

DESIGN FOR REPURPOSE

*practical guidelines for
circular product design*

*Master
Integrated Product
Design
Industrial Design*



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Executive Summary

Through this explorative project a new Repurpose Design Approach created to apply within a designers’ workflow. Several interviews with design companies (connected to the HvA Repurpose project and consortium) together with testing the guidelines with a Design Case provided by Springtime lead to a first version of the practical design approach.

Towards a Circular Economy

“Scaling up the Circular economy...to the mainstream economic players will make a decisive contribution to achieving climate neutrality by 2020...while ensuring long-term competitiveness” (EU commision, Brussel, 2020). However, current Repurpose attempts often result in one-off products or products with a smaller sustainable impact (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020) , while “up to ‘80% of products’ environmental impacts are determined at the design phase” (EU commision, Brussel, 2020). Companies do often apply recycling, although this is one of the least value maintaining methods in the 9R framework (Potting et al., 2017, p. 14). From practice, it becomes clear that circularity methods are often applied with “different worlds or thoughts” (Kirchherr et al., 2017) and they are clearly difficult to define, while literature research in this report shows limited research has been done for Repurpose so far. This asks for a clearer definition of Repurpose and a more evident and easy approach to apply Repurpose. Therefore, this project aims to answer the following Research Questions:

- 1. How should Repurpose be defined so it can be effectively applied to maintain value over multiple use cycles?
- 2. What guidance is needed to make Repurposable Products feasible, viable and desirable from a Designer’s point of view?

The project

The AUAS/ HVA (Hogeschool van Amsterdam, 2019) has set up a research group and

consortium of companies to develop a Repurpose Design Framework. The framework aims to Repurpose: “to create new products by effectively reusing current obsolete products or parts” as “residual waste is often too valuable for recycling or incineration, but not valuable enough for methods higher up the 9R-ladder, such as Repair, Refurbish and Remanufacture” (Potting et al., 2017, p. 14)(Technopolis group et al., 2019). This graduation project has a slightly different focus on Repurpose: Design for Repurpose product designs in which parts are optimized for reuse before their End of Life. Although Repurpose is a promising strategy for dealing with residual waste, it seems to be more beneficial to immediately consider future products during the design of the first product. The expectation is that the reuse of product parts (measurable with ‘Repurposability Rate’) will increase. A definition on Design for Repurpose is proposed as:

Incorporate infinite re-use of product parts, during the design of the first product, to maintain as much value as possible over time.

Repurpose in Practice

From interviews with 9 design companies (connected to the HvA Repurpose project and consortium) (Hogeschool van Amsterdam, 2019) it becomes clear that designers need a change in perspective: current linear thinking makes it difficult to see products as “changing systems over time”, which is necessary for Circular product design. On the other hand it became clear from the interview that designers need a clear, familiar, and realistic goal, to minimize the risks, scope the project and to know where to start. Examples of past cases and questions about repurpose during interviews inspired designers to mention ways in which they would repurpose, leading to a first list of essential design actions for repurpose.

Overall, the study shows that Designers need a clear plan of how to approach Design for Repurpose and specific Design Guidelines for optimizing the Repurposability of their product part.

The study results in a toolset consisting of:

- a Process to find clear future product opportunities,
- and specific “Design for Change” guidelines.

A new Design Approach & Guidelines

A process of 3 phases is recommended to redesign an existing product for Repurpose:

1. Starting point: To find certain opportunities in the future by highlighting essential valuable aspects of the current product that needs to be maintained in future products.
2. Product Opportunity: The Designer is guided from evolved ‘valuable aspects’ towards 1 chosen product opportunity, by which the current product can be Repurposed. ‘Search Areas’ within this phase aim to inspire how value of a current product can be extended towards the future.
3. Design for Change: Redesign product and parts for efficient and effective transition into the subsequent use-cycle.

See fig. 27 for an overview of the guidelines.

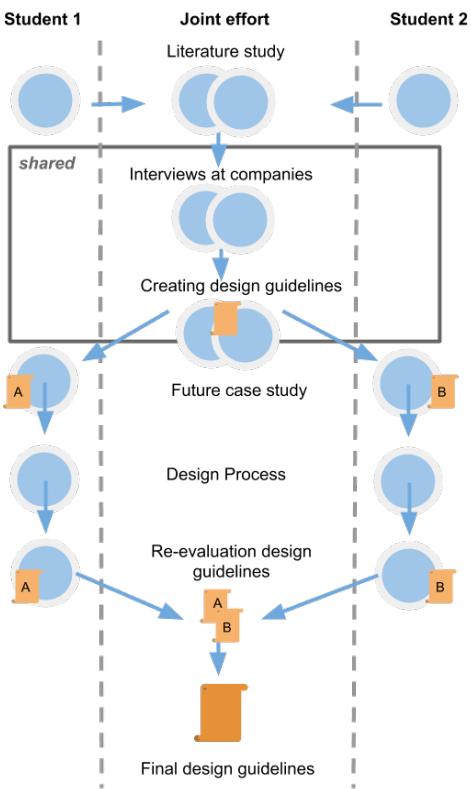


Fig. 0.a
Joint effort
- Overlap in the Design Process with Tom Schild's Thesis

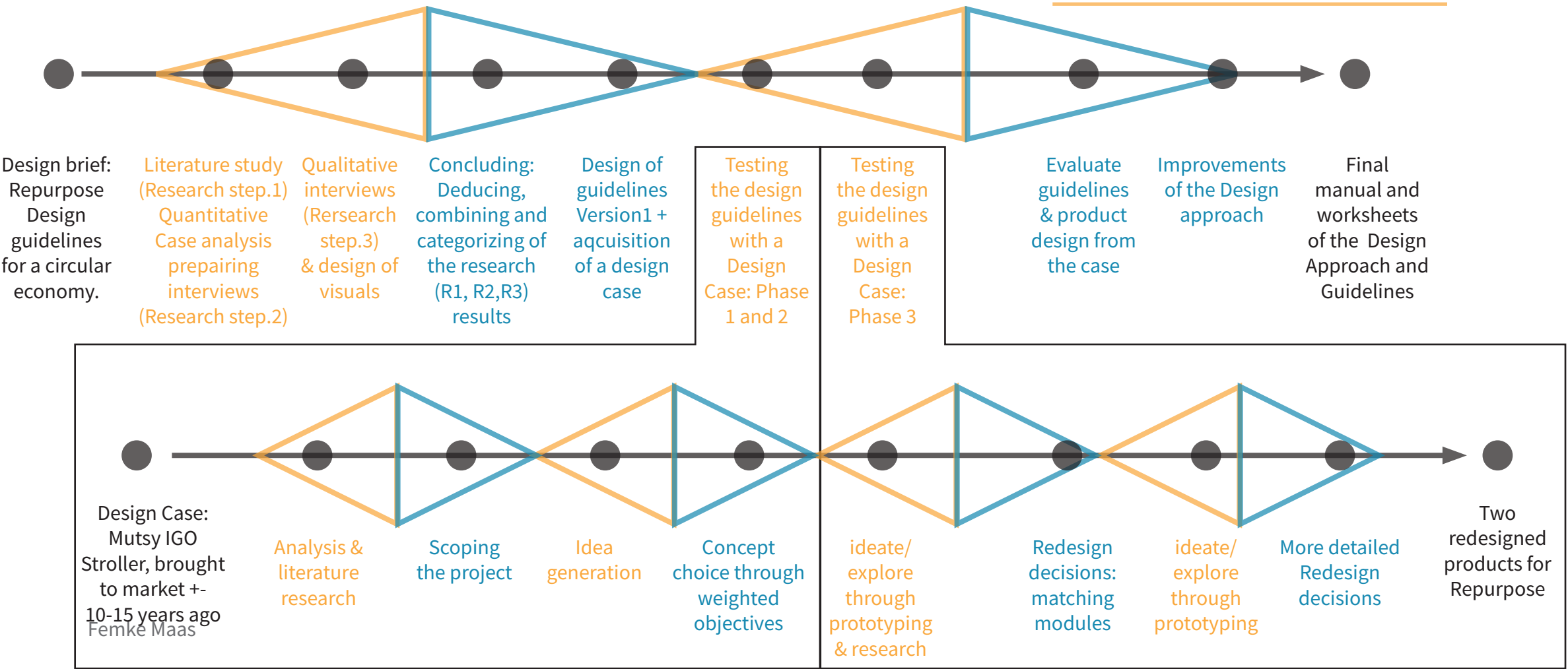
Joint Effort

Figure 0.a General Design Plan from the design brief. The first part of the design process was a joint effort with Tom Schild to be able to conduct 9 interviews, do a 80+ case analysis and create the first version of the guidelines within the limited time of the graduation project. This is further explained in the design brief, see appendices page.

