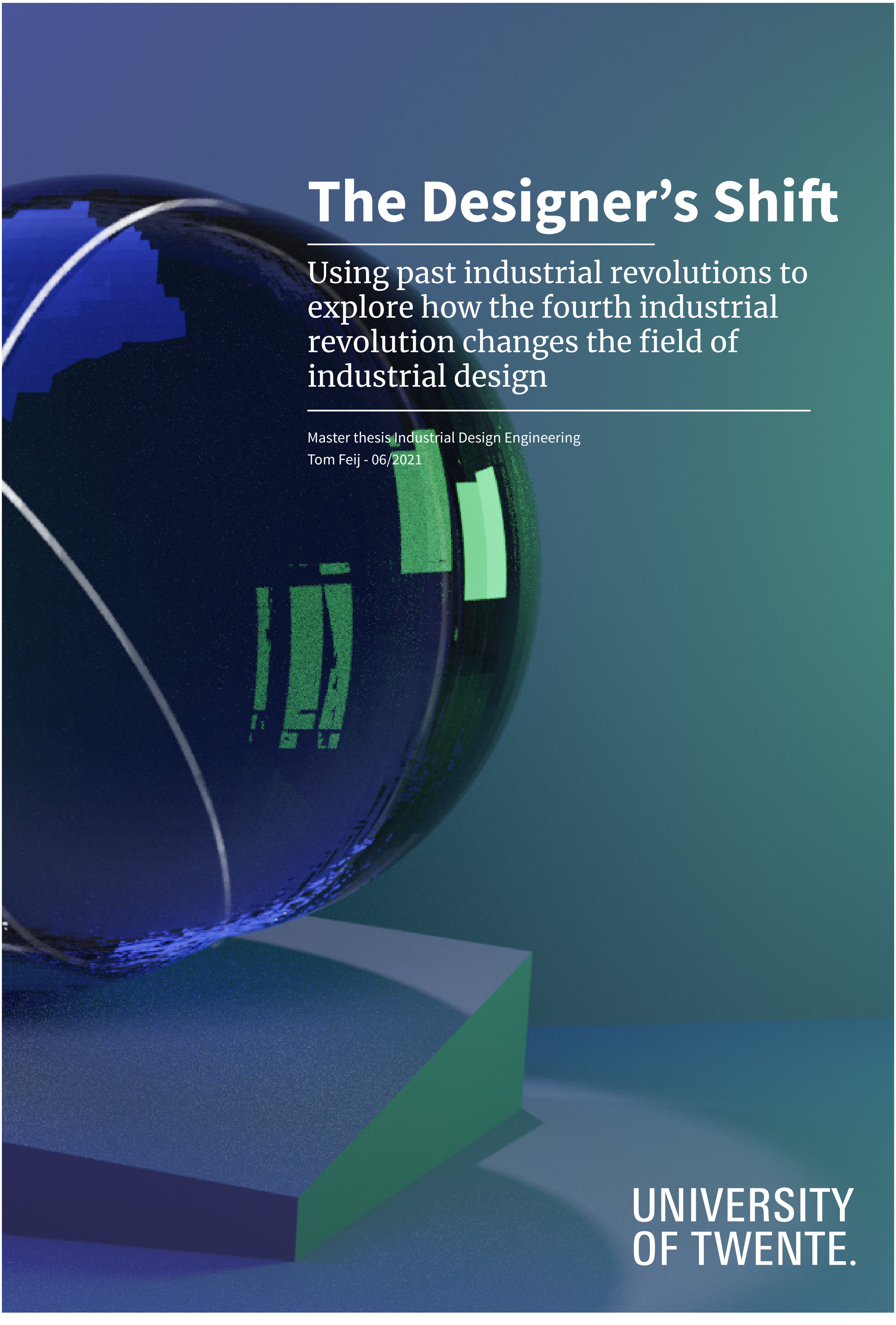

The Designer’s Shift

Using past industrial revolutions to explore how the fourth industrial revolution changes the field of industrial design

Master thesis Industrial Design Engineering

Tom Feij - 06/2021

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INFORMATION

The Designer's Shift: Using past industrial revolutions to explore how the fourth industrial revolution changes the field of industrial design

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UNIVERSITY OF TWENTE.

D'ANDREA & EVERS

Preface

At the time of the start of this project, in the early months of 2020, news reports spoke about a virus that was spreading throughout a Chinese region. Luckily it was far away still.

The first days of this project, I drove out to D'Andrea & Evers Design's office in Enter. It was spring and the weather was nice. A little warm for the time of the year. I met the people that would be my colleagues for the coming nine months. I got assigned a desk among them. I started researching the topic, listening to conversations between these people about the design issues that they were dealing with in their own projects throughout the days.

Two days later, the Covid-19 virus had reached the Netherlands and offices were asked to close. Office workers, including me, started to work from home. Temporarily, we thought.

Now, at the end of this project, in June of 2021, the last group of adult citizens are invited to get vaccinated. For now it seems that within a few months, everything can return to more or less how it was before it began. The timespan of this project: one pandemic.

These times are hard on almost everyone, including me. The pandemic brought me some difficulties, mainly on the side of mental health. Working on such a large individual project while literally isolated had a bigger impact than I could have initially imagined.

Therefore I would like to express my gratitude to all the people that helped me during this project. First, my supervisors Wouter and Tim, who did the best they could to stay in touch across the digital world. Thanks to the people at D'Andrea & Evers Design for their input when I asked for it. Especially to Viktor, Luigi and Tom.

Besides, I am also grateful to all the people that supported me in other ways: my parents and Naomi for listening and guidance, my housemates for being my colleagues in the home office for the first part of the project, my friends Kris and Frank for being my colleagues for the second half.

Lastly, my thanks to all the people that have influenced this project in all the small ways possible. Some short conversations that I had with people in passing snowballed into important insights into the contents of this project. Therefore, also many thanks to all my friends, my colleagues at the Coop and my fellow teaching assistants at the university. And special thanks to Remko for directing me towards D'Andrea & Evers in the first place.

Being one of the last people of my group of friends to graduate from university, I heard many stories about graduation projects. Those stories were about hopeful beginnings, large frustrations for most of the project and sighs of relief at the end. And even though I will probably sigh with relief at the end, there have never been large frustrations with the topic. It is both very varied and incredibly relevant for the current design world. The motivation to make something valuable out of this project never faltered and I am proud of the result. With this topic, I feel like this project could have gone on forever. There is much more to uncover.

Lastly, it was a pleasure to work with D'Andrea & Evers Design. It was inspiring to work with an experienced group of designers that show a continuous genuine interest in the topic of design. They are passionate, motivated and determined to create the best designs for their clients and the users. I hope to cross paths with them again many more times in the future.

Tom Feij
23rd of June 2021

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Summary

D'Andrea & Evers Design is a design agency in Enschede, the Netherlands. They notice that a new industrial revolution emerges on the horizon and want to know what it will mean for their way of practicing industrial design.

The goal of this project is to inform and inspire thinking about the future of meaningful industrial design. The questions that are central to this project are: What do meaningful consumer products look like under the influence of the fourth industrial revolution? And: how will the role of the industrial designer change under the influence of the fourth industrial revolution?

A considerate portion of this project is reserved for literature research. This project is D'Andrea & Evers Design's first attempt at investigating this particular subject. The literature research goes into how the previous three industrial revolutions developed and whether conclusions can be drawn about the structures of these revolutions.

The industrial revolutions are periods in the modern history of incredible economic growth that is sparked by clusters of innovations. These innovations happen in waves, where the downswing of a wave indicates a crisis and creates the need for a different technological paradigm. The next paradigm then experiences rapid growth.

All industrial revolutions lead to expansion of the world's design space, which is the space in which engineers and scientists can look for solutions to issues. That expansion happens across three axes: new infrastructures, new leading industries, and new core resources. For the fourth industrial revolution these revolve around cyberphysical systems, data and fast networks.

A trend can be found across the technological products of the successive industrial revolutions: their physical components are subject to miniaturization. Where in earlier times the physical components told the user something about its functionality, nowadays computerized products hardly have any moving parts. Much of the design of these technological products must therefore come from meaningful associations and the use of archetypes to communicate the increasingly abstract functionalities with the user. That trend is expected to continue into the fourth industrial revolution.

The information from the literature research is combined into six focal points: trust, black boxes, enduring design, AI-powered design, technological, and new materials and manufacturing. These points are used as input for a case study that is meant to inspire further studies as well as provide a peak into what possible future products may look like.

Future products are part of larger (digital) systems and therefore require clear communication to the user. Central to future products is humanity in an increasingly technological world. To achieve this, human centred industrial design may be more important than ever. Most of the job of the designer of the future will have to do with ensuring that the user remains central to everything the technologies do.

The subject is broad and complex. This report concludes with suggestions of further steps to take to be better informed and prepared for the undoubtedly exciting and dynamic future.

Introduction

According to general consensus, three industrial revolutions preceded the one which is supposedly starting just now. In short; First there was the Industrial Revolution, roughly between 1760 and 1840. This revolution introduced the steam engine, triggering the start of mechanical production. The second industrial revolution, sparked by the introduction of electricity and mass production, brought the late 19th century into the early 20th century. And almost fifty years later, around the 1960s, the world experienced a third industrial revolution, nicknamed the digital revolution. It introduced computers and the digital world, made possible by the development of semiconductors and microelectronic components. The fourth industrial revolution is justified as its own revolution due to its velocity, breadth and depth, as well as impact across systems. It has the potential to spark unprecedented change across societies and industries (Schwab, 2016a, 2016b).

Dividing the development of the modern industrial world into three or four revolutionary periods is not free from experiencing resistance. It can be useful to categorize time or events for reasons of explanation and understanding (Buchanan, 2019), but the exact definition of historical windows are rarely ever clear or widely agreed upon. The same accounts for the notion that singular inventions or technologies were the specific reasons of these sudden rises in technological and societal innovation. Besides scholars completely rejecting this view, stating that technological innovation occurs only incrementally instead of in waves, sprints or revolutions, many others hold beliefs that show only minor differences to the division of the development into four revolutions. It often feels like their disagreements are just a matter of semantics.

D'Andrea & Evers Design as a design agency wants to develop insight into the future. They see the fourth industrial revolution on the near horizon and want to explore the implications it has for them. This project is concerned with answering the questions of what impact the fourth industrial revolution will have on the world of industrial design, what future products will look like and what the role of future designers can be. Both the worlds of design and the fourth industrial revolution are very broad terms. Therefore, underlying this project are a number of assumptions and scope-defining characteristics. First of all, it is mainly concerned with the western world. Just before the Industrial Revolution took off in 18th century England, the world was relatively homogenous in terms of wealth distribution. As time progressed, the capitalist world of Western Europe took the economic lead (Freeman & Louçã, 2001; Lucas, 2004). Although the project may touch on some important developments in other economies, most of the rest of the world will be kept out of this research due to the sheer amount of complication that such elements would introduce as the parts of the world become subject to growing inequality through time. Furthermore, the project is carried out with focus on D'Andrea & Evers Design and their way of doing business in the design world. They are located in the Netherlands and thus mainly impacted by the Dutch design context.

Research approach

The main question of this project is what impact the fourth industrial revolution will have on the field of industrial design. The research questions that form the basis for answering that broad question are concerned with (1) what future designs will look like and (2) what future designers will do.

This project attempts to anwer these questions by drawing conclusions about the fourth industrial revolution based on trends and structures found in the previous three revolutions. The details of historical events are often incidental and can not tell much about the future. The structures in which they exist, however, may show recurring elements that tell something about how the fourth industrial revolution will develop.

Chapter one looks at D'Andrea & Evers Design as a company and provides background on their work to define a scope within the broad field of industrial design. It features a quick analysis on their portfolio. The findings from literature in this chapter have been discussed and verified with a small team at D'Andrea & Evers Design to refine the definition.

Chapter two starts the investigation into the three previous industrial revolutions in two parts. The first gives brief overviews of the developments of those revolutions. The second part looks into underlying structures that allow for generalization of these revolutions. The final part of chapter two, after the investigation of the first three revolutions, goes into applying these structures to the fourth industrial revolution.

The third chapter attempts to draw the information from chapters one and two together. It also draws on historical information, like chapter two, but this time more specifically focused on design. It attempts to connect the generalized technological aspects of the industrial revolutions with developments in design. Especially design in the manner that D'Andrea & Evers Design practices. Chapter three is about the nature of the transition that design will face as a result of the fourth industrial revolution. This is done mostly through literature research, connecting multiple theories and models.

Chapter four builds on that and interprets what the result of that transition will be. The results of previous chapters are presented to the designers at D'Andrea & Evers Design in order for them to be able to give their own insights informed by their design practice. Their input combined with the theoretical data from earlier chapters can validate the previously found information and indicate what the important concerns are. Through this, it is attempted to provide an answer to the second research question: what will future designers do in their job in the future? The chapter also provides a general answer to the first research question: focal points for design of the fourth industrial revolution.

Those focal points form the basis for the case study in chapter five. That case study attempts to provide a more specific example of an answer to the first research question.

Chapter six provides a conclusion and interprets the value of the results of previous chapters.

Chapter seven gives suggestions on futher research, providing the reader with several specific questions or subjects that may increase insight into the developments of future design. Furthermore, it provides a method for designers to carry out their own design case based on the results of the research. It will aid them in gaining more insight into the future of design.

Chapter 1
D'Andrea & Evers Design

Many people know what design is through intuition. But it can be challenging to put to words. Therefore, this chapter attempts to create an image of what design is that is relevant to this research.

1.1 Design activities of D&E Design

Design can mean everything. Everyone does it, unconsciously, all the time. The design process is a process of planning towards a desired end (Papanek, 2019). The design process that will be examined in this research however also has the purpose of helping businesses improve their way of doing business (through profits or otherwise) by helping them to be able to mass produce for selling. This is what ties design to business and separates it from the fine arts (Cuffaro et al., 2013). Of course this definition is a generalization and there will be exceptions. For example: when a client would ask for help to redesign the outer shells of their own machines for ease of use, in which case the result of the design process is not a mass produced product for selling. But its general premise rings true. The result of the design process is often a well thought-out plan for production of a product.

For businesses to stay in business, product development is crucial (Cuffaro et al., 2013; Eger, Bonnema, Lutters, & van der Voort, 2010). Whether the business produces physical or digital products or provides a service; To grow, the products need to move with the market. There are however several different varieties of product development within the business environment; Either having to do with new or existing products and new or existing markets.

A simplified representation of the complete process of marketing a product in the business context would be built up out of four steps: purpose finding, product design, implementation and use and after care (Eger et al., 2010). The first two of those four make up the product development process as characterized in figure 1 under diversification: to find a purpose for new products or technologies in new markets and additionally design the product fit for that new market. Both product development and market development as stated in the table above (new products-existing markets or existing products-new markets) fit within the second step of the process.

D'Andrea & Evers Design as an agency practices product design: product development in the narrow sense. Their work frequently falls into the categories of market development and product design as stated in the table. It rarely touches

	Existing products	**New products**
Existing markets	Market penetration *Attempting to increase market share, mostly through marketing, not design.*	Product development (product design) *New or improved products for existing markets. Often through product design and (re)styling.*
New markets	Market development *In terms of design only minor changes; Change the type of plug or minor adjustments to better fit the culture of new markets.*	Diversification *Major product development in which product design is expanded with a process of purpose-finding.*

Table 1: Varieties of product development in business context. Adapted from Eger, Bonnema, Lutters & van der Voort (2010). p.10

on diversification. Diversification, the quadrant of new product in new markets, is where innovation happens. And product design is certainly a part of that innovation process, but it is mainly driven by the purpose brought forth by the designers' client. Product design is therefore not a process of innovation per se. Their clients come to them with a purpose often already formulated and will take over again when it is time to market the product. Within the product design stage, D'Andrea & Evers Design will work closely with their client to utilize their expertise on the product and fulfill needs in terms of what they and the product should do and could do within the strengths of the business (Eger et al., 2010). The design process that D'Andrea & Evers Design adopted is therefore a process that helps businesses forward through product design. It is characterized by the effort to intentionally plan towards their client being able to reach a goal. But that can mean a lot of things; The outcome of the design process can take an infinite number of shapes (Papanek, 2019). Therefore, the designer has to inhibit a certain form of feeling for the craft; Often called intuition. It is that aspect of the design process that makes it so complex. A product shows many different aspects, its functionality, aesthetics or production method for example. A product that functions very well but is not appealing, or difficult and expensive to produce can hardly be typified as successful.

Many different aspects of product function are identified (Papanek, 2019). Aspects can however not simply be minimized or maximized, they are interconnected too. An aesthetic choice may slightly reduce the ease with which a product is produced for example. Therefore, every single one of these aspects need to be balanced, and for that reason it is impossible to find a single right answer. The final answer depends on the resources spent on the process, but mostly on the designers' intuition. The design process is comprised of a series of choices that are informed by gathered intellectual and intuitive resources; In other words: research and skill. The combination of this and the relatively short time span that design is involved in the total lifecycle of a marketed product makes design a costly and valuable aspect (Eger et al., 2010). And it is for that reason that businesses hire design agencies.

1.2 Meaningful design

D'Andrea & Evers Design has been balancing the aspects of product function for more than twenty years. It can be assumed that they possess the designers' intuition that paragraph 1.1 speaks of. The type of design that they practice has a strong focus on meaning. Through their focus on meaningful design they mean to separate themselves from other design agencies that might be more engineering-centered or otherwise focused. However, they carry out the design process as a whole, including these non-central aspects. Engineering, for example, is still a part of daily business practice for the agency.

The focus, however, lies on product (re) design and meaning. The design of meaningful consumer products combines three aspects: archetypes, physical components and meaningful associations (figure 1) (Eger et al., 2010). Archetypes are typical versions of a product. If the design assignment includes an existing product, an archetype is often available. The designer can choose to follow or reject it, but he has to deal with it in any case. Older products have more geographically or culturally dependent archetypes. Internet and global mobility have brought a more international style to modern products. Many of these products only have minor geographical variations (Eger et al., 2010; Heskett, 2002).

With regard to physical components, the designer is dependent on the technical specifications of the product; How many components are there? How big are they? And what is a good way to organize them so the user can easily reach the necessary components? This aspect is concerned with ergonomics and the functional aesthetic (Eger et al., 2010).

Lastly, giving meaning to products. This aspect is concerned with giving emotional significance to a product through styling and aesthetics (Eger et al., 2010). This is a challenging aspect due to its amount of different facets.

Meaning is something the designer tries to intentionally include in a design. Though meaning is formed only in the mind of the user. The designer can merely try to understand the user and introduce clues, symbols or associative elements to trigger the intended meaningful reaction within the perceiver (Chapman, 2014; Norman, 2004). This in itself is a challenge, for the meaning that people read from artifacts is not embedded solely in the artifact itself, meaning is not independent of context (Crilly, Good, Matravers, & Clarkson, 2008). It is shaped by the characteristics of the product, those of the user itself, actions, processes and the context (Desmet & Hekkert, 2007).

Furthermore, many users view objects as designed, in contrast to viewing it as an independent artifact. That means that meaning does not only come subconsciously, but that the user sometimes also more or less consciously tries to find the intended meaning (Crilly et al., 2008). With more durable or emotionally significant products, that might be more apparent than with products that people do not think about as much.

Due to its complexity, product users can even read meaning that a product manufacturer never would have thought of (Heskett, 2002). It is therefore clear that understanding the process of embedding the right meaning into product design is important for the product development process. It is often impossible to achieve the exact intended meaning for every user of a product. Industrial design is traditionally concerned with mass production and therefore is characterized by a process of making choices based on generalizations about ergonomics, symbolism and other aspects. These choices are often made intuitively by designers that use experience in combination with research.

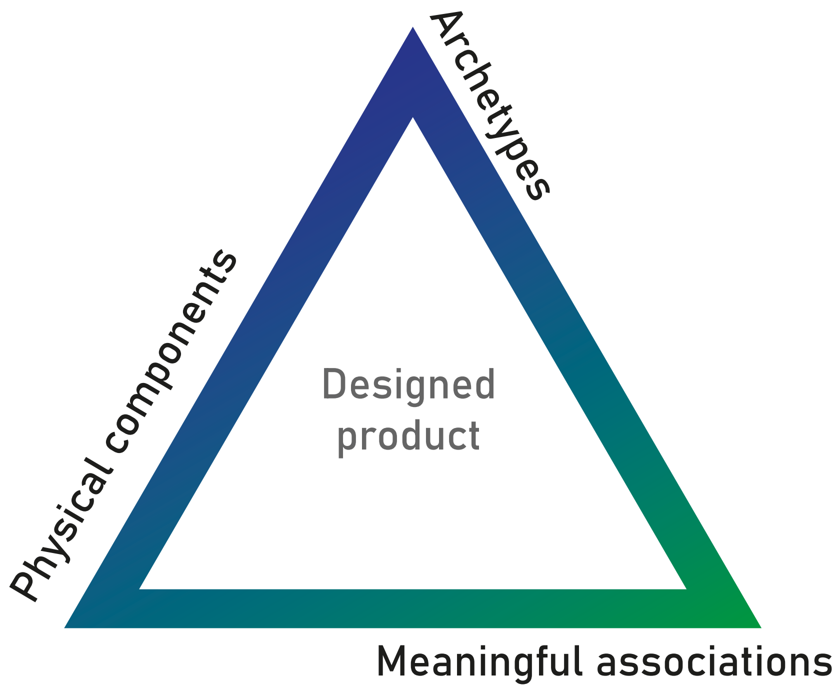


Figure 1: Schematic representation of three aspects that form a meaningfully designed product. Will be elaborated upon in chapter 3.

D’Andrea & Evers Design once identified four paths through which they can embed meaning in products; Technology, emotion, nature or nostalgia (Eggink, 1998). With these four pillars they attempt to achieve the intended meaning that the manufacturer has in mind. In uncertain times, such as the Covid-Pandemic during which this project takes place, people might find meaning and comfort in nostalgic associations for example. Highly advanced products may speak to the right people when they showcase a lot of technological elements. Emotional associations seem to be largely universal throughout populations. People generally tend to associate similar feelings to the same color, shape or texture (Eger et al., 2010).

Thus, in short, the goal of D’Andrea & Evers Design is to help their clients develop meaningful products. The role that they take in that development process is that of designer, not developer. The client mostly provides the functionality and technological means for which the designer then finds shape. That shape is distilled from the physical aspects (components and ergonomics) and emotional aspects (meaning). Every designed product that is around has some form of dominant design: an archetype. Archetypes of products often emerge as products integrate in people’s lives. And for existing products, designers can thus relate to the archetype.

For future products, products with functionalities that we do not yet use much or are only slightly integrated in our lives as of now, there might not yet be an archetype. Sometimes design agencies are hired to develop a design language for a product that does not yet exist and therefore does not have an archetype yet. As one can imagine, with such a project, the designer, not being able to base choices on a clear existing example, needs to draw a lot of choices from intuition; Especially when trying to establish a meaningful design.

1.3 Product phases

To further determine what to focus on and what type of products D’Andrea & Evers design tend to work with, a quick portfolio analysis was carried out. A selection of products from their portfolio has been sorted by product phase as found in Eger & Drukker (2010). By doing this, it can be determined what to focus on for the rest of the project as indicated by the characteristics of the dominant product phase.

The success of new products is measured differently than that of existing products. New product types are successful if they manage to establish a market, existing products attempt to outsell their competitors. Completely new products will ask much attention of the designer in terms of functional aspects and less in terms of giving meaning. Completely new products are often unsuccessful in the long run (Eger et al., 2010). They pave the way for the products to come. Products thus move through different stages in their lifecycles. Six of these product phases have been identified; performance, optimization, itemization, segmentation, individualization and awareness (Eger & Drukker, 2010). A certain product group starts in the innovative first phase of performance, in which fulfilling a function is central. The technology gets pushed from the inventor to the realm of user products and typically has a lot of problems. Aesthetics are not important and prices are high. Eventually the product will mature through other phases. Multiple phases, especially the last ones, can exist alongside each other.

In the itemization phase, the product type is sufficiently functional to cultivate an actual market for it. In this phase, the product gains a dominant design, or archetype. When a product reaches the segmentation phase, mere ownership of that product is no longer unique. It has reached a large audience and is produced by multiple manufacturers. Therefore, new products in that category need to distinguish themselves in other ways. Often the product becomes more expressive and is given a cultural or aesthetic meaning to fit a certain lifestyle (Eger et al., 2010).

It depends on the product type to what extent meaning should be attributed to the product. For example: professional medical products should carry other meanings than jewelry (Heskett, 2002). Though in general, products that are newly introduced to the market tend to be more focused on utility (technical functionality) before the segmentation and individualization phases lead to more significance (emotional functionality) in designs. The last stage of awareness is more focused on marketing and the image that the product and the company that manufactures it built up throughout the earlier phases.

A design agency such as D'Andrea & Evers Design, that practices industrial design with an emphasis on meaningful design, can be positioned as practitioner of design in the middle stages of itemization, segmentation and individualization. With extra emphasis on the first two. For most product categories in which they act, an archetype has already been established. This becomes clear from their current published portfolio. A large amount of the products are existing products with existing markets that distinguish themselves not through superior functionality, but through meaningful use (figure 2).

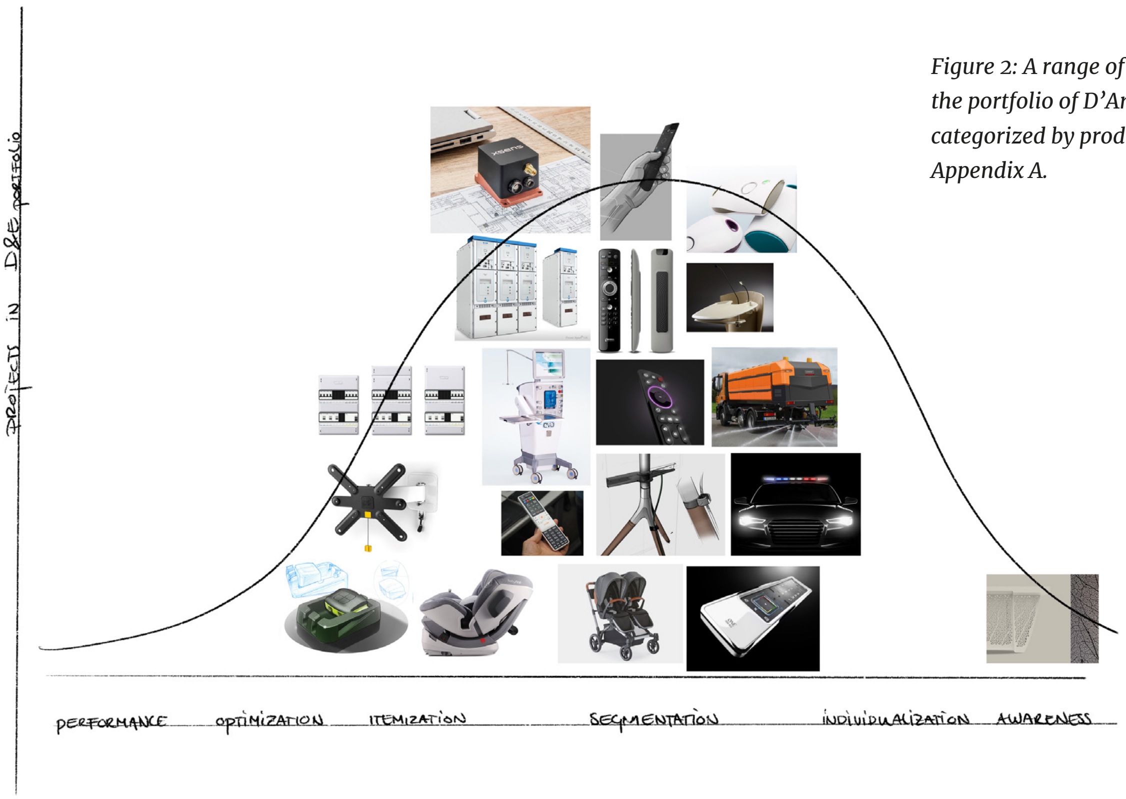


Figure 2: A range of different designs from the portfolio of D'Andrea & Evers Design categorized by product phase. See also Appendix A.

Chapter 2
Industrial Revolutions

2.1 Three historical revolutions

This chapter investigates what the three past industrial revolutions (figure 3) entail and how they developed. Furthermore, the structures of industrial revolutions are investigated to be able to apply the historical knowledge to the fourth industrial revolution.

2.1.1 The first industrial revolution

In the first industrial revolution, muscle power made way for mechanical power by means of water power or steam engine technology. It brought an increase of productivity. Before the industrial revolution, societies responded to productivity increases with population growth, since higher productivity meant more resources to support more people. Up until around 1800, the difference between population and production remained roughly the same, indicating that production numbers per capita did not increase significantly. After 1800, production numbers relative to the population increase, showing great increase of production per person moving into the twentieth century and continuing into the present time. This increase remains visible when measured on average around the world, indicating that the whole world experiences higher production per capita than before. However, this increase is especially visible in certain countries in western Europe, North America and eastern Asia. The initial boom occurred in Great-Britain, the rest of Europe and Japan followed suit and eventually caught up after the Second World War (Lucas, 2004).

Global income inequality has been relatively small for centuries. The quality of living remained the same for the majority of people the majority of the time. The wealthy landowners of medieval times were the prime source for development before 1800. Their aim was to increase production and resources, but not to increase the quality of living of the families that worked their fields and tended to their cattle. The most logical choice for the common people in these agricultural societies to preserve their future was to have as many children as their resources would allow. There was no perspective for growth and therefore no reason to invest extra resources into a single child that could be lost to the high mortality rates of the time (Lucas, 2004).

This changed when the inventions and technological development of the previous centuries reached a climax with the invention of machines that could replace muscle power of workers with mechanical power (Buchanan, 2019). These machines were powered by rivers and streams and later steam. A society with growing technological involvement required a growing number of skilled workers. Skill became a new means to reach a successful future. Therefore, parents seemed to increasingly choose to allocate more resources to a smaller amount of children in order for them to be able to become skilled workers. This development signals the start of a time where productivity and population were no longer as intertwined as they had been before. A greater amount of productivity could be achieved with the same amount of workers (Lucas, 2004). The definitive start of the modern era.

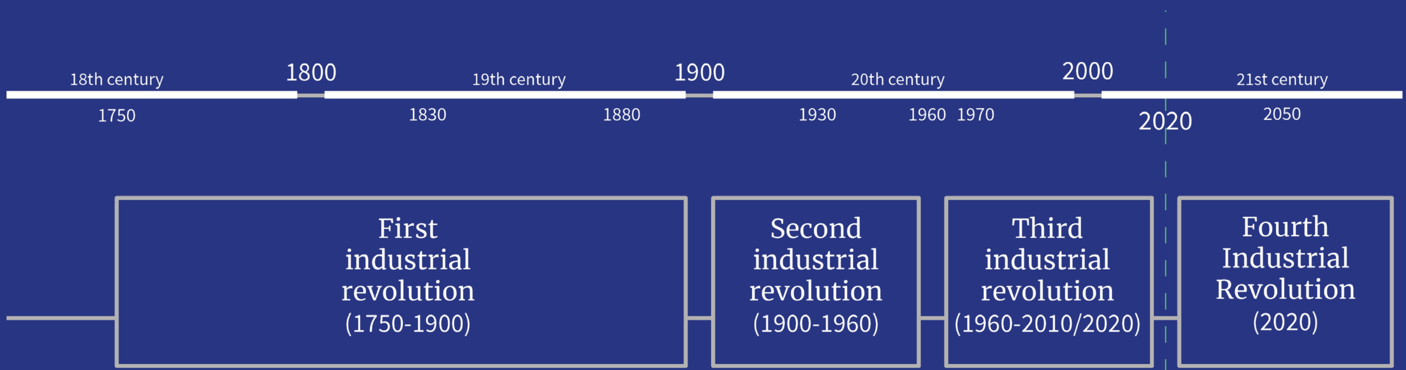
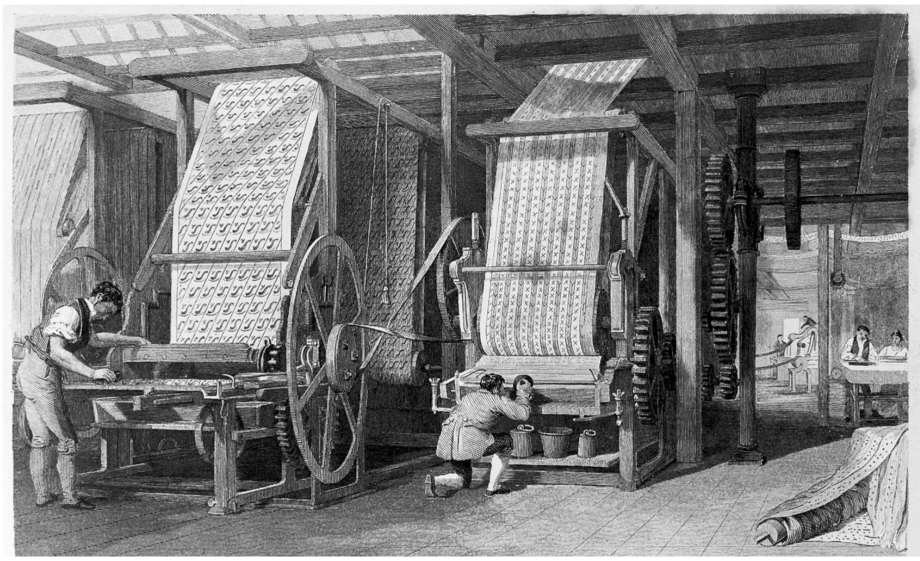


Figure 3: Timeline of three past industrial revolutions followed by the fourth.

The steam engine had an enormous impact on eighteenth and nineteenth century Europe. The large inequalities in the world today are at levels that humanity has never experienced before and started to emerge during those times (Lucas, 2004). Productivity worldwide, but especially in Europe and North America, has been growing rapidly ever since. The invention of the steam engine proved just the start. Its development did not stop. Its knowledge was applied to other power-generating instruments with more efficient power conversion, which in turn allowed for faster growth of productivity (Buchanan, 2019). However, the improvements were small in comparison to the boom at the beginning of the revolution and eventually the growth started to slow down (Landes, 1969). Change and innovation had become part of the new system. The first industrial revolution was primarily a revolution of power; Replacing muscle with machines (figure 4) that were dependent on coal and iron, of which there was plenty (Freeman & Louçã, 2001).

2.1.2 The second industrial revolution

After the slowed growth of the later years of the first revolution, a series of new developments was introduced; Electrical power and motors, internal-combustion engines and automotive products, organic chemistry, synthetics, precision manufacturing and assembly-line production (Landes, 1969). Halfway the nineteenth century, many previous developments were brought from Britain to the United States, such as the concept of dividing up the tasks of the production process (figure 5). The Americans developed modern industrial mass-production (figure 6). They achieved this by introducing standardized parts as well as rethinking the organizational structures of their businesses (Overbeeke & Hummels, 2014). The rise of the United States as the new industrial leader and these technological and organizational developments mark the start of the second industrial revolution at the beginning of the twentieth century (Freeman & Louçã, 2001; Landes, 1969).



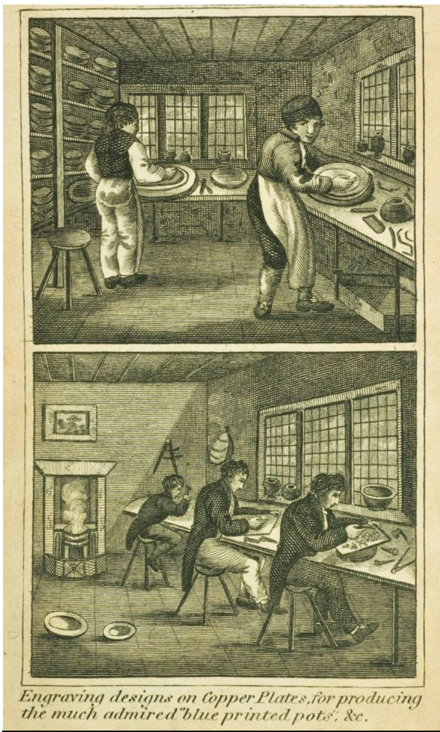


Figure 4 (right): Workers with roller printing presses for printed cottons in the early nineteenth century. From Forty (1992) p.47
Figure 5 (left): Division of labour in pottery workshops in 1827. From Forty (1992) p.35

Electric power harnessed a significantly larger amount of transmissibility and flexibility than steam power; It could be transported over long stretches and therefore the source of the power could be further removed from the machine it was powering. Whereas with steam, the power source was directly attached to the axis that needed to be moved in order to further the manufacturing line (Landes, 1969). The sudden large demand for electrical power led to the construction of a new network of electricity-distribution infrastructure, made possible by the rise of another driving resource of the era: steel. Through this network, electrical power eventually reached factories, offices, and even homes (Freeman & Louçã, 2001).

A lot also changed in terms of organizational structures of businesses. Steel railroads and electric communication methods such as telephones and telegraphs brought the development of more complex structures for company management. They allowed businesses to expand. Management in organizations shifted from senior craft workers, who acted as foremen on the shop floor, to professional managers (Freeman & Louçã, 2001).

In the first years of the twentieth century, Henry Ford started manufacturing his famous Model T Ford. The modern facilities of the car manufacturer were revolutionary because of its use of interchangeable parts and a moving assembly line to produce the cars (Heskett, 1980). Its system was built on quantity production and poses a major development in technology history: true mass production through electrification of industry (Freeman & Louçã, 2001). Although mass production was technically achieved with the Model T, it was still an interim stage to mass production as it is known now, where it is approached more flexibly. Different products aim for different markets. Such a system was introduced by General Motors as a refinement of Ford's production system (Sparke, 2004). The mass production paradigm of the second industrial revolution had its upswing of radical growth after the Great Depression in the thirties and would last until late in the twentieth century (Freeman & Louçã, 2001).

2.1.3 The third industrial revolution

The third industrial revolution is also known as the digital revolution. As with the two previous revolutions, the preceding years already showed signs of what was to come (Perez, 2009). The prominent technological developments revolve around computing technologies in all their shapes and sizes. People were already experimenting with calculation equipment as early as the 1640s. These machines gradually became more advanced as time went by. It was not until the twentieth century that the developments managed to push the technology into the realm of widely used tools and technologies (Freeman & Louçã, 2001).

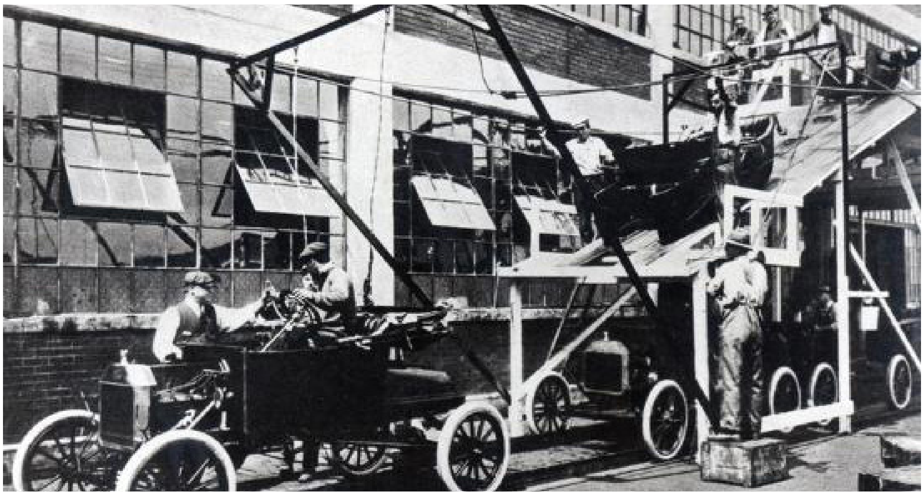


Figure 6: Ford Model T automobiles on the assembly line at Highland Park Factory in 1915. From Sparke (2004) p.36

When electronic components became more widely available during the second industrial revolution, they also became cheaper and faster to produce. It led to an increased interest in these calculating machines. Designs for these machines, that used to be mostly theoretical, suddenly could be brought into reality due to the introduction of these previously non-existent electronic components (Freeman & Louçã, 2001; Williams, 2017). These components became more efficient with every few years that passed.

