyond.Io*. Accessed November 30. https://www.beyond.io.

Bihr, Peter. 2017. "A Trustmark for IoT." 1st ed. ThingsCon. https://github.com/openiotstudio/general/raw/master/publications/a_trustmark_for_IoT_thingscon_report.pdf.

Bilton, Nick. 2016. "Nest Thermostat Glitch Leaves Users in the Cold." *The New York Times*, January 13, Style edition. http://www.nytimes.com/2016/01/14/fashion/nest-thermostat-glitch-battery-dies-software-freeze.html?_r=0.

Bjögvinsson, Erling, Pelle Ehn, and Per-Anders Hillgren. 2012. "Design Things and Design Thinking: Contemporary Participatory Design Challenges." *Dx.Doi.org* 28 (3). MIT Press 55 Hayward Street, Cambridge, MA 02142-1315 USA journals-info@mit.edu: 101–16. doi:10.1162/DESI_a_00165.

Bjørn, Pernille, and Carsten Østerlund. 2014. *Sociomaterial-Design*. Cambridge, United Kingdom: Springer International Publishing. doi:10.1007/978-3-319-12607-4_9.

BNR Radio. 2016. "Eye Openers." BNR Radio. https://www.bnr.nl/player?type=column&audioId=2618692.

Borgmann, Albert. 1984. *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press.

Borgmann, Albert. 1999. *Holding on to Reality*. University of Chicago Press.

Bowles, Nellie. 2016. "I Thought My Instagram Was All Mine, Until the Algorithm Proved Me Wrong." *The Gaurdian*. March 17. https://www.theguardian.com/technology/2016/mar/17/i-though-my-instagram-was-all-mine-until-the-algorithm-proved-me-wrong.

Bowles, Nellie. 2018. "Thermostats, Locks and Lights: Digital Tools of Domestic Abuse." *The New York Times*. June 23. https://www.nytimes.com/2018/06/23/technology/smart-home-devices-domestic-abuse.html?login=email&auth=login-email.

Bridgens, Ben, and Debra Lilley. 2017. *Understanding Material Change: Design for Appropriate Product Lifetimes. Understanding Material Change: Design for Appropriate Lifetimes*. © 2017 Delft University of Technology and IOS Press. doi:10.3233/978-1-61499-820-4-54.

Bright.nl. 2016. *Gevaren Van Internet of Things: Kun Je Je Broodrooster Nog Vertrouwen? Dutch Design Week*. https://www.youtube.com/watch?v=U9SMGU0qfHw.

Buchanan, Richard. 1992. "Wicked Problems in Design Thinking." *Design Issues* 8 (2). The MIT Press: 5–21. doi:10.2307/1511637?refreqid=search-gateway:03892df0745b26be3a4b48ce17be207f.

Candy, F, S Sommerville, M Kalviainen, and H Oksanen. 2004. *Temporal Transformation of Materials: Can Designers Harness the Effects of Time to Create Contemporary Aesthetic of "Worldliness" Within New Products*.

Cave, James. 2016. "A Genius Guide to Understanding the Laundry Symbols on Your Clothes." *Huffington Post*. August 23. http://www.huffingtonpost.com/entry/laundry-symbols_us_57b38324e4b04ff883993f91.

Chapman, Jonathan. 2013. "Meaningful Stuff: Toward Longer Lasting Products." In *Materials Experience*, edited by Elvin Karana, Owain Pedgley, and Valentina Rognoli, 135–43. Butterworth-Heinemann.

Creative Heroes Award. 2017. "Samenwerking - Creative Heroes Award." https://creativeheroesaward.com/genomineerden/product/samenwerking/.

Croon, Anna, and Erik Stolterman. 2003. "Everyday Aesthetics and Design of Information Technology." *Techne: Design Aesthetics Die Frage Über Technik*. University of Barcelona, Spain, 1–9.

Cross, Nigel. 1982. "Designerly Ways of Knowing." *Design Studies* 3 (4). Elsevier: 221–27. doi:10.1016/0142-694X(82)90040-0.

Dalsgaard, Peter. 2016. *Experimental Systems in Research Through Design. The 2016 CHI Conference*. New York, New York, USA: ACM. doi:10.1145/2858036.2858310.

De Ingenieur. 2017. "Paal Maakt Laadproces Elektrische Auto Zichtbaar." *De Ingenieur*, October. https://www.deingenieur.nl/artikel/paal-maakt-laadproces-elektrische-auto-zichtbaar.

Deleuze, Gilles, and Félix Guattari. 1980. *A Tousand Plateaus*. Translated by Brian Massumi. London and New York: Continuum.

Dodd Mead and Company. 1902. *Three Color Process*. *Wikimedia Commons*. New International Encyclopedia. https://commons.wikimedia.org/wiki/File:NIEdot367.jpg.

Dorst, Kees. 2010. "The Nature of Design Thinking." In, 131–39. Sydney.

Dorst, Kees. 2015. *Frame Innovation*. MIT Press.

Dourish, Paul. 2006. "Implications for Design." In, 541–50. New York, New York, USA: ACM. doi:10.1145/1124772.1124855.

Dourish, Paul. 2014. "NoSQL: the Shifting Materialities of Database Technology." *Computational Culture*, no. 4 (November). Computational Culture.

Dourish, Paul. 2016. "Algorithms and Their Others: Algorithmic Culture in Context." *Big Data & Society* 3 (2). SAGE PublicationsSage UK: London, England. doi:10.1177/2053951716665128.

Dourish, Paul, and Melissa Mazmanian. 2011. "Media as Material: Information Representations as Material Foundations for Organizational Practice." Corfu, Greece: Third International Symposium on Process Organization Studies.

Dove, Graham, Nicolai Brodersen Hansen, and Kim Halskov. 2016. *An Argument for Design Space Reflection*. *The 9th Nordic Conference*. New York, New York, USA:

ACM. doi:10.1145/2971485.2971528.

Dutch Design Awards. 2018. "Dutch Design Awards 2018." *Dutch Design Awards*. June. https://www.dutchdesignawards.nl/nl/gallery/product/the-incredible-machine/.

Ehn, Pelle. 2008. *Participation in Design Things*. Indiana University.

Engle, Emily. 2016. "17 Dutch Design Week Events to See This Week - Core77." *Core 77*. October 24. http://www.core77.com/posts/57239/17-Dutch-Design-Week-Events-to-See-This-Week.

Eriksen, Mette Agger, and Anne Louise Bang. 2013. *Experiments All the Way : Diagrams of Dialectics Between a Design Research Program and Experiments*. The Royal Danish Academy of Fine Arts, Schools for Architecture, Design and Conservation.

Eslami, Motahhare, Aimee Rickman, Kristen Vaccaro, Amirhossein Aleyasen, Andy Vuong, Karrie Karahalios, Kevin Hamilton, and Christian Sandvig. 2015. "'I Always Assumed That I Wasn't Really That Close to [Her]': Reasoning About Invisible Algorithms in News Feeds." In, 153–62. New York, New York, USA: ACM. doi:10.1145/2702123.2702556.

Fallman, Daniel. 2009. "A Different Way of Seeing: Albert Borgmann's Philosophy of Technology and Human–Computer Interaction." *Ai & Society* 25 (1). Springer-Verlag: 53–60. doi:10.1007/s00146-009-0234-1.

Fallman, Daniel. 2011. "The New Good: Exploring the Potential of Philosophy of

Technology to Contribute to Human-Computer Interaction." In, 1051–60. New York, New York, USA: ACM. doi:10.1145/1978942.1979099.

Ferri, Gabriele, Jeffrey Bardzell, Shaowen Bardzell, and Stephanie Louraine. 2014. *Analyzing Critical Designs: Categories, Distinctions, and Canons of Exemplars*. *The 2014 Conference on Designing Interactive Systems*. New York, New York, USA: ACM. doi:10.1145/2598510.2598588.

Film Archives NYC. 2014. *Mimeograph Machine (Stock Footage / Archival Footage)*. *YouTube*. https://www.youtube.com/watch?v=XFIUm0DWA74.

Fischer, Gerhard, and Elisa Giaccardi. 2006. "Meta-Design: a Framework for the Future of End-User Development." In *End User Development*, 9:427–57. Human-Computer Interaction Series. Dordrecht: Springer Netherlands. doi:10.1007/1-4020-5386-X_19.

Fisher, T H. 2004. "What We Touch, Touches Us: Materials, Affects, and Affordances." *Design Issues*.