Design Process

Figure 0.b shows the converging and diverging nature of the phases in this graduation project. The thesis' table of content roughly follows these phases. The figure illustrates how a set of Design Guidelines was created and below that how a Design Study was used to test the Design Guidelines

Fig. 0.b Design Process



Testing the new Design Approach

A practical case study, a redesign of the Mutsy IGO Stroller provided by Springtime, was performed to test feasibility, viability, and desirability, leading to a final and second iteration on the practical design approach. It shows that the proposed toolset has some issues regarding effectiveness and efficiency: the guidelines were adjusted to be more practical, intuitive, easier to comprehend and with more focus on essential Repurpose design steps, and as such, it should be more feasible to incorporate this in the workflow of the Designer.

Furthermore the test case showed a measurable increase of the Repurposability Rate and prototyping led to more specific Redesign insights: how to generalize modules across subsequent products, simplify the overall construction and still maintain specific brand shapes. In addition, it became clear that envisioning the future product is essential for a sound Circular business model. The toolset is improved by adding extra validation steps during the process, amongst other to validate the future user demand and to validate the Redesign method as a Circular business model (ellenmacarthurfoundation, z.d.). See fig. 76 and 77 for The final version of the Design Approach & Guidelines.

Further Case studies are recommended, to align the Design approach in more depth with designers and to find out if the approach is also applicable on other type of products. This Design Case concludes that Repurposing boils down to generalize across multiple products within one design process. This can be complex and it requires prioritizing design requirements differently.

Concluding it takes investments on the short term to apply the Guidelines which will likely lead to a more Repurposable product on the long term. The final question remains: Are designers willing to consider this for supporting the Circular economy?

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“...Repurpose design... is a promising strategy to help achieve the circular economy. The new application should retain the value and quality of the original as much as possible.”

Conny Bakker (Graduation brief, 2019) (see appendices)

0.1 Project Objectives

Aim & research objective

Quite some research has been done for the Circular Economy so far, but very few for Repurpose driven design (PBL, 2019). Repurpose driven design is now often defined as: “Using discarded products or product-parts in a new product, with a new function”(Groene Brein, 2020). As stated by the European Union in the Circular Economy Action Plan: “Scaling up the circular economy from front-runners to the mainstream economic players will make a decisive contribution to achieving climate neutrality by 2020 and decoupling economic growth from resource use, while ensuring long-term competitiveness.” (Brussel, 2020, p. 2). However, current Repurpose attempts often result in one-off products or products of a smaller batch, e.g. products with a smaller sustainable impact (see fig. 5). It seems that existing methods for repurpose aren’t as evident, complete or easily applied; there hindering factors at play. Therefore this graduation projects aims to find

out how designers can apply repurpose, for it to increase its contribution to scaling up the circular economy. The AUAS/ HVA (Hogeschool van Amsterdam, 2019) has set up a research group and consortium of companies to develop a Repurpose Design Framework (see figure 1). The framework aims to create new products by effectively reusing current obsolete products or parts as residual waste is often too valuable for recycling or incineration, but not valuable enough for methods higher up the 9R-ladder, such as Repair, Refurbish and Remanufacture (see fig.2). This graduation project serves as an addition to the HvA Repurpose Research project, with a focus on the redesign of products before use, which leads to product designs in which parts are already optimized for reuse before EoL. It is assumed Design for Repurpose leads to a more effective and efficient repurposing.

INTRODUCTION

Repurpose for the circular economy



Involved Parties

Figure 1. -
See figure 1 to see the companies involved in the consortium: (Hogeschool van Amsterdam, 2020) (TuDelft, 2020), (Tolhuijs, 2017), (Bugaboo, 2020), (Ahrend, 2020), (Springtime, 2020), (NS, 2020), (Hamerhaai, 2020), (Flex/design, 2020), (Verdraaid Goed, 2014), (Fiction Factory, 2020), (Cartoni Design, 2020)

0.2 Problem Definition

How can design companies/ designers design a product for more than one life-cycle, while “using discarded products or product-parts in a new product, with a new function” (Groene Brein, 2020) with minimal loss of product value (see fig. 2, 9R-framework)?

There seems to be a trend/ ambition with several companies to divers away from the linear business model (Oliver Wyman, 2017). Design in itself can be a complex and demanding job, but sustainability and circularity are too (Pheifer, 2017). There still seems to be a lack of investments in the circular economy (Oliver Wyman, 2017). When companies do invest, recycling is often the easy way out and a lot of potential product value is lost (Pheifer, 2017). So, why is Repurpose not more widely applied as this is a method higher up the value chain and considering the goal for the circular economy is to capture as much value as possible (see figure 2, 9R-Framework). As stated by the European Union: “The current linear pattern of “take-make-use-dispose” does not provide producers with sufficient incentives to make their products more circular” (Brussel, 2020, p. 3) (European Commission et. al., 2014). Therefore the question arises: is not there a way to make Repurpose design easier to apply, by providing a set of standard guidelines, and by doing so lowering the threshold to become circular?

Various questions arise about what role designers can play in effective Repurpose design. Designers are product-service-systems decision makers, a holistic view necessary also for tackling circular issues. However what is their real and perceived influence on the “circularity” of a product design? There are always multiple parties at play. Furthermore, how does the role of a designer change when they design for multiple life-cycles? And are there certain design activities/methods which contribute more effectively to Repurpose design?

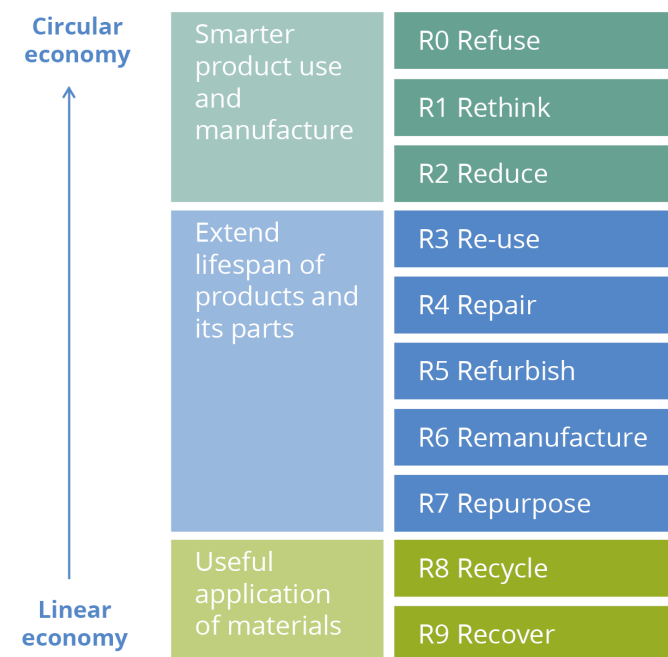


Figure 2. 9R-Framwork, showing various applicable methods from a linear to a circular economy. A method higher up the table theoretically maintains more value. (Gaasbeek & Valencia, 2018) (Potting et al., 2017, p. 14)

0.3 Research questions

Main Research Question

Following from the introduction and problem definition, the following Main Research Questions are defined:

How should Repurpose be defined so it can be effectively applied to maintain value over multiple use cycles?

What guidance is needed to make Repurposable Products feasible, viable and desirable from a Designer point of view?

Sub Research Questions

During this case the following Sub Research Questions were raised:

- How should Repurpose be defined?
- How can Designers be stimulated and helped to incorporate Design for Repurpose in their workflow?
- What guidance do companies need, to apply design for repurpose?
- Which process needs to be followed to Design a Repurposable product?
- What are the experiences when applying guidelines for ‘Design for Repurpose’ on a practical case and can the effects be measured?

0.4 Project approach

The aim of this graduation project is to create and test a new design approach with guidelines for repurpose design. 80 past-cases of previously designed repurpose products (of the partnered companies in the consortium) are collected and categorized by the HVA research group. By analysing the repurpose products’ characteristics more generic methods and opportunities might be found to give product, materials or parts a new business purpose. Interviews with the partnered companies in the Repurpose HvA consortium are done to give a first insight on the two main research questions. Hindering and stimulating factors of current Repurpose Design will be derived from the results of these interviews and will lead to a first draft of Design Guidelines. The design guidelines will be tested with a Design Case provided by Springtime. The design process will eventually result in a product design concept, a prototype and a final iteration on the design guidelines.