Not the calculation machines, or computers as we know them now, were the core input of the third industrial revolution. They were a result that emerged from the real core input: the technology of integrated circuits. The previously mentioned electronic components became so small that they could be combined on circuit boards that eventually became microchips. Innovation in the realm of electrical components was the result of previous developments in the radio and television industries. The benefit was obvious. The act of combining these components in large numbers on a small scale led to "spectacular reductions in cost and improvements in performance of […] goods" (Freeman & Louçã, 2001). Advancements in the field of semiconductors made it so that these microchips could do increasingly more with a decreasing amount of energy (Williams, 2017). The Intel company eventually developed a microprocessor that made it possible to put a computer on a chip. It changed the semiconductor industry. The microelectronics of that industry were increasingly integrated in products on a vast scale due to the strong ties that existed between the three central industries: semiconductors, telecommunications and computers.

The semiconductor-filled chips made the creation of computers and telecommunication devices easier and cheaper. At first it was still an expensive and difficult process, but the price reduced exponentially with scale (Williams, 2017). Soon, microprocessors could be found in many devices, even outside the core industries. Everything that required sequencing, control or computation could benefit from the new technology (Freeman & Louçã, 2001).

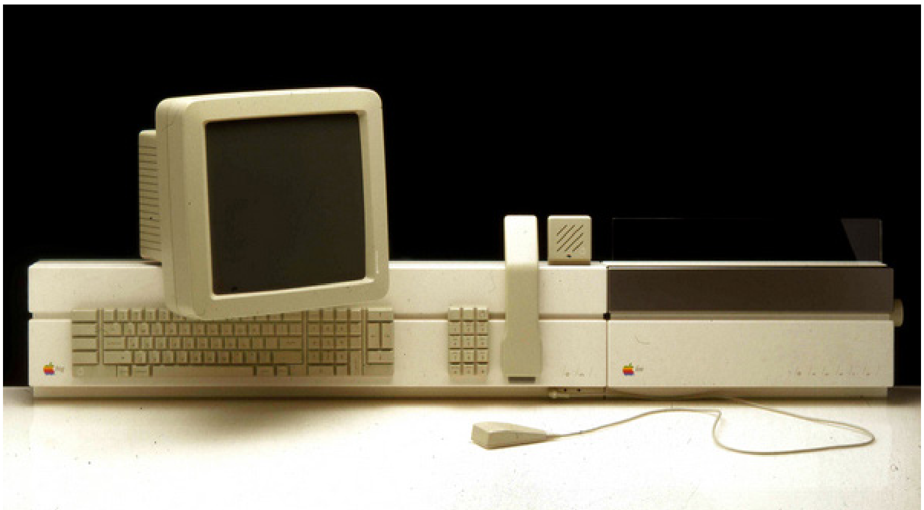


Figure 7: Hartmut Esslinger's (Frog design) 'Snow white' design for an Apple Computers design competition in the early 1980s. Much of Apple's design originated from this, bringing the computer to the home. From Katz (2015) p.80

After two world wars in an increasingly more connected world where air travel had become a more common transportation method, governments would play an amplifying role in the development of new technologies. They could be used by the military or other government branches and therefore governments often would try to recognize potential in new technologies and invest in further developments of these industries. Soon, integrated circuits were the subject of many R&D departments in the western world. The technologies often emerged from the labs of businesses or universities (Freeman & Louçã, 2001). These were also the places where the newly developed devices were mostly used. Around 1970, computers were located almost exclusively in IT departments at universities and large businesses. The development that would unrecognizably alter the future was making these devices available for individuals (Williams, 2017). Large mainframe computers slowly moved to the background and made space for Personal Computers (PCs). Companies such as Apple (figure 7), Atari and Commodore serviced this market together with IBM, the manufacturer of the PC. IBM's PC had an operating system developed by an, at the time, small company called Microsoft and it would eventually lead to Microsoft's dominance on the software market (Freeman & Louçã, 2001).

As seen before, in the twilight days of the steam engine, growth under the old paradigm started to decrease. The Fordist way of mass producing was starting to lose its role as the leading agent of growth. Oil crises and increasing concern for environmental impact aided this development. The computer market offered a new, technically reliable and economically efficient way of achieving growth on a large scale. The technologies diffused across the world at a fast pace due to the huge reductions in price and "huge improvements in design, performance, and user-friendliness in the 1980s and 1990s" (Freeman & Louçã, 2001). Personal computing changed the home and workplaces of many people so much that many of them find it "difficult to remember what life had been like before" (Williams, 2017).

Meanwhile, due to the explosive growth in the electronic and computer industries, the telecommunications market experienced growth too. The three industries grew together and eventually converged into an industry that we now know as internet and communication technologies (ICT). They are closely intertwined. New innovations in electronics such as an increase of the carrying capacity of cables or expanded abilities of microchips made it possible to advance telecommunications and introduce the internet (Freeman & Louçã, 2001). The internet brought about major shifts in how people live and work. It was the result of research in the US and at research institute CERN in Switzerland. People started to ask questions about how pages on the newly formed internet should be viewed. Netscape and Microsoft introduced their web browsers and the increased accessibility spawned new pages. At first, lists of all available pages would suffice in finding the information, but this solution proved unsustainable when the amount of pages kept growing. Google, the search engine, was launched in 1998 (Williams, 2017). Thus, development and release of a new, broadly applicable technology such as the internet introduces previously unknown problems that seem so be solved with other innovations (Perez, 2009). Keeping progress moving.

2.2 Structures of the industrial revolutions

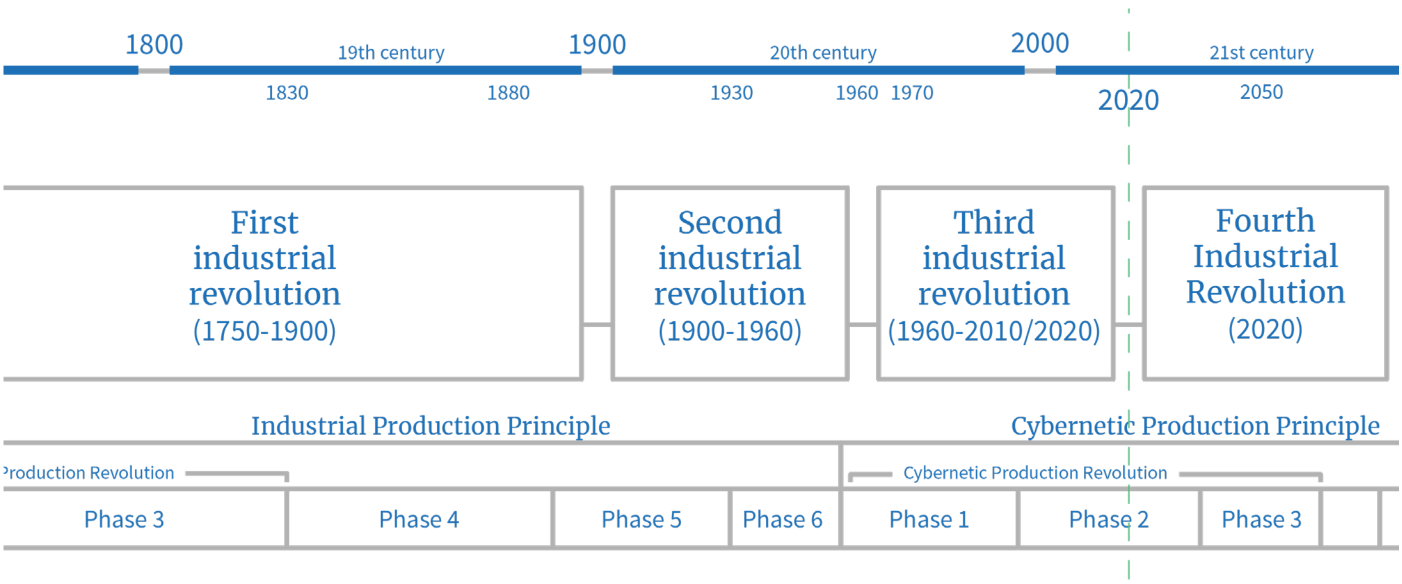
The industrial revolutions revolve around technological changes that have a significant impact on how we live and work as human beings. The inventions from which this change stems emerge from the scientific or technological domain. The reason that these technologies have such a large influence is not only due to their technological achievement. They are able to make the jump towards the socio-economic sphere outside the realm of science and technology because they are also socially acceptable and economically feasible. The technologies that change the world are the ones that experience massive adoption and therefore diffuse (Bruland & Mowery, 2006; Perez, 2004; Rip & Kemp, 1998). This chapter shows three levels of looking at the revolutions: at a large scale over many millenia (2.2.1), a medium scale over the past three centuries (2.2.2) and at a small scale within a revolution itself (2.2.3).

2.2.1 Production paradigms

Technological change on a very large scale can be mapped in production paradigms. Since the beginning of human history, various technological regimes existed. These are periods in which the productive forces of the human population share similar characteristics. Four of these production paradigms have been identified. These are: hunter-gatherer and craft-agrarian until around 1430, trade-industrial until roughly 1955 and since then we are living in the scientific-cybernetic production paradigm (Grinin & Grinin, 2016). The scientific-cybernetic paradigm revolves around production and services based on self-regulating systems (Grinin & Grinin, 2015).

Each of these paradigms follows a path through six phases. The first three span the revolutionary transition from one production paradigm to the next (Grinin, 2012). In the first phase, a new production sector emerges, often in scientific or industrial laboratories. In the second phase, the methods diffuse outside the labs and are improved upon. And in the third

Figure 8: Timeline of the recent production principles and their phases in the context of the industrial revolutions.



phase, the performance of the new method matures and it is starting to be applied broadly (Grinin & Grinin, 2016).

Then, in phase four, the paradigm expands and matures onward to absolute domination in phase five. Phase six shows non-system phenomena, which are hints of the next principle that will emerge and challenge the existing paradigm (Grinin & Grinin, 2016). In short, in the first three phases the world experiences a production revolution with rapid growth and broad experimentation and in the last three phases there is the maturing and eventual downfall of the principles where they make room for the next paradigm (Grinin, 2012).

Putting the phases of the production paradigms into the perspective of the industrial revolutions shows us that we currently find ourselves around the second or third phase of the scientific-cybernetic production paradigm. In that regard, the period in which we find ourselves now is similar to the phase in which the original industrial revolution was initiated. It would mean that the products of the third industrial revolution are merely the beginning of what is to come. What still awaits us according to this theory is further diffusion and adaption of the cybernetic production principles and eventually absolute widespread domination of that paradigm of self-regulating systems (Grinin, 2007).

The first industrial revolution was the product of centuries of previous development of the principles. During phases one and two of the trade-industrial production paradigm, developments were made in the fields of mechanical manufacturing. Those developments were accelerated by the discovery of power generation from water or steam It lead the world into phase four of the production paradigm, where the industrial revolution mainly took place.

The fifth phase of that production paradigm took those developments out of the industrial or scientific context and applied it to the world at large through the introduction of electrical power that reached offices and homes. This development is known to us as the second industrial revolution.

The third industrial revolution took place during phases one and two of the new scientific-cybernetic production paradigm and therefore is characterized by early experimentation and specific implementation of the principles. As previously stated, computing technologies were mainly found in universities or research labs. We have seen that with phase two of that paradigm, the technology and the ways of working that it brought along made its way into more and more environments. It found uses in business offices and even homes. And according to the theory, it will continue to expand until it is applied into every aspect of human productivity.

What can be taken away from this theory is the fact that industrial revolutions can happen at any given time within an industrial paradigm. Such phenomena have taken place during the early phases, like the third industrial revolution, or the middle phases, like the first industrial revolution. And even in the last phases, productivity developments can still prove revolutionary, as in the case of the second industrial revolution. All of them have a somewhat similar timespan of a little under two complete phases. It is therefore that the fourth industrial revolution is expected to span a timeframe from the last years of the second phase, to the first years of the fourth phase of the scientific-cybernetic production paradigm. Continuing the further development of cybernetic technologies.

2.2.2 K-Waves

The industrial revolutions make up a popular view of technological history. They belong to a group of theories that believe technological innovation happens in waves. Another such theory is the theory of Kondratiev-waves or K-waves. Five of these K-waves have been identified in scientific literature (Freeman & Louçã, 2001) and every wave indicates a technological revolution with its economic growth and decline (Perez, 2009). The K-waves occur on smaller timeframes than the industrial revolutions and an industrial revolution can consist of multiple K-waves.

These waves have recurring elements. One: each has one or more core inputs. These are resources that became cheap and universally available and therefore expanded the possibilities of application. Two: products that are based on the availability of the core inputs can stimulate other industries that grow and in turn stimulate an entire economy. These industries are called carrier branches. As can be understood, the core inputs and carrier branches are industries that are strongly interconnected. If one grows, it elevates the other. Third: the new industries and their growth are also stimulated by new infrastructures. Those serve the need of the core input industries and carrier branches. An example of this is an improved highway system that expands the use of automobiles in the second industrial revolution. Four: in the wake of the aforementioned leading sectors (motive, carrier and infrastructure) follow the induced branches. These are industries that emerge from the changes that the revolution brought about (Freeman & Louçã, 2001).

Table 2: Leading sectors of the revolutions. (Freeman & Louçã, 2001; Perez, 2009)

	K-Wave	Core inputs	Carrier branches	Infrastructures
First industrial revolution	First wave: Water powered mechanization of industry	Iron Cotton Coal	Cotton Textile Iron products Water wheels	Canals Sailing ships Roads
	Second wave: steam powered mechanization of industry/transport	Iron Coal	Railway industries Steam engines Machine tools	Railroads Telegraph Steam ships
Second industrial revolution	Third wave: Electrification of industry, transport and the home	Steel Copper Metal alloys	Electrical products Steel products Heavy engineering	Electrical grids Telephone Conveyor belts
	Fourth wave: Motorization of transport, civil economy and war	Oil Gas Synthetic materials	Automotive Diesel engines Aircraft industries	Radio Motorways Airports and airlines
Third industrial revolution	Fifth wave: Computerization of entire economy	Integrated circuits (chips)	Computers Software Telecommunications Biotechnology	Networks (internal, local, global)

Shown in figure 10 are the various elements of the five waves as found in literature. Besides, if the waves are visually put into the context of the industrial revolutions on a timeline (see figure 11), it becomes clear that the downswings of some of the waves roughly correspond with the end of an industrial revolution. The amount of waves that account for every industrial revolution is either one or two, but does not seem to hold much significance for this research.

What is important to note, however, is that the downswing of a wave often indicates a crisis that leads into the upswing of the next wave. The Great Depression and the First World War in the beginning of the twentieth century for example. Such an event often leads to a more risk-taking attitude from governments and entrepreneurs as an attempt in order to lessen the damage of the crisis (Freeman & Louçã, 2001). After all, if things are going well, there is often little incentive to change. If, however, a world war breaks out and entrepreneurial people in your country are experimenting with the motorization of transport, it can be a logical decision to allocate extra funding for development of motorized war-vehicles that will give you an advantage over your foes. Therefore, a crisis can incentivize change. This phenomena can also be observed during the worldwide Coronavirus pandemic of 2020 and 2021 that the world experiences at the time of this writing. Video calling, remote work and many other digital industries are reaching heights that would otherwise have taken them many years to accomplish.

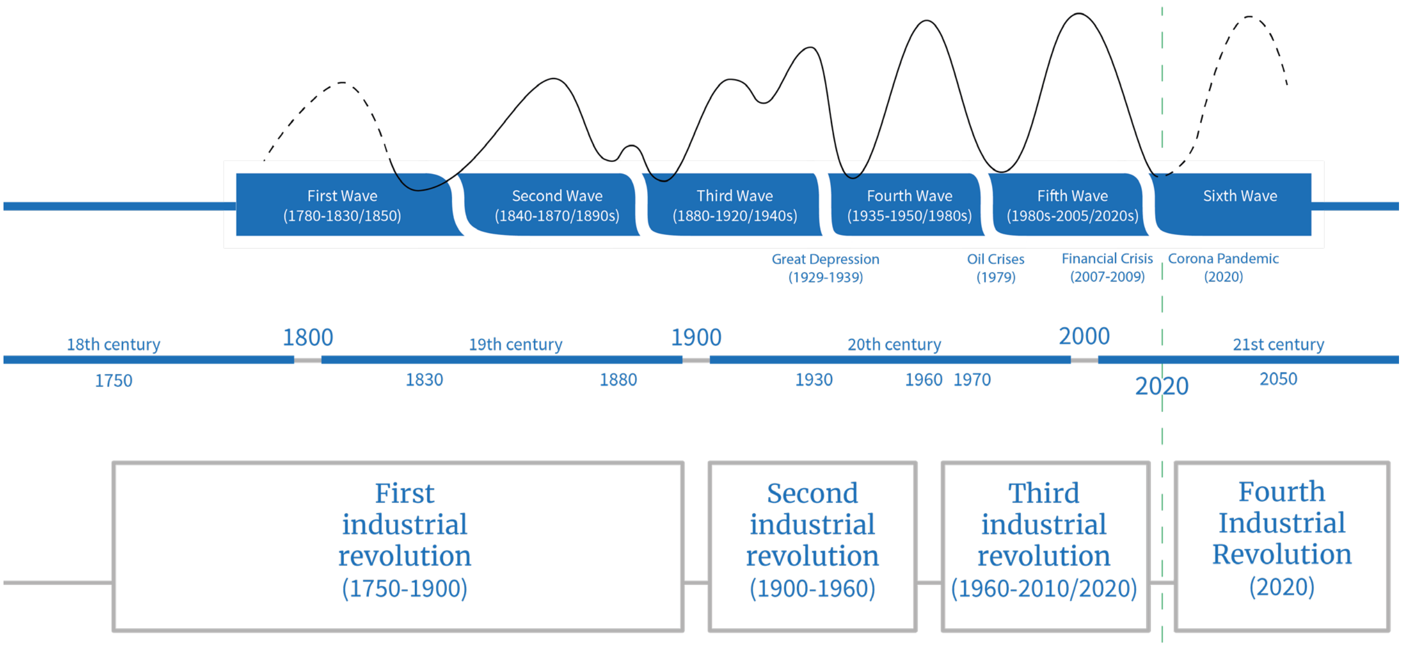


Figure 9: Timeline of the identified K-Waves in the context of the industrial revolutions.

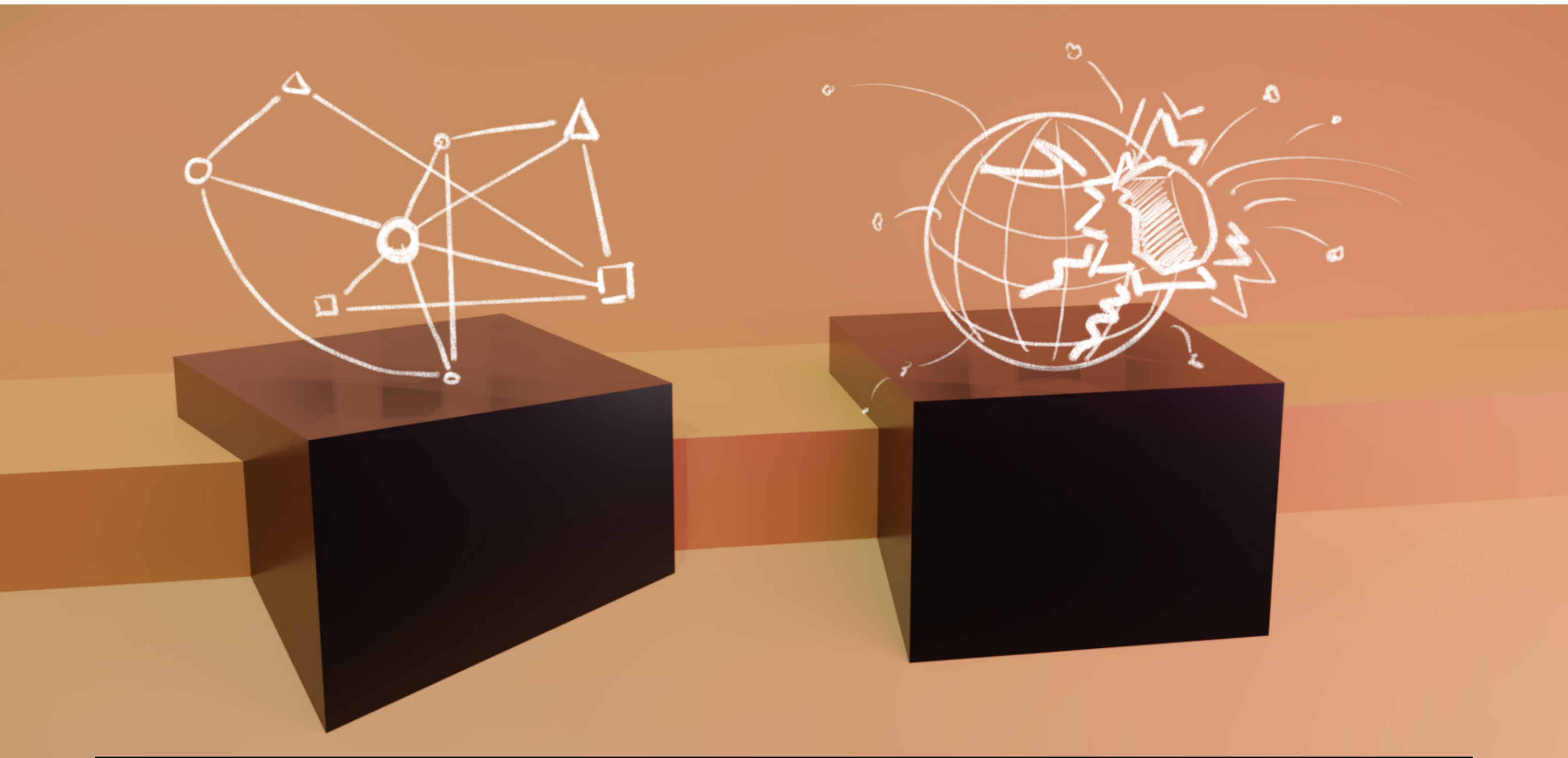
2.2.3 Constellations of innovations

A third way to look at industrial revolutions is seeing them as constellations of innovations. Major innovations, such as the worldwide web, the steam engine or the internal combustion engine tend to spark further innovations. If these innovations are radical enough, they have the ability to stimulate entire industries (Perez, 2009). The invention of the internal combustion engine, for example, had a huge influence on the emergence of the automobile industry. These industries and their products are interdependent. This interdependency allows for rapid growth across all industries that form a cluster of new technologies (Freeman & Louçã, 2001). Another example of this is the interconnected industries of the third industrial revolution: computers, telecommunications and microelectronics.

Besides a strong interconnectedness, what distinguishes a technology revolution from a regular innovation is its ability to transform economies and societies by introducing something new (Perez, 2009). Whether a technology constellation has the ability to do this often is not yet clear in the first phase of their lifecycle, where incremental improvements are mainly focused on functionality. After that, it becomes clear whether a product is economically feasible, which is a prerequisite for its success on the market for it will allow the technology to be adopted by the masses (Freeman & Louçã, 2001). The adoption of a technology is more important than its introduction (Rip & Kemp, 1998). For adoption will allow it to spread.

The revolutions bring transformation that requires rethinking or organizational structures. New developments are necessary to distribute, manage, use, produce and also specifically design the new industries, services, products and technologies. The new common sense

Figure 10: A strong interconnectedness and and ability to transform the world are two of the most important characteristics of revolutionary technologies.



develops gradually through trial and error. As it diffuses through industries, it can also spread to general culture and society. The period where a new technology is to take over the previous is a time of great turbulence. It is characterised by the declining growth of certain industries next to explosive growth of others (Perez, 2009). These processes succeed each other quicker today than ever (Economist, 2014). Both theories mentioned earlier, the production paradigms and the K-waves, show decreasing timespans between new innovations. This is known as the Law of Accelerating Returns (Kurzweil, 2001) and states that progress has been perceived as mostly linear throughout history, but is in fact exponential. The rate of technological advancement doubles roughly every decade, meaning that one hundred years worth of progress at the rate of 1900 would be one thousand times faster in 2000, which would be a little under a month. Of course, this notion is abstract. However, exactly that illustrates both the severe speed of exponential growth and the inability for the human mind to comprehend it well.

2.3 Design spaces of the industrial revolutions

In chapter one, three aspects of product design that D'Andrea & Evers Design have to combine in their designs were mentioned: physical components, meaningful associations and archetypes (Eger, Bonnema, Lutters, & van der Voort, 2010). The first one, physical components, encapsulates the technical and ergonomic possibilities. Which is constrained by the limits of the physical world. But when a new technology enters that physical world, the possibilities get expanded. The space in which engineers and designers can search for solutions, the so-called design space becomes bigger with technological innovations.

The other two aspects: meaning and archetypes, have not been established yet when new technology constellations start their expansion of the design space. In short, the lifecycle of a constellation follows six phases. The first phase of a new technology is about its functional performance. After which decisive demonstrations show the technical and economic feasibility of the system in the second phase. In the third phase, the technology takes off explosively, often due to a structural crisis in the world that demands a new mode of being. After the third phase, in the next consecutive phases, the technology slowly becomes common sense, matures and slowly loses its huge impact before it either disappears completely or coexists with the next technology constellation (Freeman & Louçã, 2001; Perez, 2009). An example of this is the audio industry where the success of technologies that enabled users to listen to music in their home sparked many more innovations in that field leading to record stores, repair shops, cassette players, CDs, walkmans, speakers, amplifiers and many more. Today, that world, especially vinyl records, coexists with music streaming services such as Spotify.

This timeline of six phases shows similarities to the theory of product phases discussed in the first chapter and also structural likeness to the six phases of a production paradigm. Most of these tend to follow a line that starts with slow, but accelerating growth. Then lead to a steep increase in growth after which the growth declines again. This is known in forecasting as the S-curve (Saffo, 2007). It is not until the third phase (explosive growth) of a technology system, after two phases of incremental performance optimization, that a dominant design, and thus an archetype, starts to emerge for a product (Perez, 2009). Besides that, the market for the new product slowly will become saturated and therefore producers will start to try to distinguish themselves from their competitors by introducing additional features to their product. Giving additional meaning to a product is an example of this. A product that fits the lifestyle of the owner will be perceived as more meaningful and thus stand out amongst similar products. This happens during phases of itemization and segmentation of the product phases model (Eger et al., 2010) and thus follows behind the expansion of the design space that happens at the early phases of performance and optimization. Therefore, here it is attempted to define the design space of the consecutive industrial revolutions.

The design space spans the width of human technological knowledge and is bounded by the actors and factors that work on its frontiers. The developments of the industrial revolutions follow in the wake of its carrier branches, use its core infrastructures and use the inputs provided by the motive branches. These three fields are on the frontiers of their corresponding industrial revolutions and therefore expand the general design space (Freeman & Louçã, 2001), advancing the design possibilities of the whole industrial world. A representation of the expanding design space and the corresponding industries and resources can be seen in figure 11.

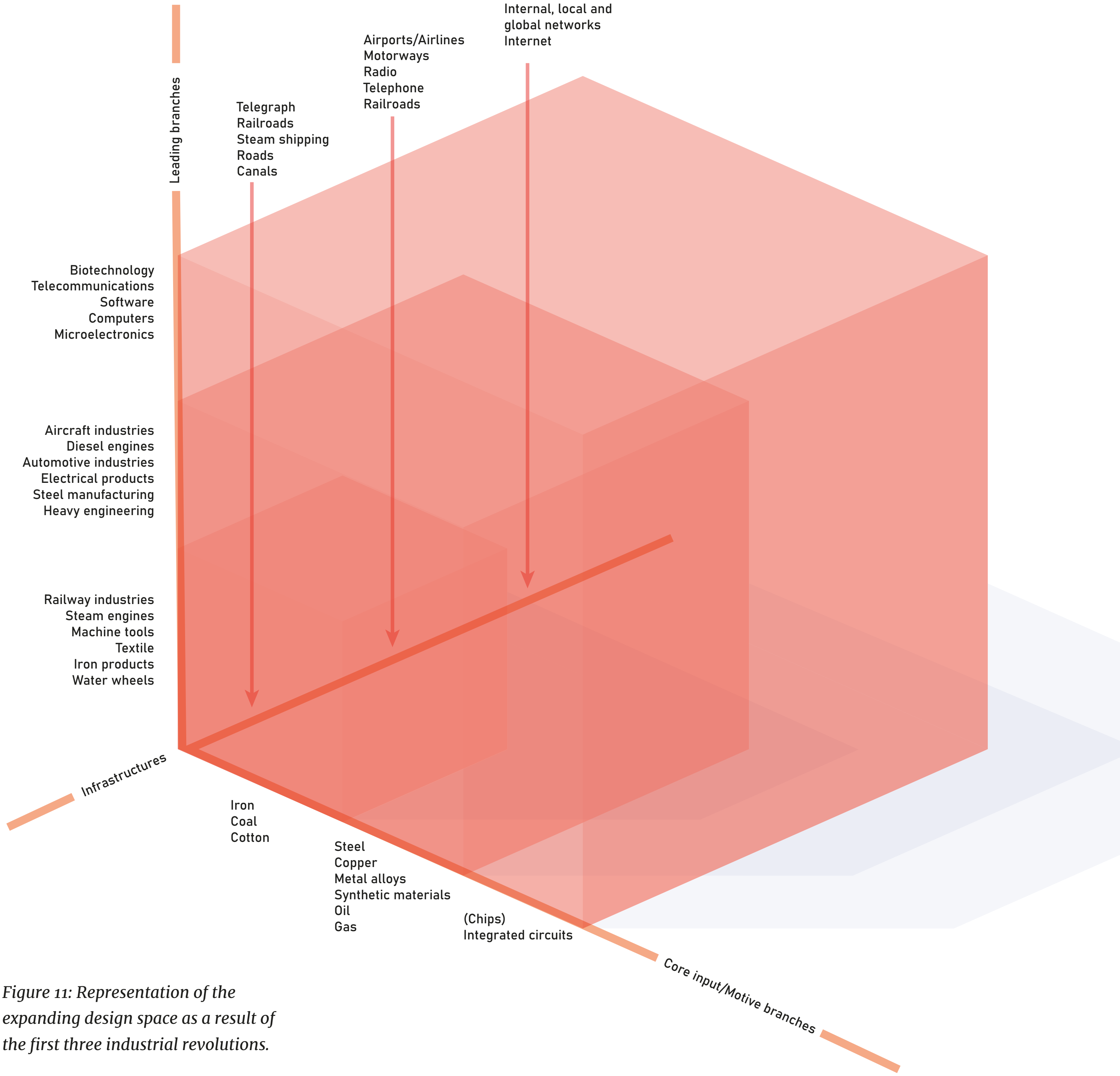


Figure 11: Representation of the expanding design space as a result of the first three industrial revolutions.

2.4 The design space of the fourth industrial revolution

To summarize, the design space as mentioned earlier is thus defined by three elements of the subsequent industrial revolutions. On one axis the core inputs, which are resources provided by industries in the motive branches and characterized by becoming universally available and at low prices. These inputs are used directly or indirectly by industries known as carrier branches. These stimulate the rise of other new industries. New infrastructures stimulate both inputs and carrier branches in their growth (Freeman & Louçã, 2001). A lot of these infrastructures focus on improving communication between technological systems and with that stimulate co-evolution of these systems as well as aid in achieving a common technological agenda (Rip & Kemp, 1998).

Besides that, it is known that innovation happens within the context of the existing sociotechnical regimes. That means that besides technology trajectories being influenced by engineering and industry communities, they are also influenced by more social groups such as policy makers, investors, users and societal groups (Geels, 2002). This notion also corresponds with the earlier statements that new technologies should be socially acceptable to be successful (chapter 2.2). New technologies do not suddenly appear, they are the product of years of development to overcome the limitations of what was before. Some limitations of using iron were overcome when steel was introduced. And the limitations of using one large steam engine to power a factory were largely taken away by the introduction of electrical power (Rip & Kemp, 1998). Furthermore, new technologies often will be added to existing artefacts before branching off into their own industries. That means that it is likely that the technologies of the Fourth Industrial Revolution will first be applied to the sociotechnical regimes of today in order to solve existing concerns by augmenting existing technologies.

2.4.1 Government strategies for a cybernetic future

Radical innovations often take place during crises or wars, when rapid solutions are required, regardless of the costs (Freeman & Louçã, 2001; Perez, 2009; Rip & Kemp, 1998). An example of this is the surprisingly rapid shift to remote work that the world experienced during the beginning of the Covid-19 pandemic in 2020. Many companies and educational institutions were slowly experimenting with the possibilities, but the sudden crisis forced rapid adaptation.

Governments have become a large factor in steering research efforts (Freeman & Louçã, 2001) through funding and developing shared agendas. Especially after the Second World War (Rip & Kemp, 1998). The technologies that come from government-funded projects often also find their way to the consumer world. Examples of this include the internet or telecommunications (Freeman & Louçã, 2001; Katz, 2015).

Germany and China are among the world leaders when it comes to manufacturing (Li, 2018; Rojko, 2017). A logical first step to uncover the future of industry would be to examine the official plans that were released by those governments. The idea for Industry 4.0 was introduced at a German industrial fair in 2013 and has since been adopted as the German national strategy for their manufacturing industry (Li, 2018). It is focused on using cyberphysical systems to make connections across the value chain and therefore transcend any singular enterprise (Rüßmann et al., 2015). Germany is a European frontrunner in the industry and therefore also relevant for the other countries in Europe. China adapted a similar strategy. They aim towards producing higher quality products and eventually becoming the single most important industrial power in the world by transitioning from a labor intensive regime towards knowledge based manufacturing. Both strategies involve setting up cyberphysical networks and focus on an amount of specific fields that will lead towards that goal.

Both strategies prioritize quick automation by industrial robotic developments that enable collaboration. To achieve this, connectedness through the internet of things is a large factor (Li, 2018). Therefore, industries in machine manufacturing, software development and network infrastructures will be involved in the process. Cyberphyisical systems bridge the gap between the physical and the digital world. In the scope of the theory of production paradigms (paragraph 2.2.1) these developments also seem a logical next step. The timeline of the scientific-cybernetic production paradigm shows that the fourth industrial revolution will span mainly the third and fourth phase of that paradigm. Therefore, the developments of the third industrial revolution and the paradigm that it introduced will continue to diffuse and mature in the years to come and be widely applied to almost all aspects of industry and society. Including our physical environment.

Besides industry 4.0, the European Union also has eyes on industry 5.0. This concept builds upon the developments of industry 4.0, but takes it a step further. In the production paradigm, industry 5.0 will be the period where the technologies are completely integrated in the lives of people and society. It is a concept that connects the technologies of industry 4.0 directly to people's lives and is therefore relevant for D'Andrea & Evers Design. Industry 5.0 brings forward three pillars to focus on when the new technologies of the fourth industrial revolution find wide application. The first one is human-centricity, the second one sustainability and the third one is resilience (Breque, Nul, & Petridis, 2021; Müller, 2020). Especially for the first two, design could potentially play an important role as a bridge between technology, the world and its people.

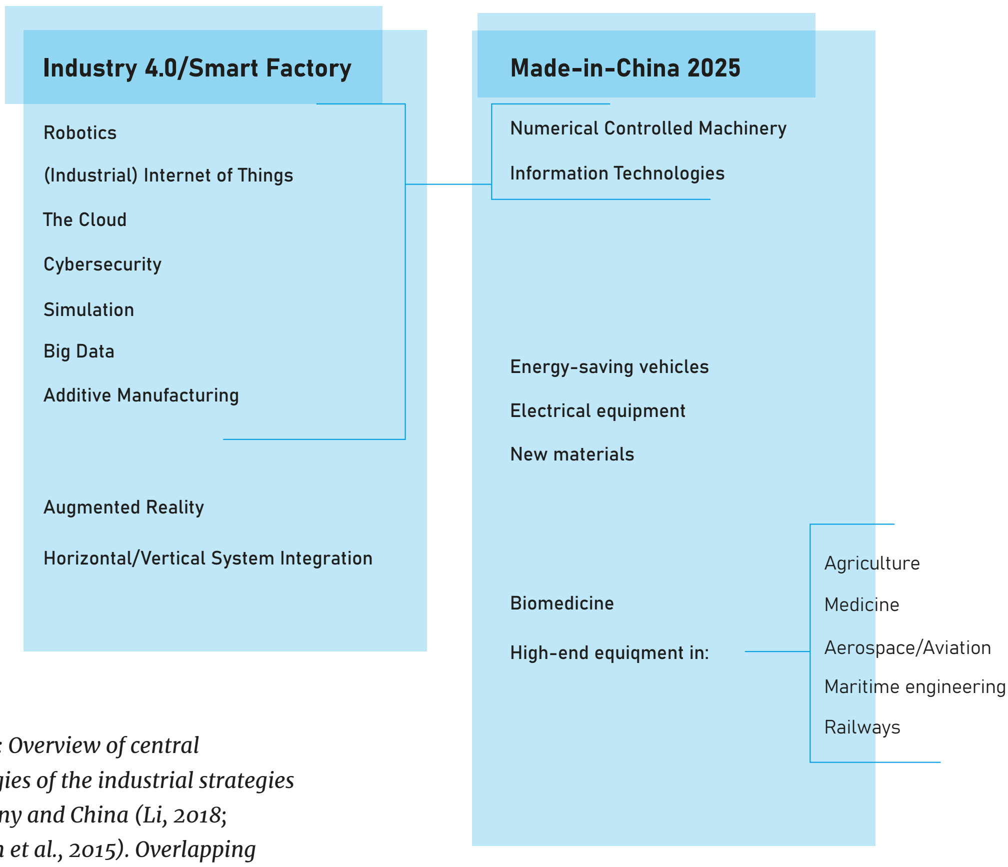


Figure 12: Overview of central technologies of the industrial strategies of Germany and China (Li, 2018; Rüßmann et al., 2015). Overlapping concepts can be found.

2.4.2 A network of future technologies

Since the 1990s, society is undergoing trends of spreading user-friendly information technologies (Grinin, Grinin, & Korotayev, 2017) and increasing economic globalization (Grinin & Grinin, 2016). It is a phase in the scientific-cybernetic paradigm that is followed by a stage where its principles gain advanced characteristics (Grinin, 2012). Eventually it will be a revolution of self-regulating systems that take inputs and process them in pre-programmed or even autonomous ways. This trend is also visible in the national strategies centred around cybernetic systems that were discussed earlier. (Paragraph 2.4.1)

The cybernetic revolution (which is the period during the first three phases of the scientific-cybernetic production paradigm) will revolve around these self-regulating systems, which will have their large initial applications in the fields of biology and medicine. On a larger scale, the trends will include: increasingly complex systems, decreasing sizes (being able to do more with less volume), decreasing use of energy and resources, increasing individualization, smart technologies with more human-like functions (speech) and elimination of the negative impact of the human-factor. (Grinin et al., 2017) A large trend that keeps on growing is the trend towards green technologies. Eventually all industries must make the transition towards greener and sustainable business. The efficiency of self regulating systems will play a role in that transition of decreasing the amount of used resources. Another factor that plays a role in decreasing the use of energy and resources is the field of biotechnology and nanotechnology which show a trend towards controllability of ever smaller things; Leading to new, smarter materials (Allianz, 2010).

Besides green trends and increasing globalisation, which are so-called megatrends, others include: nanotechnology, biotechnology and health (Allianz, 2010; Grinin & Grinin, 2013). An aging and more individualistic society leads to increasing investments in the healthcare industry. People are willing to spend more money on their health, making innovations in this field economically feasible and socially acceptable and therefore the industry grows and keeps on growing. It is a field where many new technologies emerge on the intersection of the physical, digital and biological. A holistic idea of health as driver of the new technological revolution (Allianz, 2010; Nefiodow, 2020; Nefiodow & Nefiodow, 2014).