Fritsch, Ester, Irina Shklovski, and Rachel Douglas-Jones. 2018. "Calling for a Revolution: an Analysis of IoT Manifestos." In. Montreal, QC Canada: ACM. doi:10.1145/3173574.3173876.

Gaver, Bill, and John Bowers. 2012. "Annotated Portfolios." *Interactions* 19 (4). New York: ACM: 40–49. doi:10.1145/2212877.2212889.

Gaver, William. 2011. *Making Spaces: How Design Workbooks Work*. *The 2011 Annual Conference*.

New York, New York, USA: ACM. doi:10.1145/1978942.1979169.

Gaver, William. 2012. *What Should We Expect From Research Through Design? The 2012 ACM Annual Conference*. New York, New York, USA: ACM. doi:10.1145/2207676.2208538.

Geertz, Clifford. 1973. "Thick Description: Toward an Interpretive Theory of Culture." In *The Interpretation of Cultures Selected Essays*, 3–30. Basic Books.

Giaccardi, Elisa, and Gerhard Fischer. 2008. "Creativity and Evolution: a Metadesign Perspective." *Digital Creativity* 19 (1). Routledge: 19–32. doi:10.1080/14626260701847456.

Giaccardi, Elisa, Chris Speed, and Matthijs Netten. 2016. *Things2Things - Designing in the Connected Everyday*. Delft University of Technology.

Giaccardi, Elisa, Chris Speed, Nazli Cila, and Melissa L Caldwell. 2016. "Things as Co-Ethnographers: Implications of a Thing Perspective for Design and Anthropology." In *Design Anthropological Futures*, edited by Rachel Charlotte Smith, Kasper Tang Vangkilde, Mette Gislev Kjærsgaard, Ton Otto, Joachim Halse, and Thomas Binder, 235–48. Bloomsbury Publishing.

Giaccardi, Elisa, Elvin Karana, Holly Robbins, and Patrizia DOlivo. 2014. "Growing Traces on Objects of Daily Use." In, 473–82. New York, New York, USA: ACM Press. doi:10.1145/2598510.2602964.

GINETEX. 2011. "GINTEX Newsletter 03-2011." http://www.ginetex.net/files/pdf/

extranet/ginetex_newsletter_sept2011.pdf.

Granados, Nelson. 2016. "How Facebook Biases Your News Feed." *Forbes* 18 (3): 154–82. doi:10.5840/techne201411322.

Gunn, Wendy, Ton Otto, and Rachel Charlotte Smith, eds. 2013. *Design Anthropology*. Bloomsbury.

Halpern, Sue. 2018. "Cambridge Analytica, Facebook, and the Revelations of Open Secrets," August 21. https://www.newyorker.com/news/news-desk/cambridge-analytica-facebook-and-the-revelations-of-open-secrets.

Helbing, Dirk, Bruno S Frey, Gerd Gigerenzer, Ernst Hafen, Michael Hagner, Yvonne Hofstetter, Jeroen van den Hoven, Roberto V Zicari, and Andrej Zwitter. 2017. "Will Democracy Survive Big Data and Artificial Intelligence?." *Scientific American*. February 25. https://www.scientificamerican.com/article/will-democracy-survive-big-data-and-artificial-intelligence/.

Hermans, G. 2015. "Opening Up Design: Engaging the Layperson in the Deisgn of Everyday Products." Sweden: Umeå Institue of Design.

Hern, Alex. 2017. "How Social Media Filter Bubbles and Algorithms Influence the Election." *The Gaurdian*, May 22. https://www.theguardian.com/technology/2017/may/22/social-media-election-facebook-filter-bubbles.

Higgs, Eric, Andrew Light, and David Strong. 2000. "Introduction." In *Technology and the Good Life?*, edited by Eric Higgs, Andrew Light, and David Strong, 1–15. University of Chicago Press.

Hill, William C, James D Hollan, Dave Wroblewski, and Tim McCandless. 1992. "Edit Wear and Read Wear." In, 3–9. New York, New York, USA: ACM Press. doi:10.1145/142750.142751.

Höök, Kristina, and Jonas Löwgren. 2012. "Strong Concepts: Intermediate-Level Knowledge in Interaction Design Research." *ACM Transactions on Computer-Human Interaction (TOCHI)* 19 (3). New York: ACM: 23–946. doi:10.1145/2362364.2362371.

Hughes, John, Val King, Tom Rodden, and Hans Andersen. 1994. *Moving Out From the Control Room: Ethnography in System Design*. The 1994 ACM Conference. New York, New York, USA: ACM. doi:10.1145/192844.193065.

Hughes, John, Val King, Tom Rodden, and Hans Andersen. 1995. "The Role of Ethnography in Interactive Systems Design." *Interactions* 2 (2). ACM: 56–65. doi:10.1145/205350.205358.

Ihde, Don. 1993. *Postphenomenology*. Evanston, IL: Northwestern University Press.

Ingold, T. 2013. *Making: Anthropology, Archaeology, Art and Architecture*. New York, NY: Routledge.

Junte, Jeroen. 2015. "Life Sciences en Social Design." *De Wereld Van De Architecht*, November.

Just Things Foundation. 2016. "Just Things Foundation." *Just Things Foundation*. https://justthings.org.

Karana, Elvin, Elisa Giaccardi, and Valentina Rognoli. 2017. "Materially Yours." In *Routledge Handbook of Sustainable Product Design*, edited by Jonathan Chapman, 206–21.

Karana, Elvin, Elisa Giaccardi, Niels Stamhuis, and Jasper Goossensen. 2016. "The Tuning of Materials: a Designer's Journey." In, 619–31. New York, New York, USA: ACM. doi:10.1145/2901790.2901909.

Koskinen, Ilpo, John Zimmerman, Thomas Binder, Johan Redström, and Stephan Wensveen. 2011. *Design Research Through Practice*. Elsevier.

Kuijer, Lenneke. 2014. "Implications of Social Practice Theory for Sustainable Design (Doctoral Dissertation, TU Delft, Delft University of Technology)."

Kuijer, Lenneke, and Elisa Giaccardi. 2018. "Co-Performance: Conceptualizing the Role of Artificial Agency in the Design of Everyday Life." In, 125–13. New York, New York, USA: ACM. doi:10.1145/3173574.3173699.

Latour, Bruno. 2005. *Reassembling the Social: an Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Lee, Moon-Hwan, Oosung Son, and Tek-Jin Nam. 2016. "Patina-Inspired Personalization: Personalizing Products with Traces of Daily Use." In, 251–63. New York, New York, USA: ACM. doi:10.1145/2901790.2901812.

Lee, Moon-Hwan, Seijin Cha, and Tek-Jin Nam. 2015. "Patina Engraver: Visualizing Activity Logs as Patina in Fashionable Trackers." In, 1173–82. New York, New York, USA: ACM. doi:10.1145/2702123.2702213.

Leetaru, Kalev. 2018. "Why 2017 Was the Year of the Filter Bubble?." *Forbes*, December 18. https://www.forbes. com/sites/kalevleetaru/2017/12/18/ why-was-2017-the-year-of-the-filter-bubble/#35563626746b.

Lilley, D, G Smalley, B Bridgens, G T Wilson, and K Balasundaram. 2016. "Cosmetic Obsolescence? User Perceptions of New and Artificially Aged Materials." *Materials & Design* 101 (July): 355–65. doi:10.1016/j.matdes.2016.04.012.

Manzini, Ezio. 1989. *Materia Dell'invenzione*. MIT Press (MA).

Marder, Jenny. 2015. "How Communism Turned Cuba Into an Island of Hackers and DIY Engineers." *PBS News Hour*, January 7. https://www.pbs.org/newshour/science/ isolation-generation-master-inventors-cuba.

Mazmanian, M, M L Cohn, and Paul Dourish. 2014. "Dynamic Reconfiguration in Planetary Exploration: a Sociomaterial Ethnography.." *Mis Quarterly*.

Millen, David R. 2000. *Rapid Ethnography: Time Deepening Strategies for HCI Field Research*. *The Conference*. New York, New York, USA: ACM. doi:10.1145/347642.347763.

Mozilla Open IoT. 2016. *Open Internet of Things Lab Notes*. Anstruther: Mozilla's Open Internet of Things Studio.

Nansen, Bjorn, Luke van Ryn, Frank Vetere, Toni Robertson, Margot Brereton,

and Paul Dourish. 2014. "An Internet of Social Things." In, 87–96. New York, New York, USA: ACM Press. doi:10.1145/2686612.2686624.