Figure 3. An example of a past Repurpose (Looped Goods, 2020) (Verdraaidgoed, 2015) (Looped Goods, 2015)

1 REDEFINING DESIGN FOR REPURPOSE

How to capture value effectively through Repurpose projects?

1.1 Introduction

In this chapter

This chapter aims to define Repurpose so it can be effectively applied to capture value over multiple use cycles. Discussing Repurpose with students, teachers and designers showed that it is easy to create your own version of what Repurpose means. The many parties involved are enthusiastic to apply Repurpose, but when there is no consensus on the definition of Repurpose it becomes more difficult to apply it effectively and on a larger scale. This chapter tries to answer what type of Repurposing is really effective to capture value in a circular economy. This serves as the foundation for the rest of the report: defining and testing a design tool for designers to help them apply Repurpose.

Research Approach

Redefining Repurpose is done through literature research. Various papers are read on the following topics: general circularity definitions, the 9R Framework, Product Integrity, various types of value and systems thinking (den Hollander, M. 2018) (Potting et al., 2017, p. 14) (Complex Systems Design, 2020) (Meadows & Wright, 2015). This chapter starts with the definition of Repurpose Driven Design.

An analysis is done of 80+ past Repurpose cases (cases provided by the HvA as part of their research on Repurpose) (see appendices). The cases are analysed to understand which elements have a large influence on the outcome of Repurpose projects. These form the basis for interview question, directed to designers, in Chapter 2. Secondly the amount and kind of value maintained through past Repurpose projects are reviewed, with the aim to learn about “effective” Repurposing (see the conclusion of this chapter).

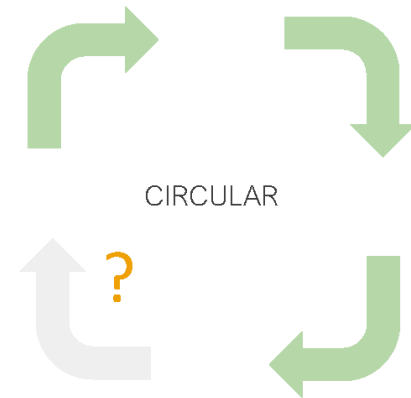
The HvA has set up a framework for applying Repurpose Driven Design as a design strategy for reusing discarded products. Discussions and workshops with teachers and students of the HvA about this framework helped in defining “Repurpose Driven Design” and “Design for Repurpose”. Pitching to this group and extensive discussions with Tu Delft students and teachers served as iterations to develop the final definition of “Design for Repurpose”. Complex Repurpose-related topics were discovered through reoccurring moments in conversation were the goal and meaning of repurpose were unclear. This led to a set of visuals (“conversation starters”) which are used in later interviews to communicate effectively about Repurpose (guide the conversation direction and understand a participant’s perspective on Repurpose).

1.2 Defining Repurpose

Repurpose driven Design

Uptil now Repurpose driven design concentrates on reusing from waste for a different product after the end of life of a product (Hogeschool van Amsterdam, 2019)(Groene Brein, 2020). It dealt with the handling of capturing value from "thrown away" product parts. Often this is not the core business and aim of the original manufacturer and designer, leading to difficulty of making business cases and finding partners (Pheifer, 2017) (see fig. 6).

Therefore Repurpose Driven Design does not stimulate fully transitioning to a circular economy (see fig.4). If the sole purpose of Repurpose is to maintain value effectively over multiple use cycles, Repurpose design should concentrate on a system change regarding product design, which prevents the creation of waste (Pheifer, 2017) (Meadows & Wright, 2015) (Haffmans & Gelder, 2020). The system design change should aim for designing products which enables re-use of product parts and as such thinking ahead of the next iterations of the product (parts): "Design for Repurpose".



Envisioning Design for Repurpose

When envisioning Design for Repurpose, the goal in product design practice would change. Instead of seeing 1 product as the end goal of a design process, iterations of use become the goal: reshaping the product (parts) for use in subsequent use cycles. It becomes important how the product parts "flow" easily from use cycle to use cycle (Meadows & Wright, 2015) (Haffmans & Gelder, 2020). This means there is a shift in the role of the designer. Read about the perspective of designers on Repurpose in chapter 2.

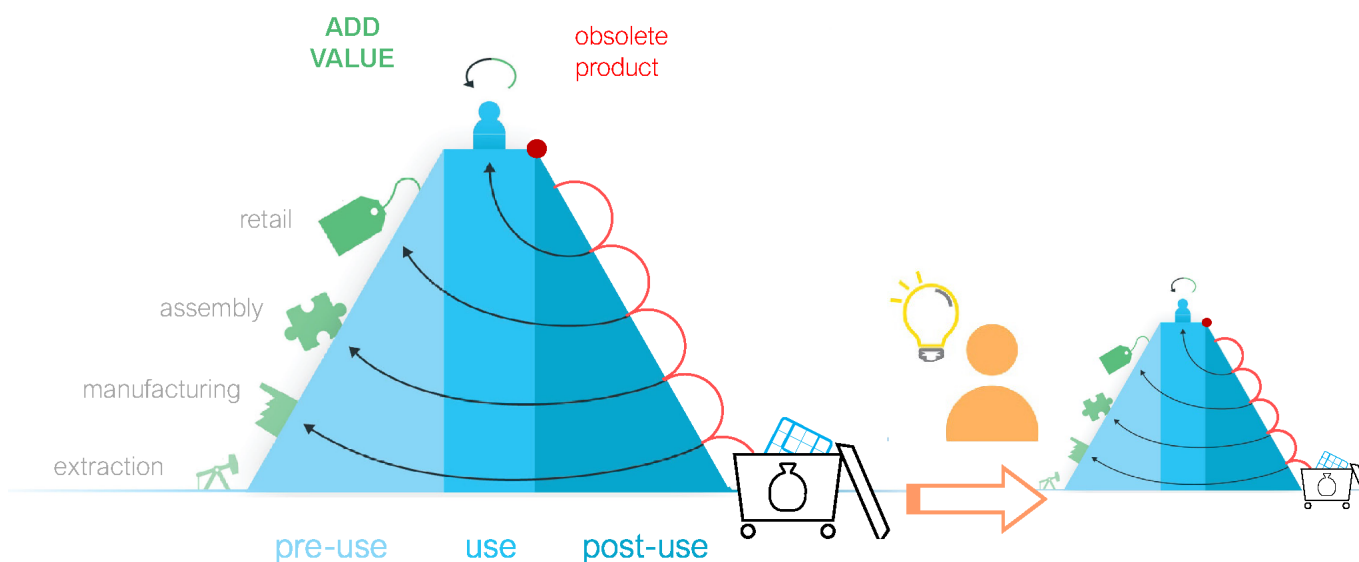


Figure 4. The moment of repurpose matters: in case the designer designs from a waste product, this will more likely lead to a second product hill containing less value than when the designer would Design subsequent products beforehand, before the first value hill, (Sustainable Finance Lab et al., 2016).