The perspective above is different from the perspective taken in previous paragraphs. Earlier the emphasis was more on the industrial world while for the scholars used here it is more about societal developments of aging and individualism. Nevertheless, they arrive at similar conclusions when they talk about the prospected driving technologies of the future. That fact is important to note since it shows the important characteristic of broad applicability across industries that many leading technologies share. Such as the steam engine or computing technologies. It gives them the ability to transform economies and societies.

Furthermore, they also show that second important characteristic: interconnectedness (figure 15). The technologies of industry 4.0 and its Chinese equivalent revolve around cybernetic systems. If one of them fails to deliver, the other industries suffer. More importantly, growth in one industry stimulates growth in other industries. In the other perspective, the societal one, all technologies revolve around health technologies and the same principle applies.

To define the design space of the fourth industrial revolution, three dimensions need to be determined. The carrier branches are now known. The most important ones are: medicine, additive technology, nanotechnology, biotechnology, robotics, IT and cognitive technology (Allianz, 2010; Grinin et al., 2017) as well as: cyber-physical systems and therefore also augmented reality (Culot, Orzes, Sartor, & Nassimbeni, 2020; Kipper, Furstenau, Hoppe, Frozza, & Iespen, 2019; Rüßmann et al., 2015; Schwab, 2016; Wan, Cai, & Zhou, 2015). Many other branches may pop up as the processes evolve, but these are the fields in which large commitment can be observed.

The second dimension defines the core inputs. Core inputs generally get more accessible and cheaper quickly and allow the carrier branches to grow. It is likely that the core inputs of the fourth industrial revolution are largely intangible assets such as data or knowledge. Some highly valued companies nowadays have few

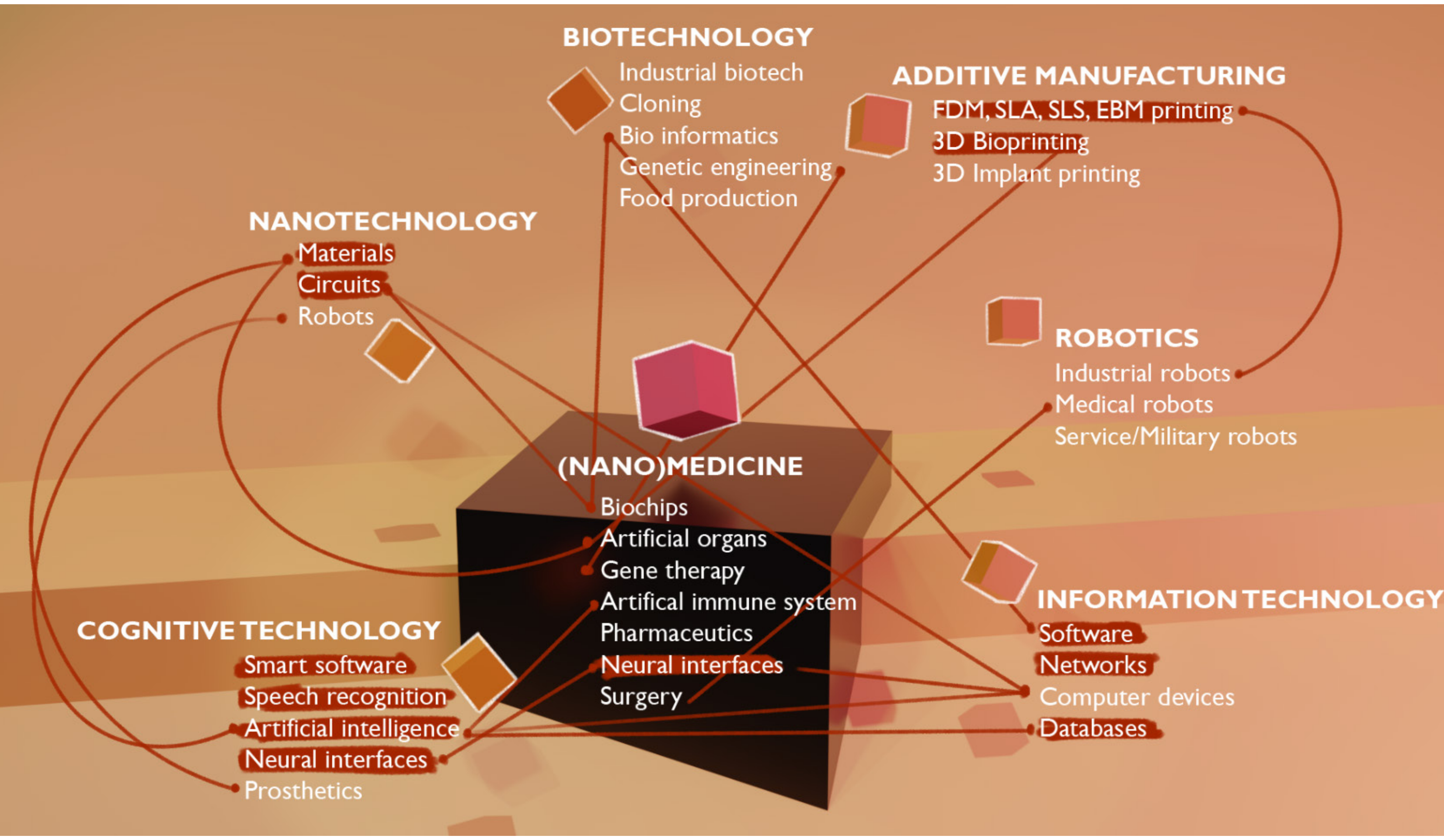


Figure 13: Selection of interconnectedness in future industries around medicine. Red marked technologies are examples that relate directly to the field of industrial design, although many of the others can also have their influence on the field. The amount of connecting lines is not exhaustive. Many more exist. Adapted from: Grinin et al. (2017).

physical assets. These companies run on connecting users to physical assets, such as Uber, Alibaba or Airbnb. These are companies in the platform-oriented economy where not assets, but services are sold (Schwab, 2016). In reality, they run on a new type of intangible asset: data. Through advancements in computing power and algorithms, the amount of data is growing rapidly. For many purposes, the larger the quantity of data is, the more valuable it is. Most of the leading branches mentioned before lean on data to work optimally.

The third dimension names important infrastructures that stimulate growth in the other dimensions. Large amounts of data are going to be used by the systems of the fourth industrial revolution. It is similar to the problem that large factories had at the beginning of the second industrial revolution. The amount of machines that could be powered by the steam engines that were used at the time was limited by the fact that the engine as a power source should be placed in close vicinity to the machines. The power needed to be transmitted through a series of belts and rods directly attached to the wheel of the engine. The problem was solved by the introduction of electric power that allowed the power source to be geographically disconnected to the factory floor. The large amounts of data that are used to inform algorithms and artificial intelligences (AI) cannot be stored locally. Datacentres are needed to store that data and therefore fast networks that can quickly transport large amounts of data are necessary.

Furthermore, a lot of the data that companies nowadays have of consumers are gathered by websites that at first glance offer their services for free. It is often said though, that users are in fact paying for the service with their data instead of monetary assets. These websites, social networks, are large infrastructures that can be incredibly powerful and are capable of regulation people’s experiential sphere in the digital world.

Lastly, infrastructures within enterprises are linked horizontally and vertically. That means that systems will focus on the whole chain instead of a singular link within that chain. Products and services can be followed from their origin to their end.

The design spaces of the first three industrial revolutions were consecutively about replacing muscle power with mechanical power, mobilizing the masses, and automating control of processes. The newest revolution is about emulating human thinking. It will allow systems to operate without human intervention as the steam engine allowed machines to operate without human muscle power. And at a much greater strength for that matter.

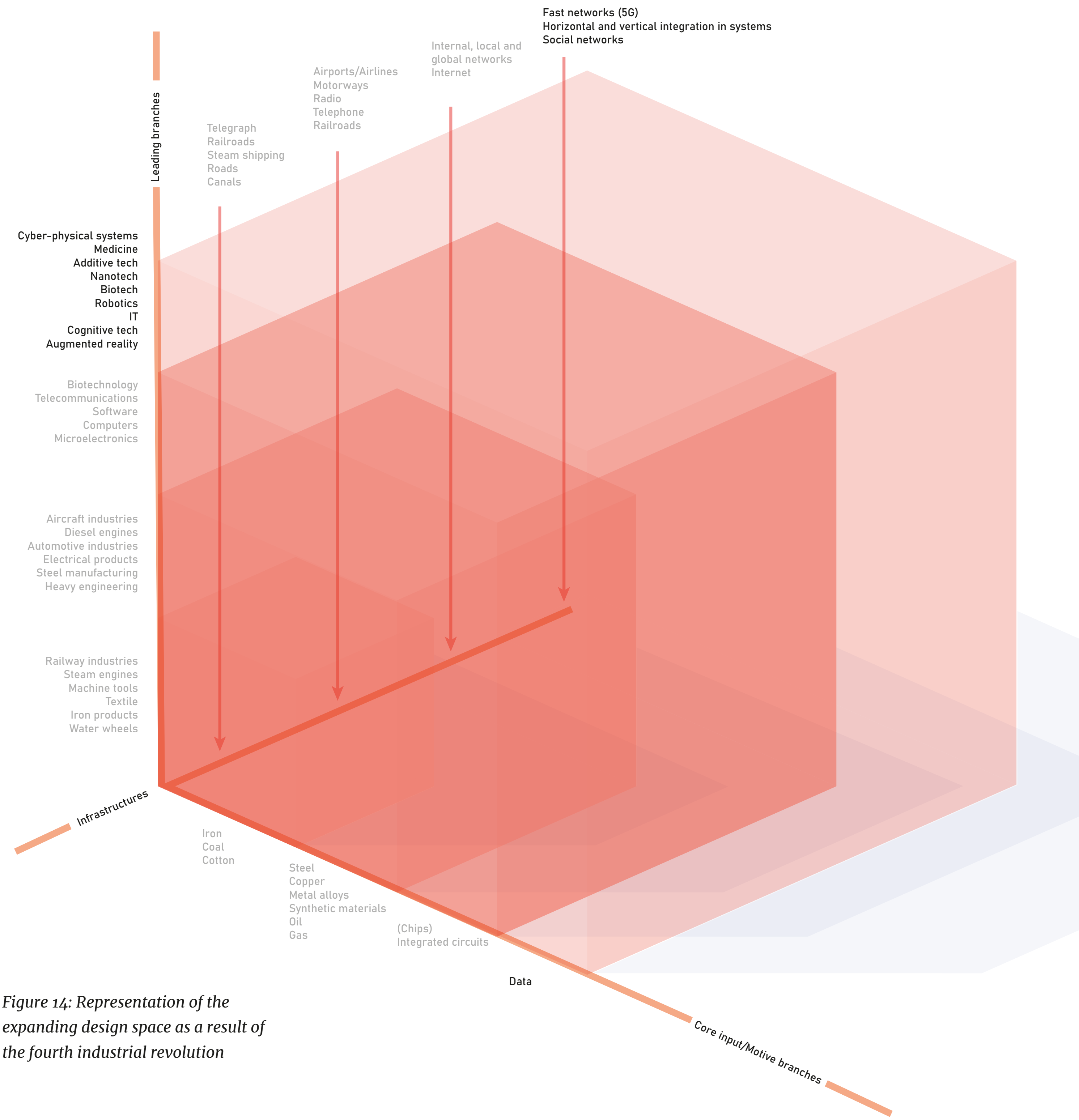


Figure 14: Representation of the expanding design space as a result of the fourth industrial revolution

2.5 The shape of progress

The characteristic of data as a core input, as stated before, is that the more there is of it, the more valuable it becomes. Therefore, companies that rely on data for their products have incentive to implement it as broadly as they can. Furthermore, industry 4.0 and its Chinese equivalent, have expressed an interest in aiming for horizontal and vertical system integration. Which means as much as being able to follow assets throughout the value chain. From the theory of production paradigms, we know that the cybernetic paradigm will grow until it fully dominates all productive practices that it can. Since data is so versatile, the assumption that a large majority of assets, including consumer products, will exist partially, if not fully, in the digital realm is relatively plausible. It is also likely that this trend will not limit itself to produced goods, in the fourth industrial revolution it can extend into the biological world too (Schwab, 2016).

In history, other technologies have spread in a similar fashion. The steam engine, and related industrial equipment, continued to grow until most of the industries were machine-powered. The internal combustion engine and the concept of electricity had similar paths in the industry. They all brought great change to the way that produced goods were manufactured. Those were manufacturing revolutions. And they certainly changed how these goods manifested aesthetically. However, for design, the real revolutions occurred when some of these technologies were introduced on the mass market, since that is the moment that these revolutionary concepts required a physical shape. In the second industrial revolution that was the introduction of electrical products, or the introduction of internal combustion engine powered automobiles, or the first personal computers or telecommunications devices during the third industrial revolution.

These products all were built around their physical components and direct predecessors at first. During the third and fourth phase of the product lifecycle (chapter 1) a coherent visual design language was required. Cars shed their stagecoach-like appearance and adopted sleek, forward-looking, strong designs that visualized the power of the combustion engine. Electrical products transitioned from old fashioned hand-powered products with an electrical plug attached to it into a product category with their own design language of modernity. With smooth surfaces and shapes that emphasized how clean, quick and powerful electricity was and how well it would fit in the modern home. In the third industrial revolution, computers were large, scientific machines that required dedicated rooms at universities and intelligent people to function. Their design was merely an enclosure of its functional parts. Some of the designs from previous generations carried over into the new technology, such as the designs of typewriters for keyboards or televisions for screens, as was the case with previous new technologies too. When the technology, as with combustion engines and electricity, proved not only useful for the industrial-scientific world but also the consumer world, a need for design emerged. As computers were turned into personal computers, designers developed a design language of digital, computer-powered devices. This language revolved around usability and the products remained box-shaped for a long time. With time, computer devices developed meaningful designs and nowadays we can determine whether a product is electrical, digital, or both by looking at the cues that the design provides us with.

These new technologies, due to their universal nature, got introduced in existing products. Motorized leaf blowers, motorized lawn mowers. Or electrical stoves, electrical brooms (vacuum cleaners), electrical heating. Or digital clocks, computer mouses, digital music players. Some of the design language of the motorized, electrical, or digital, carried over into the new product. The computer revolution changed how radios looked for example. The old aesthetic merged with the aesthetic of the new technology to create a new look for the product. The prediction is that cyberphysical, data-powered technologies will make their way into consumer devices with time as these previous technologies did. The difference is that the motorization, electrification or digitization of consumer products limited themselves to certain product groups. Data technologies, however, being largely intangible and more valuable with scale, will likely expand into larger amounts of product groups than these previous technologies.

The design of future products will combine the existing archetype of the product, such as a refrigerator, a vacuum cleaner or an alarm clock, with the archetype of the central revolutionary technology that is embedded within that product (see also figure 20). This was for example clearly visible in early electrical products. A vaccuum cleaner, for instance, looked like a broomstick covered with a sauce of electrical aesthetics (Müller, 2017). Therefore, by developing the shape language of cyberphysicality and data, designers can develop a coherent shape language central to the fourth industrial revolution that tends to carry over to large amounts of different consumer products.

Chapter 3
Shifting focus

3.1 The meaningful shift

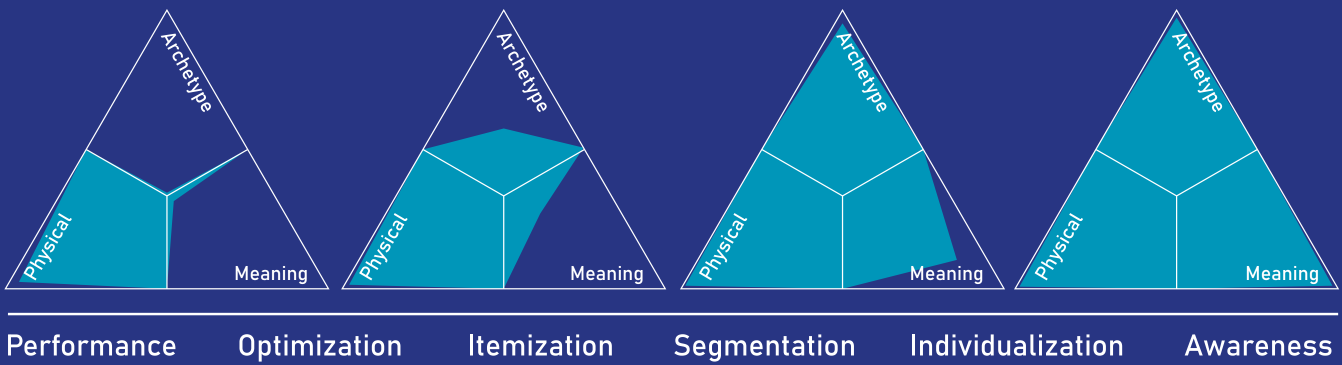
As established in chapter 1 (figure 1), designed products are at the intersection of three parameters. The physical characteristics, the experienced meaning and how the product relates to its archetype (Eger, Bonnema, Lutters, & van der Voort, 2010). Physical characteristics refer to the technological and physical ergonomic possibilities. Meaning is seen as the emotional characteristics of a product such as its relation to the user or its cultural significance. Archetype is a dominant design for a certain product that emerges as the market for the product gets more saturated (Eger & Drukker, 2010; Perez, 2009).

Although archetypes can hardly be seen as a constant, for products that have existed for some time experience changes and the archetype will therefore expand. The term encapsules the generally accepted dominant design of a product in a certain time and place, and is based upon previously experienced versions of the product. For example: the design of an archetypical phone has changed throughout the years and a user of an early phone would probably hardly recognize today's landline or mobile phones, although some aspects such as speakers and a microphone at opposite sides of the product have carried over in modern designs. To design a phone that looks like early telephones would require a conscious choice to deviate from the current archetype.

These three aspects account for the designer-side of the design process. From the receiving side, the side of the user, other aspects play important roles. User response consists of a physical dimension, a behavioral dimension and a reflective dimension (Crilly, Moultrie, & Clarkson, 2004; Jensen, 2014; Norman, 2004). The first two are tools that can be used to create the meaning that is housed in the reflective dimension (Jensen, 2014). Although these three elements are different from the elements that describe the perspective of the designer, connections can be found because they are concerned with the same object. A designer has to balance physical characteristics, meaningful characteristics and the product's relationship to its archetype. Through these three facets, a designer designs for visceral, behavioral or reflective experiences. Or, more often, a combination of the three.

The importance of the elements on the side of the designer change relatively to each other throughout the phases of the product's lifecycle. The first phases, performance and optimization, are all about the shape. An archetype has yet to be formed and the focus is on developing a working product. In the third phase, itemization, the product gains a dominant design, in other words: an archetype. The archetype is formed by knowledge of previous versions of the product. With the fourth phase and beyond, performance is of lesser importance when it comes to distinguishing a product on the market. Therefore, the share of meaning within the design grows to better fit to the target audience (Eger et al., 2010; Eger & Drukker, 2010).

Figure 15: Representation of the relative change of the aspects throughout the lifecycle of a product type.



As established in an chapter 1, D'Andrea & Evers Design as a company has a strong emphasis on product styling and product development from a standpoint of predetermined technology and use-case. Therefore, the three elements of a product design will be viewed from the perspective of the physical, mostly visual, manifestation of the product. That means that in the following analysis, a lower influence of the aspect of shape on the product design does not mean per se that the techno-physical characteristics of the product have become less important for the product to function, but merely that they do not have such a large influence on the user-perceived manifestation of the design.

This chapter looks at how the design of technological products that are associated with the industrial revolutions evolved from the perspective of the three elements: physical, meaningful and archetype.
The influence of the physical dimension declines and the meaningful dimension relatively becomes more important. Furthermore, literature research into the history of design in the three previous revolutions indicates a similar trend in the evolution of manufactured products as a whole, not just technological products.

Around the late eighteenth century, craftsmen mostly sold their products, say pottery, directly on the market or to a merchant. A change came around when some started to sell through advance orders. It brought to the table a new need: the need for consistency. If someone saw a product in a showroom and ordered it, it could be expected that the received product would closely resemble the showroom object. Through a process of eliminating the influences of individual workers on the product, this lead to a process where tasks were divided among several workers (Forty, 1992).

One of those tasks is the task of designing the prototype product that would have to be recreated by the other workers. Often, this task was performed by a senior worker in the workshop. Though when catering a larger audience, something that any non-custom product does, a certain sense of fashion may help increase sales. Artists, who had more of a feeling of what was in fashion were commissioned to design prototypes. The product should then be able to be manufactured using the tools that the workshop provides. It is an example of how tools can influence how something is designed. Even long before the first steam engines were put to use in the industry. These machines merely brought speed and an unprecedented amount of power to the table, but many of the tools were already in use by then. The mechanization of industry meant that the whole process remained the same, except for one thing: the amount of products that could be sold (Forty, 1992).

It also means that the nature of products did not change a whole lot during the first industrial revolution. Manufacturers did their best to design and market products that were similar to what people were used to, but at a much larger scale. Though some people argued that the mechanization of the production process lowered the quality of the products (Forty, 1992). Hardly any new technologies that are associated with the revolution were incorporated in consumer products directly. The products in which these new technologies were used, such as trains, were mostly large industrial products.

Looking at the design of those products though, it becomes clear how much the designers tried to emulate existing products. The railway carriages aesthetically took after stagecoaches and other carts that were around at the time. The locomotives, and many other products for that matter, were mainly decorated with two-dimensional elements as if it was an afterthought. The shape of products such as locomotives was almost completely derived from their functional parts (Heskett, 1980). And product meaning was largely personal or dictated by fashion.

Therefore, the overall distribution of the three elements, archetype, physical and meaning, in the products of the first industrial revolution, such as steam engines and trains, was highly focused on the side of the physical. The new technologies were meant for utility, the decorative arts brought meaning. At the same time, the new technologies of the first industrial revolution were large and required a lot of space. It is therefore quite logical that they were formed after their functional parts (figure 16).

There are two types of products that get influenced by the industrial revolutions. The first are the new technologies themselves: steam engines, electrical products, computers, etcetera. The second type are products that are not necessarily new, but are manufactured or formed by processes that incorporate new technologies. An iron cooking pot, or a chair that was manufactured by bending wood with steam, which are also products of the first industrial revolution, would hardly be formed by the new manufacturing technology, but were especially heavily influenced by existing archetypes. Though new forms became possible to make with certain material such as wood.

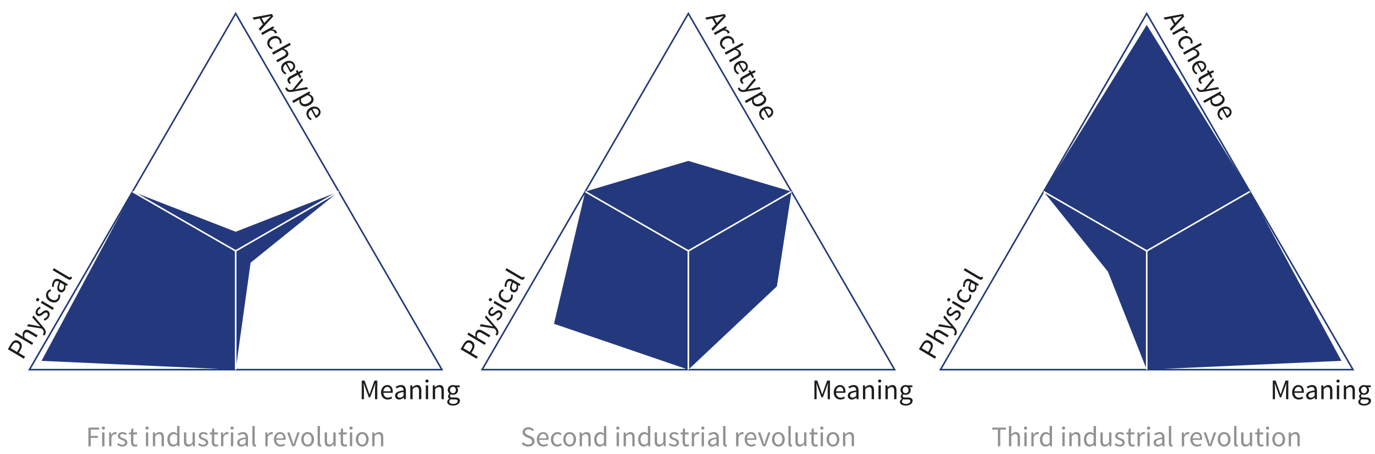
Eventually, true mass consumption showed its face around the beginning of the twentieth century. Capitalist goods started to take over from the decorative arts in providing people with meaning in the sense of comfort, being symbols of propriety and relationships and eventually signs of aspiration and taste (Sparke, 2004). It was also the time that design started to gain footing as a profession. The markets for mechanically produced products became saturated and manufacturers started to look for new ways to outsell their competition.

With the second industrial revolution came more scientific and technological innovations and developments. Modernity brought a sense of forward looking technologic optimism. The future would be better with these technologies. They would make life easier, better and more comfortable. Many of these innovations initially were used mainly in professional contexts. Until manufacturers noticed a possibility to spread their products to markets for domestic use. This corresponds with the theory of product phases: as soon as a product functionally works well, producers start to search for other ways to expand their activities. The typewriter was at first primarily used in offices. But when it made the jump to the home, the appearance of the machines proved too industrial for people to comfortably let into their house. Designers would work on these products to give them a face-lift and make them suitable for the home. They would enclose anything about the machine that could be enclosed to give it a softer look that was more fitting to the new environment (Forty, 1992).

Electricity brought greater efficiency to the factories. Campaigns to promote electricity for domestic use were aimed at creating electrical products for the home environment too. Again, it took a while for manufacturers to notice that people tend to want to see as little machinery as possible. They hardly want to know their products are machines at all. Therefore, they hired designers to bridge the gap between consumers and the highly technological products. The products were created to improve people's health and lives, but their appearance hardly conveyed that. The functionality of these products were easy to sell in the era of technological rationalism, but they did not fit in the home environment. They looked harsh and crude. There was a gap between the image that electrical products had and how they looked. Electricity was marketed as energy, clean, fast and modern. Therefore, designers took it on themselves to create products that conveyed that message. They added meaning to the styling. The product looked like people wanted their house to look. And it worked (Forty, 1992).

The electrical products at the start of the second industrial revolution were often modeled after their functionality and especially archetype. That means that early vacuums looked like broomsticks, early electric water kettles looked like older kettles and early electric stoves looked like gas stoves. The producers were not very imaginative and it initially was not their greatest concern after all. But as the products matured, a new aesthetic emerges: the aesthetic of domestic electrical products (Müller, 2017). Furthermore, for other product categories of the era as well, modernity brought the need to convey an image of technological and scientific progress. The large jumps that were made in the transport sector were used as a metaphor to provide the modern products with an aesthetic that conveyed motion and shiny newness (Forty, 1992; Sparke,

Figure 16: Relative proportions of the aspects for new technologies throughout the revolutions.



2004). The products thus came to convey more meaning due to the involvement of dedicated designers and a growing need to distinguish oneself from the market. However, a large movement in the world of design at the time, functionalism, held beliefs that utility should be a leading factor of design. Therefore, the new aesthetic was a combination of shapes derived by its functional parts that were encased to communicate to the user that these products were safe and meant to use in the home of the modern family.

Functionalism as a principle can be quite literally put to use in simple, non-technological, products such as chairs and cupboards. These products were made using new technologies such as electricity. But due to the functionalist movement, their shapes would still be determined by utility. Though some meaning would be involved since the idea of functionalism is meaningful in itself. The intangibility of the new technologies, however, required that designers would think about how people would use these products. The concept of the user in product design stems from this era (Müller, 2017). The archetype that eventually emerged, was no longer derived from the sum of the functional parts of a product, but was partially made up by the manufacturers as an interface between the need of the user and the intention of the manufacturer.

The first computers of the third industrial revolution were, to be honest, pretty much shaped by the physical technology. A lot of wires and components were put together to massive machines. However, just as with electricity, the central technology (microelectronics) lacks moving parts. The functionality is invisible. Besides that, the utility is not even singular (Müller, 2017). Computers can do many things and to shape it after what task it performs would be impossible. Therefore, the nature of computer devices already requires a more generalized design direction.

The digital revolution mainly originated from Silicon Valley, where engineering ruled. The computer technologies had a major drawback. Many companies had only small, if any, industrial design departments. The cases of the products that they manufactured were mostly utilitarian boxes. The engineering departments mainly focused on functionality, any aesthetic or ergonomic features were byproducts. The design departments had to prove that they could bring more to the table than merely aesthetics in order to gain trust from the engineering companies in that they could be a valuable addition. Essentially, with the new technology, something similar happened as before, when electrical products entered the markets (Katz, 2015). The new technology is seen to follow the product phases. In the early phases, engineering seemed to be strongly favored above design. Later in the process, the roles would be reversed.

A major difference with how electrical products were developed was the rate at which the technology grew. Tech companies such as Hewlett-Packard had fast growing product lines in the early years of the third industrial revolution, many of which had been developed independently of each other. The new problem was that products quickly became obsolete, aesthetically or in terms of performance. At the same time, almost none of the products was designed for maintenance. The clients, who were mainly industrial partners, could not access their products for service. The lifespan of the products continued to shorten (Katz, 2015).

The multipurpose nature of the digital technologies allowed for a revolution within the design departments of Silicon Valley. Instead of starting from a predetermined product type, such as an oscilloscope, in HP's case, their one-man design department reframed the brief into a broader assignment to satisfy the requirements of the instrument, the environment and the people who use it. They generalized the problem they tried to solve (Katz, 2015). In short, they attempted to eliminate the influence of the archetype as much as possible from the design brief to shift their focus to ease of use, safety and aesthetics to create an overall corporate image. Industrial design came in earlier in the product development process, and therefore, meaning was embedded earlier in the process too (Valtonen, 2005). And not just as an afterthought.

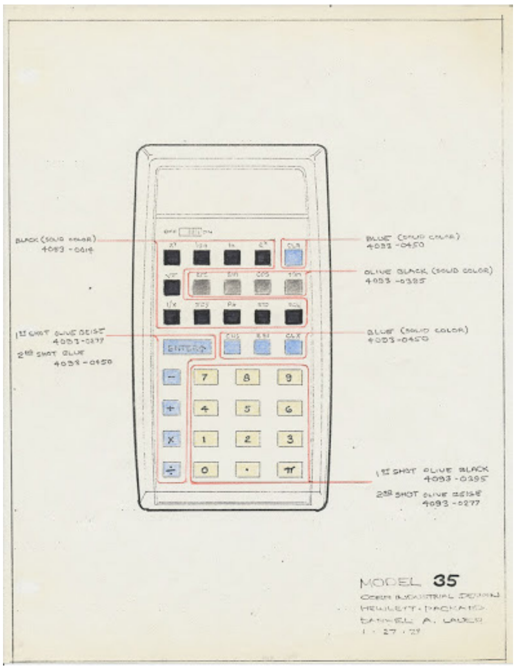


Figure 17: a study of the HP-35 pocket calculator. From: Katz (2015)

An example of where design was involved from the start is in the development of the HP-35 pocket calculator (figure 17). The starting point of that process was the idea of a calculator that an engineer could put in their shirt pocket. The engineering department had to, for one of the first times ever, work together alongside the designers who had designed the device to be ergonomically sound and even a little wedged in its shape to allow it to slide into a pocket easier. It was a success, not only among engineers, but also non-professional consumers. It was also an anomaly. It would take a lot more years before the technology firms of Silicon Valley would definitely embrace the consumer market (Katz, 2015).

Computing devices are highly unspecific. And therefore, the visceral experiences are very basic. The true experience constitutes at the meaningful levels. The experience of these devices are its interfaces that often simulate a physical form for the formless inner workings (Müller, 2017). This notion becomes more significant in later years. In products of the digital age, such as personal computers and smartphones, the physical devices were seen as important but highly replaceable. The primary source of meaning was the digital information that they held (Orth, Thurgood, & Hoven, 2019). The physical shape of these devices mainly has to do with ergonomics, interaction and being sufficiently legible by users. Designers, now being involved earlier, could add value by determining the interfaces of these products during development, instead of merely creating a housing for the electronics. The interfaces were physical manifestations of the mental models that were designed to ensure greater usability (Katz, 2015; Norman, 1988; Valtonen, 2005). A large difference with the focus on the visceral level of pleasant aesthetics earlier in the century.

For the field of design, as with earlier industrial revolutions, the real change did not come with the new technologies. Design would be brought into it later, when the technology would be developed enough for widespread use. Such was also the case during the digital revolution. The real revolution was the notion that not only computer hobbyists would be interested in these devices if they only were more approachable. Most people wanted to just plug it in and be able to get to work (McCue, 2017). It led to research on interaction devices such as the mouse, the desktop computer and all sorts of consumer products (Katz, 2015). The technologies were out of the early product phases and design was involved more. The Apple company used design to make the box-shaped computer more fit for the domestic environment with attention to user-friendliness in interaction and style. Later on that would even be implemented more when Apple computers became very much lifestyle objects in the nineties (Sparke, 2004). Designers became concerned with human factors, first in the behavioural sense, but later also in the meaningful sense. They attempt to create experiences rather than merely the physical interaction (Valtonen, 2005). In a sense, that is an extension of the transition from the design of good looking enclosures for electronics to a more delightful interaction through logical mapping of buttons and switches on devices such as the HP-35 calculator.

The job of the designer, as technology continued to evolve, was to be a bridge between technology and culture. With portable devices such as the Walkman (figure 18) and laptop computers, the boundaries that separated the work and leisure, the domestic and public spheres, were shifting. The possibilities for products to perform were rapidly increasing. From Japan came products that looked highly technical, and also performed accordingly: products such as a watch that was not just a clock, but also an alarm and a stopwatch and that looked like it came from outer space. With black and silver, they brought a certain high-tech aesthetic that would normally be reserved for the workplace. It brought technology closer to the people (Sparke, 2004).

In short, as the technologies shrunk in size while at the same time increasing their already seemingly endless applicable possibilities, the meaning of products became increasingly dominant in their design. Asian manufacturers started to customize similar products for specific markets, changing the colors of television cabinets marketed in different parts of the world. The increased possibility to step away from Fordist mass production and cater to more specific niches led designers to design products with distinctive identities so that they appealed to consumers as best as they could. The faster pace due to automatization also led to products in a sense becoming more temporary and disposable. Something that we now know poses an enormous challenge to the natural environment. Conspicuous consumerism is growing as society gets more technologically advanced (Sparke, 2004). Meaning for consumers is about growth towards the desired self (Norman, 2004). With meaning being increasingly dominant in product design, it is easier than ever for designers and companies to appeal to the desired self of the consumer without too much restrictions of physical shapes. And technology allows them to do that at an exponentially increasing pace.

To summarize, the third industrial revolution brought about global change. Technology became increasingly smaller and more portable as automatization in factories as well as computerized assistance in the design world allowed for a more efficient and versatile product development process. Catering to niches became easier and meaning, through marketing and user research, was a major selling point for products in general. In the meantime, products that used the digital technologies directly, were defined by their interfaces as the technology itself hardly had any physical manifestation. In that sense, archetypes became the major influential factor of these interface designs as designers had to search for analogies to explain the workings of these devices to users. A physical desktop as an analogy for the computer desktop, a hand to indicate where the mouse is pointing, etcetera. It is quite possible that the inherent meanings of the products that were acting as metaphors for digital technologies were partially carried over into the digital variants. Though eventually, as the consumer got used to using these devices, they became their own archetypes. And still today, without the archetype of a computer, it would initially be hard for us to understand how to work with abstract digital devices. For the technologies of the third industrial revolution, metaphorical archetypes and meaning are the dominant factors for the design of these products.

This chapter established that within the subsequent revolutions, certain transformations in the relative proportions of the three elements of design in relation to each other can be seen. For new technologies, as their inner workings have become less physical and more abstract, archetypes have become more relevant as more efforts were focused towards usability. At the same time, with the growing intangibility of new technologies, as established in chapter two, the aspect of physical components has become less dominant in the visual appearance of new technologies. In a way, archetype took over the task that was previously carried out by the physical constraints of the technology. It tells people something about what the product does and how to operate it. Many of these archetypes are used only digitally because of the multipurpose nature of computer devices. The physical design of these devices at the beginning of the third revolution relied very little on archetypes because of the revolutionary newness of the products. There simply was no archetype to build upon (figure 19). That changed when more similar products were introduced.

In a similar fashion, miniaturization of technology imposes less constraints on the physical appearance of products. Therefore, and because of increasing consumerism and technological possibilities, meaning in product design has become a much more important factor in relation to its design. More often, meaning is created to sell as

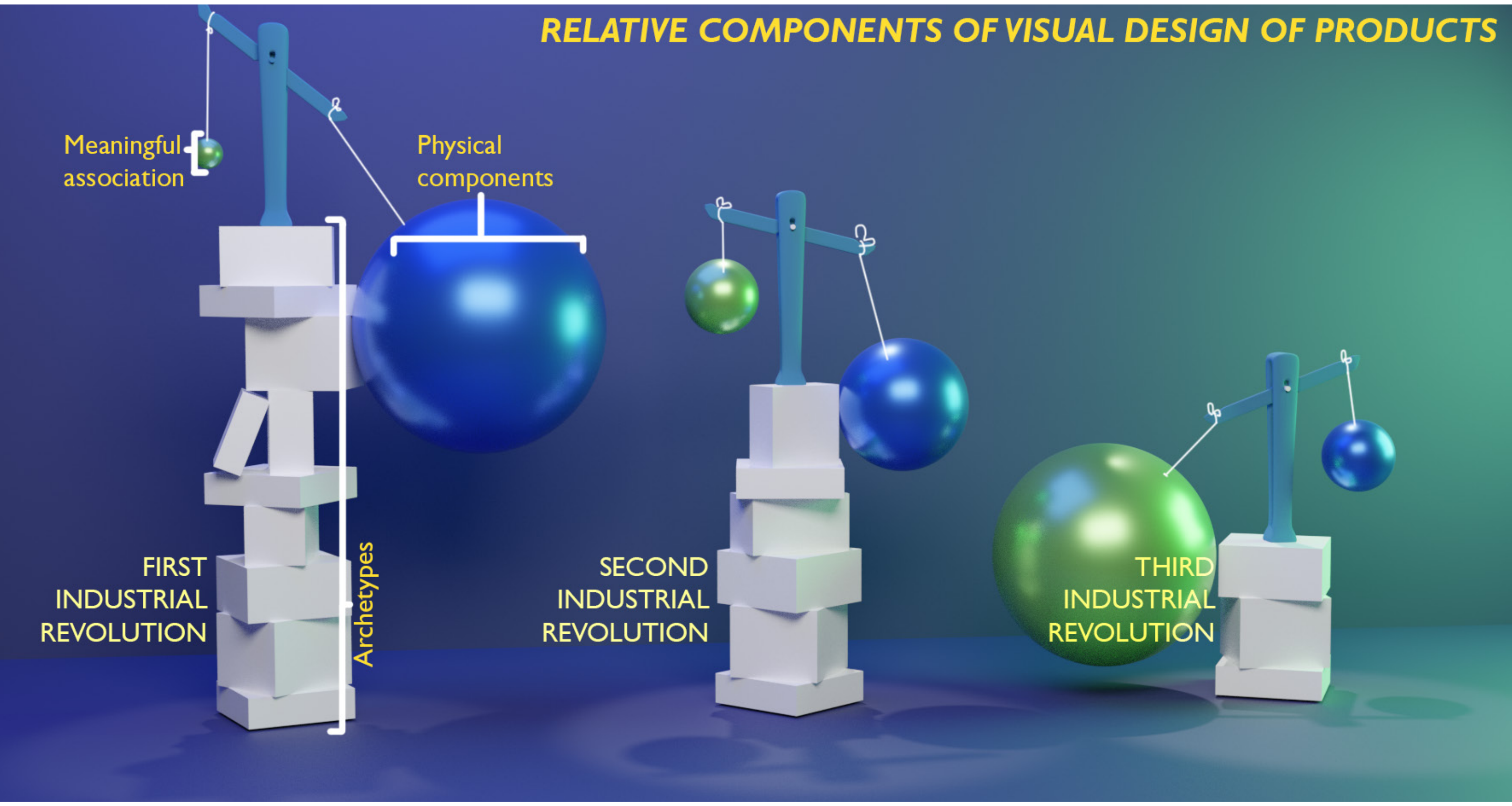
Figure 18: Advertisement for Sony Walkman. A clear example of a link between product design and a lifestyle (meaning). From: Sparke (2004)

much as possible, to appeal to people until a product becomes out of fashion and then sell another meaning to consumers (Sparke, 2004).