Orlikowski, Wanda J. 2007. "Sociomaterial Practices: Exploring Technology at Work." *Organization Studies* 28 (9). Sage PublicationsSage UK: London, England: 1435–48. doi:10.1177/0170840607081138.

Otto, Ton, and Rachel Charlotte Smith. 2013. "Design Anthropology: a Distinct Style of Knowing." In *Design Anthropology*, edited by Wendy Gunn, Ton Otto, and Rachel Charlotte Smith, 1–29. A&C Black.

O'Connor, Erin. 2006. "Glassblowing Tools: Extending the Body Towards Practical Knowledge and Informing a Social World." *Qualitative Sociology* 29 (2). Springer US: 177–93. doi:10.1007/s11133-006-9013-1.

Redström, Johan. 2017. *Making Design Theory*. MIT Press.

Redström, Johan, and Heather Wiltse. 2015. "Press Play: Acts of Defining (in) Fluid Assemblages." *Nordes* 1 (6).

Rittel, Horst W J, and Melvin M Webber. 1973. "Dilemmas in a General Theory of Planning." *Policy Sciences* 4 (2). Kluwer Academic Publishers: 155–69. doi:10.1007/BF01405730.

Robbins, Holly. 2015. "Disrupting the Device Paradigm: Designing for Mutual Praxis in Connected Objects." In, 478–84. The Hauge, The Netherlands. http://sites. thehagueuniversity.com/pinc2015/home.

Robbins, Holly. 2017. "Design to Situate Im/Material Context." In the proceedings of the Society for the Philosophy of Technology (SPT 2017). Darmstadt.

Robbins, Holly, Elisa, Giaccardi. *Forthcoming.* "Capturing Knowledge Exchange Loops in Research ____through Design." *CoDesign International Journal of CoCreation in Design and the Arts.*

Robbins, Holly, Elisa Giaccardi, and Elvin Karana. 2016. *Traces as an Approach to Design for Focal Things and Practices*. *The 9th Nordic Conference*. Gothenburg, Sweden: ACM. doi:10.1145/2971485.2971538.

Robbins, Holly, Elisa Giaccardi, Elvin Karana, and Patrizia DOlivo. 2015. "Understanding and Designing with (and for) Material Traces ." *Studies in Material Thinking* 13 (01): 1–24.

Robbins, Holly, Just Things Foundation. 2017. "The Path for Transparency for IoT Technologies." Edited by ThingsCon. *Medium*. June 12. https://medium.com/the-state-of-responsible-internet-of-things-iot/ hollyrobbins-6d2f81512242.

Robbins, Holly on behalf of Just Things Foundation. 2018 "Where Does the Responsibility Lie: A Case Study." In The State of Responsible Internet of Things (IoT). Medium. https://medium.com/ the-state-of-responsible-iot-2018/where-does-the-responsibility-lie-a-case-study-dfe33872354e

Rognoli, Valentina, and Elvin Karana. 2014. "Towards a New Materials Aesthetic Based on Imperfection and Graceful Aging." In *Materials Experience*, edited

by Elvin Karana, Owain Pedgley, and Valentina Rognoli, 145–68. Butterworth-Heinemann.

Rognoli, Valentina, and Ernesto Oroza. 2015. "'Worker, Build Your Own Machinery!' a Workshop to Practice the Technological Disobedience.," June. Nottingham. https://www.researchgate.net/publication/277326650_Worker_build_your_own_machinery_A_workshop_to_practice_the_Technological_Disobedience.

Rosner, Daniela. 2014. "Craft, Computing & Culture." In, 1–4. Seattle.

Rosner, Daniela K, Miwa Ikemiya, Diana Kim, and Kristin Koch. 2013. "Designing with Traces." In, 1649–58. Paris: ACM Press. doi:10.1145/2470654.2466218.

Rosner, Daniela, and Alex S Taylor. 2013. "Antiquarian Answers: Book Restoration as a Resource for Design." In, 2665–68. Butterworth-Heinemann. doi:10.2307/40264048?ref=search-gateway:37bfd8097fb11bfdafa44ac0ae6d2ea2.

Rosner, Daniela, Jean-François Blanchette, Leah Buechley, Paul Dourish, and Melissa Mazmanian. 2012. "From Materials to Materiality: Connecting Practice and Theory in HCI." In, 2787–90. New York, New York, USA: ACM. doi:10.1145/2212776.2212721.

Rowland, Claire, Elizabeth Goodman, Martin Charlier, Ann Light, and Alfred Lui. 2015. *Designing Connected Products*. O'Reilly Media, Inc.

Saito, Yuriko. 2008. *Everyday Aesthetics*. OUP Oxford.

Sanders, Elizabeth B N, and Pieter Jan Stappers. 2008. "Co-Creation and the New Landscapes of Design." *Co-Design* 4 (1). Taylor & Francis: 5–18. doi:10.1080/15710880701875068.

Sarewitz, Daniel. 1996. *Frontiers of Illusion*. Temple University Press.

Savič, Domen. 2017. *Alja Isaković: IOT Design Manifesto. IOT Meetup Temni Vitez Usode*. Vimeo. https://vimeo.com/214926003.

Schön, Donald A. 1983. *The Reflective Practitioner*. New York: Basic Books.

Schuler, Douglas, and Aki Namioka. 2017. *Participatory Design*. CRC Press.

Shove, Elizabeth, Mika Pantzar, and Matt Watson. 2012. *The Dynamics of Social Practice*. SAGE.

Sinnreich, Aram. 2010. *Mashed Up*. Univ of Massachusetts Press. doi:10.2307/j.ctt5vk8c2.

Smith, Rachel Charlotte. 2013. "Designing Digital Cultural Futures: Design Anthropological Sites of Transformation."

Smith, Rachel Charlotte, and Mette Gislev Kjærsgaard. 2014. *Design Anthropology in Participatory Design From Ethnography to Anthropological Critique? The 13th Participatory Design Conference*. New York, New York, USA: ACM. doi:10.1145/2662155.2662209.

Smith, Rachel Charlotte, and Mette Gislev Kjærsgaard. 2015. "Design Anthropology in Participatory Design." *Interaction Design and Architecture(S) Journal - Ixd&A* 26: 73–80.

Smith, Rachel Charlotte, Kasper Tang Vangkilde, Mette Gislev Kjærsgaard, Ton Otto, Joachim Halse, and Thomas Binder, eds. 2016. *Design Anthropological Futures*. Bloomsbury Publishing.

Speed, Chris, and Jon Oberlander. 2016. "Designing From, with, and by Data: Introducing the Ablative Framework." In. Brighton. http://www.drs2016.org/433/.

Stappers, Pieter Jan, and Elisa Giaccardi. 2017. "Research Through Design." *Interaction Design Foundation*. August. https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/research-through-design.

Steinhart, Christine. 2017. "The Next Big Thing: Thing-Centered Design." *Mindrevolution*. May. https://mindrevolution.com/de/blog/beyond/the-next-big-thing-thing-centered-design.

Sterling, Bruce. 2015. "Casa Jasmina: ThingsCon 2015." *Casa Jasmina*. May 13. http://casajasmina.cc/casa-jasmina-thingscon-2015/.

Stolterman, Erik. 2008. "The Nature of Design Practice and Implications for Interaction Design Research." *International Journal of Design* 2 (1): 55–65.

Stolterman, Erik, and Mikael Wiberg. 2010. "Concept-Driven Interaction Design Research." *Human–Computer Interaction*, June. Taylor & Francis Group.

Strauss, A, and J Corbin. 1998. *Basics of Qualitative Research: Techniques and Procedures for Producing Grounded Theory*. Sage.

Suchman, Lucy. 2007. *Human-Machine Reconfigurations*. 2nd ed. Cambridge University Press.

Tatum, Jesse S. 1994. "Technology and Values: Getting Beyond the 'Device Paradigm' Impasse." *Science, Technology, & Human Values* 19 (1). Sage PublicationsSage CA: Thousand Oaks, CA: 70–87. doi:10.1177/016224399401900105.

Tatum, Jesse S. 2000. "Design and the Reform of Technology: Venturing Out Into the Open." In, edited by Eric Higgs, Andrew Light, and David Strong, 182–94. London: University of Chicago Press.

The Incredible Machine. 2017a. "The Incredible Machine." Accessed November 30. https://the-incredible-machine.com.