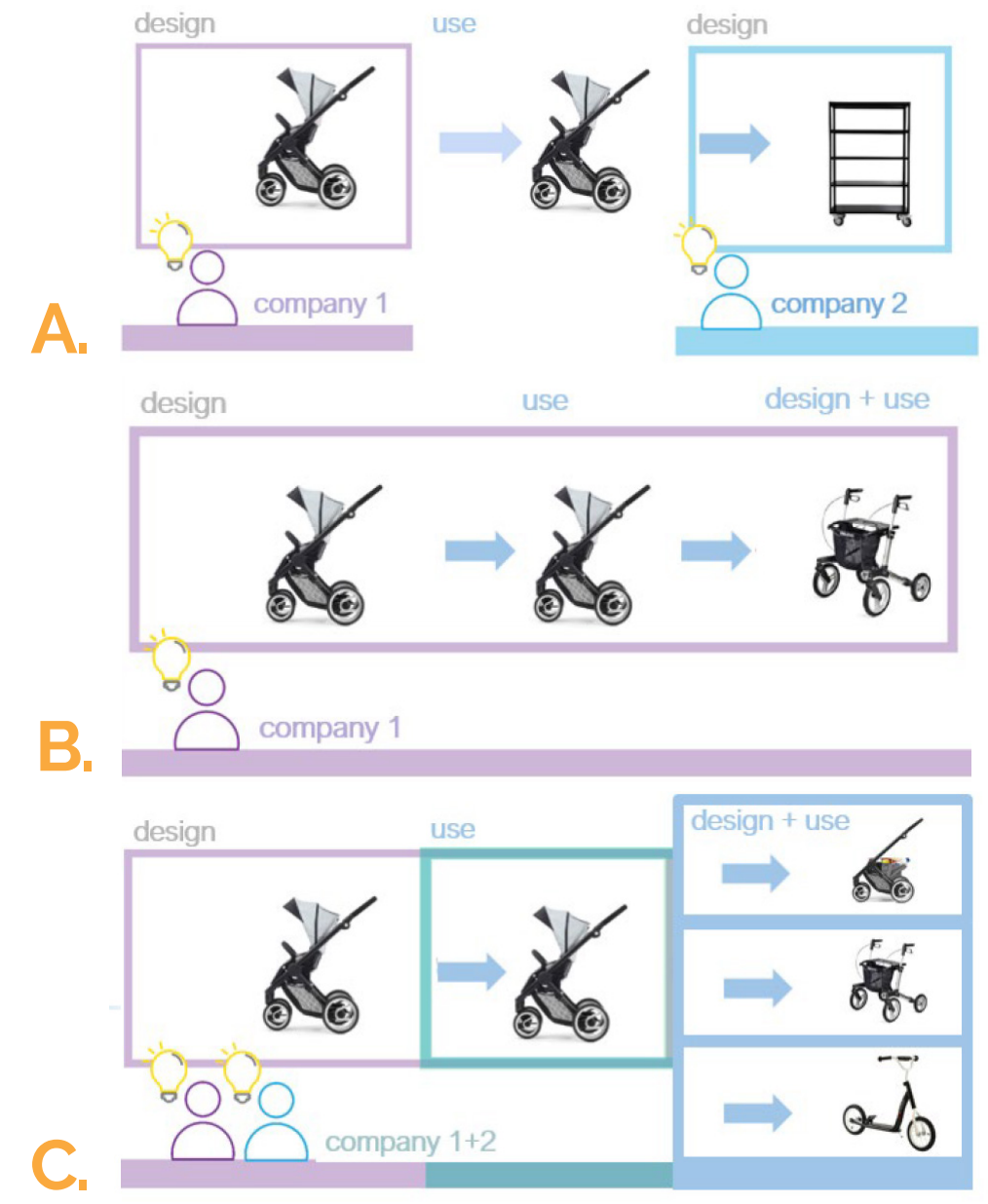


Figure 5. Conversation starter 2: Repurpose in a linear and circular economy and various envisioned roles of a design company in this. A and C show an envisioned cooperation with another company. (Handicare Rollators, 2020) (Mutsy, z.d.)

Envisioning the role of design companies in product lifecycle

There could be various ways to apply Design for Repurpose: see fig. 2a and 2b. Fig. 2a shows what happens in Repurpose driven Design: A product, made by company 1 is sold and eventually becomes obsolete. A second company comes across the obsolete product in the form of waste and reuses still visible valuable product parts. This illustrates that Repurpose driven Design has the disadvantage of a full restart of a product design & business case by a new company, especially since the two companies operate separately from each other (Pheifer, 2017).

Fig. 2b. shows the advantage of Design for repurpose as the company would maintain control over the EoL and new purpose, and therefore can design for this upfront. The disadvantage of this is that a company should know upfront what the next product is going to be exactly. Fig. 2c therefore shows another iteration of the envisioned product lifecycle: When companies are used to creating products together, this might increase the match between supply and demand across companies/markets. This is further discussed in Chapter 4 in the form of marketing strategies (Haffmans & Gelder, 2020).

1.3 Capturing Value Effectively

What value to retain?

As with circularity, value is “a concept with a lot of traction”, which can blur their definition as they are often applied and with “different worlds or thoughts” (Kirchherr et al., 2017). Therefore it would be helpful to pinpoint different types of value in a product, to clarify in the design process what valuable product elements to reuse.

From the value hill (Sustainable Finance Lab et al., 2016), several types of value can be distinguish (see fig. 8) pre-use towards in -use. Pre-use value: There is demanding value from what a user needs or requires and there is value from realisation of the product, developed by designers, manufacturers, producers and mining companies. Subsequently the product is distributed, and sold into its first use cycle (in-use) for a certain price, defining the product’s economic value (Jackson, 2012).

“Maintaining product realisation value within the Repurpose process” can be described as maintaining a high level of “product integrity”: The aim to keep “..a product ... identical to its original ... state, over time.. at the level of products and components...”. (den Hollander, M., 2018). Following from this it could help designers see the product as a state with different product integrity levels (system, module, component) to see the products full potential of value (Ashby & Ashby, 2012) (see fig. 6) (Nederland Circulair, werkgroep DFD et al., 2016). It shows that a product has a large range of functions (at different product integrity levels, which could be reused. As fig. 7 illustrates, by reusing modules most value is retained (after the reuse of the product/system as a whole).

The above definitions of value give focus in how to apply Design for Repurpose (see design guidelines in chapter 3).

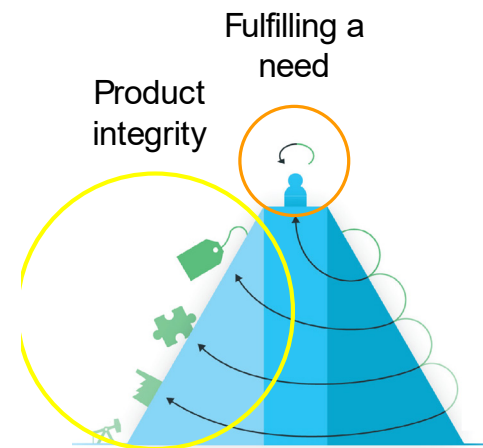


Figure 8. Types of value within the Value Hill framework (Sustainable Finance Lab et al., 2016)

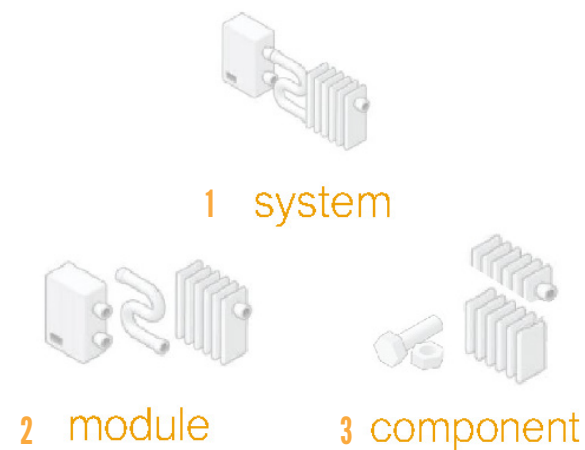


Figure 6. Levels of Product integrity (Nederland Circulair, werkgroep DFD et al., 2016)



Figure 7. Pinpointing product value in modules for reuse (Mutsy, z.d.16)

1.4 Redefining Repurpose

When following the definitions in the “Design for managing obsolescence handbook”, “Repurpose driven Design” can be described as “Reversing Obsolescence: a design approach for recovery” of product parts. Following: “Design for Repurpose” could be described as a method of “Postponing Obsolescence: a design approach for extended use” of product parts. In both cases the aim is to maintain “products’ economic value over time...” (den Hollander, M., 2018).

Preventing a full design restart from a waste product by applying “Design for Repurpose” instead, would result in a higher product value at the start of the re-use.

Following from this the definition of a new type of Repurpose is given below. In this definition the product can be defined as a system with a changing state over time and value can be defined as a combination of User demand, Product integrity, which are represented by economic value.