Due to the growing amount of flexibility that is possible in manufacturing and design, because of digital tools and improved materials, meaning has become more dominant in derived products too. These are products that are manufactured with the help of new technologies.

During the first industrial revolution, manufacturers tried to emulate existing products as much as they could using new manufacturing methods. In the second industrial revolution new technologies brought a sense of technological optimism and a modernist approach to product design. Application of those ideas infused meaning and a sense of the era in products (Forty, 1992; Sparke, 2004). The third industrial revolution allowed designers to work with computers to rapidly decrease the time needed to design. Automated machines and plastics allowed for a large variety of products to cater to niches of the market. Meaning therefore became the major selling point of many products. They needed to spark a desire for the product in the consumer. At least for a while, until another desire emerged.

Figure 19: a representation of how the relative components of design changed with the revolutions. The relative scales tip more in the direction of meaningful design as time passes. The designs are built on a growing group of archetypes. The longer a product exists, the more likely it is to have many archetypes. Newer products have fewer archetypes.



Chapter 4

The fourth industrial revolution

4.1 Sharing the findings

Fitting to the times, an online meeting was arranged with all employees of D'Andrea & Evers Design. The information presented to them was a relatively compact rendition of much of the information from chapters one through three. A short overview of the three previous revolutions was given together with information about the structure that the industrial revolutions share. The most important characteristics of the fourth industrial revolution were given: the interconnected technologies that revolve around the medical world and how the design space expands into a world where the biological, digital and physical sphere merge into one. As a summary at the end of the presentation, ten core findings were communicated about the influence of the fourth industrial revolution on the designers. Five about the future context of design and five about the future of technological products. The summary allowed the presentation to ease into discussion afterwards. The central findings are presented in table 3. The presentation can be found in appendix B.

The discussion from that meeting was combined with information from previous chapters. This resulted in the list of focal points at the end of this chapter (table 4) which are a first, general, answer to the research questions. Those focal points will be the input for the case study to provide a more specific answer to the research question of what design will look like in the future. To summarize, the meeting confirmed that industrial design as D'Andrea & Evers Design practices should guard that the designs that they are involved with remain centered closely around the human user. The humanity of the designer can be the bridge between the technological side of the product and the humanity of the user. AI can become a tool to the future designer as mentioned in the previous chapter, but within the foreseeable future it lacks human emotion, intuition and general humanity. Therefore, it was argued, the human designer will remain central to the process and the human user will remain central to the result. All technology that surrounds this idea should always be in service of that, giving the designer more space to reach the human nature of the user.

4.2 Historical revolutions

The transition to increasing intangibility of technologies will continue into the fourth industrial revolution. What the first industrial revolution was for the human muscles, the third industrial revolution was for the mind. The fourth industrial revolution will then do for the third what the second industrial revolution did for the first, it seems: it will largely remove geographical constraints from the technology. Websites and dataservers are already connected through the internet to be accessed by computers worldwide, though much is still happening within the computer devices themselves. Through faster networks and increasing power, the fourth industrial revolution will also remove the need for computers to do their processing work locally. The work will be done in the cloud. When that happens, computer devices will be reduced to mere

Future technologies
Systems (able to change based on context)
Exists in physical and digital spheres
Data is connecting factor
Interacts with human user and other systems
Almost no physical components, works invisibly
Future context
Designers at further distance from market
Almost all products contain data technology
Smart, biological materials
Growing need for durable design
AI will influence the design process

Table 3: The core findings that were presented to the designers at D'Andrea & Evers Design.

interfaces to that digital cloud. This will almost completely eliminate the shape constraints from the technology. Although, certain products such as refrigerators or washing machines will still need the physical components for their core task, The underlying technologies of control and power will miniaturize. Much of the communication from the product to the user then runs through archetypes and meaning. Designers have to develop metaphorical designs that allow users to bridge the gap between themselves and the technology. Especially when those products start to deviate from traditional designs due to new cooling or washing technologies in the case of the fridge or washing machine for example.

The changes that industrial revolutions bring are twofold. On the one hand they bring new products with new technologies: steam engines, electrical products, automobiles and personal computers are examples of this category of change. On the other hand there are the new production technologies that allow the manufacturing industries to enhance their practices with new technology. These technologies have an influence on the manifestation of products and the process of product design, but are not directly embedded in the products themselves. These include for instance CAD/CAM software and power tools, new materials and even logistic improvements such as the assembly line. This chapter lays down focal points that indicate possible large changes for design in the fourth industrial revolution: *trust, base technologies, black boxes, enduring design, new production,* and *artificial intelligence*.

4.3 Products with new technologies

4.3.1 Trust

In the early years of the twentieth century, even engineers that knew how electricity functioned had their reservations with regard to the new type of energy. People were anxious of it and found it hard to trust something invisible. It had the image of being a lethal, dark and powerful force. Eventually through many persuading efforts by the electrical industries and an evolving design direction, that notion reversed and electricity became a symbol of bright futures and forward thinking (Forty, 1992). Its initial image shows some similarities with today's view of artificial intelligence and using data as a tool. Many people seem to approach it with caution and are reluctant to engage too much (e.g. "The Privacy Project" 2019). Chances are therefore that the big data industries, Google, Facebook and more, will attempt to transition the image of AI into something that will bring benefits and prosperity to all aspects of life. The design language that will emerge from the design community will have to relate itself to that intended image, positively or negatively.

It is not the purpose of this research to judge whether increased use of data and algorithms is right or wrong. It might not even be a relevant question. Rather, the question is about how approach product design in a world that runs on data and algorithms. As in the past, the design industry is a translator of the ideals of the client. Although, as humans, even the design industry has responsibilities. The purpose of meaningful design is to create value by bridging the gap between crude technologies and human users. Such a task provides the designer with a large influence on how users perceive the technology. Design will contribute to the design language that surrounds these new technological products. It will be focused on accentuating the beneficial elements of the technology, giving it a positive image, while also being good for the user in terms of experience in such a way in which the electrical products and computer products also started introducing user ergonomics and user experience as an influential factor in the design (Müller, 2017; Norman, 1988). The more invisible and incomprehensible a technology is, the more a user would need a designed interface and a positive image to trust a technology to act in the user's interest.

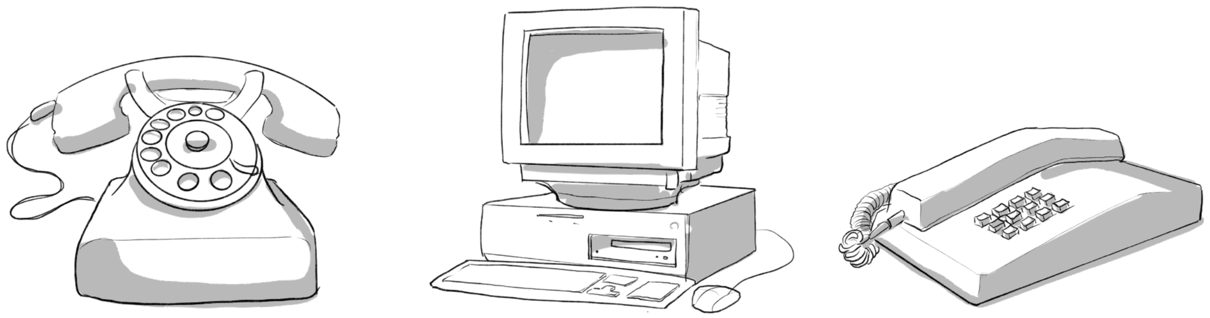
4.3.2 The base technology

Assuming the trend continues, the design of products with the technologies of the fourth industrial revolution embedded within will be based on the design language that the producers of the most important leading branches will establish. For example: in the first industrial revolution a steam-powered power tool had a look that could be seen as similar to the look of a steam engine. Though, for those machines, that would be logical, since their functional parts were more or less the same. They both worked through metal rods and gears. However, in a similar fashion, a computer controlled machine tool also borrows design features from existing computer technologies. Computerized consumer products share a design language that is based on the design of the dominant leading consumer product branch that is the personal computer industry. For domestic electrical products at the beginning of the twentieth century, the language was formed from an intended image of electricity that the industry wanted to carry out. The language of this type of product, the one where new technologies get directly implemented, seems to originate from the current archetype of the central product, technology or concept such as steam engines, electricity, computers or automobiles.

For the fourth industrial revolution, it is therefore important to discern what that base technology or concept will be. It will be the answer to the question of what technology will play a central role in a large amount of products in the future. That technology should be able to fulfil a large range of purposes, as steam engines, electricity, the combustion engine and computer chips were able to do too. It is almost certain that products will be more digitally connected and make more use of data as an invaluable resource for both producers and consumers. As seen in earlier chapters, the central technology will therefore be the merging of physical, digital and biological worlds through the exchange of data. Turning many products into cyberphysical systems.

With data, however, comes another interesting aspect. In chapter 2, it was mentioned that data becomes more valuable with a greater volume. It is therefore not unthinkable that more products than ever will be equipped with data technologies. This notion is backed up by the fact that the manufacturing industry, for example in the plans surrounding Industry 4.0, sees horizontal and vertical system integration, which allows a manufacturer to follow assets throughout the value chain, as one of the important

Figure 20: Example of how a base technology influences the design of a product.



Product archetype + technology archetype = technological product pillars to develop upon. Furthermore, data is largely shapeless and can therefore be implemented almost invisibly.

Utilizing data to enhance the performance or experience of products for both producers and consumers alike will be a point of focus for the future industries. This does not necessarily mean that all products will become digitally connected, they could also utilize data technologies passively where the product and its components can be tracked throughout its lifespan. Clothing items could for example be followed from the cotton fields to the recycling plant (Visram, 2020). That concept also fits the notion of merging physical and digital worlds very well, products in that case increasingly would require some sort of digital twin, where an exact copy of the same product exists in virtual space.

Of course, when a piece of clothing is enhanced with data, it still has to relate to the archetype of that type of clothing and it should have the physical shapes required to actually fit the human body, though when enhanced with the technologies of the fourth industrial revolution, it will likely adopt certain elements of the design language that develops around those technologies. This will become even more apparent in the case of truly technological products.

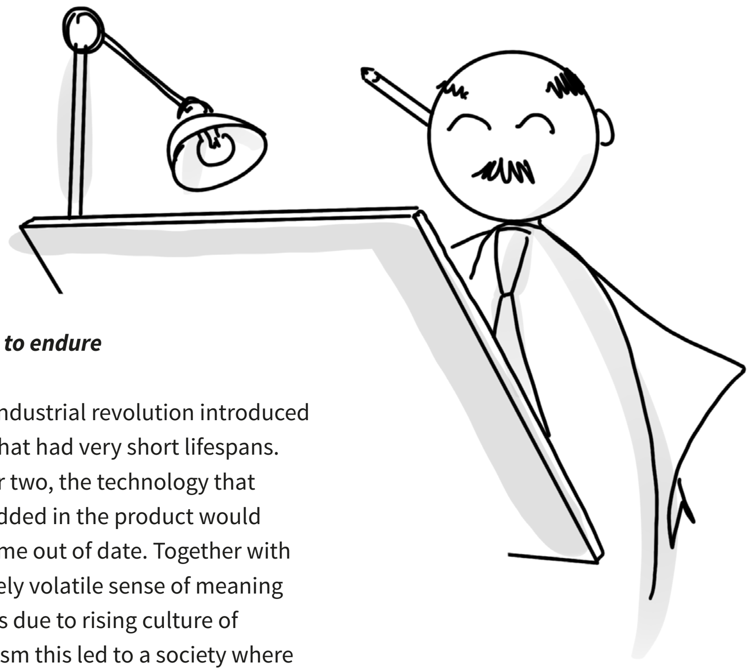
4.3.3 Black boxes

As stated in chapter 3, the physical components of technological products get smaller. The physical technology necessary to make a technological product becomes increasingly complex, though also smaller. The function cannot be determined from its physical shape any longer. This development essentially turns every technological product into a black box. Therefore, its design language will rely more on meaningful associations and agreed metaphors or archetypes for its shape than on its physical components, which introduces a job that is cut out for the field of industrial design.

Everything indicates that the role of the designer to be the bridge between advanced technology and the user will become more important. Besides that, the rate of technological change increases exponentially (Kurzweil, 2001; Schwab, 2016). This given poses a challenge. Change incites cultural response. The response depends on someone's perspective on that change. The more involved someone is with the past paradigm, the more they have to lose (Sparke, 2004). Older people therefore are more prone to resist change than younger people. However, when major change does not occur every fifty years, but multiple times per year, which is not farfetched when speaking of exponential growth, people will find it increasingly hard to follow along. Furthermore, different people will follow along with different streams of change, creating different levels of the markets.

During the third industrial revolution, through design combined with marketing and a trend of faster production cycles and cheaper materials that allowed

manufacturing in small batches, it was possible to cater to different audiences and provide appropriate meaning to specific groups (Sparke, 2004). However, if the trend continues, there will be a time where the technology change matches the rate of human thinking. And even beyond that, if artificial intelligence becomes more capable of emulating human (or superhuman) thinking. We will enter a world where technological advancements and innovations will go over the heads of possibly even the technological elite. One can imagine that having an appropriate mental model, or archetype, of such technologically advanced products would be of the utmost importance for human users to even interface with the devices at all. In such a world, it can be imagined that the role of the industrial designer is to design these mental models that allow human users to interact with the technologies at all. To ensure that the human user remains central to these technological products.



4.3.4 Built to endure

The third industrial revolution introduced products that had very short lifespans. In a year or two, the technology that was embedded in the product would have become out of date. Together with an extremely volatile sense of meaning in products due to rising culture of consumerism this led to a society where products are made to be thrown away (Sparke, 2004). Luckily, nowadays, increasing amounts of people see that that is in fact not a sustainable way of living. However, the rate of progress is not slowing down. On the contrary, it is increasing. So products versions become obsolete even faster than before. The fourth industrial revolution with its cloud technology, enables consumers to theoretically buy a new, updated version of a product without replacing the physical form. Product lifecycles transition from sequential towards cyclical, which makes product development a process of continuous renovation (Pessôa & Becker, 2020). This combination of possibility and necessity signifies an opportunity for producers of consumer goods.

For design, this would mean a focus and opportunity for creating products that are truly meaningful because of their long lasting nature. Shared history is a way for meaning to form (Norman, 2004). Products that have been in someone's possession for longer are generally perceived as more meaningful. Creating longer lasting products that are more durable in both their physical shape and interaction may therefore be a sound strategy for design and product development. Modern subscription business models or other strategies in the platform economy may also allow for longer lasting products since they do not rely on customers buying as many and often as possible. Instead, it incentivizes continuous service. Its idea is vastly different from the conspicuous consumerism of the eighties and nineties (Sparke, 2004).

4.4 New production technologies

Besides new technologies being embedded in consumer products, the industrial revolutions are first and foremost about new industrial technologies. These certainly have an impact on how products are produced and therefore manifested, but are not necessarily embedded within the products themselves. They influence design indirectly. They require different models, procedures, management and priorities. In the first industrial revolution, the need for consistency in product quality led to a division of labor in the workshops and that influenced the design of certain products. The use of mechanized tools also led to changes in the products, though the craftsmen did their best to emulate the quality of handcrafted items of earlier days.

4.4.1 Materials and production

New industrial revolutions also often introduce material innovations. The second industrial revolution brought steel and synthetic materials that were newly used in products and provided other qualities than earlier materials. The forward looking technologies of modernity allowed for modernist designs with efficient material use. In later times the use of synthetics was also brought in, when in the second half of the twentieth century it allowed consumer culture to grow rapidly due to its flexibility.

The innovative production technologies of the fourth industrial revolution are beginning to emerge. They include additive manufacturing, possibly with biological materials, bridging the gap between the physical world of manufactured goods and the biological world.. At the same time, the biological world is enhanced with digital technologies that come closer to emulating human thinking. Artificial intelligence will be able to take over certain tasks that we now deem as specifically human. Machine tools in the early industrial days took over parts of the physical craftsmanship of product-making and they continued to do so until this day, where 3D printers and CNC machines eliminate more and more of the physical skills required to create forms. It did not eliminate the human from the process though, the designers found ways in which the machines would enhance their work. At first they helped in creating larger amounts in less time, and later the machines enabled forms that were unthinkable before in those mass produced amounts.

With the third industrial revolution, computers started to chip away parts of the design process that would occupy the minds of the designers rather than their muscles. With time, the design industry started using computers to radically decrease the time spent on certain tasks and that freed time. This trend continues until this day and will eventually lead to the moment where the tasks that seem the core of the designer's job today, as crafting and drafting were in earlier times, are a mere fraction of the things that a designer will do in the future. This development opens up time in the design process that can lead to even faster development timelines for all products, feeding global consumerism, or it can lead to the time being allocated to a task that the designers of today are unable to concern themselves with. It is likely a combination of both, according to historical trends, though the growing concerns for the drawbacks of global consumerism may create a bias towards the latter.

It might be that the fourth industrial revolution shows similarities to the first industrial revolution in that the introduction of the new technologies called for resistance that argued that the use of machinery within the manufacturing process lead to lower quality products. The craftsman was less involved in its creation (Forty, 1992). When an AI aids a designer in the design process or even fully forms the product, with today's eyes, it might feel as if that product loses part of its authenticity. In analogy with the machine production before, it misses a human touch. People attribute human made objects with more meaning than objects that are constructed by a computer. Largely independent of how well it is crafted (Gibbs, Kushner, & Mills, 1991). However, as history shows us, we learn to live with these machines. They become tools in the designer's arsenal.

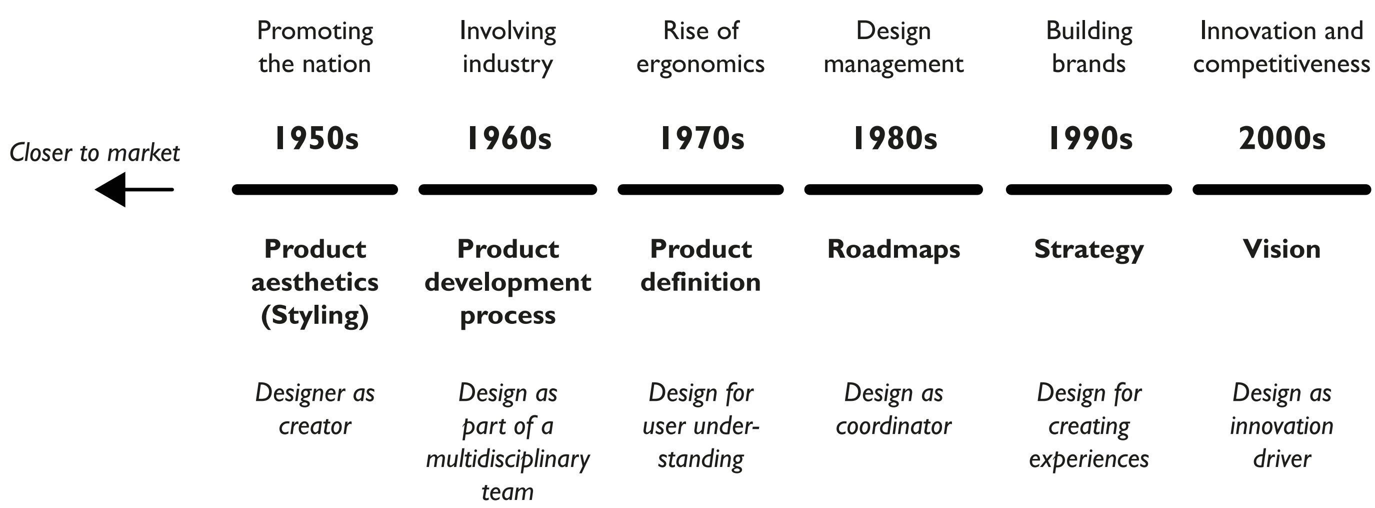
4.4.2 The AI-powered design revolution

The new tools of the designer free time in the process. One theory could be that the role of the designer as a reaction once again expands to a higher level above the market (figure 21) (Valtonen, 2005). Artificial intelligence (AI) can take over specific tasks from the designer in order to give the designer a managing role in the design process. The AI can take on the role of a design team that brings proposals and solutions to the table. The role of the human designer, with experience and human intuition, is then to steer the process and efforts of the AI. This is already partially done within the large tech companies. Facebook and Google make heavy use of algorithms that can influence how their users perceive and therefore react to their environment. As physical products become increasingly digitally connected, a next step for design is about how to approach phenomena like this, where design has a profound impact on users' behaviour and thinking. The human should remain central in design. That requires decisions from the designers in order to determine how to enable human thinking and behaviour without influencing it negatively.

The designer shifted from designing mere visual cues and physical objects towards designing experiences throughout recent history. The next stop would be to design entire systems in which experiences and products as well as visual messages are embedded (figure 22) (Buchanan, 2001). With the increasing abstractness of technology and the ever present nature of our digital counterparts, it is apparent that the ways in which we interact and live together with technology and data in contexts and environments, rather than the actual physical interaction, becomes the central focus of design (figure 22). The fourth industrial revolution is also a design revolution because it is of vital importance that this data and the AI that utilizes it keeps a human standard at all time.

In terms of appearance, during the third industrial revolution, office workers that worked with the products of that revolution

Figure 21: development of the design industry. From: Valtonen (2005)



did not want to feel like they were working in a factory. They were autonomous people, not machine people as workers were during the second industrial revolution. The office products to be designed would have to identify as products for the modern office rather than a factory. This resulted in a more polished look for office equipment at the time. The work environment started to shift towards a domestic, friendly and egalitarian type of styling, but still within the industrial hierarchical culture of a factory. As computers themselves become more autonomous, the people of the future will want to move away from feeling enslaved to the will of the machine that makes them do monotonous work (Forty, 1992). Those people will work together with the future products as the generations before them have done. If the trends continue, the design language used in professional environments will certainly deviate from designs of earlier eras. The offices of today, with their open floorplans and flexible arrangements, especially during the ongoing Covid-19 pandemic, may look silly and restrictive to the people of the future. The future office and its furniture will be formed by the tasks that are performed there.

The jobs that designers and manufacturers of today take pride in revolve around creativity and complex strategies that are simulated and worked out by computers. But in the essence, these computers merely carry out the decisions that come from their human operator. Offices and workplaces are configured to facilitate that. They have collaborating spaces and flexible workplaces to facilitate human thinking and creativity. They also have silent places for focused thinking. These offices are at the core of what results from the third industrial revolution. It is not the factories where the change happens, it is at an earlier stage, where the processes originate at the office. Since the industrial world is the cradle of technological change in the industrial revolutions, and the design offices may be a central player in the revolution that dawns upon us now, it is their design language that may be leading for products that eventually take the leap towards the consumer market.

In the future, with the growth of artificial intelligence, many of these decisions that encapsulate the jobs of the human office worker will be made by AI. The office worker then needs to take a step up towards a job that the computer cannot yet do. The worker's job will be to provide the computer with the data that it will use to formulate its design proposal.

All focal points for design in the fourth industrial revolution, as dicussed throughout this chapter, can be seen in table 4.

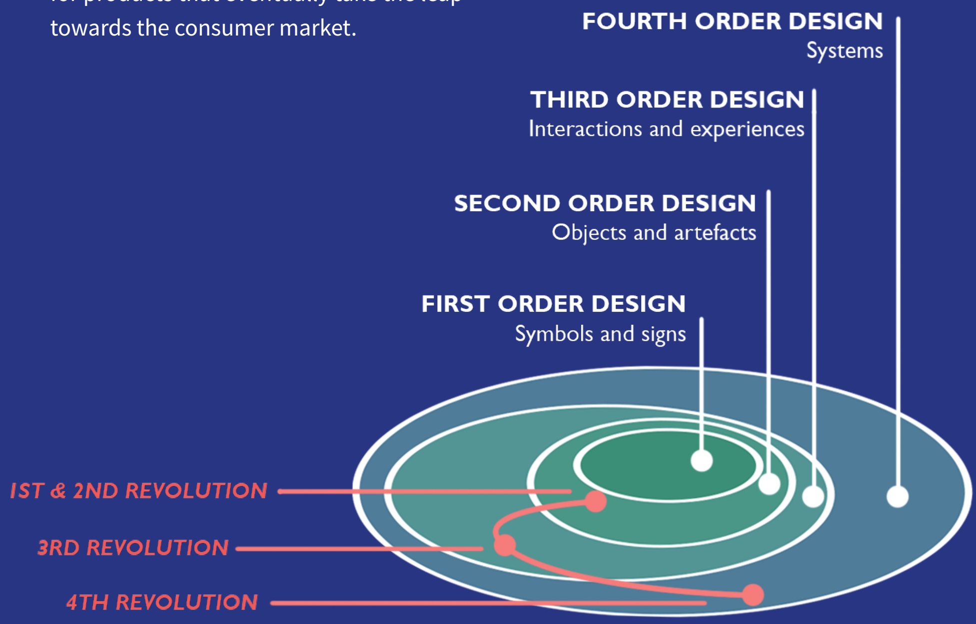


Figure 22: Representation of four orders of design and the position of design throughout the revolutions. (Buchanan, 2005)

Trust

- Positive imagery
- Human experience remains central
- Clear communication to user

Base technology

- New technological products combine archetype of existing product with archetype of cyberphysical systems that will develop

Black box

- Physical interfaces
- Complex functionality should be comprehensible to all users
- Digital presence of product should be communicated

Enduring design

- Both the physical design and meaningful associations become more focused on durability

New manufacturing

- Materials become more smart (have a temporal dimension, can change throughout time)
- Materials become more biologically based
- New manufacturing allows for more complex forms

AI-powered design

- Designers can create very complex forms in relatively little time
- The focus needs to remain on the human
- Industry needs to adress their influence on human behaviour, experience and thinking

Table 4: Focal points for the design in the fourth industrial revolution.

Chapter 5
Exploring the future

For this chapter, the goal is to explore how the focal points from table 4 in the previous chapter can manifest in the design of a consumer products. The purpose of this is to give a more specific answer to the first research question of how design might look in the future. A design case is set up and carried out in this chapter to give a possible specific answer to that question. The reason for this is that the designers at D'Andrea & Evers Design would like for this project to provide a peak into the future of consumer products and inspire thinking about how it can take form. A design process informed by the research into the focal points of the fourth industrial revolution can result in a visualisation and product description that can quickly do both and can be utilized by D'Andrea & Evers Design for both internal and external use. Furthermore, through a case study, multiple possible directions are explored, which gives insight into the broad nature of the subject.

5.1 Context for the case

For the case study, some boundaries must be set in terms of what product will be investigated and how far technologies and society have developed at the time of the case scenario. The system in which the product will be situated is the kitchen, the main product will be the refrigerator in this context. It is best to choose a product that has not too many purposes to prevent the case product from becoming too generic. Furthermore, the product should have multiple possible use contexts, since that lends itself well to the view of system-products depicted in figure 22. Besides, it would be good if the product has both active and passive functionalities, which a fridge has. It is both a household appliance and a piece of furniture. It allows for interaction and also performs a task when the user is absent.

5.2 Approach of the case study

The focal points from table 4 will provide the base for the approach to the case. They will be guidelines for the process because these are the issues that require answers that are specifically aimed at the fourth industrial revolution. However, two of the six points are less prominently featured in the case study. First, the theory of the base technology is more of a result of cases like this and will therefore not be used as a guideline yet. Using that theory in the design process is only possible when the base technology (cyberphysical systems) has an archetype, which it has not. That archetype can be a result of performing case studies like this, though doing only one is not enough. However, the case study contains some collages around the other focal points that provide possible inspirations for such cyberphysical archetypes. That inspiration is made visual in collages around systems (figure 25), networks (figure 26) and the cyber world (figure 27).

Besides that, the focal point of AI-powered design is more about the process of designing and less about the design itself. It does state that using AI in the design process allows for more complex designs, but the focal point about new manufacturing also states that and therefore AI-powered design will also be dropped as a guideline for this case study. Without proper AI it is difficult to simulate a design process with AI support well. Although it is encouraged for D'Andrea & Evers Design to turn some efforts towards investigating this subject more and start experimentation with tools that allow AI to aid their designers in their design process.

For the process of the case study, first some brief boundaries were set in the previous paragraph. The second step is to solidify what the case scenario is to form an image of what the refrigerator of the future might do. Such a scenario will also determine the amount of technological advancement for the case. The scenario can be found on page 56.

What is central to future consumer products is the merging of the digital and biological spheres with the physical sphere (figure 23). Both the biological world and the digital world are built on systems, ecological or digital. The ideation phase for the case starts with a collage on systems in order to provide inspiration for functional characteristics of a fridge of the future. These functional elements of the fridge are not set in stone from the beginning to allow a broader search that fits better to the act of *exploring*. The ultimate purpose of this case is not to create a refrigerator. The design is a way to find out what could be possible.

Ideation sketching is the tool that is then subsequently used to diverge into different idea directions from that starting point. After some initial sketches, those directions will be shown to a small group of designers at D'Andrea & Evers Design. That presentation can be found in appendix C. The sketching process follows the various focal points roughly. The focal point of trust, for example, led to a series of sketches around the concept of nostalgia.

Those focal points are approached loosely rather than as a recipe. That does not mean that they are not well represented in the design process, on the contrary, the process is heavily influenced by them. It does however mean that the process leaves much room for imagination, and that is vital to the purpose of the case study.

Sketching is a fitting tool for such a diverging process. However, at the end, a direction for the product design is chosen and visualized. That will be the final result of the case study: a visualization of a conceptual product of which the design originates from the focal points of the fourth industrial revolution.

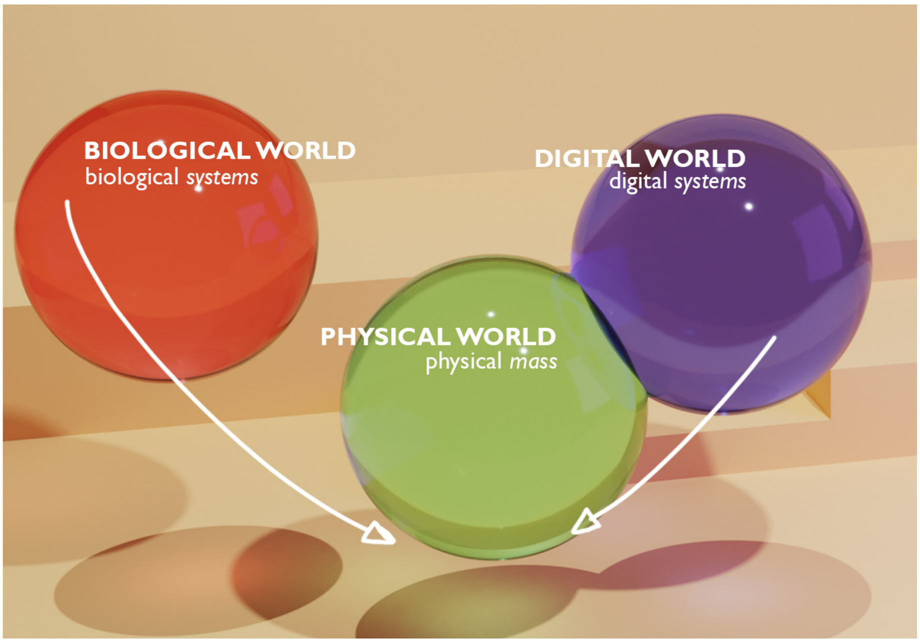


Figure 23: A visualization of the merging of the different worlds. Future technologies exist in multiple spheres at the same time.

Scenario to give context to the future in which the case takes place

It is the future. The fourth industrial revolution is well underway. Many products are connected into systems of products to allow the user to experience the convenience of these modern times. All people have digital counterparts of themselves. Some of them more elaborate than others. Technology enthusiasts happily share their information in exchange for ease of use and advanced product features. The average person, however, is still a little hesitant and more guarding of their privacy. They like the possibilities that the new products bring, but at what cost? It is unclear where their data is stored and who has access to it, so they try to be careful.

It is still relatively early for these new technologies. Although biological and smart materials have become quite common, and many of the digital technologies that make these product systems possible have come very far, no major biological enhancements have made their way into human users yet. No widespread neural interfaces or augmented reality implants. Though, some are visible on the horizon already. The medical world is conducting experiments with prosthetic limbs, printed organs and biotechnological treatments against certain genetic diseases, but almost no physicality-altering technologies have broken the barrier into the human body.

The refrigerator that most consumers have at home is similar to the one that most people had all those years ago only in that it keeps stuff refrigerated. The amount of space that it takes in the kitchen has decreased when the grocery and food services started delivering multiple times per day. Within an hour a reasonably sized shopping list can be delivered directly inside the food storage units of your house. When it is time for a meal, the fridge collects it in the order that it appears in the recipe. The rest of the kitchen anticipates the steps seamlessly: the oven warms up, the water gets put up to a boil. And that is if you like cooking. If you do not, it is even easier: just take the prepared meal from the fridge and put it in the oven, close the door and wait two minutes. That is it.

The only thing that resembles anything like the early fridges is the small grocery compartment in some models where other food and drinks can be kept. Except that it is not necessarily a metal insulated case with a door anymore. With today's materials, it can function differently. Besides, with those delivery times, it does not need to be so large anymore. Some kitchen service packages allow the kitchen to manage stock by itself. Based on consumer behaviour, the system orders items when it runs out. It knows when it arrived, because the delivery lockers at the front door are within the smart home system (figure 24). One thing is for sure, the features in this service package for the kitchen will become outdated soon. Who knows what our kitchen can do with the new updates.

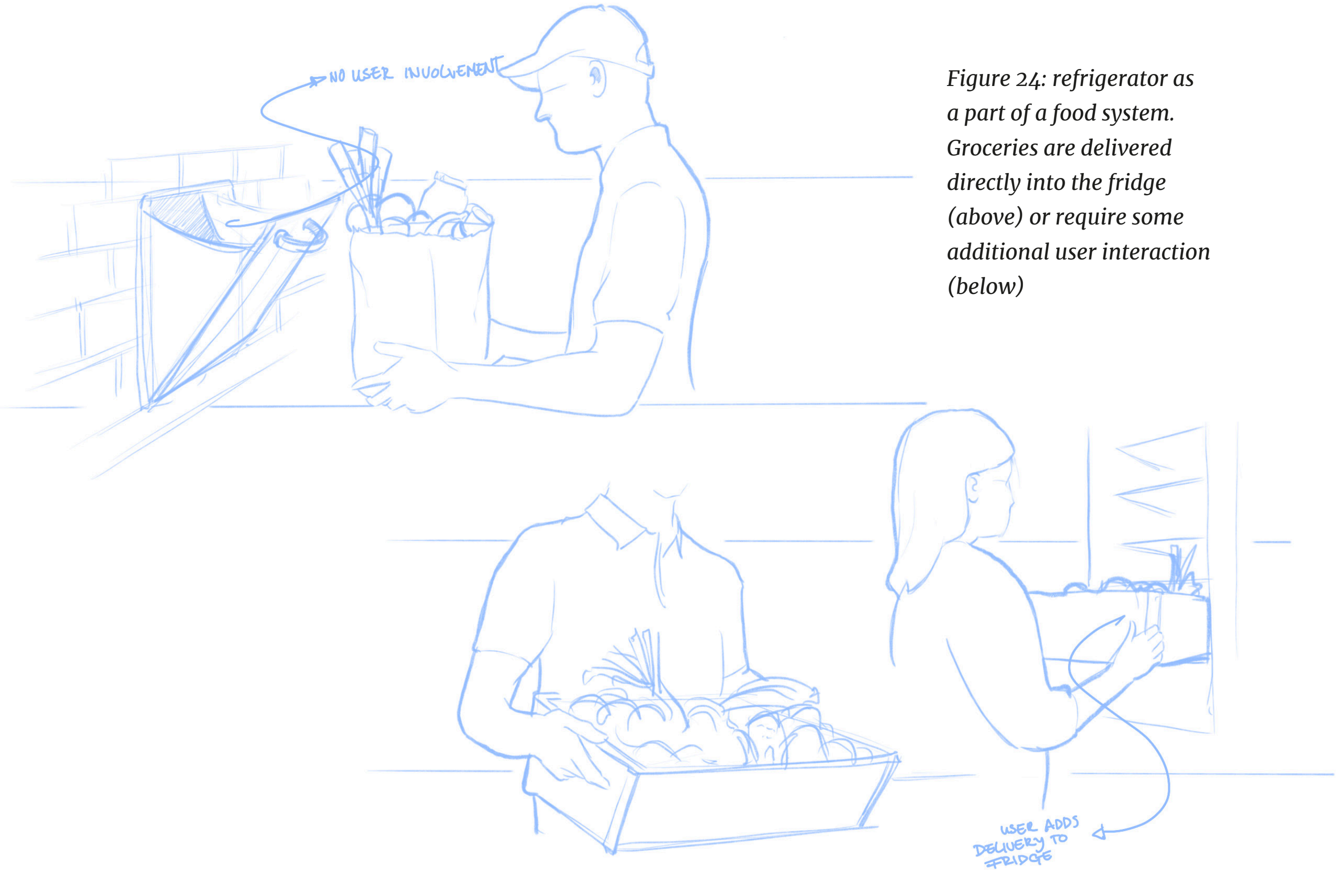


Figure 24: refrigerator as a part of a food system. Groceries are delivered directly into the fridge (above) or require some additional user interaction (below)

5.3 Case study: refrigerator

Products that are systems are not that uncommon anymore. New in the fourth industrial revolution is that these systems have gain physical characteristics. Not only the behaviour of the product can change based on context, but also the actual physical shape if necessary. These system products have, besides their three spatial dimensions, also a temporal dimension. At different times, the product may satisfy different needs.

The field of architecture already attempts to achieve such a temporal dimension with conventional design. Especially in public buildings, the designed environment has to account for several different scenarios. What also makes an architectural project a system is that it is often designed as a whole. The space station in one of the images in figure 25 (bottom row, second from the left) is not perceived as a series of metal plates and air filtration units, but as a space station. Although the variety in the parts is large, they are perceived together. In biological systems that is also the case, and maybe even proves a better analogy for the field of industrial design. A forest can be perceived as a whole, although the individual trees and organisms that make up the forest can also be seen as a singular part or even a system of its own.

For the field of industrial design, and in particular the refrigerator of this case, it shows the future way of product perception. The fridge is a system of its own and also has to relate itself to the system of the kitchen or the house as a whole. Human minds are flexible and will undoubtedly adjust to an incoherent system in time if necessary. A better way for design, however, might be a certain shared language of interaction and communication between future products in the way that nature or architecture use shared languages to be able to create a certain predictability. Through experimentation, that language will form over time in the shape of archetypes.