The Incredible Machine. 2018. "The Incredible Machine." Rotterdam. Accessed March 22. https://the-incredible-machine.com.

The Incredible Machine. Letter. 2017b. "Kick-Off and Ideation Session on Design Brief ," February 27.

ThingsCon. 2017. "About Us." *ThingsCon*. Accessed November 30. http://thingscon.com/about/.

Thorne, Michelle, Jon Rogers, and Martin Skelly, eds. 2016. *Practices for a Healthy Internet of Things*. Visual Research Centre, Duncan of Jordanstone College of Art and Design, University of Dundee.

Tiete, Anner. Letter. 2017. "Interveiw on Thingformation Design ," May 29.

Tsaknaki, Vasiliki, and Ylva Fernaeus. 2016. "Expanding on Wabi-Sabi as a Design Resource in HCI." In. San Jose.

van Hinte, Ed. 2004. *Eternally Yours*. 010 Publishers.

van 't Hof, Jacqueline. 2016. "Conceptualizing and changing energy usage by manifesting traces of use." *Master's Thesis*. 10 June 2016. Delft University of Technology. Delft, NL.

Vanhemert, Kyle. 2015. "When Our Homes Become Connected, Designers Will Save Us." *Wired*. June 16. https://www.wired.com/2015/06/homes-become-connected-designers-will-save-us/.

Verbeek, Peter-Paul. 2002. "Devices of Engagement: on Borgmann's Philosophy of Information and Technology." *Techné: Research in Philosophy and Technology* 6 (1): 48–63. doi:10.5840/techne20026113.

Visscher, Robert. 2015. "De Slimme Wasbak Kent Zijn Gebruiker." *Trouw Letter Geest*, November 14.

Wakkary, Ron, Doenja Oogjes, Sabrina Hauser, Henry Lin, Cheng Cao, Leo Ma, and Tijs Duel. 2017. *Morse Things: a Design Inquiry Into the Gap Between Things and Us*. The 2017 Conference. New York, New York, USA: ACM. doi:10.1145/3064663.3064734.

Wax, Emily. 2013. "Beat-Up Cellphones with Cracked Screens Are Point of Pride for Some Young People." *Washington Post*, May 17, Style edition. https://www.washingtonpost.com/lifestyle/style/beat-up-cellphones-with-cracked-screens-are-point-of-pride-for-some-young-people/2013/05/17/0334ebe0-be36-11e2-89c9-3be8095fe767_story.html?utm_term=.7d16854f17a9.

Wiberg, Mikael, and Erica Robles. 2010. "Computational Compositions:." *International Journal of Design* 4 (2): 65–76.

Wiltse, Heather. 2014. "Unpacking Digital Material Mediation." *Techné: Research in Philosophy and Technology* 18 (3): 154–82. doi:10.5840/techne201411322.

Zimmerman, John, Jodi Forlizzi, and Shelley Evenson. 2007. "Research Through Design as a Method for Interaction Design Research in HCI." In, 493–502. New York.

SUMMARY

Today, the world is populated with what we colloquially refer to as "black boxes." These are technologies that perform sophisticated operations but obfuscate these complex operations, providing us with little context to what they do, how they work, and the role they play in our lives. In simple terms, this thesis addresses the following broadly framed questions: what parts of these black boxes should be made legible to the layperson? And regarding these parts: how can design be harnessed to reframe them as legible?

To approach these questions, this thesis is scaffold by philosopher of technology Albert Borgmann's framing of this particular dynamic between people and black boxes, which he refers to as the "device paradigm" (Borgmann 1984) (chapter 1). He explains that as technologies become more complex, we disburden people of that complexity by obfuscating it with design. As a result, we have limited modes of engagement with these technologies and thus also our understanding of how the *ends* of the technology (e.g., the outcome of the technology's use) are related to its *means* (e.g. the aspects of the technology responsible for the way it works). When our modes of engagement and understanding are limited, we become less aware of the role of the technology plays in our lives. As a repercussion, Borgmann argues, we can become over-reliant on that technology, and find ourselves more likely to over-consume it. The device pattern is becoming increasingly problematic in the context of our contemporary technologies, which we imbue with even more autonomy and networked capabilities such as with artificial intelligence. The implications of the illegibility behind how technologies work becomes more significant, such as with algorithms that tailor news items to what it deems to be relevant to you, but perhaps not reflective of reality.

Borgmann suggests however that the device paradigm can be reformed with focal things and practices (FT&P). In contrast to the device paradigm, FT&P draw on human engagement, and make the relation between the *ends* and the *means* legible to people. **Specifically, this thesis makes inquiries into how design can surface technologies as FT&P.**

This thesis expands upon Borgmann's notion of *means* first by relating it to "materiality." The materials are the parts that comprise the artifact, and contribute to defining it and its functioning. When we engage with the *means* of the technology, we are engaging with its materials. The theoretical lens of sociomateriality offers some perspective of our engagement with the materials or *means* of a technology. Sociomaterialits suggest that people and materials co-constitute one another, mutually defining each other. While FT&P seek to engage people in joining the *ends* and the *means* to one another, sociomateriality suggests that people are already entangled in the materials, and in this process. Thus the question becomes how to make that existing dynamic between people and materials legible and relatable as an approach to surface FT&P.

Traces are used in this thesis as a design strategy to approach exploring what aspects of

these black boxes need to be made more relatable (chapter 2). Traces provide an avenue to communicate things that may not be apparent, persistent, or perceivable to us, such as this existing co-constitutive engagement between people and materials. This touches on the objective behind FT&P, to engage people in the fullest of their capabilities and make legible the relations between the *ends* and the *means* of a technology. What traces can offer us is a way to surface, and engage us with that existing dynamic that is currently imperceivable, illegible, and obfuscated under the device paradigm.

This inquiry is pursued with a methodological approach that blends research through design and design anthropology. In essence, a series of design journeys are undertaken with a research through design approach are interpreted with a framing from design anthropology (chapter 5). In iterative research through design cycles, FT&P were translated into units of design through the making of a design brief. Designers worked with this brief to create a design concept. The brief, design process, and the resulting design concept were analyzed to reframe the research topic, which is then again explored through another cycle of research through design (chapter 3, 5). The *through* portion of this method was carried out with design anthropology, where the design process itself becomes a site of fieldwork in understanding how to navigate between philosophy of technology and design practice (chapter 4, 5). An anthropological account of four research through design cycles detail how the various research artifacts provide insight into FT&P, and also how they ultimately reframe the next cycle (chapter 5). For the reader's reference, an index of all these design concepts can be found in chapter 6.

Taking these analysis' together, three patterns emerge illustrating different modes that these technologies can engage people to surface the concept of FT&P (chapter 7). This thesis does not offer an exhaustive list of possible avenues in how to surface FT&P in technologies, but it does offer an account of what emerged in this design research process. These three patterns represent different ways in which a technology's materiality can be conceptualized, which thus suggest a spectrum of strategies by which design can support surfacing FT&P.

The first pattern mainly addresses the mechanisms that enable the operation of technologies, in which case the ways that they are used needs to be highlighted. The second pattern deals more with the broader context that the technology enables us to engage with (time, prerecorded music). Thus in this pattern what's highlighted is how we engage with that particular context. In the third pattern the technologies are composed of networks, and the existence of these networks and our role in them needs to be featured in this pattern. Together, these patterns represent the boundaries of the design space that emerged surrounding surfacing FT&P.

This thesis closes with a discussion of the various forms of "traversing" undertaken in the course of this design research, and its accompanying lessons. Firstly, this is evidenced in the traversing the particular design space that emerged, and its varying

conceptualizations of materiality and FT&P (chapter 8). Reflecting on these patterns we learn that different types of technologies are defined by their different types of materialities, which likewise require different conceptualizations of FT&P. The methodological approach also was a type of traversing. This methodological traversing is not only between research through design and design anthropology, but also in terms of the context of where these methodologies were employed: within academia as well as professional design practice. This produced a unique ecosystem of knowledge exchange, where collaborating lead to opportunities to not only inform research but also to disseminate it within industry (chapter 9). Lastly, this thesis reflects on navigating between the disciplines of philosophy of technology and design practice and the different tensions that unfolded in working between them (chapter 10).

The conclusion of this thesis summarizes the arguments presented and discusses areas for future research. It closes with final thoughts about the contributions that this thesis offers to the different communities it addresses: design researchers, philosophers of technology, and design practitioners.