Design for Repurpose

Incorporate infinite re-use of product parts for other products, during the design of the first product, to maintain as much value as possible over time

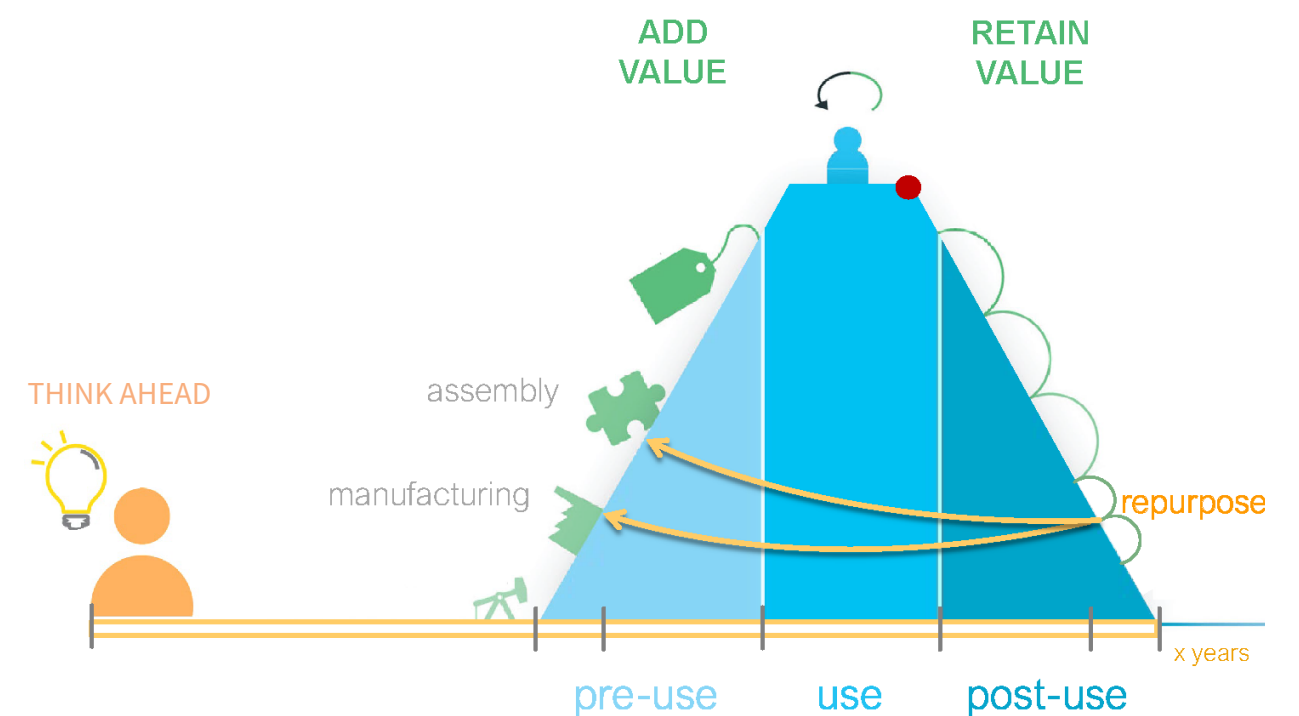


Figure 9. The value hill updated to show the definition of Design for Repurpose. Image value hill (Sustainable Finance Lab et al., 2016).

1.5 Conversation starters

Conversation starters are made to increase efficiency and effectiveness of discussions about Repurpose. These will be used in interviews about repurpose (see chapter 2).

Approach

Through the conducted research mentioned in chapter 1, it became clear that it took a long time in conversation to reach a joint understanding of Repurpose design. This is reflected in the included literature: 'Repurpose design seems to be the least defined R-method of the R-ladder towards a circular economy' (Technopolis group et al., 2019).

This led to the use of a set of 'visual conversation starters' with the aim to be able to talk at the same level about the definition of Repurpose in all the different designer-company-interviews.

Previous research about education has shown that (especially visual) examples help students to quickly understand complex problems. Therefore Visuals and Examples are convenient for quick learning about the complexity of circular processes. Visuals and Examples with high level components help to create a holistic view on complex processes and systems. (Atkinson et al., 2000, p. 183) (Buhl et al., 2019, p. 1253) (SEVALDSON, 2011, p. 7).

These 'conversation starters' include the following topics:

1. **Examples of Repurpose design.** (see fig. 10) The examples were partly provided by the HVA 80+ cases. Some additional examples were added to that study, to explain the Repurpose definition more clearly and to inspire the participant to what is possible with Repurpose. (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020)(see appendices)

Femke Maas

2. **Repurpose in a linear and circular economy.** (see fig. 5) Images of the design process, which illustrate a hypothetical difference in approach to design between the current linear economy and the envisioned circular economy with Repurpose. This can be used to encourage people to talk about their own design approach and make them envision how they would tackle a Repurpose design process (by comparing their approach with the presented image).
3. **Repurpose compared to other circularity methods** (see fig. 12) An overview with Repurpose examples to illustrate where Repurpose lies on the R-ladder, to define Repurpose more clearly. During discussions it is noticed that this visual often made the conversation abstract and not about applying the main goal: to maintain as much value as possible. Therefore this visual is not or less used in later discussions.
4. **Hypothetical product part distribution after 'End of Life' (EoL).** (see fig. 11) Images of how products parts could possibly be divided over various new products/ markets, to help participants imagine a more abstract view on what a product is. Besides viewing the product as a whole, it can also be viewed as a product life cycle with a focus on modules, components or materials.

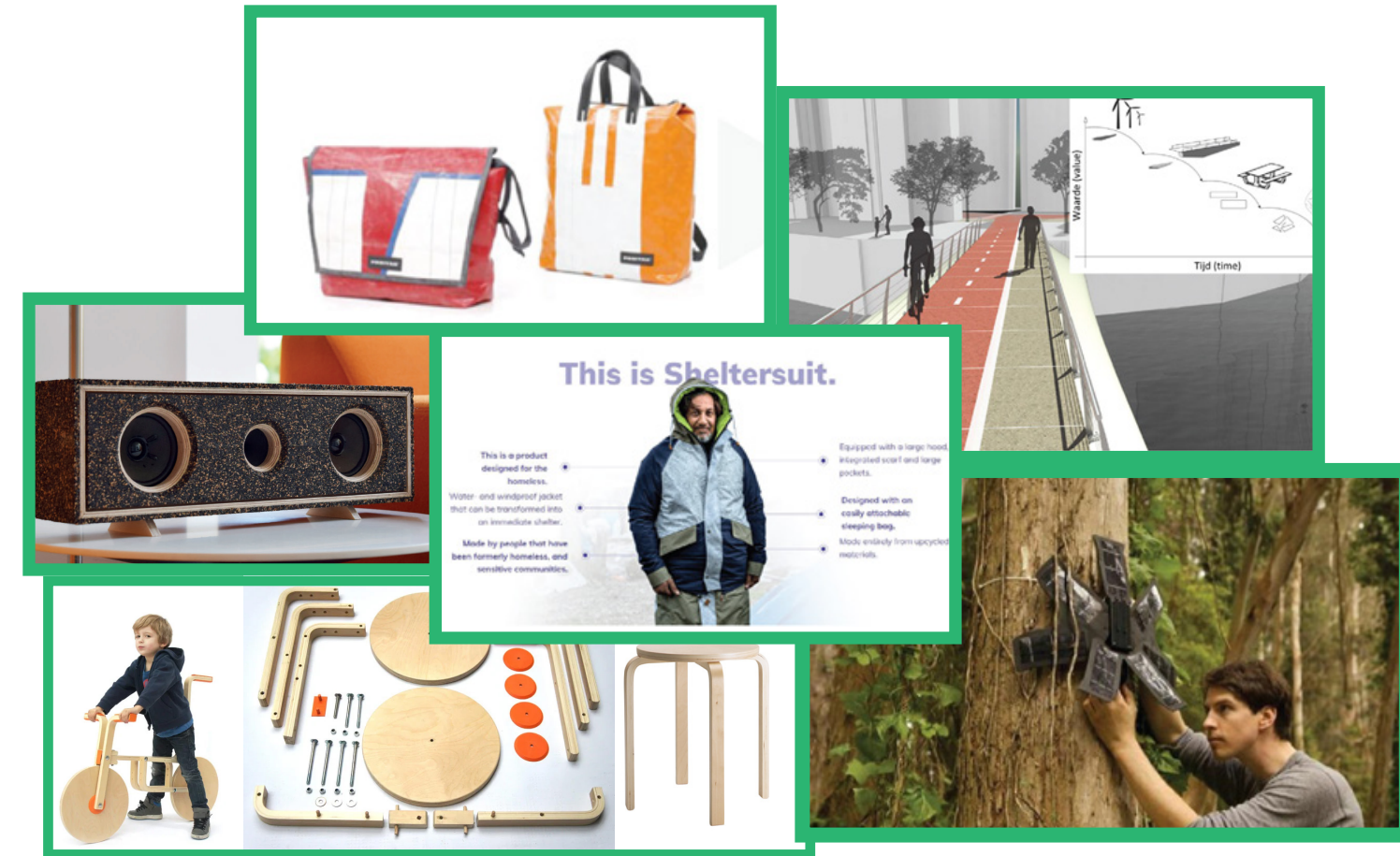


Figure 10. Conversation starter 1: examples of repurpose design. (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020) (sheltersuit, 2020) (Lucker & NS, 2020) (Bernier, z.d.)(Nederlandse Spoorwegen, z.d.) (Speksnijder, 2019) (Torti & White, 2017) (Freitag, 2020)