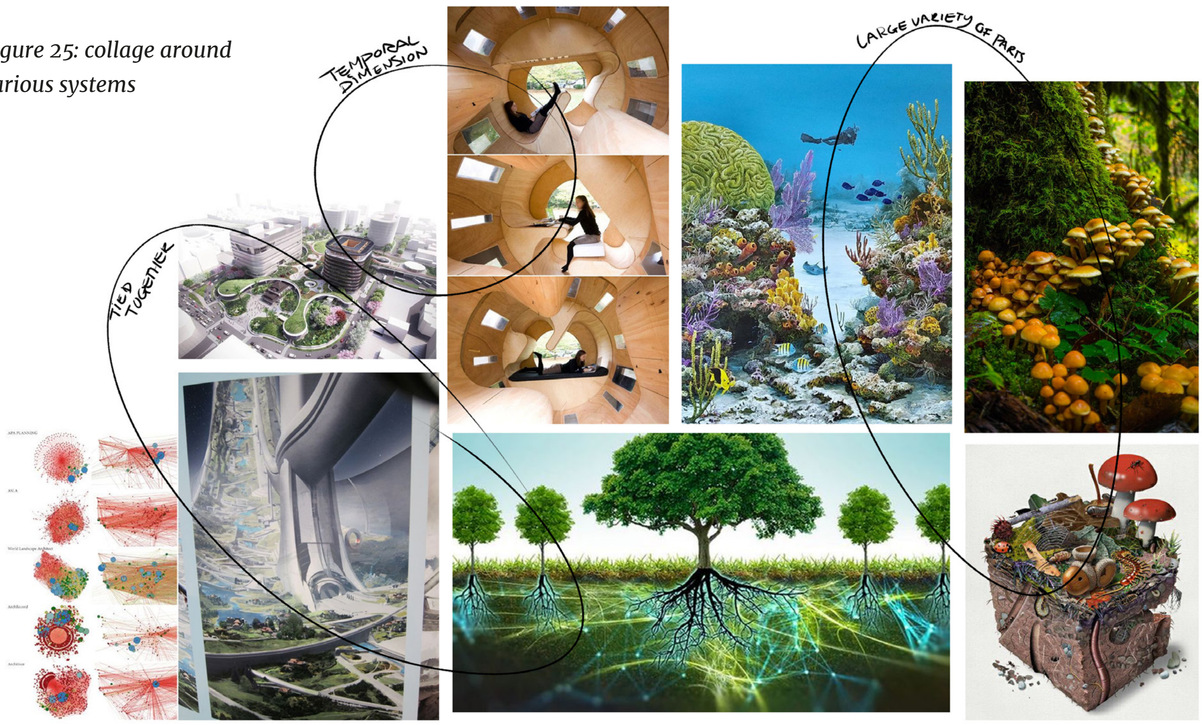
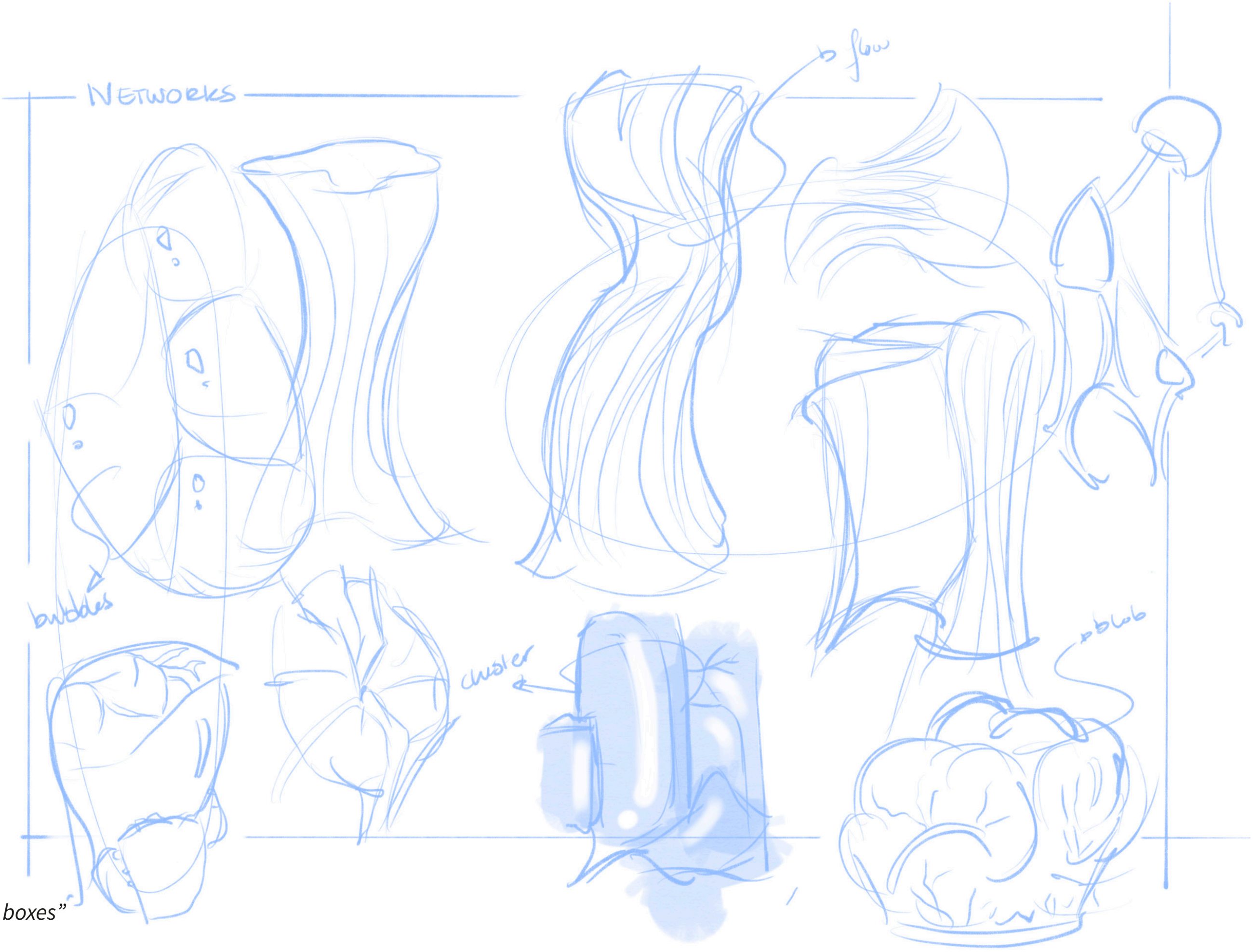


Figure 25: collage around various systems

"Trust"

Sketches based around the focal point of trust. Nostalgia may induce a feeling of familiarity and therefore allow for a more trusting attitude from the user.

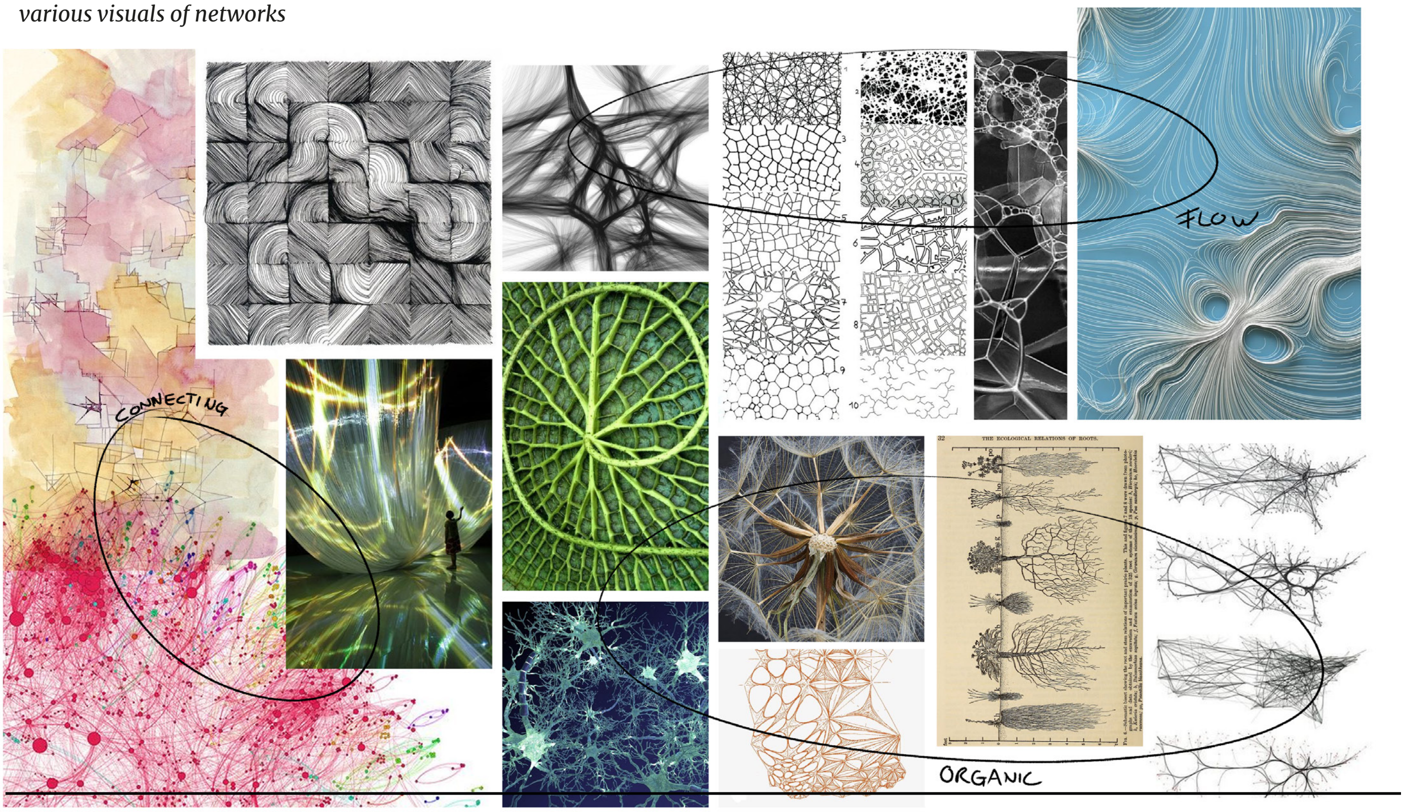
If the form language is friendly and positive, the user may be more inclined to trust the product to do good. Furthermore, if the product looks capable and in control of its functionalities, that may also lead to the user gaining confidence in the products functionalities.

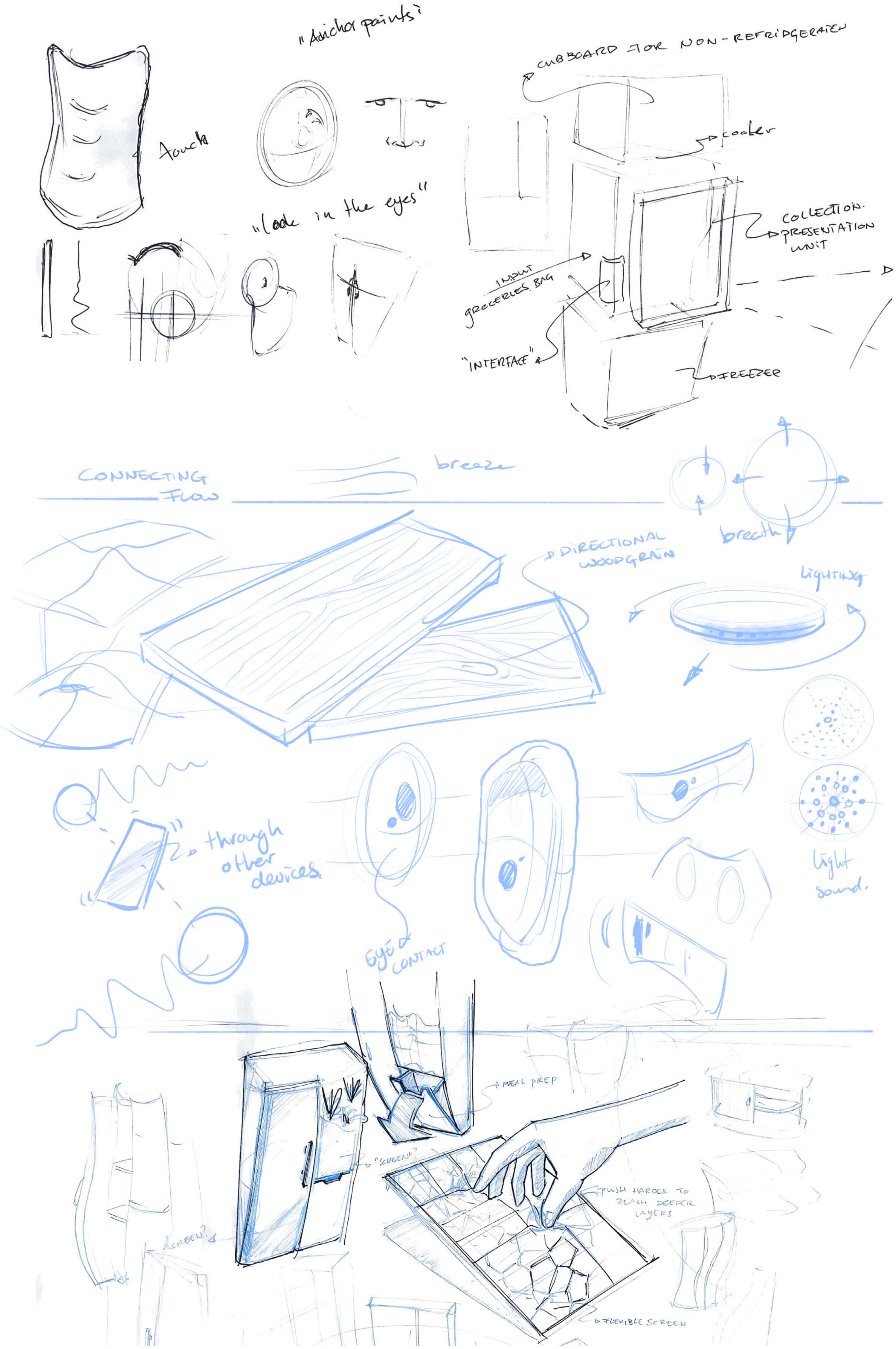


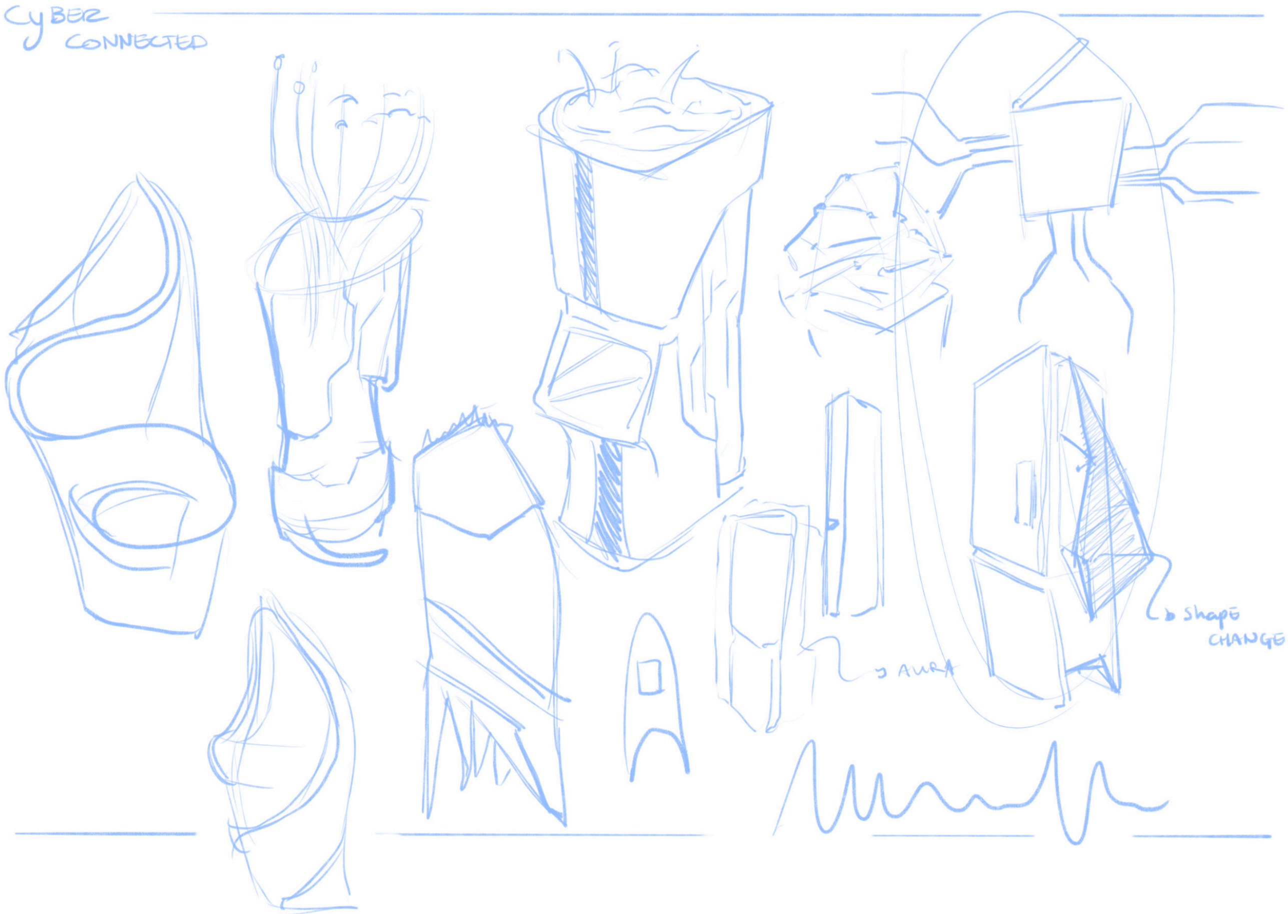
"Black boxes"

Sketches based around the focal point of black boxes. The invisible inner workings that make it hard for human users to comprehend what the product is doing may have need for clear communication and feedback to the user about what it is that the product is doing. The visuals from the collage (figure 26) show flowing connections between parts. These connections also become more defined based on the route most traveled, which leads to more traffic on that route. A product could grow towards how it is mostly used.

Figure 26: collage around various visuals of networks




"Anchor points?
touch
"look in the eyes"
CUBBOARD FOR NON-REFRIDGERATED
cooker
COLLECTION PRESENTATION UNIT
INPUT GROCERIES BAG
"INTERFACE"
FREEZER
CONNECTING FLOW
breeze
breath
DIRECTIONAL WOODGRAIN
lighting
through other devices.
light sound.
Eye contact
MEAL PREP
"SCREEN"?
SCREEN?
PUSH HARDER TO REACH DEEPER LAYERS
FLEXIBLE SCREEN



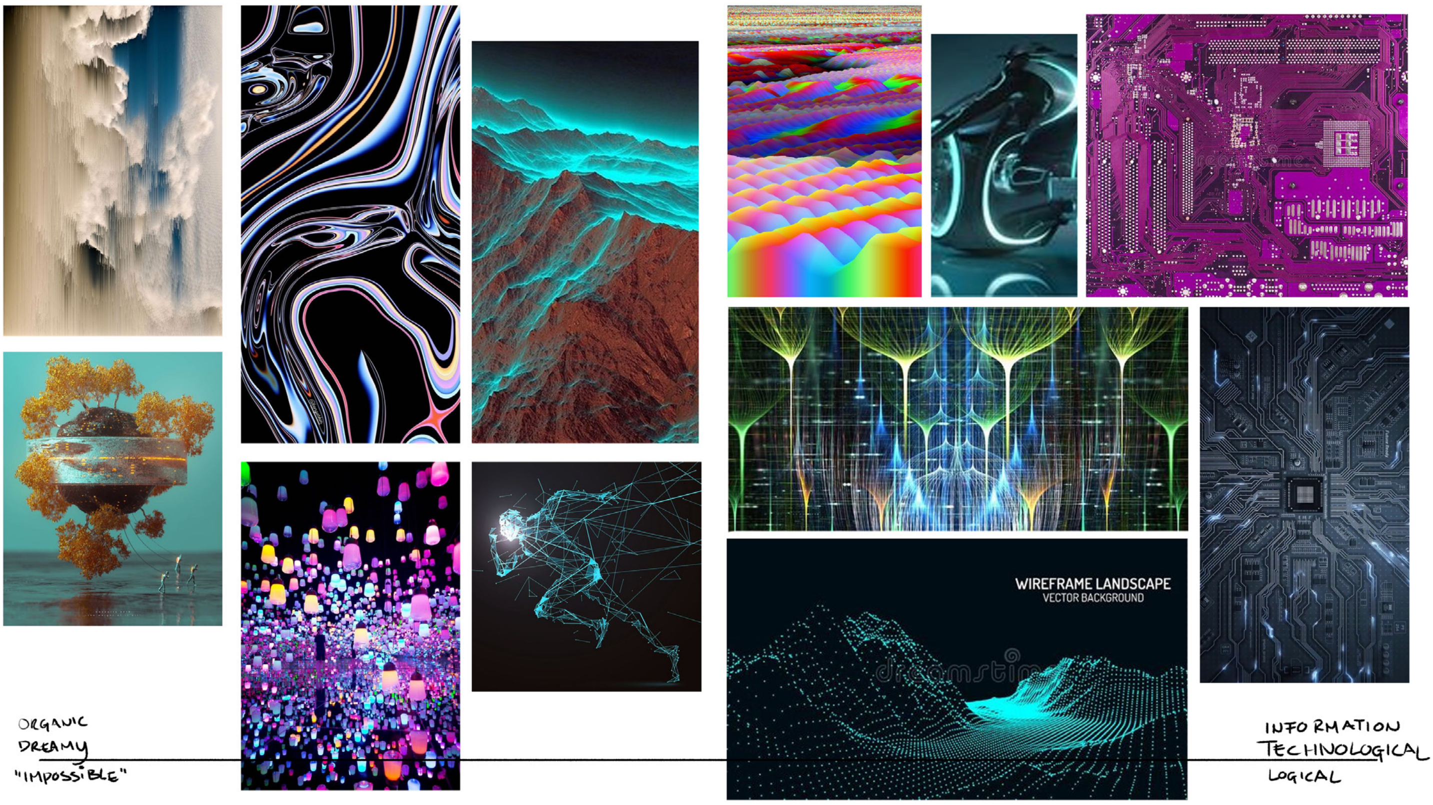
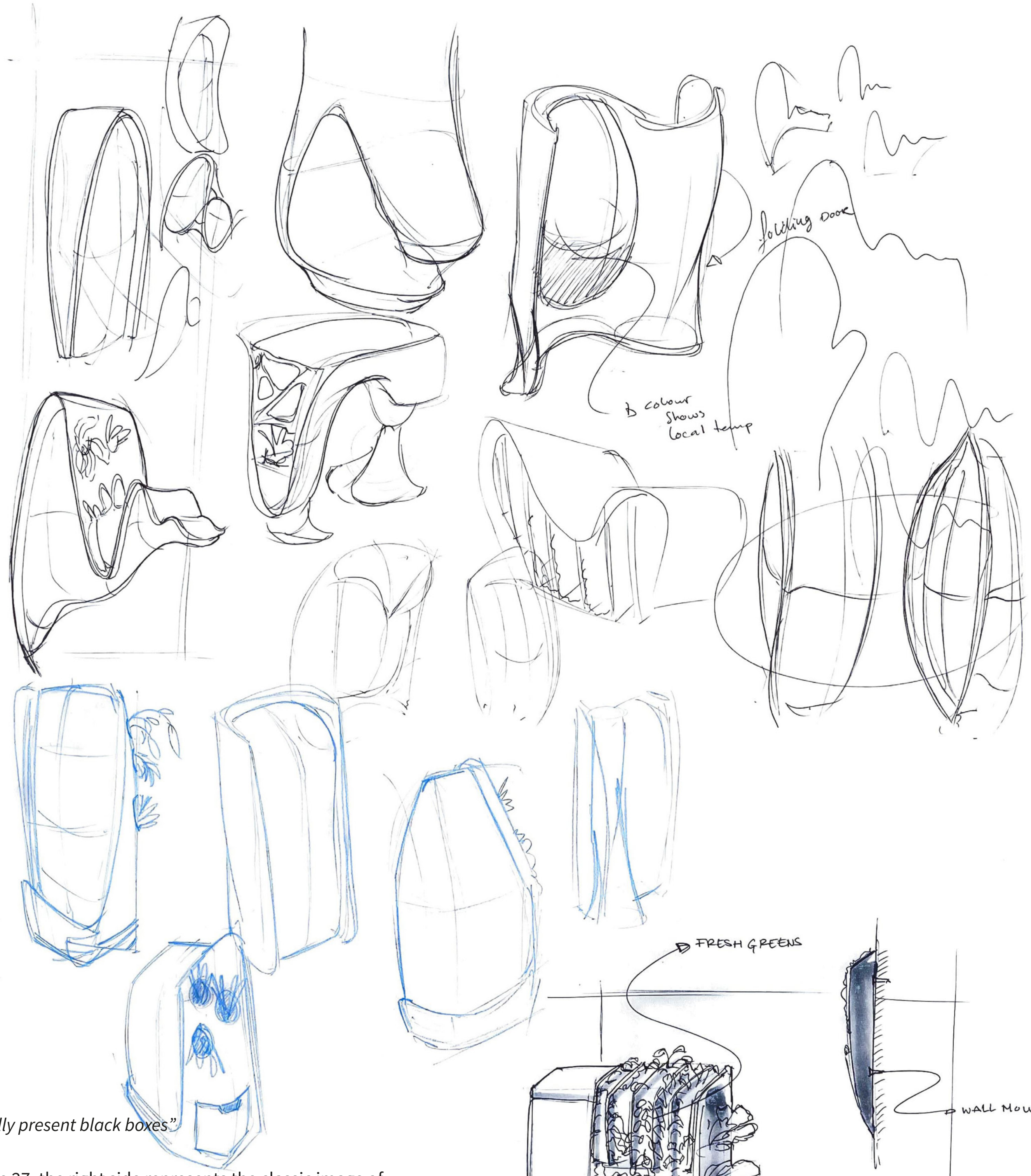
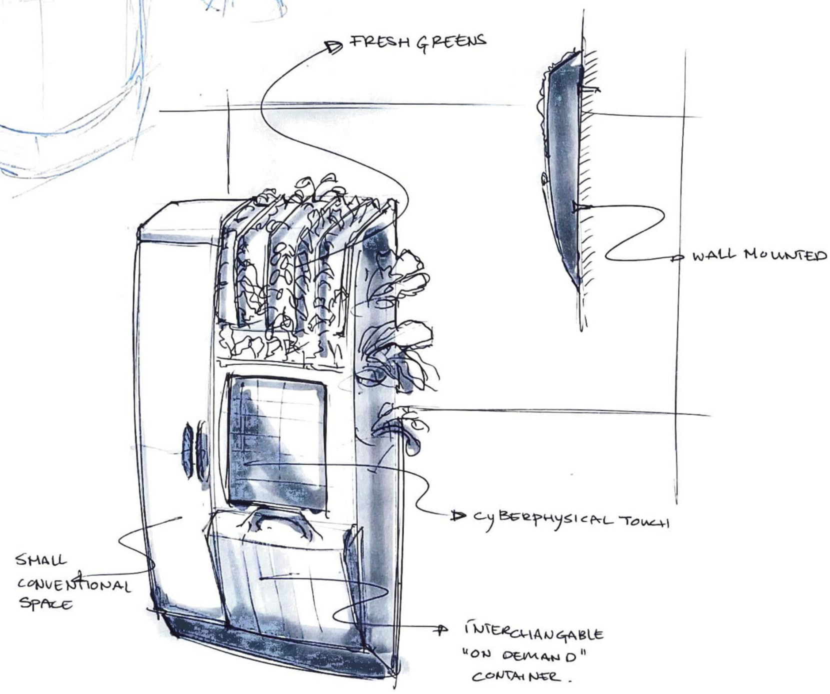


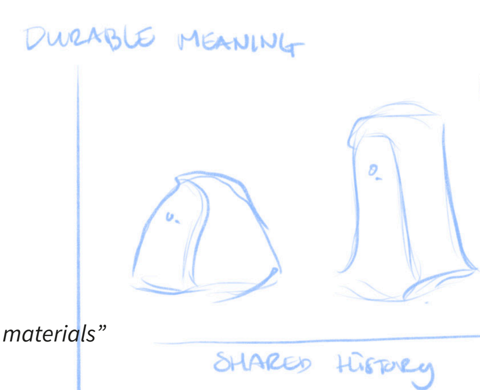
Figure 27: collage around various visuals of the cyberworld.



"Digitally present black boxes"

In figure 27, the right side represents the classic image of cyberspace: a highly technological realm of information. The left side represents the more freefrom nature of the space that is capable of defying the laws of physical nature. In reality, the cyber world does not have a perceivable form. It becomes what we make it. Bright lights and lines as well as unnatural colours or elements for natural forms may indicate that a product has digital elements. The form language for this type of product will grow with time.

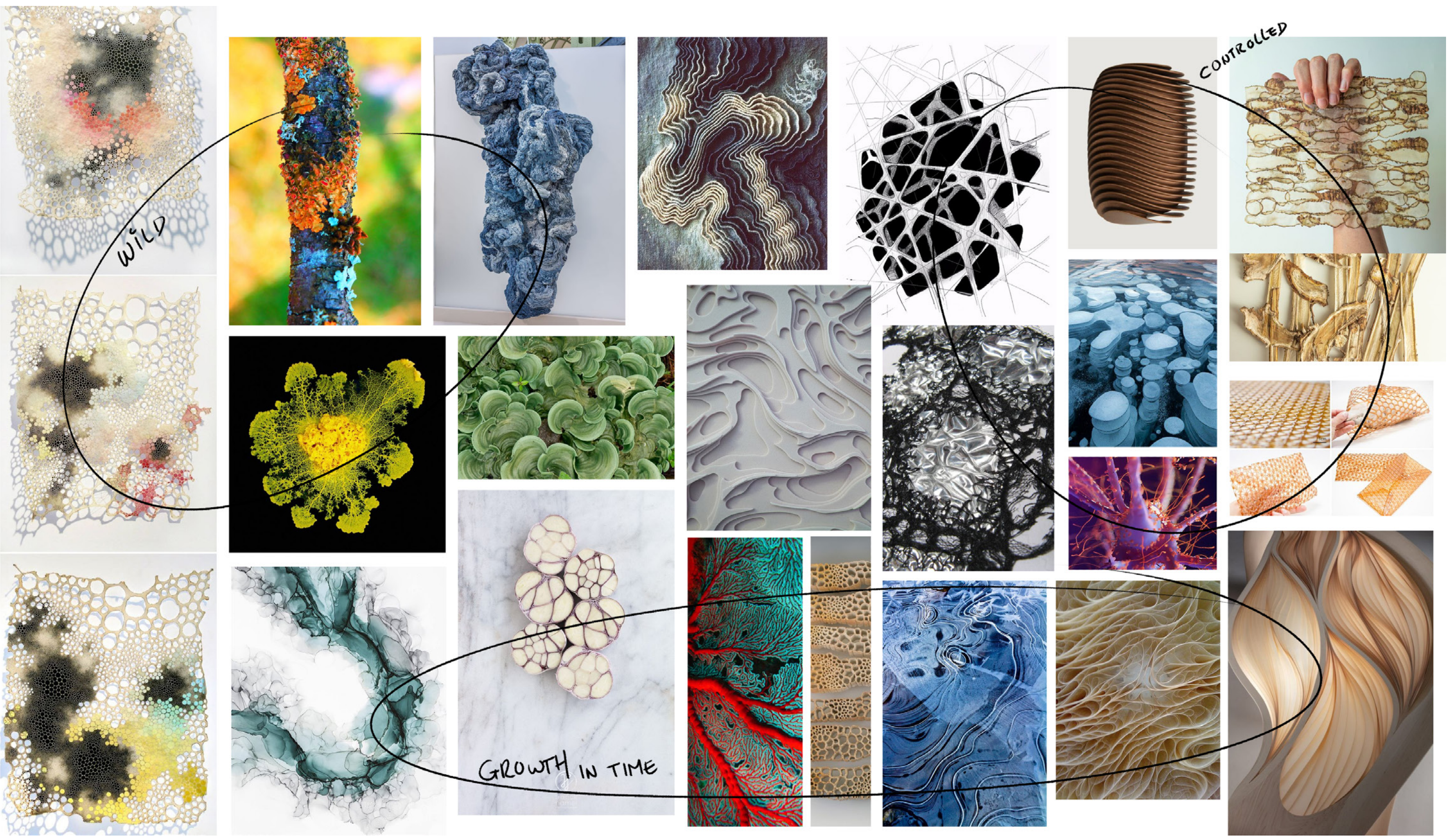


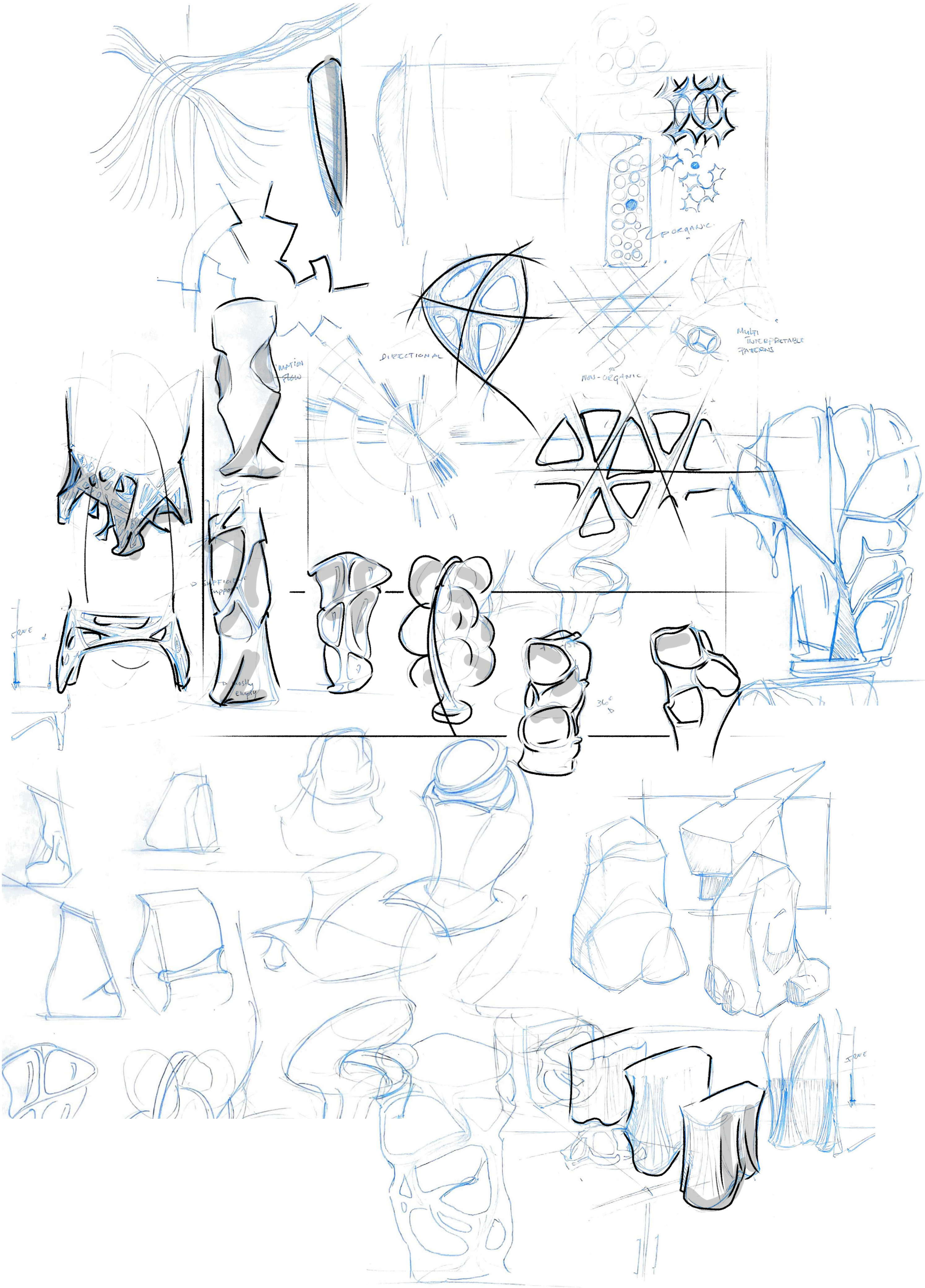


"New materials"

New materials are based on biological materials. Nanotechnology may make it possible to alter the characteristics of materials too. It may become possible to program behaviour into materials. Biological materials are about growth and organic shapes. The growth can be a form of creating a shared history with the user and is therefore fitting to the focal point of enduring design and enduring meaning. The materials form under influence of the environment. Design-wise, the difficulty with this type of material is preventing it from becoming a formless blob. Some sort of structure must give body to the material and provide it with a basis. Combining organic materials with tight geometry or smooth materials with organic shapes may work well.

Figure 28: collage around various natural visuals




ORGANIC
MULTI INTERPRETABLE PATTERNS
DIRECTIONAL
NON-ORGANIC
360°

5.4 The concept

The exact functionalities of the future refrigerator have intentionally been left relatively open. They crystallized during the ideation process. The concept is a refrigerator that is a smart system that utilizes smart, biological materials.
The main form is a gel that is held in and around a skeleton of other material. The gel is able to hold the food and cool it to a degree that the food product needs. The gel itself can locally cool and move food towards an area with the right temperature, essentially grouping food items by their cooling needs. When a food item spoils or goes past the expiration date, the fridge can move it towards an area where the user can easily reach it to dispose of it. It may also be possible that the decomposing of those products function as resource to grow fresh simple vegetables or herbs on the side of the product. The gel is largely opaque or frosted to look like condensation on a glass surface to prevent guests and other visitors to be able to see what is held in the fridge. Silhouettes of the food products are still visible, moving closer to it increases the transparency of the gel to enable anyone using the fridge to look inside. The shape of the gel slowly evolves throughout the usage of the product. The fridge starts with the gel symmetrically distributed around the product. The user places the product as preferred and the gel slowly grows toward frequently used areas of the product.

Lights embedded within the product can change the colour of the gel to give, for example, the feeling of cool morning sunrises or icy materials. Furthermore, the lights can react to the proximity of a user or pulsate directional to indicate communication from the fridge towards other products by means of the internet of things (IoT).

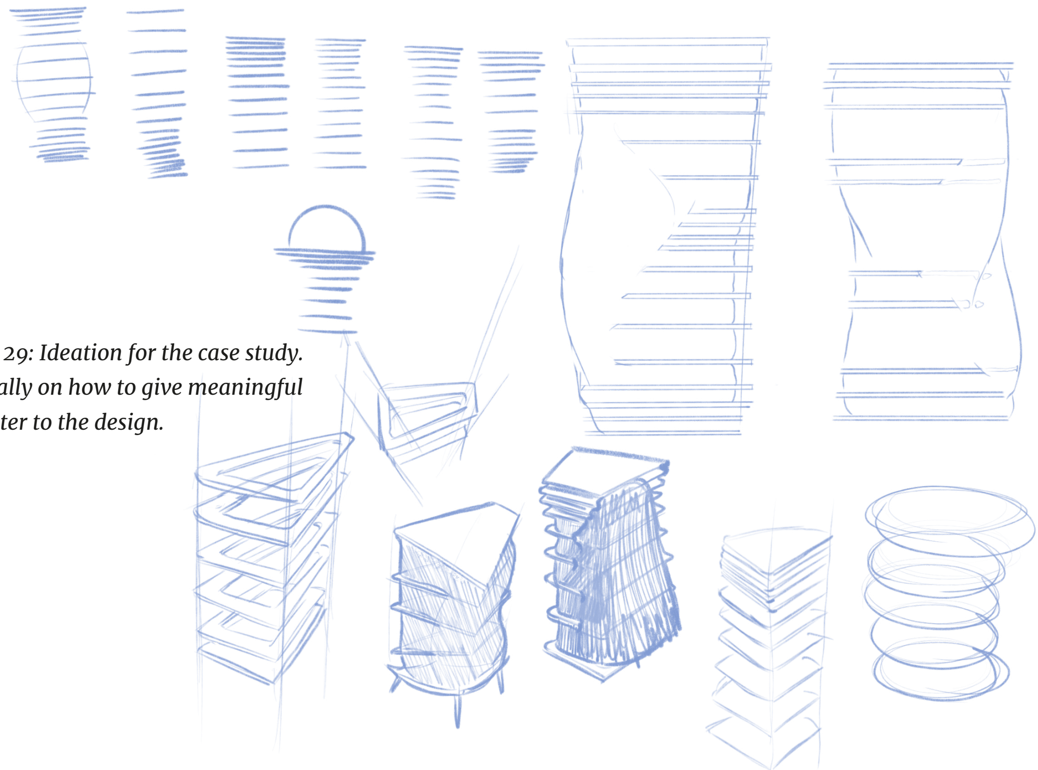


Figure 29: Ideation for the case study. Especially on how to give meaningful character to the design.