SAMENVATTING

We bevinden ons in een wereld bezaaid met technologie waarnaar we doorgaans refereren als "zwarte dozen". Deze technologieën nemen ingewikkelde handelingen voor hun rekening, maar ze verdoezelen tegelijk deze complexe handelingen, door ons weinig context te geven van wat ze eigenlijk doen, hoe ze werken, en welke de rol ze vervullen in onze levens. Simpel gesteld, kaart dit proefschrift de volgende breed gestelde vragen aan: welke aspecten van deze zwarte dozen moeten er exact inzichtelijk gemaakt worden om ze "leesbaar" te maken voor een leek? Daarnaast: hoe kan ontwerp ingezet worden om deze aspecten te herdefiniëren als leesbaar?

Om deze vragen te benaderen, wordt in dit proefschrift gebruik gemaakt van technologie-filosoof Albert Borgmann's raamwerk voor de specifieke dynamiek die optreedt tussen mensen en zwarte dozen, waarnaar hij refereert als het *device paradigm* (toestel paradigma) (Borgmann 1984) (hoofdstuk 1). Hij legt uit dat naarmate technologie complexer wordt, we mensen ontlasten van deze complexiteit door deze te verhullen door middel van ontwerp. Het gevolg is meer beperkte manieren van betrokkenheid met deze technologieën en daardoor ook een meer beperkt inzicht in hoe de *doelen* van de technologie (bv, het resultaat van het gebruik van de technologie), relateren tot de *middelen* (bv. De aspecten van de technologie verantwoordelijk voor zijn werking). Wanneer onze wijze van betrokkenheid en inzicht beperkt zijn, worden we ons minder bewust van de rol die de technologie in ons leven inneemt. Als repercussie beweert Borgmann dat we over-afhankelijk kunnen worden van deze technologie, en het waarschijnlijker wordt dat we deze technologie gaan over-consumeren. Het *device paradigm* wordt in toenemende mate problematisch in de context van onze hedendaagse technologieën, die we toebedienen met steeds meer autonomie en verbondenheid

zoals het geval is met artificiële intelligentie. De implicaties van de onleesbaarheid van hoe deze technologieën werken wordt steeds meer zichtbaar, zoals bij algoritmes die je nieuws op maat voorschotelen, zonder daarbij noodzakelijk de realiteit te weerspiegelen.

Borgmann suggereert daarentegen dat het *device paradigm* kan bijgesteld worden door middel van *focal things and practices* (FT&P). In tegenstelling tot het *device paradigm*, volgt FT&P menselijk engagement, en maakt het de relatie tussen de *doelen* en de *middelen* inzichtelijk voor de mensen. **Dit proefschrift doet specifiek onderzoek naar hoe ontwerp technologieën naar de oppervlakte kan brengen als FT&P.**

Dit proefschrift breidt Borgmann's notie van *middelen* eerst uit door het te koppelen aan "materialiteit". Materialen zijn de onderdelen die samen een artefact vormen, en dragen bij tot het definiëren van het artefact en zijn functioneren. Wanneer we ons koppelen aan de *middelen* van technologie, koppelen we ons met zijn materialen. De theoretische lens van sociomaterialiteit biedt ons perspectief op onze koppeling met de materialen of *middelen* van een technologie. Sociomaterialisten suggereren dat mensen en materialen elkaar vormen, elkaar wederzijds definiëren. Waar FT&P tracht mensen te koppelen door de *doelen* en de *middelen* aan elkaar te rijgen, suggereert sociomaterialiteit dat mensen al verwikkeld zijn in de materialen, en in dit proces. Daarmee wordt de vraag hoe deze bestaande dynamiek tussen mensen en materialen leesbaar en relateerbaar te maken als een manier om FT&P naar de oppervlakte te brengen.

Sporen worden gebruikt in dit proefschrift als een ontwerpstrategie, met als doel het verkennen welke van de aspecten van deze zwarte dozen meer relateerbaar gemaakt moeten worden (hoofdstuk 2). Sporen zorgen voor een manier om zaken te communiceren die niet per sé vanzelfsprekend, aanhoudend of waarneembaar zijn, zoals het hierboven beschreven wederzijdse vormen en definiëren van mensen en materialen. Dit raakt een doelstelling van FT&P, om mensen te betrekken in hun volste mogelijkheden en om de relaties tussen de *doelen* en de *middelen* van een technologie leesbaar te maken. Sporen geven ons een manier om dit naar de oppervlakte te brengen, en betrekken ons met deze bestaande dynamiek die op dit moment niet waarneembaar, onleesbaar en verduisterd is door het *device paradigm*.

Deze verkenning is voortgezet met een methodologische aanpak die *research through design (*onderzoek door ontwerp) en *design anthropology* (ontwerpantropologie) in elkaar verweeft. Concreet, werden er een reeks ontwerptrajecten uitgevoerd waar onderzoek door middel van een ontwerpaanpak wordt geïnterpreteerd in een raamwerk van ontwerp antropologie (hoofdstuk 5). In iteratieve *research through design* trajecten, werd FT&P vertaald in ontwerpuitkomsten door het opstellen van een *design brief* (ontwerpopdracht). Ontwerpers gingen aan de slag met deze opdracht om een conceptueel ontwerp te creëren. De opdracht, het ontwerpproces en de resulterende ontwerpuitkomsten werden geanalyseerd om het onderzoeksonderwerp te herdefiniëren, welke op zijn beurt opnieuw verkend wordt door middel van een volgende iteratie

van *research through design* (hoofdstuk 3, 5). Het *door middel van* gedeelte van deze methode werd uitgevoerd middels ontwerp antropologie, waarin het ontwerpproces zelf het onderwerp voor veldwerk wordt; in dit proces komen inzichten naar boven in hoe te schipperen tussen technologie-filosofie en de ontwerppraktijk (hoofdstuk 4, 5). Een antropologische beschrijving van vier *research through design* cycli beschrijft hoe de verschillende onderzoeks artefacten voor inzichten in FT&P zorgen, en hoe ze ook uiteindelijk zorgen voor een herdefiniëring van een volgende iteratie (hoofdstuk 5). Ter referentie voor de lezer, werd er een index van al deze ontwerpconcepten opgenomen in hoofdstuk 6.

Door deze analyses samen te nemen, komen er drie patronen naar boven die verschillende manieren illustreren waarop technologie mensen kan betrekken om het concept van FT&P naar de oppervlakte te brengen (hoofdstuk 7). Dit proefschrift voorziet geen sluitende lijst van manieren om FT&P naar de oppervlakte te brengen in technologieën, maar het biedt een relaas van wat er tijdens het ontwerp-onderzoeksproces naar boven komt. Deze drie patronen vertegenwoordigen verschillende manieren waarop de materialiteit van een technologie geconceptualiseerd kan worden, wat dus een spectrum van strategieën suggereert waarmee ontwerp het aan de oppervlakte brengen van FT&P kan ondersteunen.

Het eerste patroon richt zich voornamelijk tot de mechanismen die de werking van een technologie mogelijk maken, in zulk geval moeten de manieren waarop ze gebruikt worden onder de aandacht gebracht worden. Het tweede patroon behandelt meer de bredere context waarinde technologie ons aanzet om ons ermee te betrekken (tijd, opgenomen muziek). Daarom wordt er in dit patroon onder de aandacht gebracht hoe we ons koppelen met deze bepaalde context. In het derde patroon zijn de technologieën opgebouwd uit netwerken, en moet het bestaan van deze netwerken en onze rol hierin in het patroon voorzien worden. Samen vertegenwoordigen deze patronen de grenzen van de ontwerpruimte welke voortkwam uit het naar de oppervlakte brengen van FT&P.

Dit proefschrift sluit af met een discussie over de verschillende manieren van "oversteken" welke in dit ontwerponderzoek ondernomen werden, en de bijbehorende lessen die daaruit geleerd werden. Ten eerste, wordt dit aangetoond in het oversteken van de bepaalde ontwerpgebieden die naar de oppervlakte kwamen, en de diverse conceptualisaties van materialiteit en FT&P (hoofdstuk 8). Terugkijkende op deze patronen, leren we dat verschillende types technologieën gedefinieerd zijn door hun verschillende types materialiteit, welke op hun beurt verschillende conceptualisaties van FT&P vereisen. De methodologische aanpak was op zijn beurt ook een soort oversteek. Deze methodologische oversteek is er niet enkel tussen *research through design* en *design anthropology*, maar ook met betrekking tot waar deze methodologie toegepast werd: zowel in academische als in beroepsmatige ontwerpcontext. Dit zorgde voor een uniek ecosysteem van kennisoverdracht, waar samenwerking leidde tot kansen om niet alleen onderzoek te verrijken maar ook om deze kennis binnen het vakgebied te

verspreiden (hoofdstuk 9). Tot slot reflecteert dit proefschrift op het navigeren tussen het vakgebied van de technologiefilosofie en het ontwerpvak en de verschillende spanningsvelden die zich ontplooien wanneer beide met elkaar in contact komen (hoofdstuk 10).