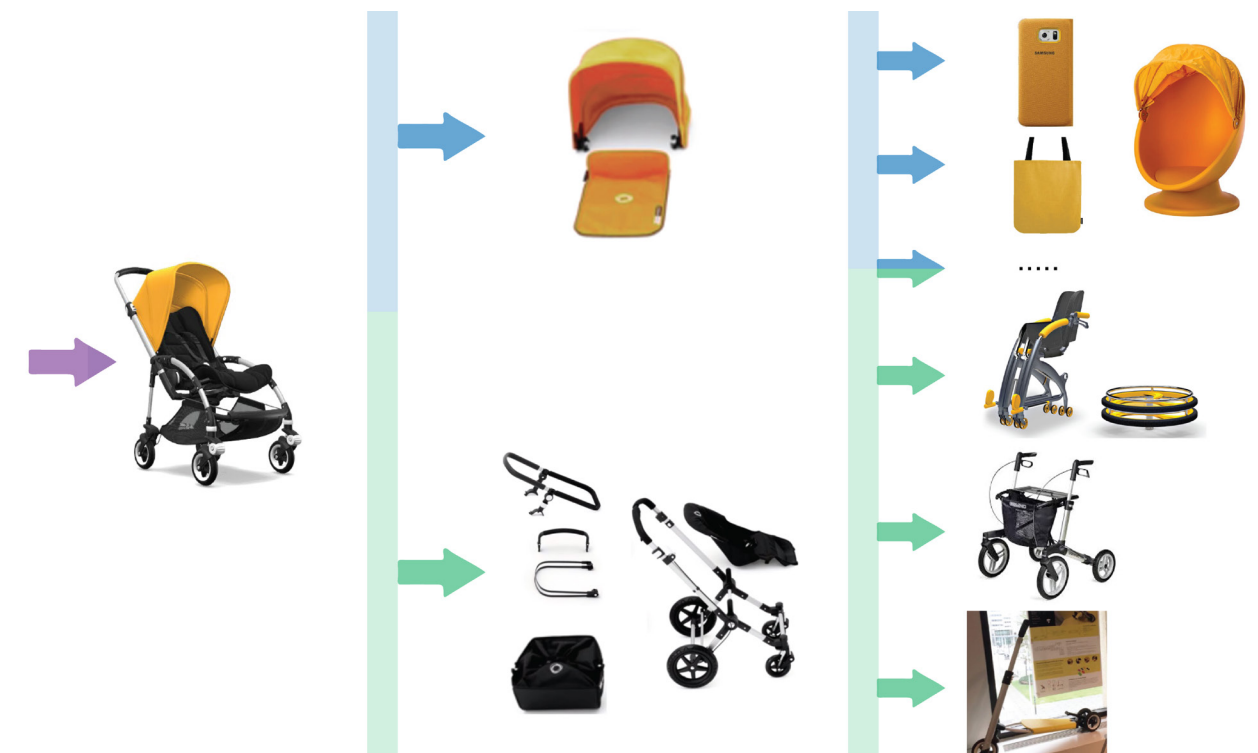


Figure 11. Conversation starter 4: Hypothetical part distribution after end of life. (Amsterdam University of Applied Sciences & Lepelaar et. al., 2020)(BugabooHQ, 2016) (Bugaboo, 2020) (Yun-Sheng & Chee Zhong, 2020) (Ikea US, 2020) (Handicare Rollators, 2020)



Figure 12. Conversation starter 3: Repurpose compared to other circularity methods, including the definition of level of product integrity. With this made illustration it becomes extra clear that repurpose is not easily defined as a part can mean many different things: a component, a module or a sub-system within a system. Therefore Repurpose could be confused as reuse up till recycling. Discussions with this conversation starter actually led to talking about the boundaries of the definition of Repurpose instead of talking about the possibilities of Repurpose.

(Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020)(BugabooHQ, 2016) (Bugaboo, 2020) (sheltersuit, 2020) (Lucker & NS, 2020) (Bernier, z.d.)(Nederlandse Spoorwegen, z.d.) (Speksnijder, 2019) (Torti & White, 2017) (FLEX/design, 2016) (stonecycling, z.d.) (Nederland Circulair, werkgroep DFD et al., 2016) (Layer Design Studio & RÆBURN, 2019)

1.6 To conclude: Past Repurpose Projects

A benchmark approach

A quantitative study is done to analyse 80+ previously created Repurpose products (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020). What can the characteristics of past repurpose projects tell about how to apply repurpose effectively?

The different Repurpose cases were checked to fit with the earlier described definition of Repurpose and definition of value. The remaining cases were mapped in various iterations and discussions over an x-axis and an y-axis with the Perceptual Map method (toolshero, 2012), see fig. 13 and fig. 140 (see appendices)

X-axis: effort of development, representing earlier mentioned “product realisation value”.

Y-axis: value of the subsequent product in use, representing the earlier mentioned “value by user demand”.

The more energy is put into product development, the higher this case is placed at the x-axis. More frequently used products, or the more a product contributes to society, the higher the case is placed at the y-axis. Intuition was used to specify the product value, as it has a definition with a lot of traction (Kirchherr et al., 2017).

Furthermore products were clustered per type of product (see figure 15)

Chapter conclusion

Most examples of repurpose within the 80+ case analysis until now have been created due to ideological reasoning towards circularity. This does not mean that these products are successful. In this chapter a successful Repurpose product is defined as: subsequent products with a high demand and where all materials are reused in full potential or fully reused (opposite to the creation of waste). It seems difficult to apply



Figure 13. Images from database Repurpose study HvA, researched further for this project (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020)

the current repurpose approach effectively and many different results are created. Is it possible to minimize creation of waste, by reasoning from a new focus point: a future product demand? In the next chapter we will show why designers/ companies have difficulties with applying Repurposability. In subsequent chapters design guidelines are proposed with the aim to create successful subsequent products.

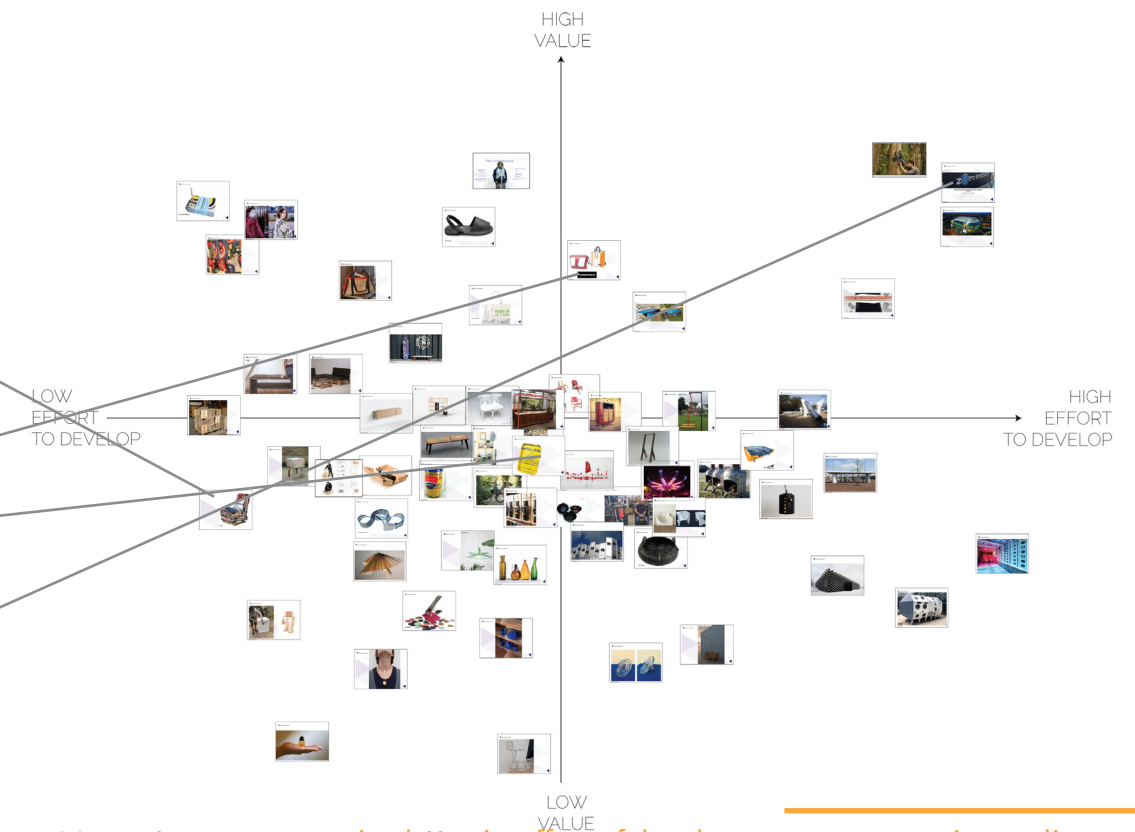


Figure 14. Images categorized: X-axis: effort of development, representing earlier mentioned “product realisation value”. Y-axis: value of the subsequent product in use, representing the earlier mentioned “value by user demand”. from database Repurpose study HvA, researched further for this project (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020)