To show the natural aspect of the materials, the form of the fridge can consist of organic shapes, textures or patterns. Besides, space to grow fresh herbs strengthen that image. The refrigerator is a product that is likely to be used by everyone in a household at multiple times each day. It makes it a centerpiece of the kitchen system. It could therefore that there is a market for more elaborate models that function not only as a household appliance, but in a similar fashion to a designer chair or light fixture also as an item to bring character to spaces and lives with a positive emotional attitude. That also has its effect on the physical design.

To gain trust, the product can draw on nostalgia by adopting the familiar rectangular shape of refrigerators. Or the product can draw from other familiarities from nature or technology. When the fridge, with an interface that is projected in the gel, shows information about a food item when the user reaches for it (figure 31), the user may gain trust that the product is capable of complex functionalities. Furthermore, such a three dimensional interface may be very intuitive, when designed well.

The idea is that the concept grows with the user to create a durable relationship. Smart materials could be configured to react to updates in a similar fashion to sofware nowadays, reducing the need to replace the physical aspect of a product. Lastly, the solid materials of the fridge are magnetic to allow fridge magnets to be placed on the surfaces for a traditional form of personalization.

This description of a concept allows for many different forms that the product could take. Here, a few possible directions are presented in figures 30, 31 and 32. Furthermore, the road towards some of these concepts is also included in figure 29.

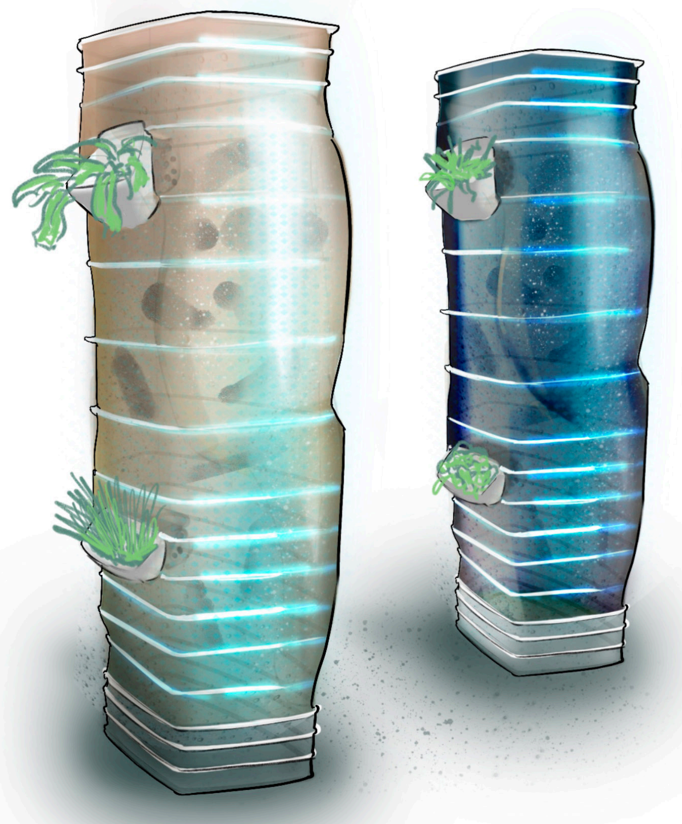


Figure 30: A possible design for the refrigerator concept. The lights can be adjusted to represent the time of day or to the user's preference.

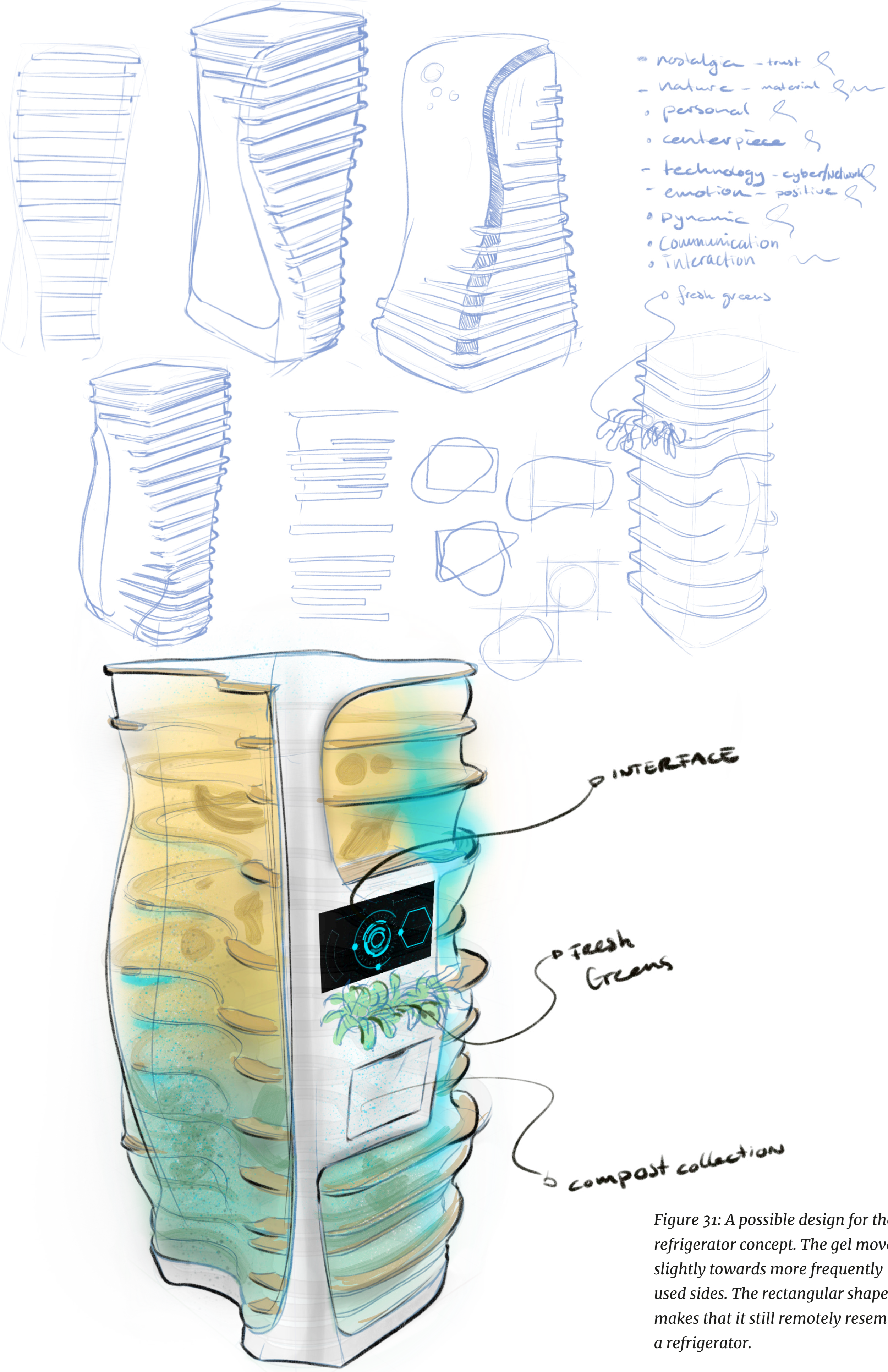


Figure 31: A possible design for the refrigerator concept. The gel moves slightly towards more frequently used sides. The rectangular shape makes that it still remotely resembles a refrigerator.

Figure 32: A possible design for the refrigerator concept. The future allows for more daring designs that show personality and a connection to both technology and nature.

Chapter 6

Discussion and conclusion

The research questions that form the basis for this research project are concerned with (1) what future designs will look like and (2) what future designers will do. To both questions, this report has a partial answer. Partial because of the uncertain nature of future forecasting and the total breadth of the topic.

6.1 Conclusions

Technological advancements come in waves where innovations spark other innovations. These innovations form interconnected clusters of technologies. These innovations can be positioned along one of three axes: leading industries, infrastructures and core inputs. Together, these three axes lead the expansion of the space in which industries can look for technological solutions to problems: the design space. With every industrial revolution, the design space expands. The frontiers of that expansion, the innovations, allow progress to happen in many different fields across many different industries. For the fourth industrial revolution, the focus is on technologies that utilize data to work. These technologies become cyberphysical systems and allow the physical world to merge with the digital.

The field of meaningful product design of technological products shows a shift from being largely determined by its physical components towards a growing relative importance of meaningful elements. Besides, the use of archetypes in design also gained importance with the introduction of abstract computerized devices. For ergonomic purposes, archetypes may have an impact on the shape of future consumer products. New methods of production also allowed other non-technological products to follow this trend. The technologies of the fourth industrial revolution will follow this trend of technological miniaturization and continue to rely more on meaningful associations in product designs for their form.

For the future of design of consumer products, six focal points have been determined. They influence the design itself, and also the act of designing. They can be found in chapter 4 and form the general answers to both research questions.

A more specific answer to the first question can be found in chapter 5. The product case described there and its result are just one of many possible outcomes for such a project. One result may not provide the decisive answers needed, but many of such results together can create a more comprehensive vision of the future. Therefore, it is recommended to play and experiment more with the findings of this project and others to expand the knowledge about the future of designed consumer products.

With regard to the second research question: the act of designing in the future will likely remain a team effort. Especially with AI-support, it is of great importance that design stays focused on the human user. A human designer with the help of one hundred AI still has only one person's worth of humanity and human empathy at their disposal. Since guarding that humanity in design is one of the core tasks of the designer in the future, the design process benefits from multiple human hands working for the good of the user. With the pandemic years of 2020 and 2021, remote working has taken a flight. There is still quite a way to go. The developments of these years will, however, improve future collaborations. If the industrial revolutions have taught us one thing, it is that a crisis often sparks a period of progress. A crisis shows us what was wrong, the years following a crisis people start fixing those mistakes. Progress has always been a human effort to improve what was into what will be. That means that forecasting the future is mainly a question of forecasting what people will put their efforts towards. We can collectively choose what the future will be.

Nevertheless, the designer of the future has to learn to work with these new technologies. These enable the consumer products of the future to have an increasing impact on the lives, experiences and behaviour of the user and that comes with a responsibility on the supplying side. The design field is not the only actor on the supplying side of course and the future requires actors to keep communicating. Luckily, the technologies of those times will allow that communication collaboration to happen more efficiently than ever.

Being prepared enables to think ahead and direct the efforts towards a future where we use technology to be better than ever and where that technology is filled with humanity. With this project, a first step is placed into the direction of understanding the future and therefore D'Andrea & Evers Design can start to think about how to put their efforts towards creating the future they think is the best for the ever evolving interaction between humans and technology.

6.2 Discussion

The design process of the case study was mostly performed by the author. There were short discussions with several people in passing sometimes to gain one or two fresh insights. At the early stages of the process some of the ideas were also discussed at a meeting with some of D'Andrea & Evers Design's designers to gather their input. The process was then finished alone. Although a design process benefits from being carried out by a team with different perspectives, the moment in time that this project took place in did not allow much space for such processes. And even though the process here is carried out as well and informative as possible, even more interesting results could possibly be taken from a longer process that involves many perspectives (Findeli et al., 2008). The set-ups for two of such projects are delivered with this report and can be found in chapter 7 to be used in times that allow more candid collaboration. This is not to say that the results of the case study are not valuable. It is built on the information gathered in previous chapters and therefore certainly provides a peek into one of the many possible futures that lies ahead.

The answer to the second research question that is given in this project is a very general answer. It does not answer the question what the act of design would look like in the future and what specific tasks a designer would carry out. It does touch on those kinds of answers here and there, but that question is never fully answered. This project does however answer the question of what the designer of the future would be concerned with and what some points of attention are if one were to carry out the act of designing in the future.

Furthermore, the answer to that second question that is given here does provide anchorpoints for further research. It shows what aspects would be valuable to investigate further. Besides those points, this project also went into the value of design as a profession in the future. Since the beginning of industry, the role of design has evolved. And it is likely that it will once again evolve.

Finally, it may be unnecessary to state that forecasting possible futures comes with many unknowns. More research is needed to solidify the conclusions of this project. The future depicted in this project is in some aspects highly likely to happen, backed up by data about governement investments and vast research done by renowned scholars. And some aspects of the projects lean towards creative speculation into the unknown. It has to be said, however, that the speculation, a word with a connotation of untrueness, in this project was never uninformed. In fact, in such a project, speculation is needed. For it brings insights to the table that deviate from the knowable, and are therefore able to open up less obvious imaginative paths that the future can take. True exploration, and a valuable activity to any forward looking design agency.

Chapter 7
Further investigations

As said in the discussion (chapter 6.2), the research presented here is, like most projects that forecast a possible future, a mere beginning of gaining insight in what the role and nature of the field of industrial design is in the future. The true future is a matter of making connections between large trends (Ford, 2021). Specific research projects like this one focused on one of many paths that has formed out of the choices made during the project. Therefore, it is recommended to conduct further research into the topic. That research should zoom in on certain aspects mentioned in this one or aim its efforts towards parallel developments. Exploring different paths leads to a more accurate representation of the future and therefore more valuable information to orientate one's strategy within the ever changing industrial world. Some suggestions for interesting unanswered questions can be found in this chapter, as well as a way for groups of people to explore the future themselves, consisting of two scenarios around which a group of designers can form a brainstorming activity to explore this project's specific future further.

7.1 Many unanswered questions

There are many unanswered questions. Many of which are not listed here. The reader of this project undoubtedly has some of its own, and it is encouraged to explore these questions. The topics listed in this paragraph are suggestions of questions and this list is by no means meant to be exhaustive.

Questions worth exploring further

6.1.1 Desirable futures

Designers are not bystanders of the future. They are active participants in the industrial world and its development. Therefore, it is valuable to determine as a design agency what direction is desirable. A few pointers have been given in this research. A process of designing future design practices in collaboration with the practicing field of design may create a shared sense of direction within the (local) field that can aid in the efforts to guard the human-centricity in design.

6.1.2 Manufacturing and processes

Materials and manufacturing practices are a large part of the design process. In this project some large trends with regard to these materials have been mentioned. They are becoming smarter and more biologically based. It is, however, unclear as of yet what it will take for those materials to make their way into designed consumer products and what possibilities or limitations their use entails. Further research into this topic of the manufacturing side of design may be very valuable to inspire design engineers to think about new shapes and processes for products.

6.1.3 New interactions

During the fourth industrial revolution, neural interfaces are expected to make their way into consumer electronics. It sounds like science fiction in that we as humans can hardly imagine what it is like to use such interfaces. And that is exactly why it is valuable to investigate. How do you interact with a product using only your thoughts? Experimentation may provide a possible answer to that. It is the ultimate version of products without physical components that can provide feedback, a trend that was established in this project.

6.1.4 Other worlds

With the emergence of NFT (Non Fungible Tokens) recently (Haak, 2020) it is not unthinkable that some future consumer products exist only in the digital sphere. This can already be seen in fashion, gaming and art. How does a traditional industrial designer approach a type of product that does not revolve around materials and masses, but around bits and information? It can be interesting to explore what it means to design digital consumer products. It can be imagined that it brings a lot of freedom. It is possible to make floating chairs out of bubble wrap or dresses out of soap bubbles. But it may also bring many restrictions.

6.1.5 Director of systems

This project established that the designer of the future is a designer of systems. To do that requires an ability to see beyond the current state of a product and imagine how it can change through time. It may require from the design process itself to be altered too. If most of the form giving is done by AI, the designer can put efforts towards mapping and connecting these product dimensions. It will be valuable to search for ways to perform the design process in such contexts.

7.2 Be the designer of the future

Presented in this paragraph is a method for the designers of D'Andrea & Evers Design to explore the topics of this project further. Imagining what the future of design may hold from scratch is not likely to be a fruitful endeavour. This chapter provides guidelines to allow designers to actively participate in a process of designing for the future. On the opposite page are two deliberately short design briefs (figures 29 & 30). They may look very open or undefined, but that is exactly the point.

These scenarios can be used by a group of designers or other professionals, preferably with different expertise and interests, to spark discussion and form a vision for a possible future.

During such a session, it is important that everyone allows their mind to wander and to not be too conservative. It is allowed, and even encouraged, to think wildly outside of the box. However, as a group, after brainstorming it is also the point of the exercise to come to a credible-looking solution or design. The goal is to come up with something that will be economically feasible, technologically viable and socially acceptable in the future. Some boundaries may, however, be stretched to proved space for creative or imaginative solutions. The participants should feel free to interpret the brief as broadly or specifically as they would like. The structure is left open on purpose. They both do, however, contain all the vital information that makes these products: products of the fourth industrial revolution.

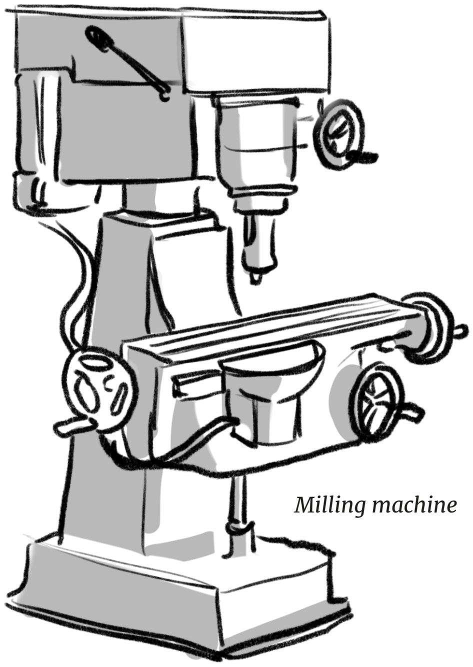


Figure 33 (top): Case prompt for a future milling machine

Figure 34 (bottom): Case prompt for a future parasol

Case card 1 - Milling machine

Characteristics of the fourth industrial revolution that can be found in this case	The physical world and the digital world increasingly merge into one. Fast internet connections and advanced interfaces allow for interactions to happen independent of geographic location. Almost every physical object, including the user, has a digital version of itself.
Possible questions that are central to this case	What is the form of a merging physical and digital world? How do interactions happen when products and users are not geographically bound to each other?
Case brief	A company developed a new kind of milling machine. It can operate autonomously. From preparation of the material to determining toolpaths, the machine can do it. An engineer can operate the machine from anywhere in the world. The company plans on placing such machines in different parts of the world, located near potential customers. Their clients can, if they want, visit the local facility to see the work or gather information from the service employees that work in the local offices. The interface of the machine is virtual. The engineer can interact with it in real time. The interaction does not look like an engineer giving directions to a machine. It looks more like an engineer discussing the work with the machine and coming up with an approach together. It can be enough for the engineers to provide mere suggestions and indicate boundaries, but they can also take more control when necessary.
Boundaries for the case	The milling machine has some physical components that need to be incorporated in the design. The system to manipulate the work, a motor, the spindle and a storage for different tools.

Case card 2 - Garden umbrella

Characteristics of the fourth industrial revolution that can be found in this case	Many products in the future are connected through the internet of things. Design is not only aimed at products with a single interaction anymore. It should also be able to design product systems. Time becomes a dimension in the physical appearance of products through the use of smart materials.
Possible questions that are central to this case	If the product function is dynamic, how will it influence the shape it gets? How can smart materials be used in future products? What interactions are still necessary if a product can operate largely autonomously?
Case brief	The manufacturer of garden furniture wants to develop a product with new materials. Inspired by the ecosystem of the garden they want to make a sunscreen for gardens or balconies. They imagine a product that can sense its environment and context. The material is able to change with the seasons. It provides shelter from the sun in the summer, shelter from the rain in the fall, or provide shelter from cold winds in the winter. Within boundaries, it can transform to change the area sheltered by it. It can locally change the material properties (e.g. the amount of UV-light that passes through) based on input it gets. It could, for example, provide more sun to flower beds underneath it or rotate with the light to protect a user seeking shelter throughout the day. Like a flower rotating with the sun.
Boundaries for the case	The product should fit multiple gardens or balconies.

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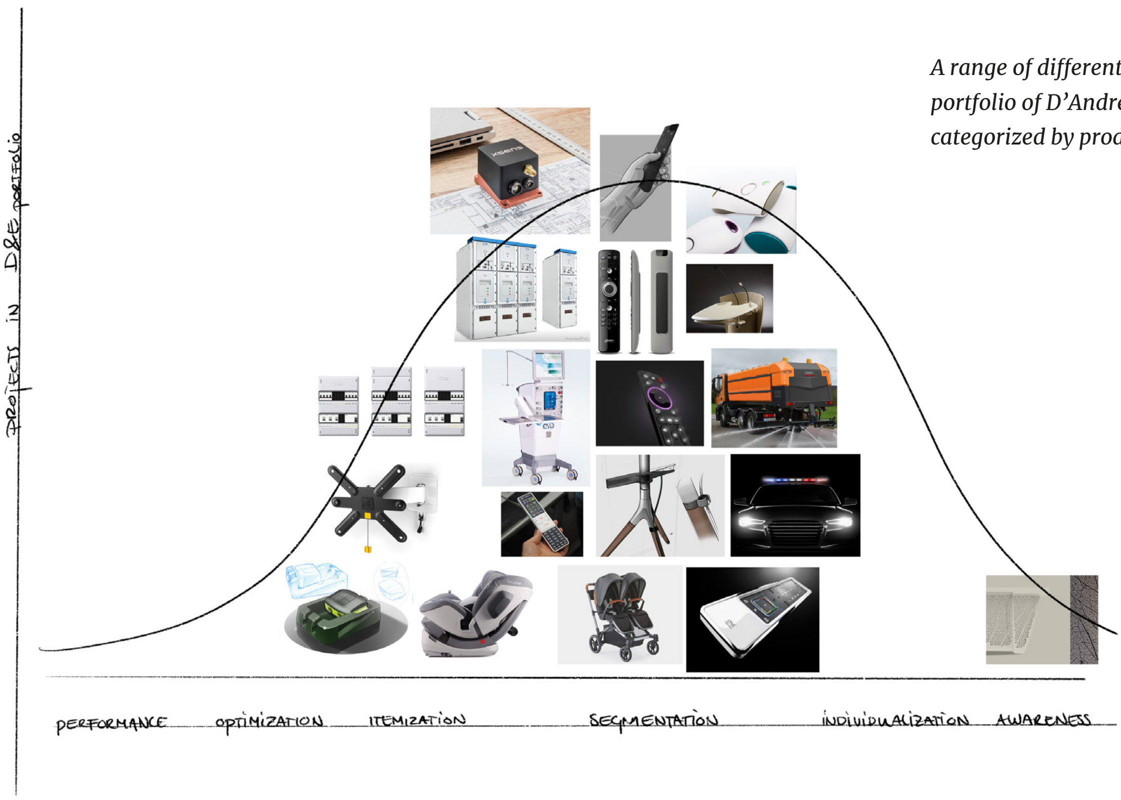
Appendix A
Portfolio analysis

For this analysis, projects were taken from D&E Design's public website. It is furthermore attempted to choose many different product types. The information on the website about the project is then qualitatively compared to the characteristics of the product phases.



A range of different designs from the portfolio of D'Andrea & Evers Design categorized by product phase.

Project: Slim TV mount and tripod
Product phase: Itemization/segmentation. Improved functionality or blends in with style of furniture.

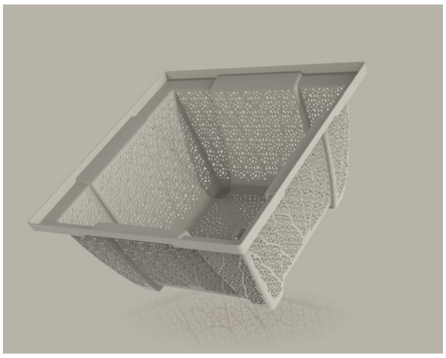
Project: Flextern
Product phase: Segmentation. Uses style to influence meaning.

Project: IO
Product phase: Segmentation. Does not look like archetypical house key. Fits lifestyle as keychain.

Project: Eaton ID
Product phase: Itemization. Project uses design to communicate brand identity but follows the archetype.

Project: System 55
Product phase: Itemization/optimization. Create encasing with focus on ease of use and brand identity.

Project: MTi – 680 series
Product phase: Optimization. Design for easy assembly



Project: ASP and Signal Supervisor
Product phase: Segmentation. Clear use of design to communicate brand or authority.

Project: Water plant basket
Product phase: Awareness. Clear use of design to influence a bigger goal.

Project: R160A car seat and Element stroller
Product phase: Itemization. Follows the archetype but tries to add features (safety, dual seat) compared to competition.

Project: Various remotes
Product phase: Itemization. Clear archetype and differs from competition through styling and ergonomics

Appendix B
Presentation I

This presentation was given online for all employees of D’Andrea & Evers Design for them to discuss what they though the important focal points for the future of design would be. The presentation took place on 25th of May 2021.

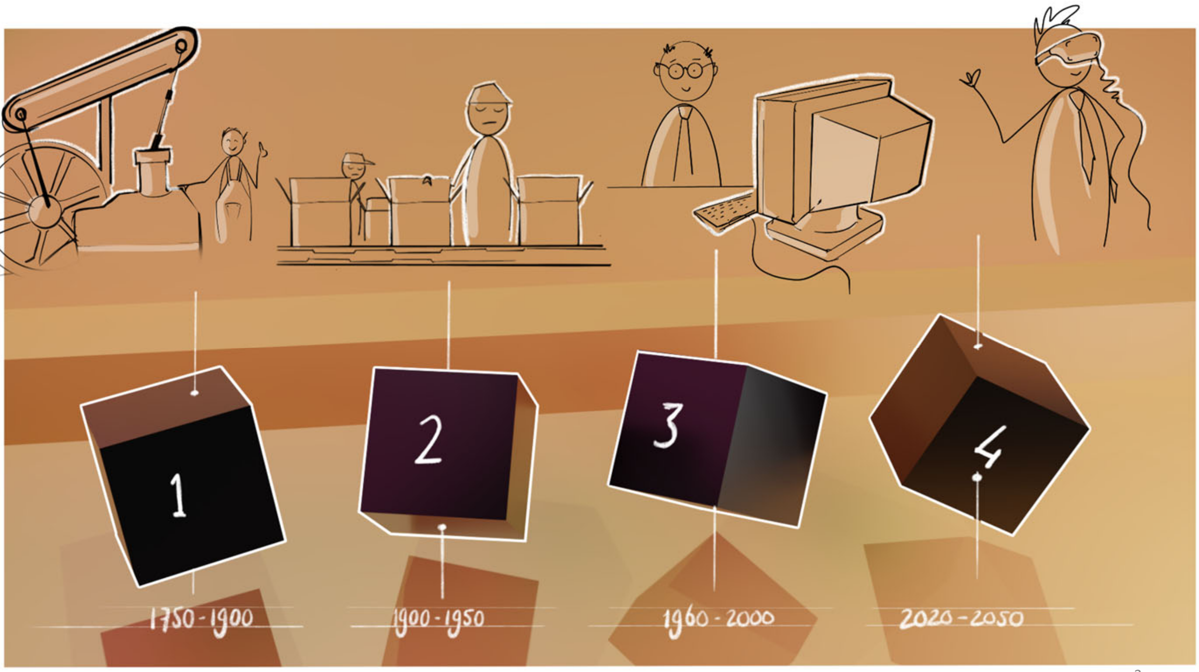
25-05-2021

1

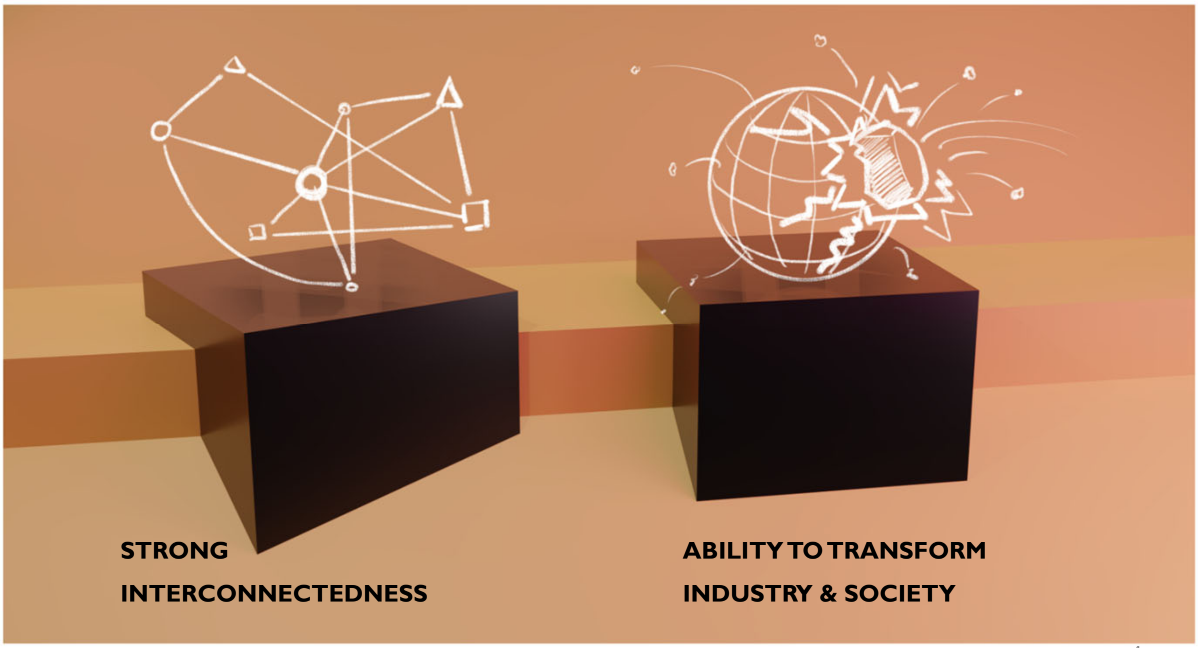
Sheet number

2

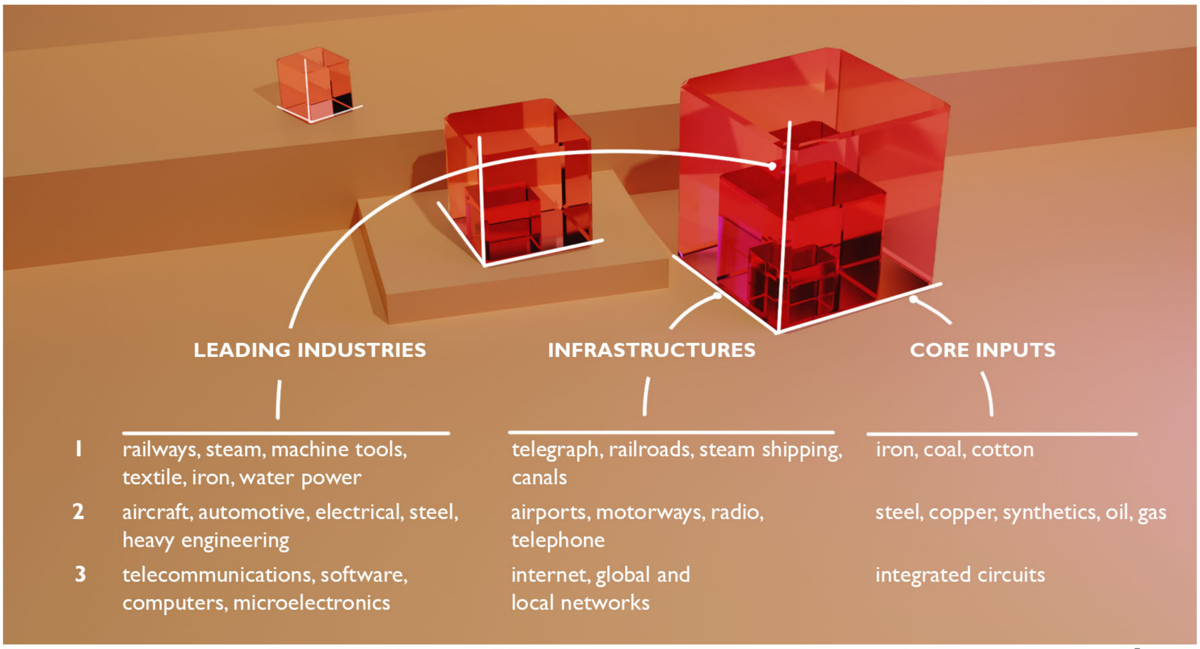
1


1
2
3
4
1750-1900
1900-1950
1960-2000
2020-2050
3

3

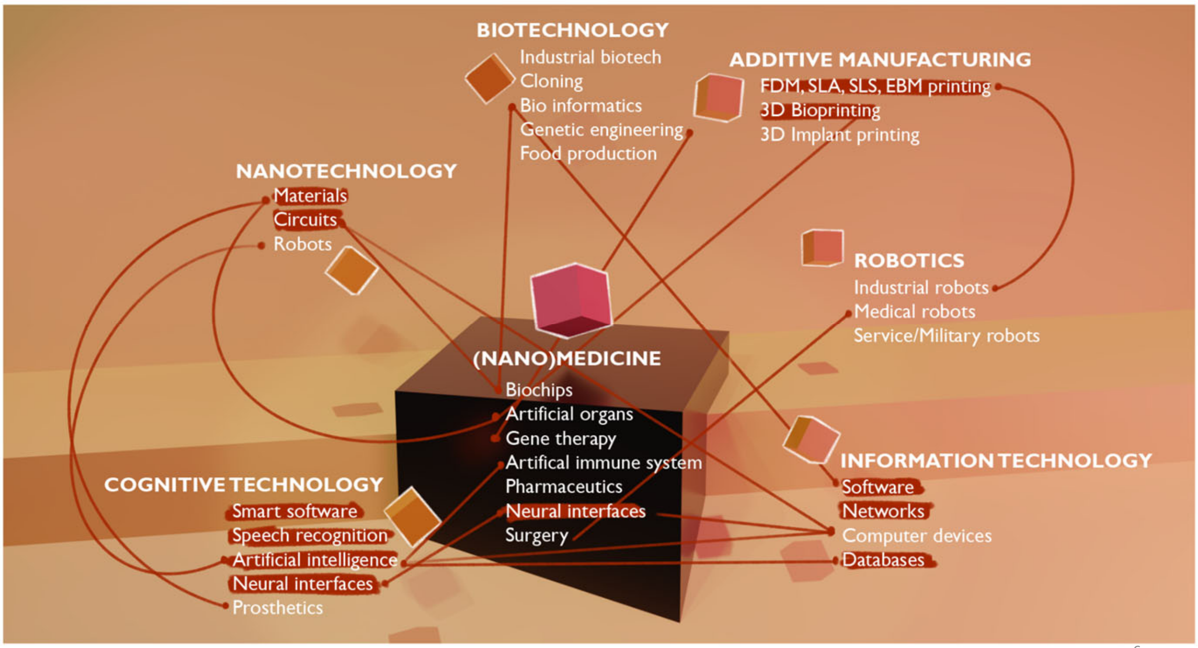

STRONG
INTERCONNECTEDNESS
ABILITY TO TRANSFORM
INDUSTRY & SOCIETY
4

4


LEADING INDUSTRIES
INFRASTRUCTURES
CORE INPUTS
1
railways, steam, machine tools, textile, iron, water power
telegraph, railroads, steam shipping, canals
iron, coal, cotton
2
aircraft, automotive, electrical, steel, heavy engineering
airports, motorways, radio, telephone
steel, copper, synthetics, oil, gas
3
telecommunications, software, computers, microelectronics
internet, global and local networks
integrated circuits

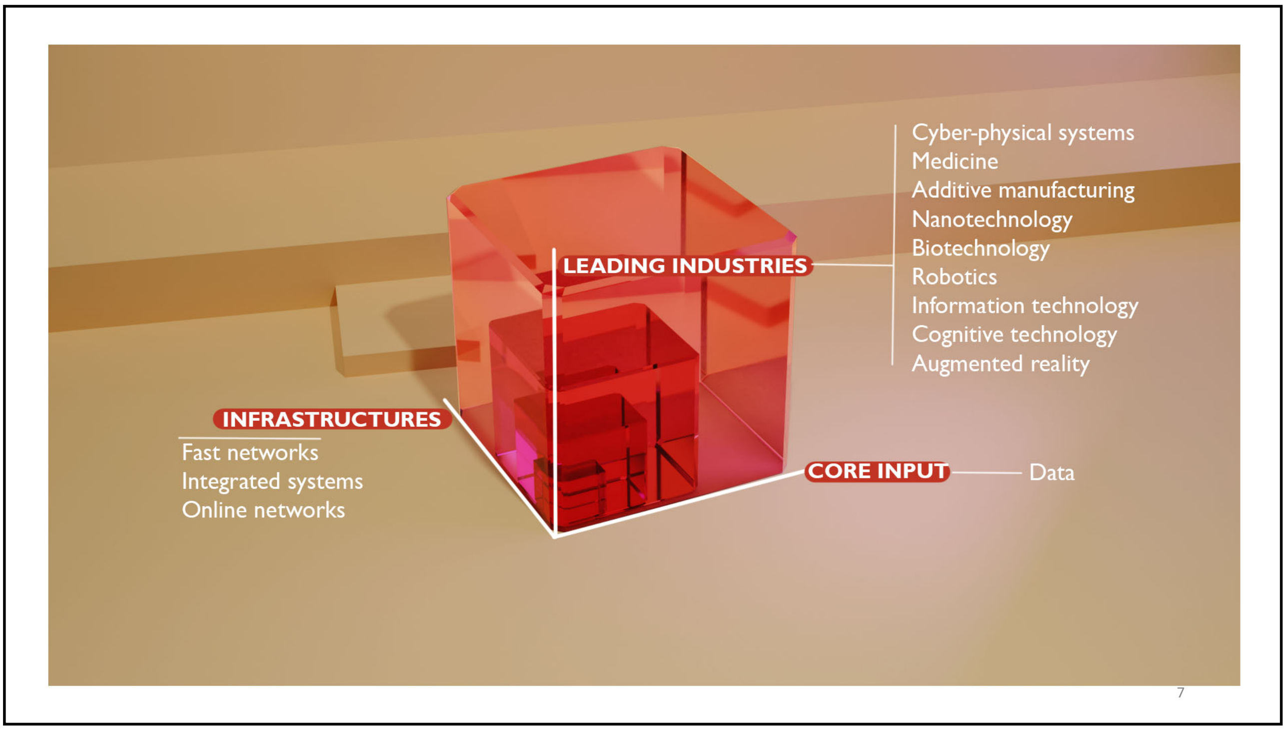
5

5

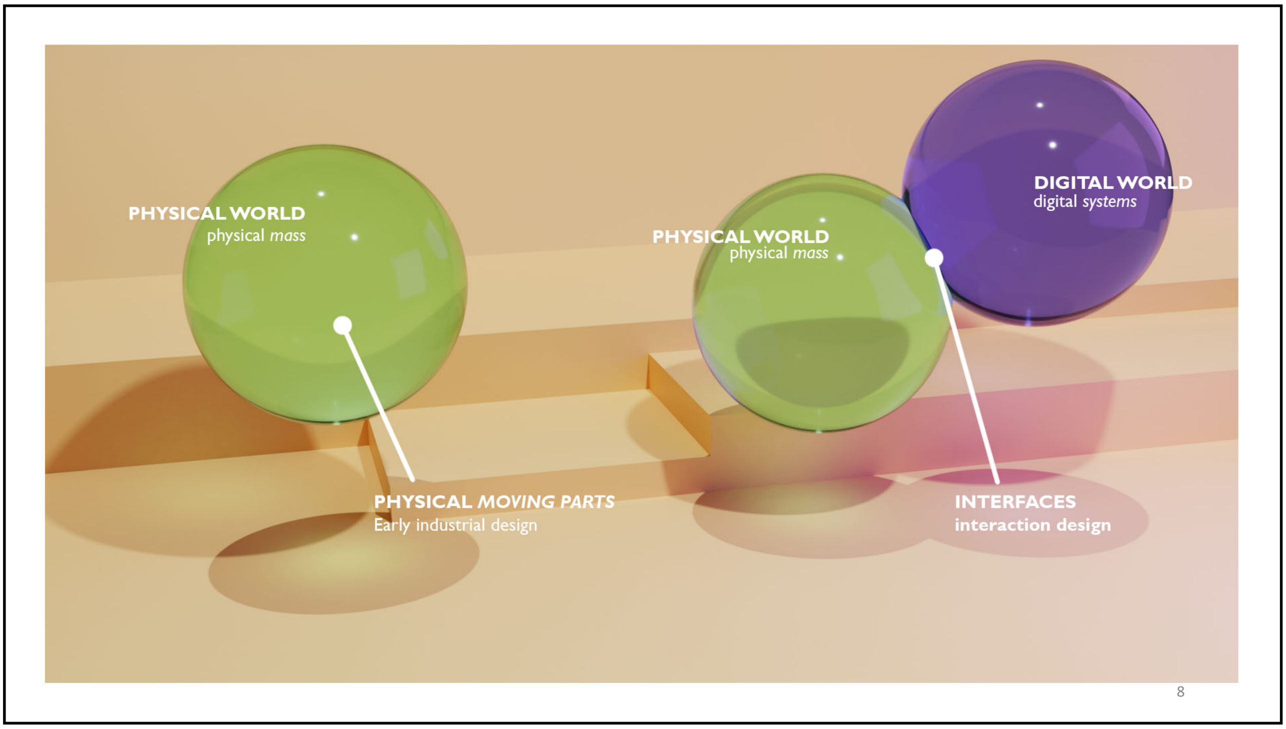

BIOTECHNOLOGY
Industrial biotech
Cloning
Bio informatics
Genetic engineering
Food production
ADDITIVE MANUFACTURING
FDM, SLA, SLS, EBM printing
3D Bioprinting
3D Implant printing
NANOTECHNOLOGY
Materials
Circuits
Robots
ROBOTICS
Industrial robots
Medical robots
Service/Military robots
(NANO)MEDICINE
Biochips
Artificial organs
Gene therapy
Artifical immune system
Pharmaceutics
Neural interfaces
Surgery
INFORMATION TECHNOLOGY
Software
Networks
Computer devices
Databases
COGNITIVE TECHNOLOGY
Smart software
Speech recognition
Artificial intelligence
Neural interfaces
Prosthetics