Het besluit van dit proefschrift vat de voorgestelde argumenten samen en bespreekt mogelijke gebieden voor toekomstig onderzoek. Het sluit af met definitieve bedenkingen over de bijdrage diedit proefschrift levert aan de verschillende gemeenschappen waaraan het gericht is: ontwerponderzoekers, technologie-filosofen, en ontwerpers.

APPENDIX 1: FIRST RTD CYCLE DESIGN BRIEF

Traces of Use, ITD 2015, Design Brief

Meta Design Brief:

Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. Within this section, there are 3 sub-briefs. Each sub-brief asks for designers to make it possible for physical traces as a means to communicate different aspects of the connected object. In each case it communicates different things about the object and its user(s):

1. communicate how the connected object is manually used
2. communicate the digital content of the connected object
3. enable the user to make use of the digital aspect of the connected object

These physical traces can not be screen-based. In each case, traces are used to serve as a manifestation of different types of data or interactions with the connected object; all in an attempt to help bridge the digital and physical use of the object.

Sub-Briefs

Variable 1: Traces to demonstrate manual use of connected object
Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. **Your design should utilize material traces as a means to manifest how the connected object is manually used. This trace is intended to serve as a manifestation of the interactions with the connected product.** Consider a leather shoe as an analog example of this. We "break in" a leather shoe to fit our feet perfectly and create material traces (the wearing and stretching of the leather) in this process. These material traces of breaking the leather in demonstrate how the object was used. Apply this process of traces to a connected object so that it communicates how it has been used.

Variable 2: Traces to demonstrate digital use
place two groups on this brief
Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. **Your design should link how the digital content of the connected object with a material trace. In other words, enable the object to use physical traces to manifest data from the connected object.** This manifestation of data can not be a screen-based interactions or traces, it must be physical and on the object itself.

Variable 3: Trace making to use digital
Hack an existing product to make it a "connected object", and give it the ability to show traces of people that use it. Connected products, such as the Nest Thermostat, are objects that are one part physical and material; while the other part is an immaterial layer of computation, data, or algorithms. **Your design should utilize physical traces as a means to use or uncover the digital aspect of the connected object. Here, physical traces are to be created by the user to interact with the "connected" dimension of the connected object.** As much as it is possible, avoid screen-based interactions.

APPENDIX 2: TRACES CHECK LIST

Traces Check List

Object characterists:

☐ Object of daily use

☐ Connected Objected (has two parts: physical and computational components)

Traces:
☐ Permanent and cumulative

☐ Reflection of how object is used/ works

☐ Result of a physical interaction with the object itself or the role that the object plays in our daily life

☐ Trace not too far removed from the object itself (trace on the object itself or in the immediate context of the object)

Variable 1	Variable 2	Variable 3
(group 1)	**(group 2 & 4)**	**(group 3)**
Traces to reflect the how the object as a whole is manually engaged with. Reflect the context of the object's use	Traces somehow reflect the computational layer of the object onto the object itself	Trace making to unmask the computational layer of the object.
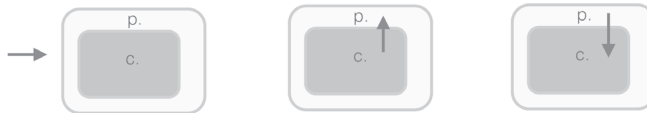
APPENDIX 3: SECOND RTD CYCLE DESIGN BRIEF

Graduation Project Design Brief
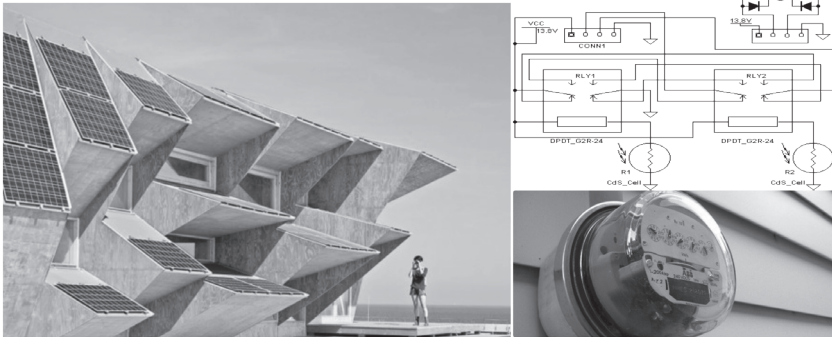**Conceptualizing and Changing Energy Usage with Material Traces**
29 June 2015

Smart, or connected objects, continue to proliferate our technological landscape. This comes with great advantages, such as technologies that are more efficient, and respond to the people using them and their environment more effectively. However, a consequence is that the people using them lack a reciprocal knowledge of that technology. Philosophers of technology argue that when the ends and the means become segregated from one another, the only mode of engagement that people can have with technologies is to consume them, and further, they become replaceable or disposable commodities.

In contrast, consider how other material objects reflect the way that they're used and demonstrate a reciprocal knowledge of the people using them and their environment. Leather shoes for example stretch and change shape to fit the wearer's foot perfectly. The scratches and the watermarks reveal the environments that the shoe lives in. This material form of communication that show traces of use are critical to our relationship with the object.

This project will attempt to help people understand their usage of solar energy by utilizing material traces as a design approach. As it has been suggested, not understanding how the technology functions and the role that it has in our lives leads to unmindful consumption. With a design that utilizes material traces, this project will attempt to make people more conscientious, and ideally more careful with what they consume. This project will produce a designed connected object that communicates how the technology functions and utilizes material traces to communicate usage as a means to help reduce energy consumption.

Requirements in detail:
- Physical, connected object is designed that represents solar energy usage
- Traces and are not screen-based. Ideally limited screen based interactions
- Traces are permanent and cumulative
- Traces reflects how the technology works and is used

APPENDIX 4: THIRD RTD CYCLE DESIGN BRIEF

co-performing with technology
design brief

There was once a time when we used technologies and there was a trace of the ways we used it. A leather shoe is an example of this: we understood that through our use we broke it in, and traces of this was that it fit our foot perfectly. However, this is not the case with more contemporary technologies where, for the sake of usability, the way the technology works and the job it does is not communicated back to us.

This does not happen with contemporary technologies. Instead of co-performing with it, we expect it to be at our service. How we work with it is made invisible to us. We favor a Nest thermostat (which is intended to be invisible and doesn't require our engagement) to a fireplace (which requires co-performance in making and maintaining and tending to leaves traces of skill and is the focal point of a home).

Your group will be given a technology that you will have to redesign the interaction for so that the technology requires people to be engaged in and participate in the task the technology performs. **Note:** This does not mean that the interaction has to be labor-intensive or inconvenient. Additionally, your design must use traces as a means to show this interaction occurred.

Design criteria:

- People should help in co-performing the task of the technology. Evidence of this co-performance should be in the form of a trace.

- Traces should represent how people engage with the with the technology in an understandable way

- Traces should be long-term and a part of the technology itself, and not temporary or disposable.

- Traces can not be screen based.

APPENDIX 5: FOURTH RTD CYCLE DESIGN BRIEF

Design Brief
Tracing Sociomateriality

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/////////////////////////

Context:
By definition, the very materials that define many of our technological advances today are ones that are not perceivable to us. These are the materials like code, the learning algorithms, energy, and data that are that shape our world, similar to how wood, and stone and plastics do. The very nature of our inability to perceive them means that we are fundamentally separating the *ends* from the *means*. We don't have a sense of how these materials work, or how we work with them. There is always a fluid relation among how people, their ways of doing, and materials are entangled and constituting one another. A Google search yields certain results because an algorithm ranks pages in terms of what appears to be the most popular pages, and a physical server that sits in a building that is constantly cooled stores that page which the algorithm ranks.