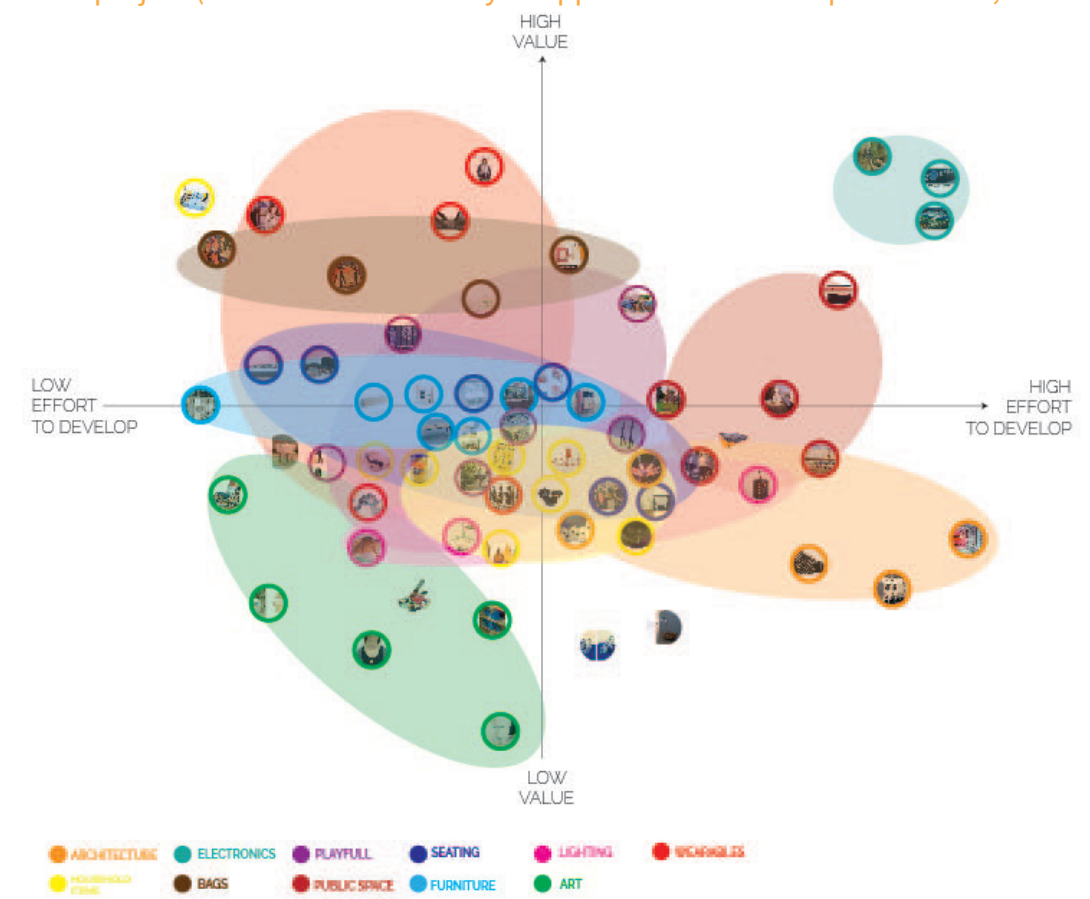


Figure 15. Further analysis on results of figure 14: mapping types of products in past repurpose projects (Amsterdam University of Applied Sciences & Lepelaar et. al., Database 2020)

2 REPURPOSE IN PRACTICE

Hindering & stimulating factors from applying Repurpose, a perspective from designers

2.1 Introduction

In this chapter

In chapter 1 it became clear that we need a new way to address Repurpose if we want it to lead to a circular economy: how can Repurpose become a more standard part of the current design process in design companies? The proposed solution of chapter 1 is to incorporate Repurpose rules within the design process before product 1 is released on the market. However, Repurpose seems to be difficult to apply companies choose recycling over more value retaining circular methods and definitions of the circular economy seem to be unclear (Technopolis group et al., 2019).

Chapter 2 tries to answer why this is the case and what factors hinder and stimulate designers to apply (Design for) Repurpose. Finally, it does a first attempt at recommending how Design Practice itself could stimulate (Design for) Repurpose. In this project the Designers are considered as the target user group. Qualitative interviews aim to answer the following Research questions,

How can design potentially stimulate designers to incorporate Design for Repurpose in their workflow?

- How do companies/ designers define and view (Design for) Repurpose?
- What is the role/ influence of the designer in a (Design for) Repurpose project?
- What are stimulating and hindering factors in applying (Design for) Repurpose?
- How could design practice possibly stimulate (Design for) Repurpose?

Problem statement

While efforts are made in practice for the circular economy, there still seem to be hindering factors and a lack of methodology as circular design thinking is not scaled up yet (Groene Brein, 2020).

As is seen in chapter 1 the circular economy is a complex topic. In the current system all sorts of companies are relying on each other and they are all benefiting from an existing linear economy system (Pheifer, 2017). Therefore, from a company perspective, there seems to be too much at stake to singlehandedly invest in structural improvements concerning the circular economy. Companies do want to invest, but quickly seem to apply Recycling, while more value can be maintained with methods which increase the lifetime of the initial product or product part such as Repurpose (Technopolis group et al., 2019).

However, since designers are used to making decisions with too little information, dealing with uncertainty and complexity and used to dealing with a varying set of stakeholders, it is expected that some hindering factors can be tackled with design methodology (Buhl et al., 2019, p. 1250) (SEVALDSON, 2011, p. 7).

2.2 Research Approach

This part describes the steps taken and methods applied during this study to obtain facts from companies and designers how Repurpose projects are experienced in practice

To answer the research questions interviews were conducted with 9 different design (related) companies (see fig. 16). The designers' views and understanding of Repurpose and their vision and experience with Repurpose Design are measured with open ended qualitative questions. These questions and corresponding visuals are set up with the research conducted for chapter 1. The results are analyzed with transcription and conventional content analysis (Hsieh & Shannon, 2005).

In the next paragraphs the approach to the questions, visuals and analysis is explained.

Participants

In total 11 participants were interviewed from 9 companies. The HVA consortium provided 7 of the interviewed companies. 2 Other companies were contacted through the network or the TU Delft network. The involved companies:

- Design studios: Cartoni, Tolhuijs Design, VerdraaidGoed.
- Product companies: Ahrend, Bugaboo, Springtime, Fiction Factory.
- Other companies contacted: NS and the design studio Flex/design.

7 out of 11 participants are Designer. 1 out of 11 is a producer and 2 out of 11 participants are managers, who both work closely with product designers and who often join a design process, 1 out of 11 is a product design intern.

Interviews

Applied method: Qualitative interviews

The designers' views and understanding of Repurpose and the designers' vision and experience with Repurpose Design are measured with open ended qualitative questions. Two different sets of questions have been created:

- Companies who have done a Repurpose project before.
- Companies who are currently busy with a Repurpose project or who will do a future (design for) Repurpose project.

The interviews resulted in 9 audio-files.

Aim and creation of interview questions

The questions were created based on the literature analysis, definition forming and analysis of 80+ cases (see chapter 1). In discussion and workshops with teachers and other students about Repurpose it became clear that the definition of Repurpose is often unclear or mixed up with the 9R Framework (see chapter 1). It became clear that the factor time is important and by reviewing the characteristics of the 80+ cases, other various impactful factors were found.

For each interview, projects and the brand of the participating company/designer were studied, to ensure relevant questions could be asked about their specific experience with Repurpose (chapter 1 shows that there are different approaches and starting points to a Repurpose project).