6

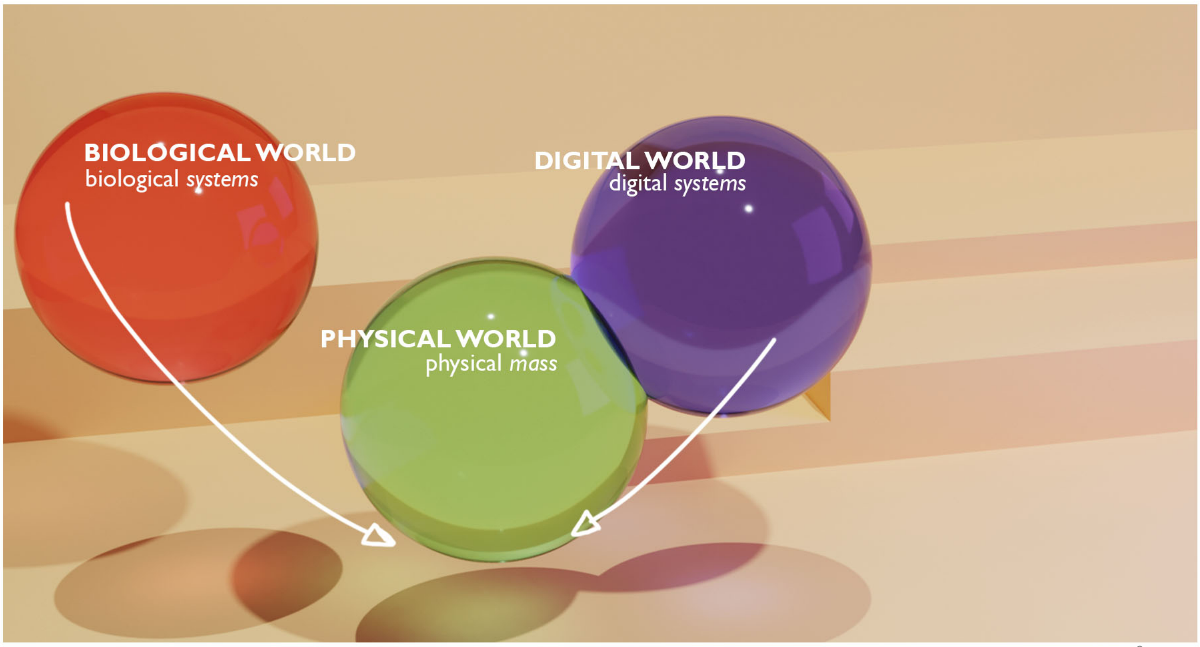
6


Cyber-physical systems
Medicine
Additive manufacturing
Nanotechnology
Biotechnology
Robotics
Information technology
Cognitive technology
Augmented reality
LEADING INDUSTRIES
INFRASTRUCTURES
Fast networks
Integrated systems
Online networks
CORE INPUT
Data
7

7


PHYSICAL WORLD
physical mass
PHYSICAL WORLD
physical mass
DIGITAL WORLD
digital systems
PHYSICAL MOVING PARTS
Early industrial design
INTERFACES
interaction design
8

8



9

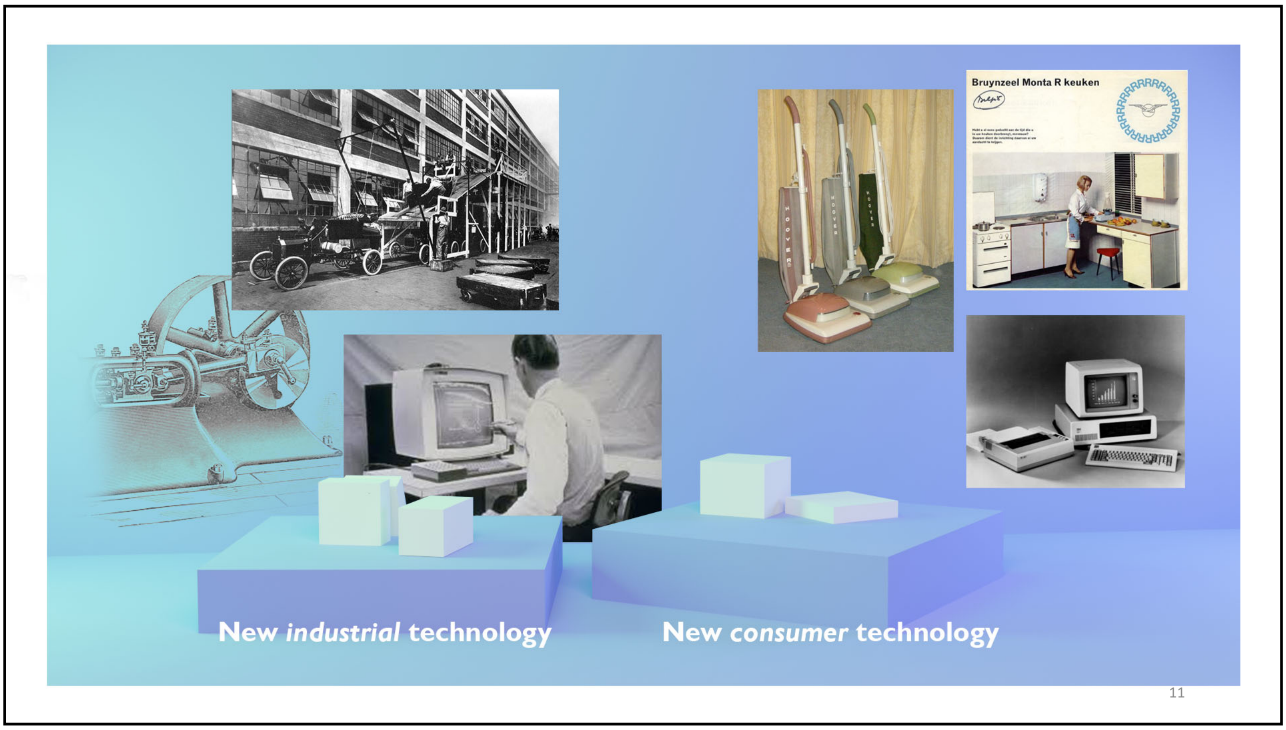
9

The fourth revolution is a design revolution

PART II

10

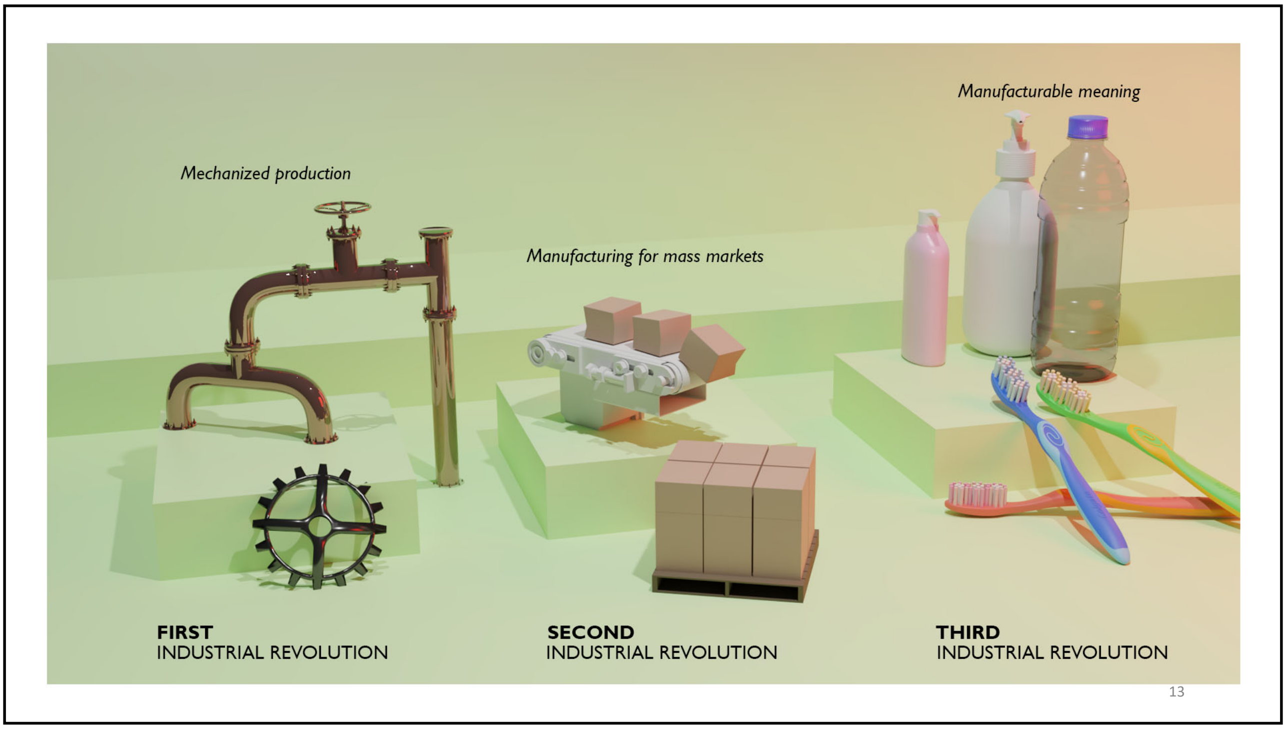
10


Bruynzeel Monta R keuken
New industrial technology
New consumer technology
11

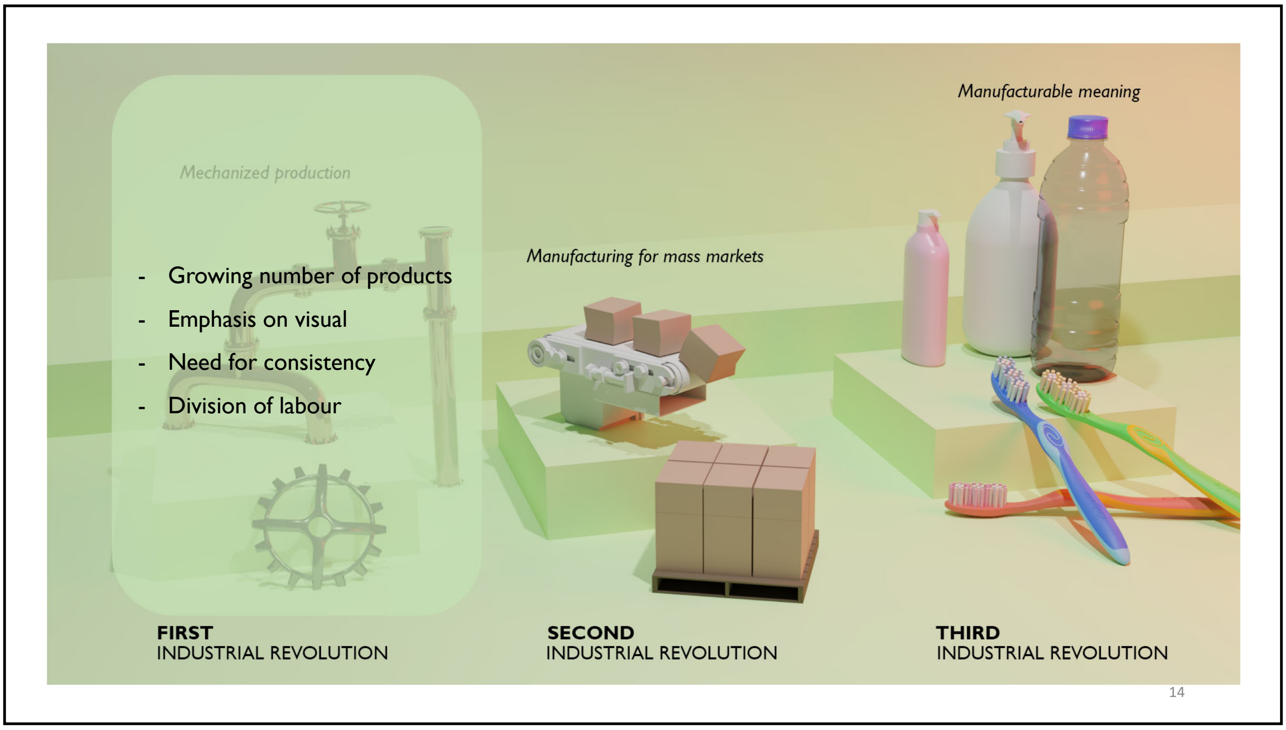
11


Bruynzeel Monta R keuken
New industrial technology
New consumer technology

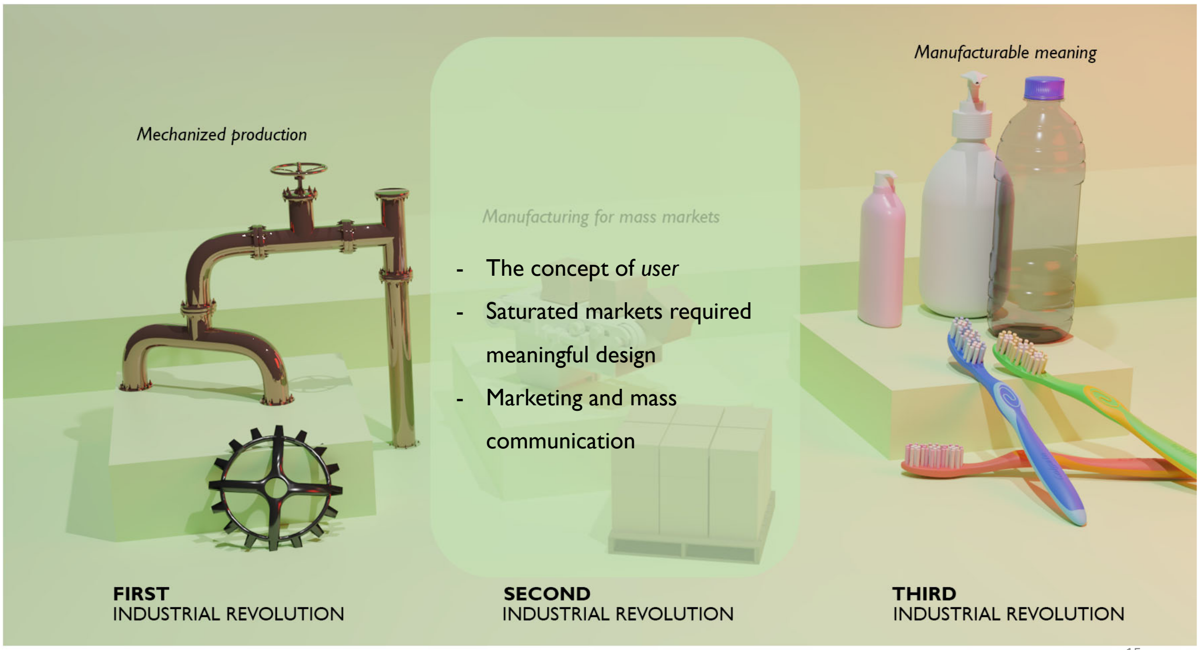
12


Manufacturable meaning
Mechanized production
Manufacturing for mass markets
FIRST
INDUSTRIAL REVOLUTION
SECOND
INDUSTRIAL REVOLUTION
THIRD
INDUSTRIAL REVOLUTION
13

13

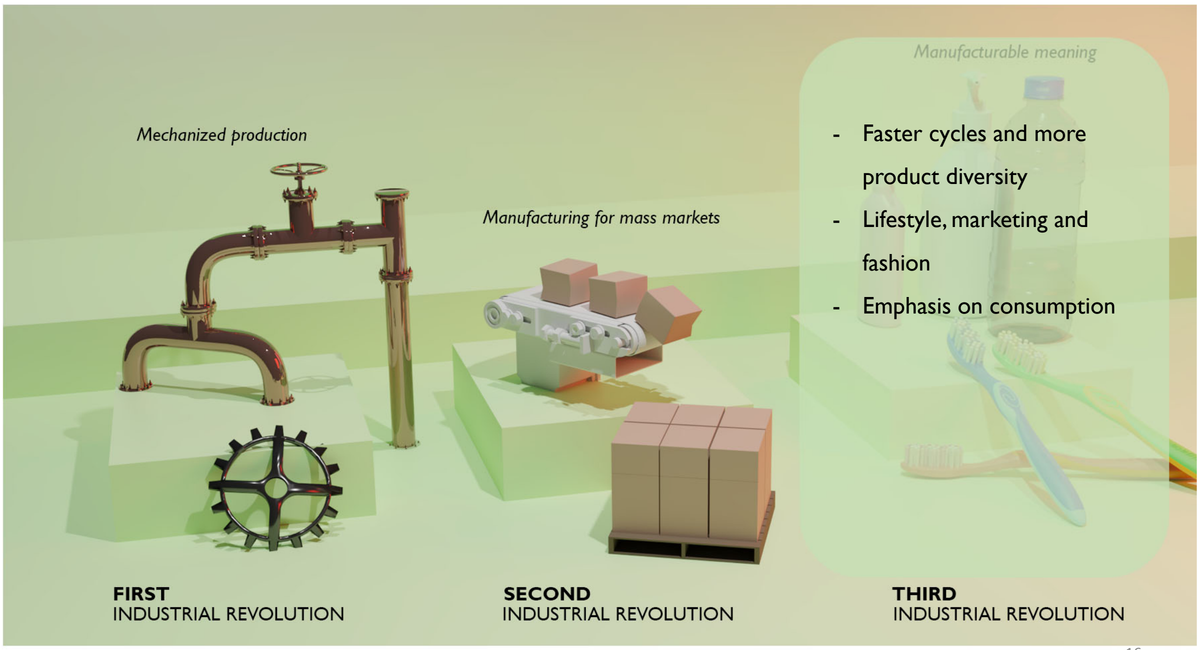

Manufacturable meaning
Mechanized production
Manufacturing for mass markets
- Growing number of products
- Emphasis on visual
- Need for consistency
- Division of labour
FIRST
INDUSTRIAL REVOLUTION
SECOND
INDUSTRIAL REVOLUTION
THIRD
INDUSTRIAL REVOLUTION
14

14


Mechanized production
Manufacturing for mass markets
Manufacturable meaning
- The concept of *user*
- Saturated markets required meaningful design
- Marketing and mass communication
FIRST
INDUSTRIAL REVOLUTION
SECOND
INDUSTRIAL REVOLUTION
THIRD
INDUSTRIAL REVOLUTION

15

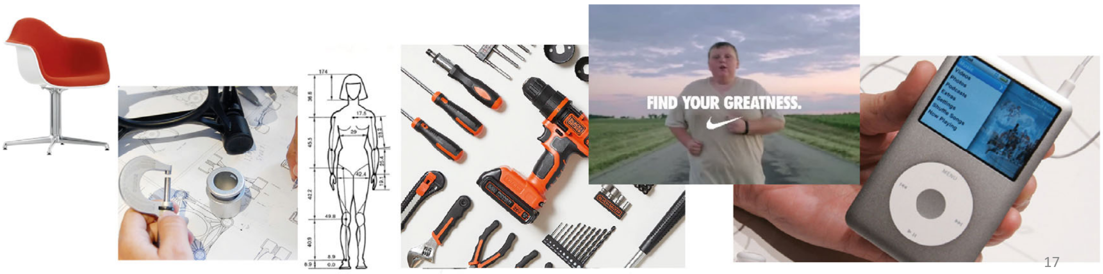
15


Mechanized production
Manufacturing for mass markets
Manufacturable meaning
- Faster cycles and more product diversity
- Lifestyle, marketing and fashion
- Emphasis on consumption
FIRST
INDUSTRIAL REVOLUTION
SECOND
INDUSTRIAL REVOLUTION
THIRD
INDUSTRIAL REVOLUTION

16

16

	Promoting the nation	Involving industry	Rise of ergonomics	Design management	Building brands	Innovation and competitiveness
Closer to market ←	**1950s**	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**
	Product aesthetics (Styling)	**Product development process**	**Product definition**	**Roadmaps**	**Strategy**	**Vision**
	Designer as creator	*Design as part of a multidisciplinary team*	*Design for user under-standing*	*Design as coordinator*	*Design for creating experiences*	*Design as innovation driver*



17

17

Industry 4.0/Smart Factory

- Robotics
- (Industrial) Internet of Things
- The Cloud
- Cybersecurity
- Simulation
- Big Data
- Additive Manufacturing
- Augmented Reality
- Horizontal/Vertical System Integration

Made-in-China 2025

- Numerical Controlled Machinery
- Information Technologies
- Energy-saving vehicles
- Electrical equipment
- New materials
- Biomedicine
- High-end equiqment in:

FOURTH
INDUSTRIAL REVOLUTION

Cyber-physical systems

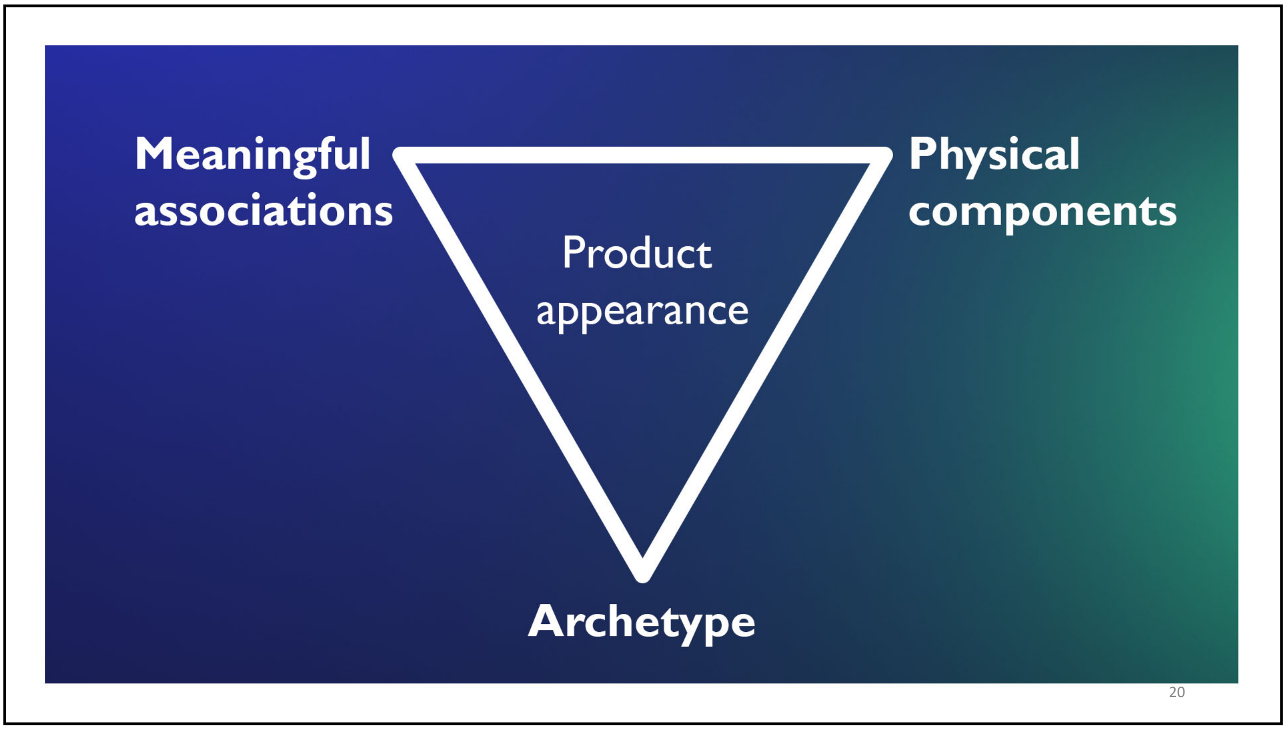
- Not geographically bound
- Ability to follow products throughout the chain
- Bio, nano, smart materials
- Continuation of third industrial revolution
- Towards durable design
- Shortening of cycles

18

18


Bruynzeel Monta R keuken
New industrial technology
New consumer technology

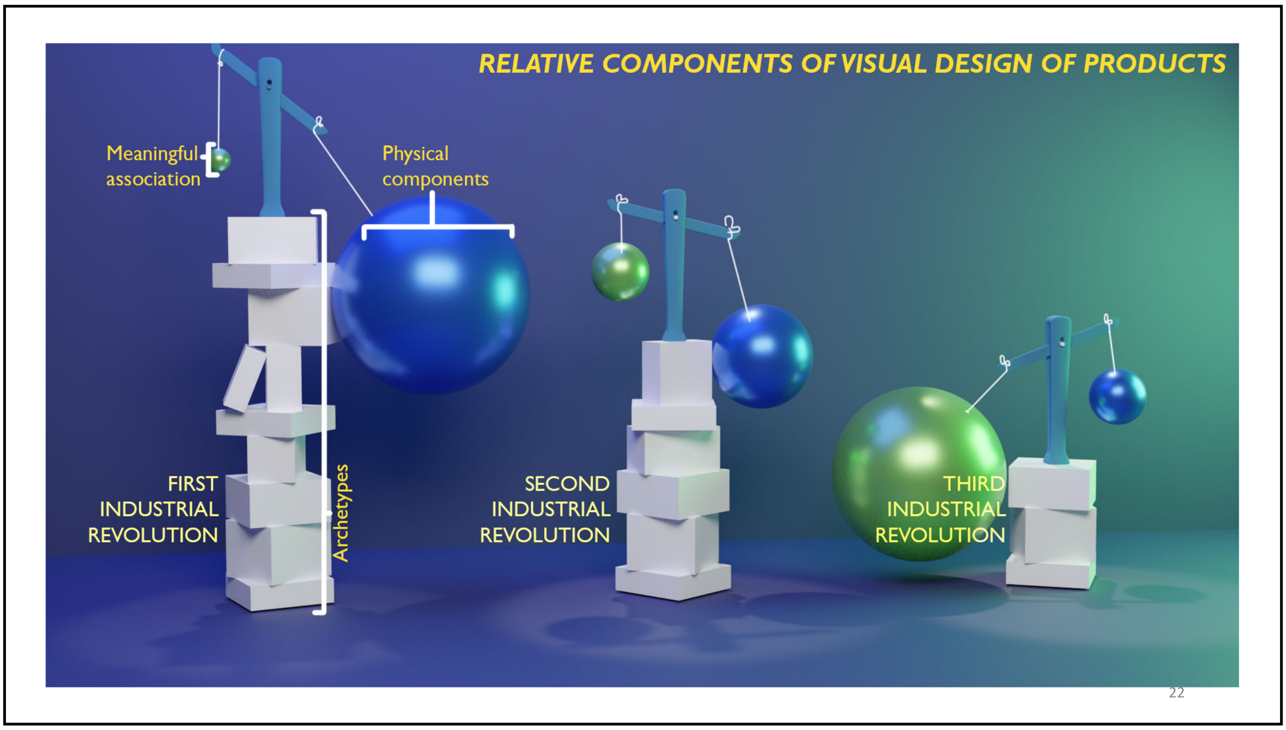
19


Meaningful associations
Physical components
Product appearance
Archetype
20

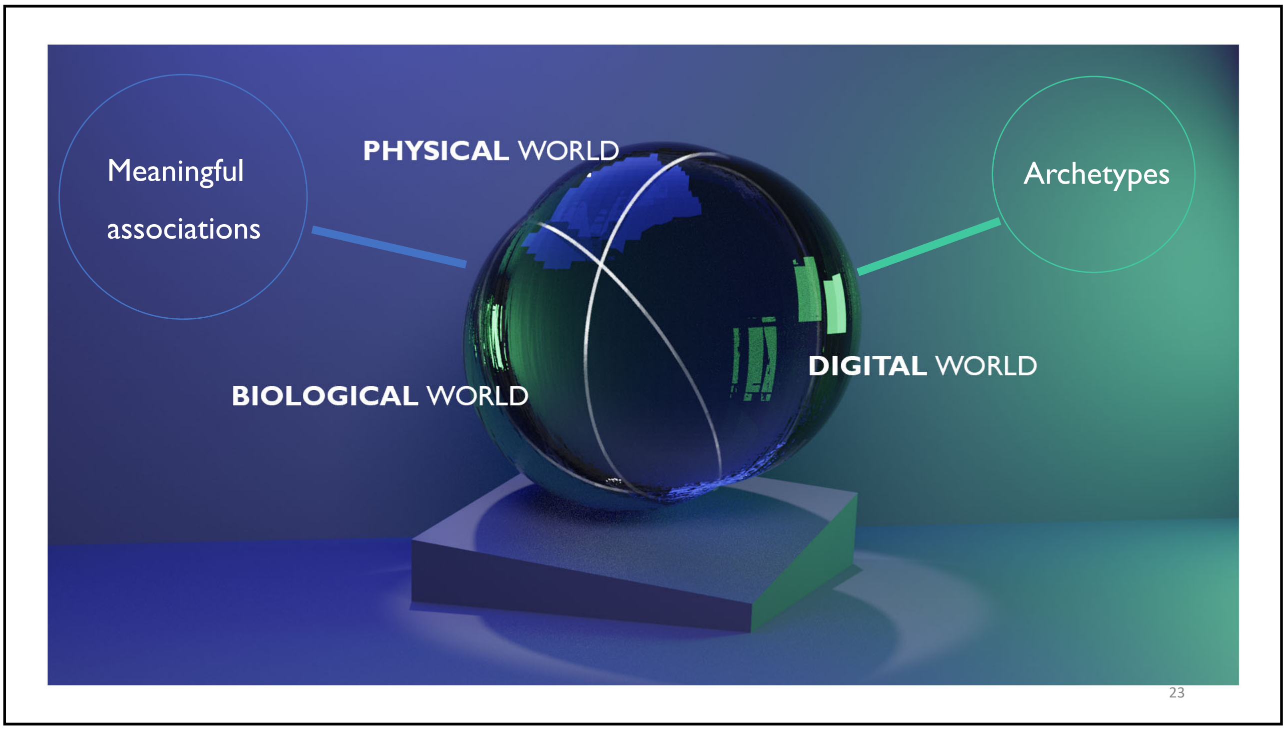
20


MEANING
PHYSICAL
ARCHETYPE
21

21


RELATIVE COMPONENTS OF VISUAL DESIGN OF PRODUCTS
Meaningful association
Physical components
Archetypes
FIRST INDUSTRIAL REVOLUTION
SECOND INDUSTRIAL REVOLUTION
THIRD INDUSTRIAL REVOLUTION
22

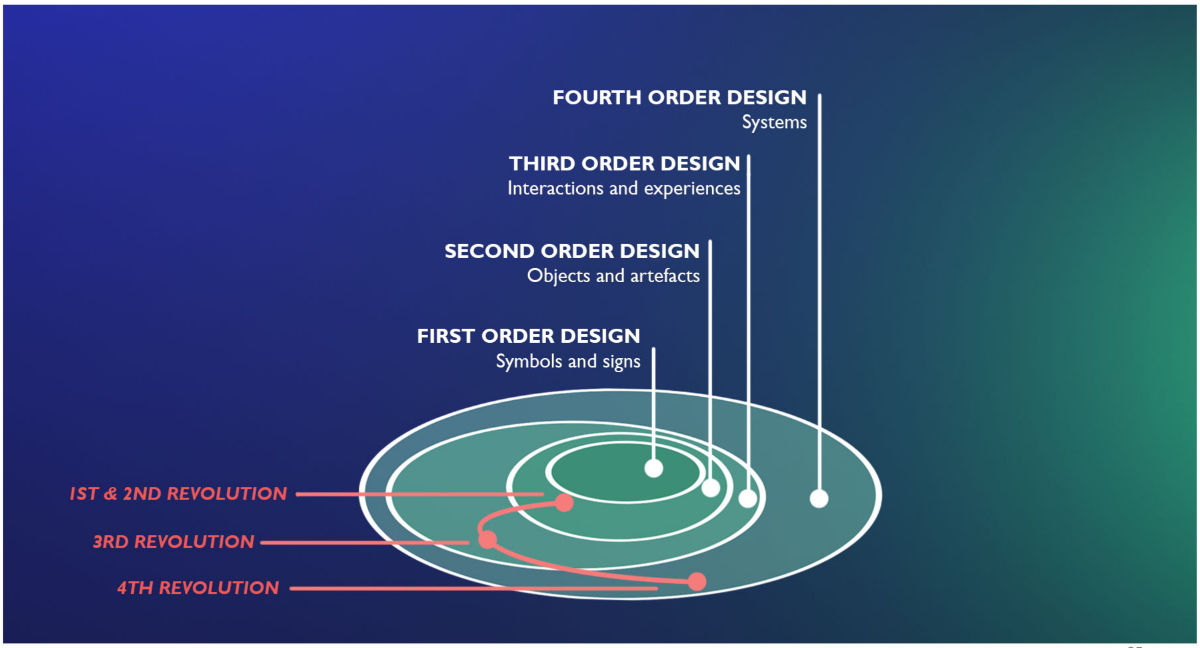
22


Meaningful
associations
PHYSICAL WORLD
Archetypes
DIGITAL WORLD
BIOLOGICAL WORLD
23

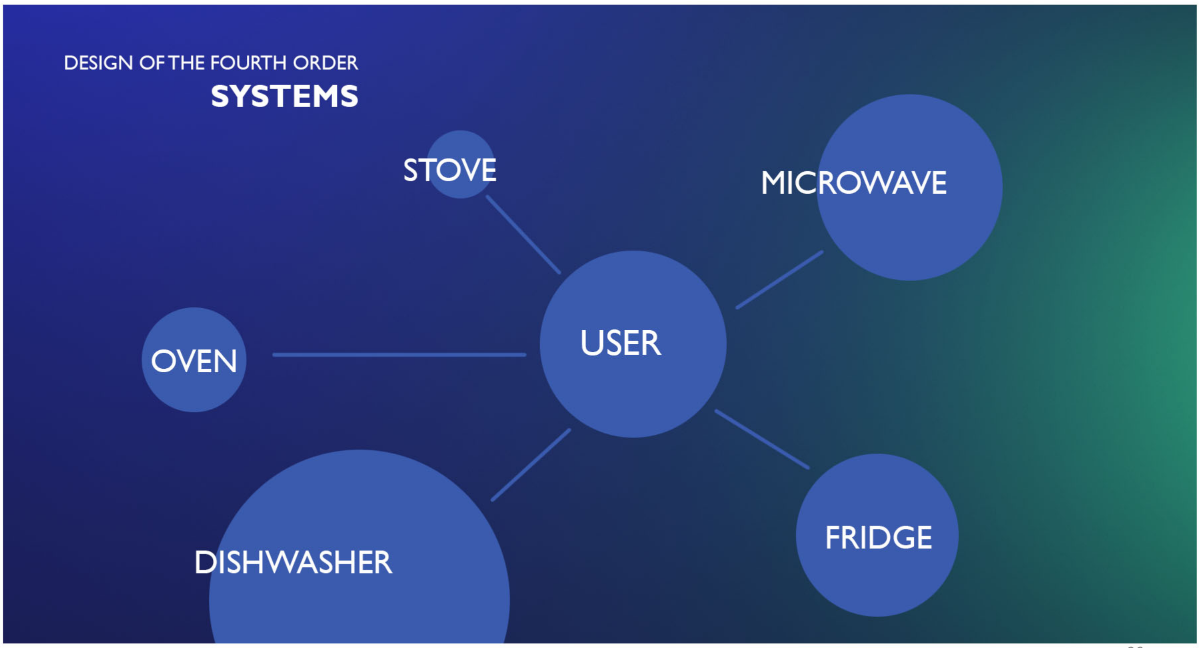
23


PHYSICAL WORLD
DIGITAL WORLD
BIOLOGICAL WORLD
CYBER-PHYSICAL SYSTEMS
24

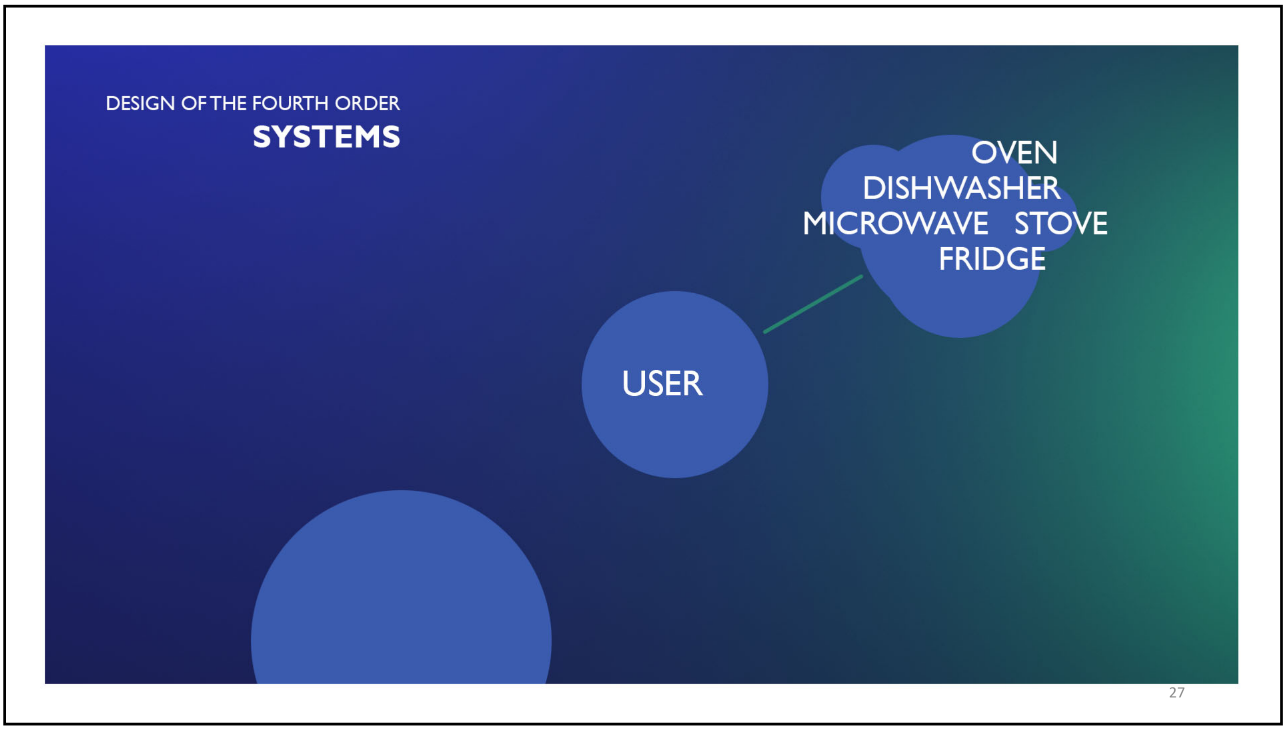
24


FOURTH ORDER DESIGN
Systems
THIRD ORDER DESIGN
Interactions and experiences
SECOND ORDER DESIGN
Objects and artefacts
FIRST ORDER DESIGN
Symbols and signs
IST & 2ND REVOLUTION
3RD REVOLUTION
4TH REVOLUTION
25