Consider this in the domain of energy. How energy is produced or delivered to our homes is very removed from how we consume it. By turning a dial on our thermostat, we have no concept of how technological devices are heating up a boiler in the basement, or collecting stored energy from a battery cell. We have no notion of the energy grid that we are a node in, or the systems that are in place to receive the energy. As a result, the energy

Domain
Home. Design for a device or practice where an object consumes energy that people use often, and regularly forget about it while it's consuming energy.

Problem
Find a way to bring the ends and the means of how energy is procured and consumed closer together. Energy consumption through this device should not be something that is automated or regulated to the background. Instead, people should be engaged in the task of the technology. Use traces as a means to illustrate this process. Traces should not be screen based.

Requirements
- Create a working prototype that can run continuously for 8 hours without needing to be maintained.
- Create a prototype that tells a story, and illustrates the problem described
- Prototype is not an art piece, but an object that could reasonably be in someone's home in the near future.
- Operating the technology should not be inconvenient

Comparable projects
- Geist
- Mizu
- Photobox
- Olly
- A/B toaster

APPENDIX 6: INTERNET OF THINGS (IOT) DESIGN MANIFESTO

V1.0 · May 2015

IOT DESIGN MANIFESTO

The world is becoming increasingly connected. This offers opportunities for designers, engineers and entrepreneurs to create unprecedented products and services. Yet, a connected world also brings new questions and challenges to the table.

This manifesto serves as a code of conduct for everyone involved in developing the Internet of Things, outlining 10 principles to help create balanced and honest products in a burgeoning field with many unknowns.

First drafted by a number of design professionals, this manifesto is intended to be a living document that the larger community of peers working within the IoT field can contribute to and improve upon.

This manifesto is a living document, we seek your input to help it grow. Please discuss, contribute, remix, and test the boundaries of these principles.

www.iotmanifesto.org

WE DON'T BELIEVE THE HYPE — I

We pledge to be skeptical of the cult of the new — just slapping the Internet onto a product isn't the answer. Monetizing only through connectivity rarely guarantees sustainable commercial success.

WE DESIGN USEFUL THINGS — II

Value comes from products that are purposeful. Our commitment is to design products that have a meaningful impact on people's lives; IoT technologies are merely tools to enable that.

WE AIM FOR THE WIN-WIN-WIN — III

A complex web of stakeholders is forming around IoT products: from users, to businesses, and everyone in between. We design so that there is a win for everybody in this elaborate exchange.

WE KEEP EVERYONE AND EVERY THING SECURE — IV

With connectivity comes the potential for external security threats executed through the product itself, which comes with serious consequences. We are committed to protecting our users from these dangers, whatever they may be.

WE BUILD AND PROMOTE A CULTURE OF PRIVACY — V

Equally severe threats can also come from within. Trust is violated when personal information gathered by the product is handled carelessly. We build and promote a culture of integrity where the norm is to handle data with care.

WE ARE DELIBERATE ABOUT WHAT DATA WE COLLECT — VI

This is not the business of hoarding data; we only collect data that serves the utility of the product and service. Therefore, identifying what those data points are must be conscientious and deliberate.

WE MAKE THE PARTIES ASSOCIATED WITH AN IOT PRODUCT EXPLICIT — VII

IoT products are uniquely connected, making the flow of information among stakeholders open and fluid. This results in a complex, ambiguous, and invisible network. Our responsibility is to make the dynamics among those parties more visible and understandable to everyone.

WE EMPOWER USERS TO BE THE MASTERS OF THEIR OWN DOMAIN — VIII

Users often do not have control over their role within the network of stakeholders surrounding an IoT product. We believe that users should be empowered to set the boundaries of how their data is accessed and how they are engaged with via the product.

WE DESIGN THINGS FOR THEIR LIFETIME — IX

Currently physical products and digital services tend to be built to have different lifespans. In an IoT product features are codependent, so lifespans need to be aligned. We design products and their services to be bound as a single, durable entity.

IN THE END, WE ARE HUMAN BEINGS — X

Design is an impactful act. With our work, we have the power to effect relationships between people and technology, as well as among people. We don't use this influence to only make profits or create robot overlords; instead, it is our responsibility to use design to help people, communities, and societies thrive.

An initiative of **Afdeling Buitengewone Zaken · Beyond.io · FROLIC Studio · The Incredible Machine**

APPENDIX 7: FISHERMAN'S INTERNET OF THINGS (IOT)

Excerpt from (Thorne, Rogers, and Skelly 2016)

What can IoT learn from fishermen?

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Peter Bihr, Holly Robbins
& Leonardo Amico

We were brought to the "edge of the world" not because it was beautiful, unspoiled, or quaint, but to work with and learn from local communities. We found a community that was very special in that it was both savvy and conservative in its adoption of technology: the men of the Fishery Museum's boatyard, who preserve, maintain, repair and revive a number of historic fishing boats—primarily the Reaper. This group is special in that it cares deeply about technology, practices, and history, and does so in a way that focuses on a very specific time. This is a snapshot of technology in the 1920s, as sailing boats were transitioning from sails to engines: a boat like the Reaper would be built with the straightforward methods and technology of a sailboat, and enhanced by a powerful engine. Digital technology was not part of the picture.

Examining the boats and speaking to experts on historical fishing vessels, we found that the way these

fishermen—the crew of the Reaper was comprised of 8 men and 1 boy— interacted with technology, their expectations, skills, as well as the way the boat was built in the first place, has a lot to offer contemporary IoT practices.

A Scottish Fisherman's vessel from the turn of the century was built for extreme conditions. The boat had to be a self-sustaining unit that could weather critical conditions. It had to make wise use of scarce resources. The crew had to be able to maintain and fix the boat, as well as improvise solutions to unexpected challenges.

A vessel like the Reaper betrays the practices and insights of hundreds of years of experience. It is, in tech parlance, a mature and self-contained ecosystem—one that has to work with a large degree of autonomy, be self-reliant, and adaptable, no matter what conditions it operates in. These constraints can provide valuable guidance for the way we can design and think about IoT systems, products, and services. For contexts of no/low connectivity, the parallels between a boat and those IoT systems are obvious.

However, we believe that even in contexts that allow for more reliable connectivity there is much to be gained from operating more like a boat: with a larger degree of autonomy, self-reliantly, adaptable, and built to work in less-than-perfect conditions.

IoT systems, like boats, are ecosystems

The vessel is operated by a finely tuned and responsive ecosystem. The boat is an ecology of the relationships among several notable nodes. It is where people, materials, technologies, and the environment converge and work together.

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Background: The Reaper

The boat we visited and examined is the
Reaper. Reaper is a Fife Sailing Herring
Drifter, the most popular design of fishing
boat on the East Coast of Scotland for the
greater part of the 19th and early 20th
Centuries. Built in 1902 she began life as a
two masted sailing lugger. She had an engine
installed for the first time in 1916. In the
late 1930's she held the record catch of
herring in Shetland, some 223 crans — almost
a quarter of a million fish.

Source: Scottish Fishery Museum

The Reaper's Capstan, Anstruther 2016

• •

This ecosystem responds constantly to its environment: weather conditions will determine how the boat is powered (engine vs. sail), and how people work together to operate that technology.

The same should happen in a networked space (a home, a village, a city), where all nodes are equally important and each has its role. IoT is more than the Internet in Things. It is an ecosystem comprised of all the nodes that play a part.

Materials live and change

The wood that a boat is made of is never static, it changes shape and size based on how much water it has absorbed, and the content of salt in that water. It is constantly in flux. A fisherman and a boat maker respond to these changes in their materials to keep the boat seaworthy. The ship consists of materials, and those materials are living and responsive. They respond to the different nodes of the ecosystem. The materials of an IoT are also not static. The IoT also consists of familiar physical materials beyond chips and screens but we should also ask: what are the basic materials of our digital world, and how might we work with their characteristics and fluidity? For example, signal can be weak or strong depending on elements the radio waves encounter; algorithms depend on their interactions with input from human and non-human sources, including that of other algorithms.

People are nodes in the IoT

A fishing vessel is a complex technology that requires several sailors to operate. To ensure that the vessel can run smoothly, every crew member needs to be able to cover all the basics and to work together in synergy. The Reaper required 8 men and a boy to operate. The line of vision from the helm to the front of the boat is obstructed by masts and equipment. Navigating alone required one man at the steering wheel, and another

upfront to serve as the eyes of the captain. In the boat people worked collaboratively with technologies to perform the tasks needed. Humans were also nodes of the vessel's ecosystem.
IoT technologies should not replace people, but instead integrate and support them. People and technologies are part of the same network and they cannot prescind from each other.