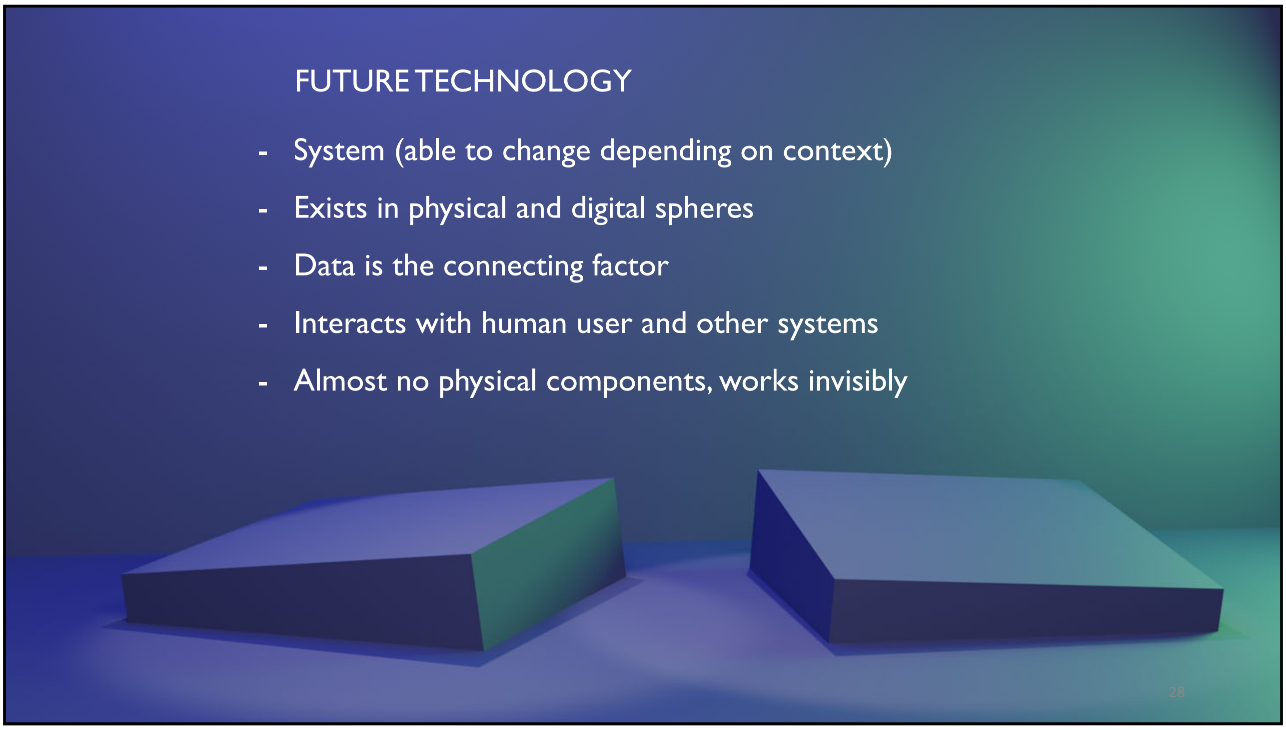
25


DESIGN OF THE FOURTH ORDER
SYSTEMS
STOVE
MICROWAVE
OVEN
USER
DISHWASHER
FRIDGE
26

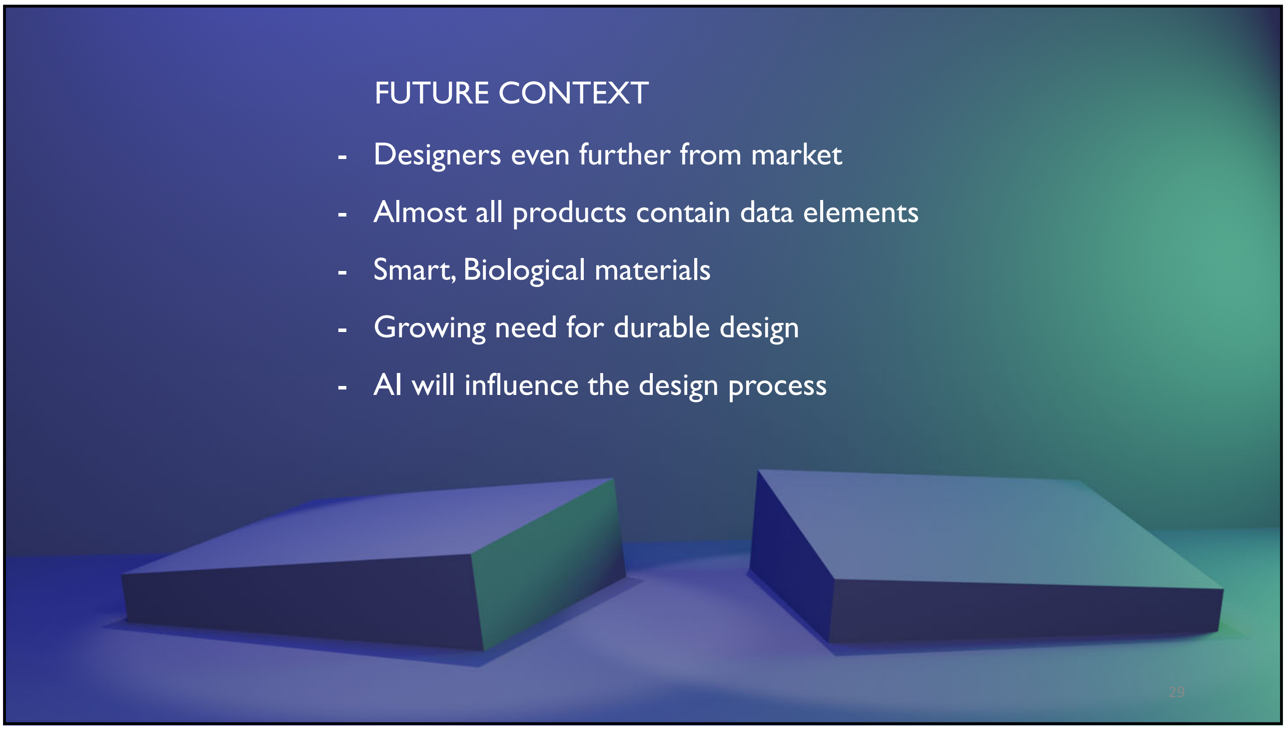
26


DESIGN OF THE FOURTH ORDER
SYSTEMS
OVEN
DISHWASHER
MICROWAVE STOVE
FRIDGE
USER
27

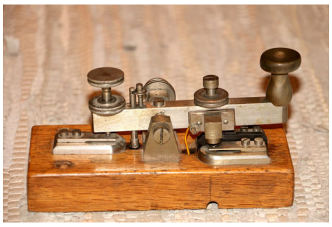
27


FUTURE TECHNOLOGY
- System (able to change depending on context)
- Exists in physical and digital spheres
- Data is the connecting factor
- Interacts with human user and other systems
- Almost no physical components, works invisibly

28



29



A common technological language: technology archetype + product archetype



30

30

31

- What will the products of the future look like?
  - Products that act in invisible ways
- What is the role of the future designer?
  - If artificial intelligence takes over the typical tasks of determining form?

32

32

Appendix C

Presentation II

This presentation was given in person to a small group of designers at D'Andrea & Evers Design as part of the design case. The presentation was given at the end of the first phase of ideation prior to making choices about the final concept. The goal was to provide them with input and spark discussion about how to approach the focal points in the final concept. The presentation was given in the temporary office of D'Andrea & Evers Design in Enschede on the 1st of June 2021.

01-06-2021

Designing for the
fourth industrial revolution

Exploring how products of the future will look

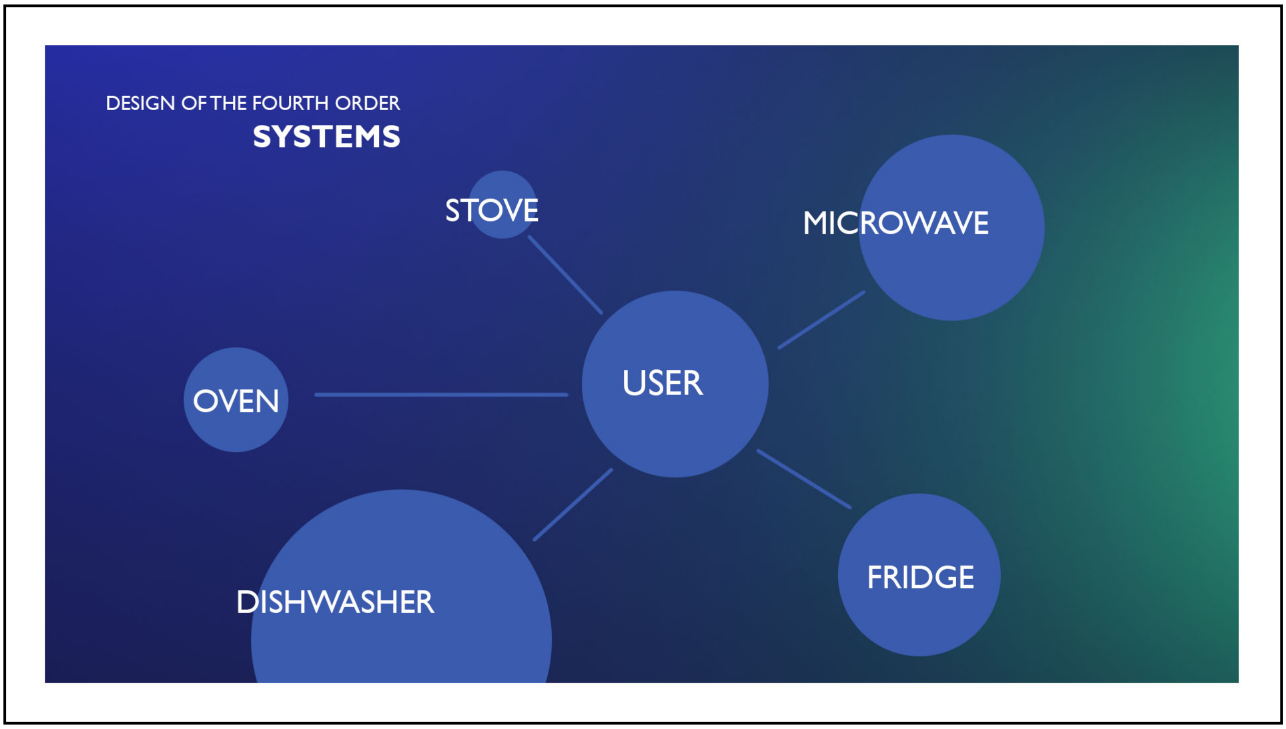
1

Sheet number

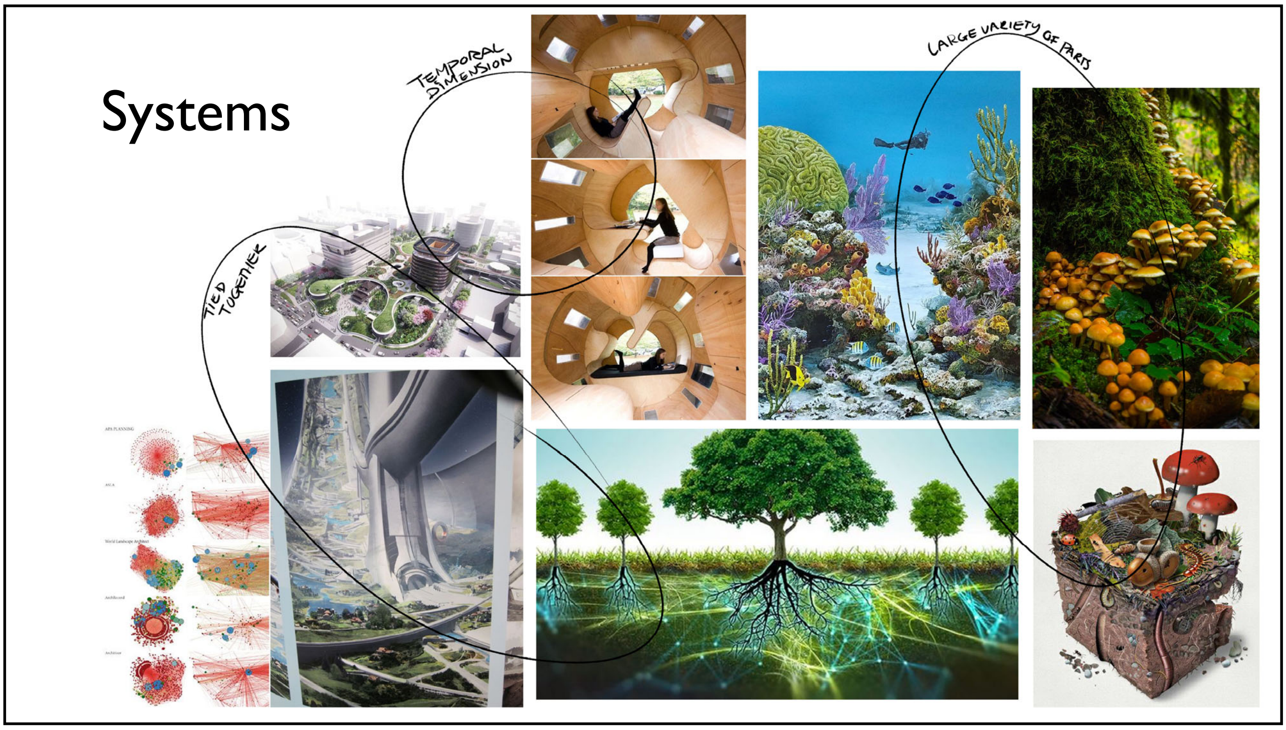
Focal points

For design to remain centered on **human** users
- Trust
- Base technology
- Black boxes
- Enduring design
- New manufacturing
- AI-powered design

2


DESIGN OF THE FOURTH ORDER
SYSTEMS
STOVE
MICROWAVE
OVEN
USER
DISHWASHER
FRIDGE

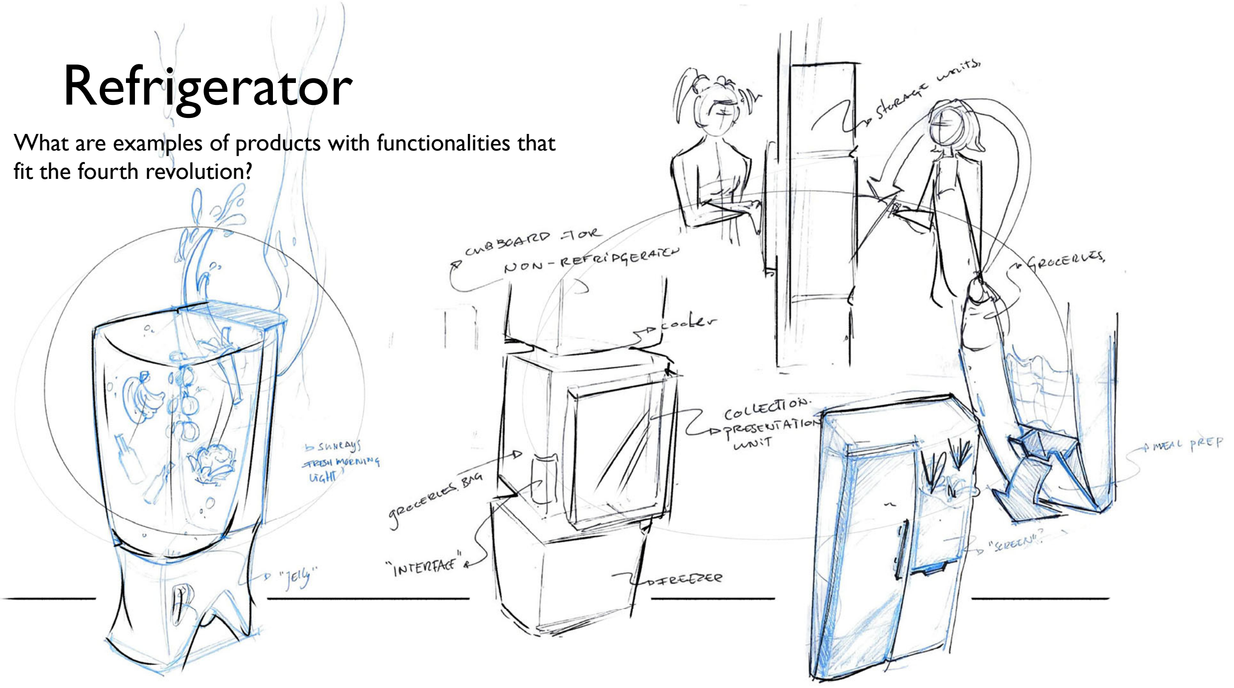
3


Systems
TEMPORAL DIMENSION
LARGE VARIETY OF PARTS
TIED TOGETHER

4

Refrigerator

What are examples of products with functionalities that fit the fourth revolution?

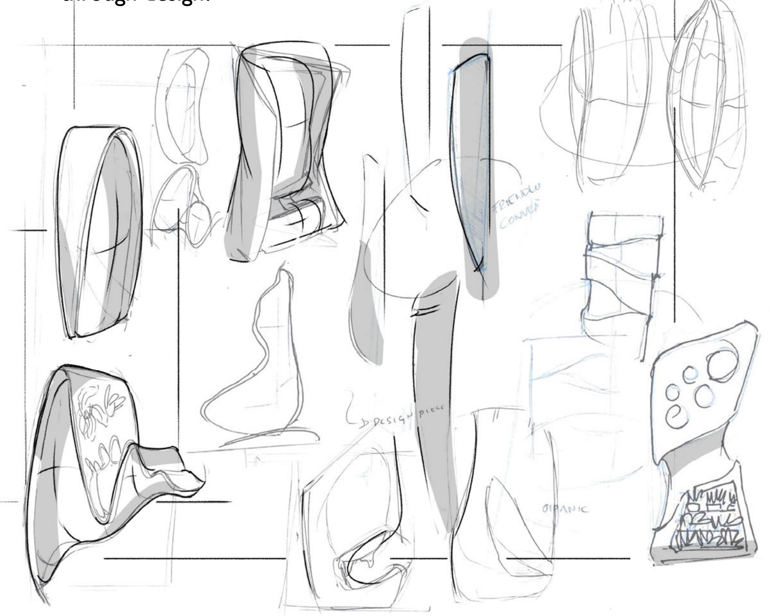


5

Trust

How to communicate trustworthiness and positivity to user through design?

1. Positive imagery
2. Human experience remains central
3. Clear communication to user



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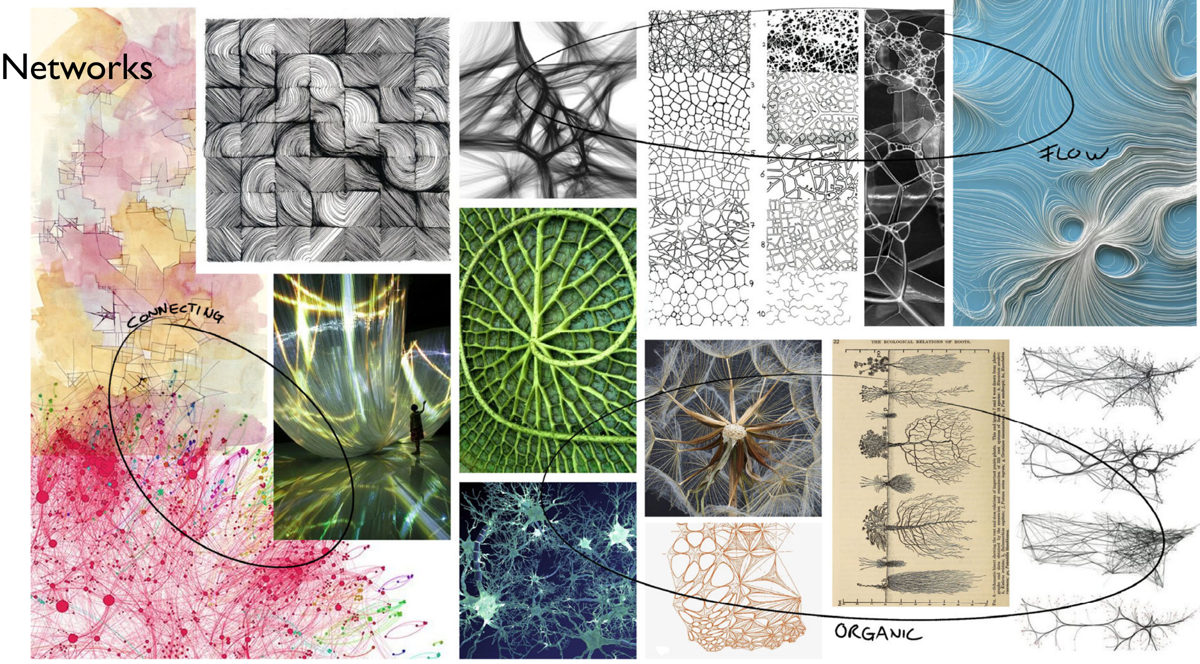
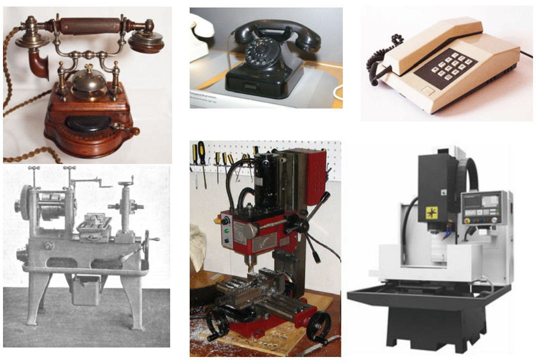


7

Base technology

New product design = product archetype + **technology** archetype (+ design efforts)

Cyberphysical systems and data



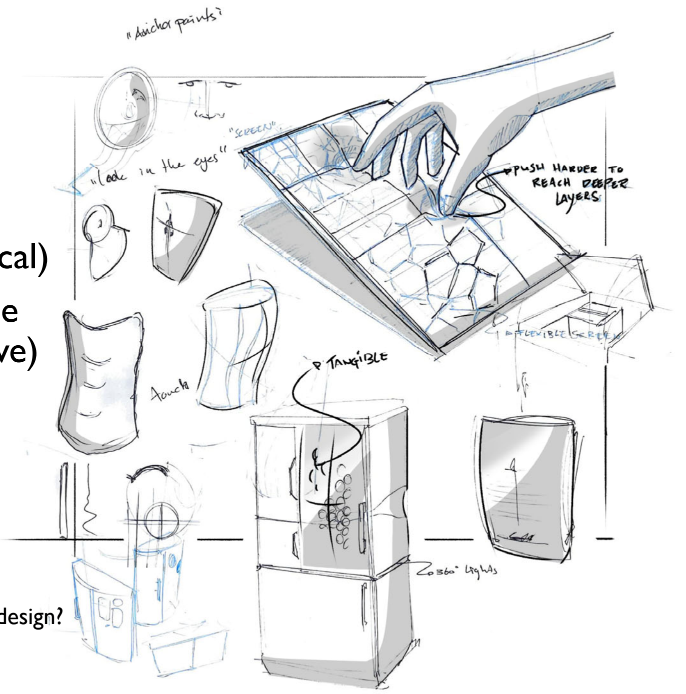
8

Black box

1. Cyberphysical interfaces

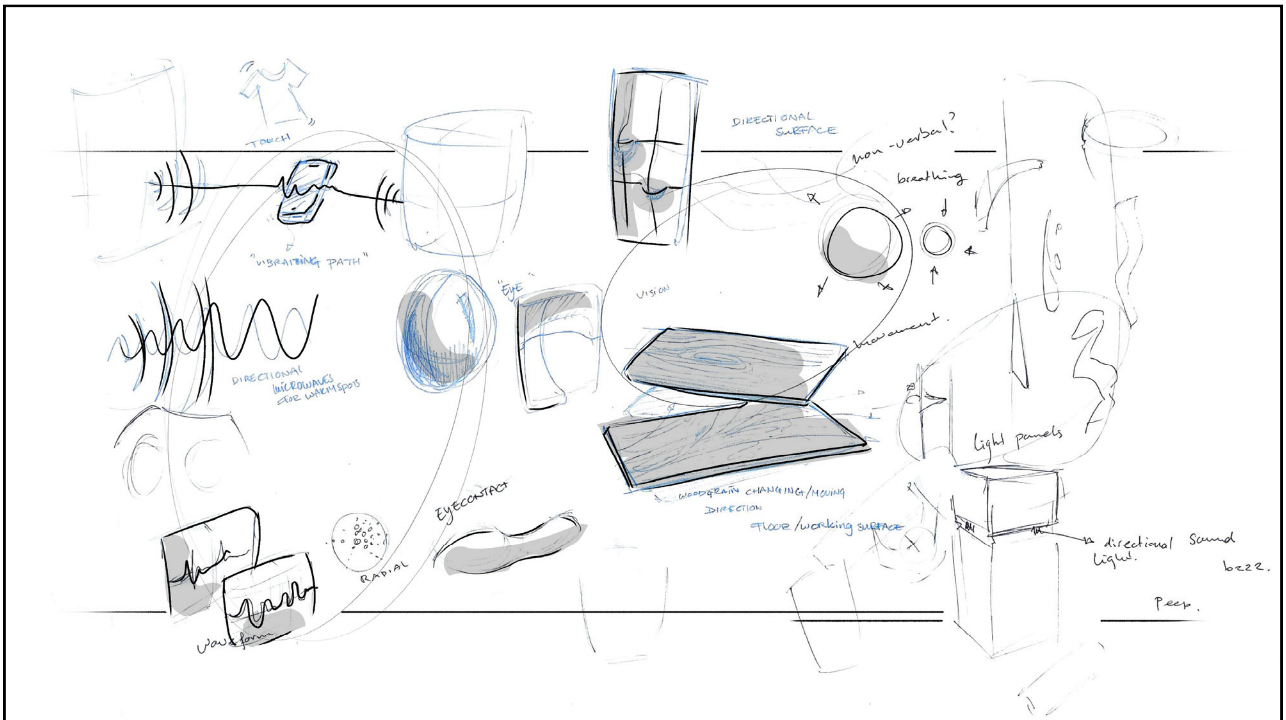
   (not just screens, but physical)

1. Complex functionality must be inclusive for everyone (intuitive)
2. Communicate data use and digital presence (trust)

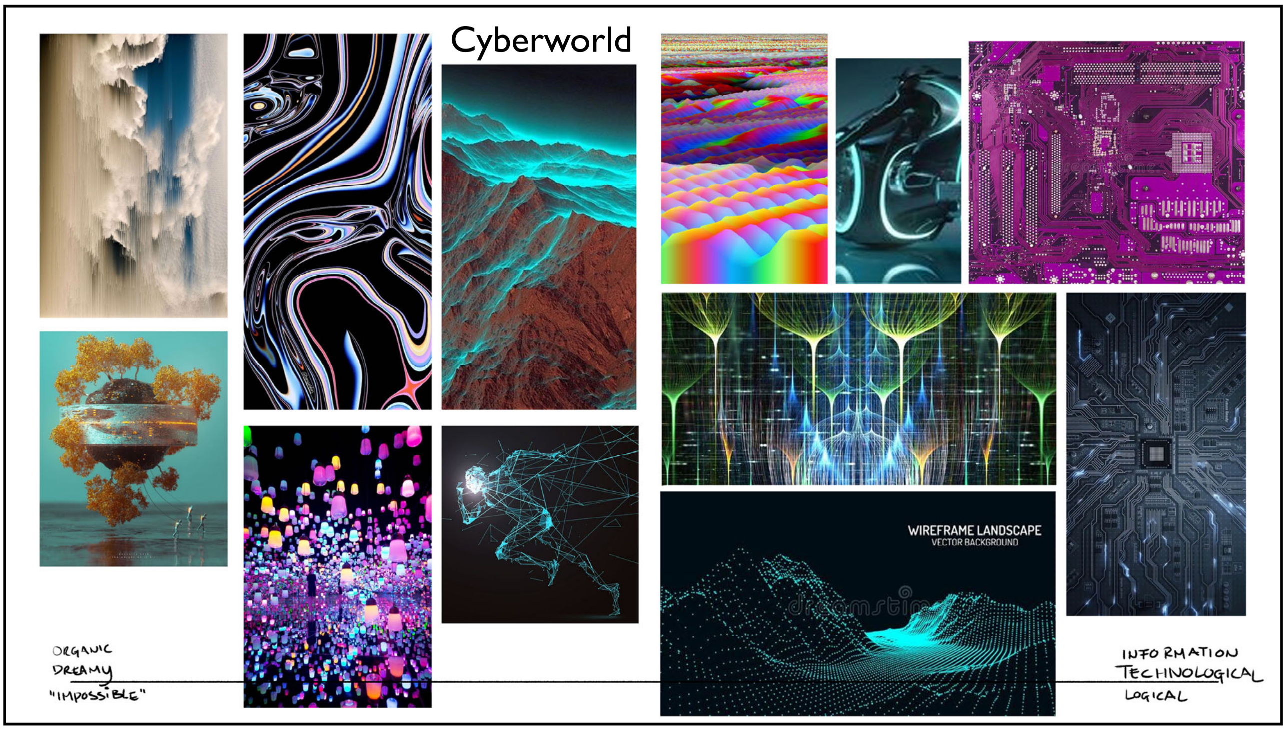


How to communicate cyberphysicality to user through design?

9



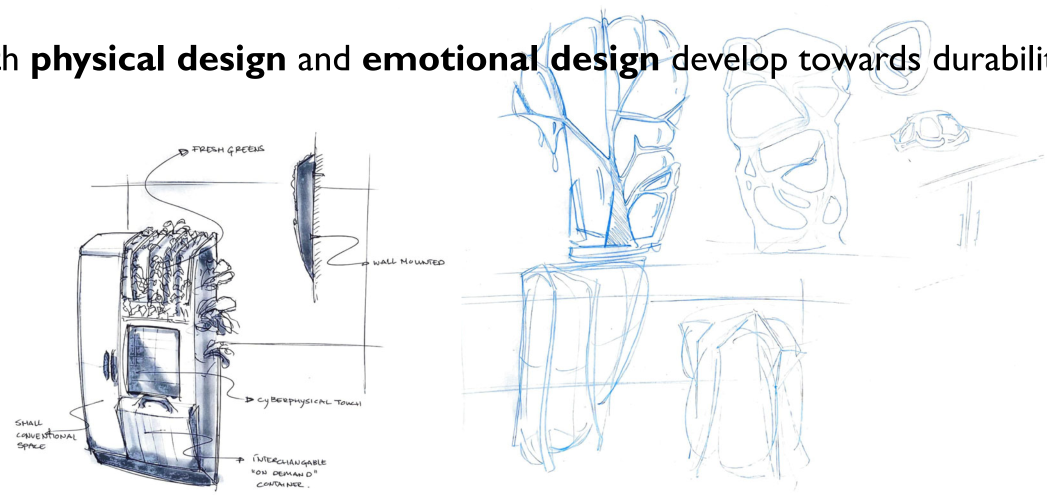
10



11

Enduring design

Both **physical design** and **emotional design** develop towards durability

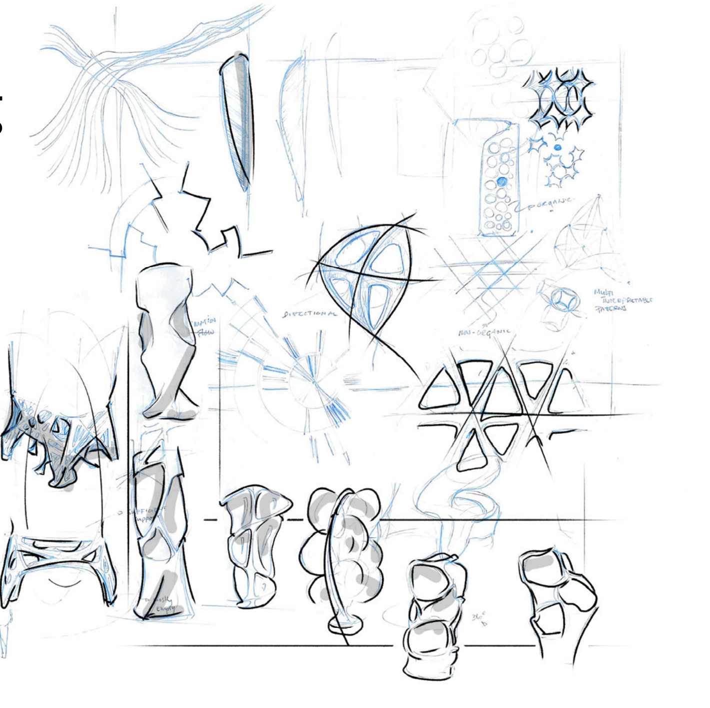


How to create sustainable meaning? (timeless)

12

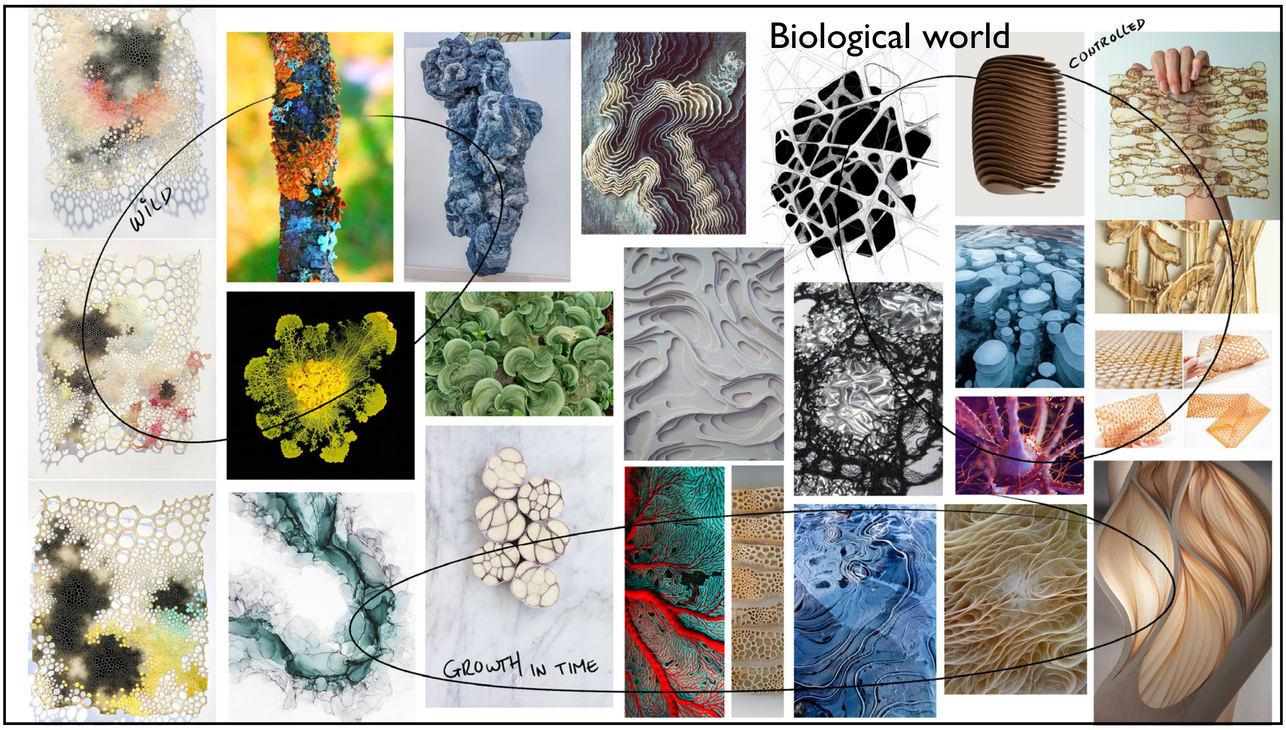
New manufacturing

1. Materials become more smart (added temporal dimension)
2. Materials become more biologically based
3. New manufacturing allows for more complex forms



13

Biological world



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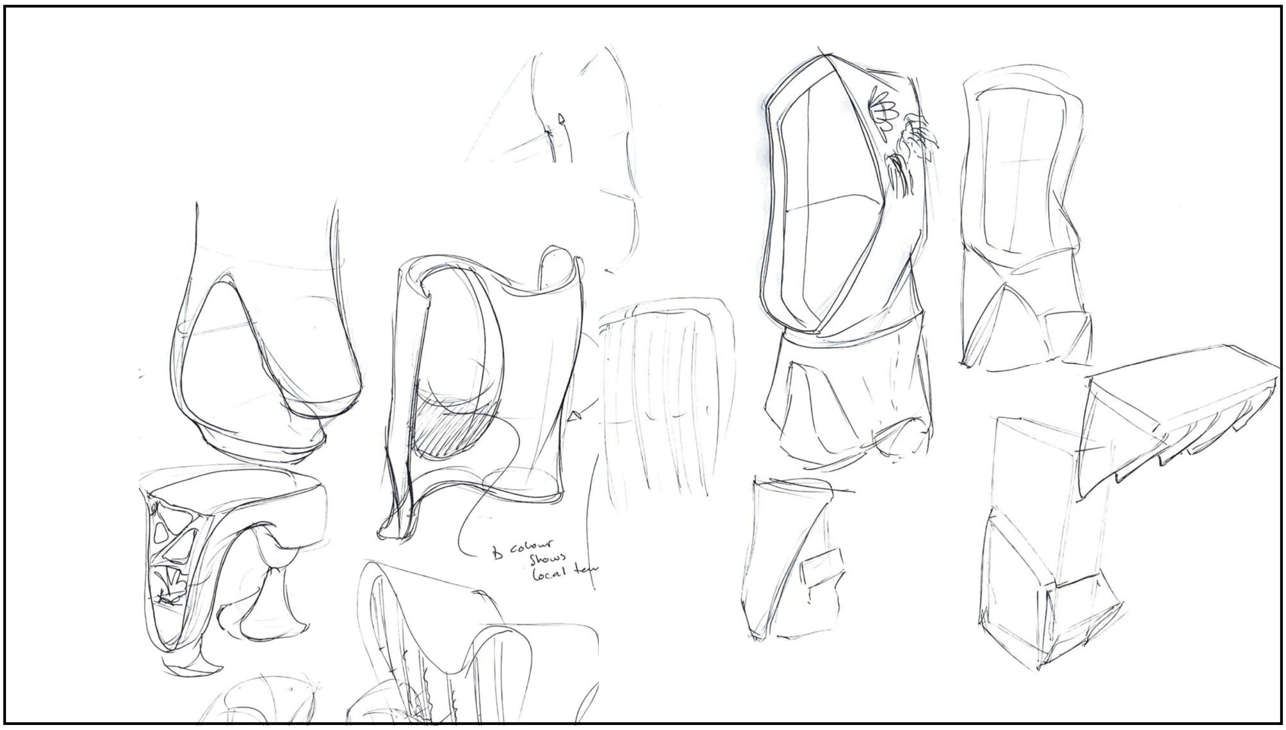

15

AI-powered design

1. Allows very complex forms in relatively little time
2. Focus needs to remain on human user
3. Design needs to address their influence on human behaviour, experience and thinking

How to be inclusive to all users?

16

Questions

1. Examples of products with functionalities that fit the fourth revolution?
    1. Kitchen appliances
2. How to communicate trustworthiness to user through design?
    1. And positivity
3. How to communicate cyberphysicality to user through design?
4. How to create sustainable meaning? (timeless)
5. How to be inclusive to all users?

17