Technology should be legible to people

A vessel was not stocked with many tools, but the tools that were there were those that could be utilised for many purposes. It was apparent how these tools could be used: rope could be used to hoist a sail, bind a broken rudder in an emergency, and when it was weak, be re-woven as a buoy to protect the side of the boat from scratches. Technologies on a boat are highly legible and hence easy to understand, modify, and work with. Many technologies on a boat didn't live a single life: Their simple technical construction made their use apparent, and made it also possible to repair or re-appropriate to address new uses when they arose. Nodes in IoT should not be black boxes. They should be legible to the general user. Low-tech can be the best tech if it is open; open in such a way that people not only can understand how to use it, but also how it could be used, repaired, or re-appropriated. This is empowering.

A technology should be robust within its environment Fishermen make use of several modes of navigation. There are those that are observable to the naked eye such as landmarks and other orientational technologies such as compasses, maps, and stars. When visual cues can not be of service, such as in a fog, audial cues come from a fog horn. Later sonar, radar, and GPS joined the menu of tools available. Each of these tools are resistant to the natural elements that the fisherman faces: rain, sea water, changes in incline,

and wind. Also, none of these technologies retired the others—they complement each other and serve as mutual failsafes. The fishermen's technologies are robust because they are resilient in their environments. They promote redundancies and failsafes. IoT should be built with critical conditions in mind, offering alternative opportunities and avenues for the same needs to be met. It should rely on perfect connectivity as little as possible.

Pragmatism over perfection

The Herring Drifter the Reaper was originally designed to hold a massive mast that stands more than 56 feet tall. For the first 14 years of the boat's life, the boat was exclusively powered by sail. Despite the fact that this sail was a part of the original design, the mast does not perfectly fit into place on the boat as the materials live and change. Instead, there is a plank of wood wedged in next to this mass that's approximately 6 feet tall extending from the deck to the cabin below to hold the mast in place.

Things don't have to be perfect. Instead of aiming for what is theoretically ideal, the practices that prevail are those that are effective and realistic. These are systems where parts can be adopted and incorporated into other parts, and make sense in their own environment. IoT should be built to evolve, and in a way that can support emergent qualities. Expect for the system to grow and adapt within itself, and to be adapted and modified by its users.

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I once took a course in anthropology where the professor insisted that we spend at least a quarter of the class discussing the acknowledgement section of the manuscript we had read that week. This was a critical tool to bring context to the intellectual heritage, orientation, and biases of the author. So, you can imagine the pressure I feel now. This acknowledgement section however will be more sentimental than anything else.

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ABOUT THE AUTHOR

Holly Robbins was born in New York City (USA). Holly joined Delft University of Technology in February 2014 as a PhD candidate in Industrial Design. She works closely with a group of professional designers in advocating for the responsible design of internet-connected and data-intensive technologies with the Just things Foundation, of which she is a co-founder.

Prior to starting her PhD, she completed her master's at New York University's (NYU) department of Media, Culture, and Communication with a specialization in human computer interaction (NY, USA). While at NYU, Holly worked at the Game Innovation Lab. In her bachelor's, her studies were focused in anthropology and politics and was completed at Sarah Lawrence College (NY, USA). Holly has also worked as a political analyst for an Arab embassy in Washington D.C. and trained as a classical musician.

CURRICULUM VITAE

Journal Articles

Robbins, Holly, Elisa, Giaccardi. (*Forthcoming)* "Capturing Knowledge Exchange Loops in Research through Design." CoDesign International Journal of CoCreation in Design and the Arts.

Robbins, Holly; Elisa Giaccardi; Elvin Karana; and Patrizia D'Olivo. (2015). "Understanding and Designing with (and for) Material Traces." Studies in Material Thinking 13(01).

Robbins, Holly, and Katherine Isbister. "Playdates with Big Brother: Playfully Repurposing Surveillance Cameras to Build Communities." Surveillance & Society 12.3 (2014): 448-458.

Conference Papers

Robbins, H., Giaccardi, E., Karana, E. (2016). Traces as an Approach to Design for Focal Things and Practices. In Proceedings of NordiCHI'16: 11th Nordic Conference on Human-Computer Interaction. October 23 – 27, 2016, Gothenburg, Sweden. ACM, 2016.

Giaccardi, Elisa; Elvin Karana; Holly Robbins; and Patrizia D'Olivo. "Growing traces on objects of daily use: A product design perspective for HCI." Proceedings of the 2014 conference on Designing interactive systems. ACM, 2014.

Book Chapter

Robbins, Holly (*Forthcoming*) "Using Design to Support Relatability of Networks." in *Relating To Things as They Relate to Us*. Eds. Heather Wiltse and Michel Puech. Springer.

Accepted Conference Talks

Robbins, Holly. "Using Design to Explore How to Unmask Black Boxes**."** In the proceedings of Philosophy of Human Technology Relations Conference. July 2018. Twente, Netherlands.

Robbins, Holly. "When "implications for design" become "implications for philosophers"" In the proceedings of Philosophy of Human Technology Relations Conference. July 2018. Twente, Netherlands.

Robbins, H., Giaccardi, E., & Karana, E. (2017). Exploring Resolutions to the Device Paradigm with Speculative Design. In the proceedings of the 2017 conference of the Society for Social Studies of Science (4S 2017). August 2017 Boston, MA.

Robbins, H. (2017). "Design to Situate Im/material Context." In the proceedings of the 2017 conference of the Society for Philosophy of Technology (SPT 2017). June 2017. Darmstadt, Germany

Workshop Papers

Robbins, Holly; Elisa Giaccardi; and Elvin Karana. "Politics of Impermanence: Traces of Use as a Design Strategy for Technologies" Workshop: Things Fall Apart. NordiCHI'16: 11th Nordic Conference on Human-Computer Interaction. October 22, 2016, Gothenburg, Sweden. ACM, 2016.

Robbins, Holly; Elisa Giaccardi; and Elvin Karana. "De-Commodifying the Device: A Materialist Design Approach for Communication With and Through Connected Objects." Workshop: The Future of Making: Where Industrial and Personal Fabrication Meet. Critical Alternatives 2015. Aarhus, Denmark. August 2015.

Robbins, Holly; Elisa Giaccardi; and Elvin Karana. "Orienting the Utility of Anthropology in Design." Conference Position Paper: Design Anthropological Futures. Copenhagen 12-15 August 2015

Robbins, Holly. "Disrupting the Device Paradigm: Designing for Mutual Praxis in Connected Objects." Participatory Innovation Conference 2015. The Hague, The Netherlands. May 2015.

Robbins, Holly, and Katherine Isbister. "Pixel Motion: A Surveillance Camera-Enabled

Public Digital Game." Foundations in Digital Games. Ft. Lauderdale, Florida. 3-7 April 2014.

Katherine Isbister; Robbins, Holly; O'Gorman, Lawrence; Yin, Yafeng; et al. "Liberating Public Cameras." Experiencing Interactivity in Public Spaces Workshop: ACM SIGCHI on Human Factors in Computing Systems Annual Conference 2013 (CHI 2013). Paris, France. April 2013.

Publications Outside Academia

Robbins, Holly on behalf of Just Things Foundation. 2018 "Where Does the Responsibility Lie: A Case Study." In The State of Responsible Internet of Things (IoT). Medium. https://medium.com/the-state-of-responsible-iot-2018/where-does-the-responsibility-lie-a-case-study-dfe33872354e

Robbins, Holly on behalf of Just Things Foundation. 2017 "The Path for Transparency for IoT Technologies." In The State of Responsible Internet of Things (IoT). Medium. https://medium.com/the-state-of-responsible-internet-of-things-iot/hollyrobbins-6d2f81512242

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This thesis explores how to support philosopher of technology Albert Borgmann's concept of *"focal things and practices"* with design. In particular it examines how to frame and engage varying forms of a technology's materiality. Research through design is employed to develop an understanding of how design can support surfacing focal things and practices of a technology by demonstrating our relation with its materialities. Ultimately, we find that different types of technologies and materialities demand different conceptualizations of focal things and practices themselves.

The through portion of this process was carried out with design anthropology, where the design process itself becomes a site of fieldwork in understanding how to navigate between philosophy of technology and design practice. This thesis maps a design space around supporting surfacing focal things and practices, while also reflecting on a meta-level about how to navigate trans-disciplinary work.