A part of the questions aims to discover the context in which the participant is working (to put their answers in perspective of the other interviews) and simultaneously aims to guide the conversation along specific topics.

The following sub research questions are incorporated in the interview questions:

- How do designers define Design for Repurpose?
- a. First general questions are asked to understand the participants concept/ notion of circularity and Repurpose to align with the general definition of Repurpose applied in this study (See also the explanation 'Approach to Conversation starters' later in this chapter).
- To what extent are designers aware of the definitions of sustainability and the circular economy?
- What motivates the company/designer to contribute to a circular economy?
- d. What factors stimulate designers to apply Repurpose design? What is the advantage?
- What factors hinder designers in applying Repurpose design?
- Hindering and stimulating factors can

address the following topics: "Materials involved, technical and organizational challenges that need to be overcome to make Repurpose happen, what actors are involved, what is the impact of the design"9, but also important: 'With what design approach skills would a participant tackle a Design for Repurpose assignment?'.

- What design approach do companies have?
- g. How much influence does a company have on the lifecycle of the designed product?
- How do companies/ designers envision to structurally apply Design for Repurpose as part of the Design method?
- How do designers/ companies envision to apply Design for Repurpose structurally in their existing design workflow?



Figure 16. Interview at Fiction Factory

Analysing the interview results

Conventional Content Analysis

Methods used: Transcribing and Conventional Content Analysis

Through listening to the audio files and by use of the transcription tool Trint (Trint, z.d.), the most important quotes will be selected and transcribed. An insight or summarizing sentence is written above each quote.

Each interviewee printed the quotes and divided them in similar themed groups. By use of conventional content analysis (Hsieh & Shannon, 2005) (see fig.17), key themes and keywords are found and supported by quotes from participants (Bazeley, 2009). A brain dump session between the 2 interviewees improved the interpretation and naming of the categories. Then quotes were reviewed as a whole in a second individual iteration per interviewee, and the most important quotes are selected.

The conventional content analysis led to the 11 categories (a to k), which could be divided in 4 main themes. A list of quotes in the various categories can be found in the Appendices. Each quote has a code.

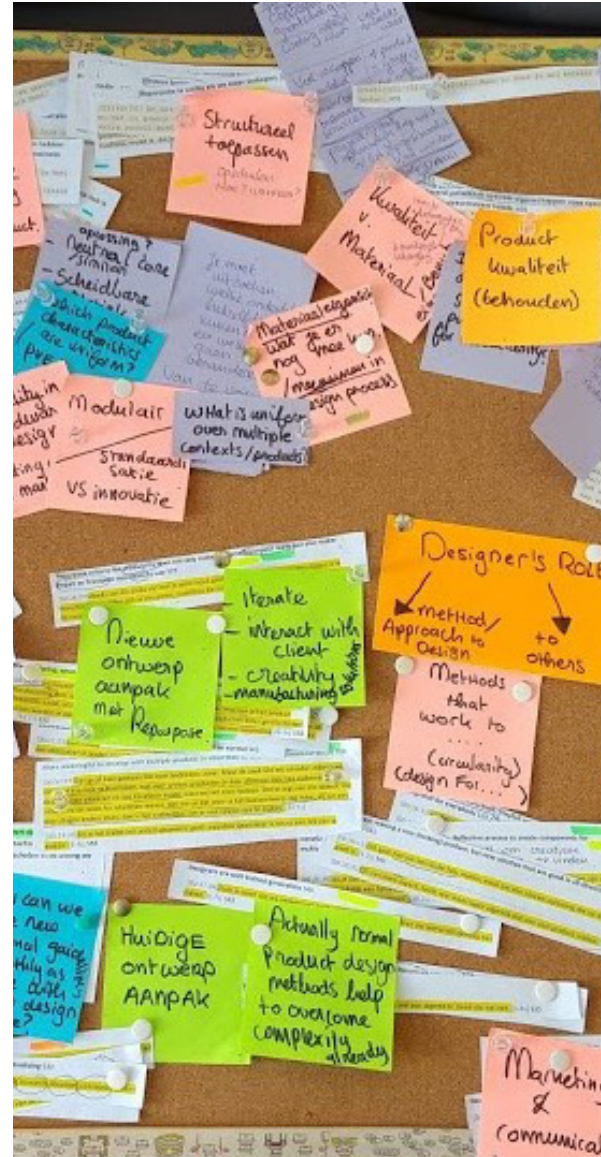


Figure 17. Creative Content Analysis of quotes

2.3 Result 1 - Designers' Perspective

This section describes the results of the “Designers' Perspective” from the interviews in detail. At the end of this chapter these results are summarized together with the “General results”.

Repurpose in Practice

Looking at the 80+ analysis, why is it so difficult to create a large scale business from a Repurposed product?

The biggest problem for companies is that it's very difficult to find or come up with a new product concept if it has to be created out of a product a company already sells. Apart from the geometry that does not directly match, most designers mention they have trouble with finding a second product opportunity with their first product's materials: linking their new supply to a new demand, i.e. capturing product value. It becomes clear that repurposing asks for technical and

system product optimization, while designers usually set up a new product experience based on a client/ consumer need. This is especially difficult when the second product use does not take place in the near future (something which seems very unknown needs to be predicted). The consequence of current Repurpose projects are therefore often low-impact or reduced-value outcomes: one-off products, art products or products which 'nobody really needs'.

“..finding a new place for my material is now too much based on coincidences..”

producer - (Fcw15)

“The need to develop something comes from a user need, which is something else than using spare parts that we still have in stock”

Designer - (B27)

Why companies don't invest: Main & current issues

To design from technical boundaries first makes it contradicting to create a good Repurpose business case that companies are willing to invest in. Another reason for this, is that circularity itself does not seem to sell very well to a large target group. Thirdly, companies have trouble finding partners who are interested in their supply of EoL products. Furthermore, circular projects still costs a lot of R&D and many companies aren't aware yet about what circularity and sustainability mean. The consequence is that they create one new product out of waste, instead of

“The emotional value of a circular product lies with someone who recognizes the product material, this person is not necessarily you're client.”

Design agency - T5 (C56)

understanding they have to reinvent their system to truly reach circularity. In that way they will always run into feasibility problems like: not knowing what the quantity and quality is of their supply, having to retrieve and “clean up“ their EoL products, storing their EoL products until they find a new demand for their product. Therefore, circular investments feel currently more like a black-box, a risk, than an opportunity to harvest value and become more agile .

“...chairs have developed a lot in the past. Most new developments are aesthetical trends.”

Design Company - A16

“...technical or material value can be sold through a story, but creating one is not easy”

Producer - A16

“... The salmonpink walls aren’t beautiful anymore, according to trends, and client experience is very important for us. However, painting the walls is not allowed due technical requirements, so the walls have to be thrown away.”

Company - N16

A change in perspective: embracing uncertainty + certainty

Looking at the 80+ analysis, why is it so difficult to create a large scale business from a Repurposed product?

What companies/ designers need in the first place is a toolset consisting of design guidelines and an approach to address the Lifecycle of their product.

Designers already have the skills necessary to design for complex and wicked problems such as the circular economy. They just need some guidance to know where to start and to know how to tackle the problem efficiently and effectively.

Currently business models are based on what the client or consumer desires in the first iteration of the product: fulfilling needs creates revenue. Maintaining the value over multiple use iterations requires that the perspective of the designers should change to iterative products as a system.

Embrace certainty

So, why aren’t we designing Repurpose products from a (future) need/ product experience instead? Why not make use of the company’s existing product-service-systems and the companies’ existing infrastructure as a starting point for the second product design (This could be material, user and context related). After all, starting with a too unfamiliar business proposal will cost so much R&D it will feel like setting up a new company. Another much mentioned approach is cooperating more with other parties with a certain skillset, to be inspired in new unknown contexts.

Embracing Uncertainty

Repurpose techniques such as modular design and design for disassembly do have opportunities to create new (business) value: flexibility in product design. This is especially convenient for difficult to predict future product cases.

Although the future can never be fully predicted, there are patterns which have a certain chance of occurring, some a higher chance than others (see fig. 18). Why not make use of this predictability and uncertainty, by creating either multifunctional products or products which can be transformed to another product at the time that they are needed. In this way a company could hypothetically prepare itself better for unforeseen changes in society. Uncertainty becomes an opportunity, becomes certainty, instead of being a risk. A designer starts to design for change, with respect of expected future product, based on the patterns applicable for the type of business (see figure “Predicting Need Patterns”),.

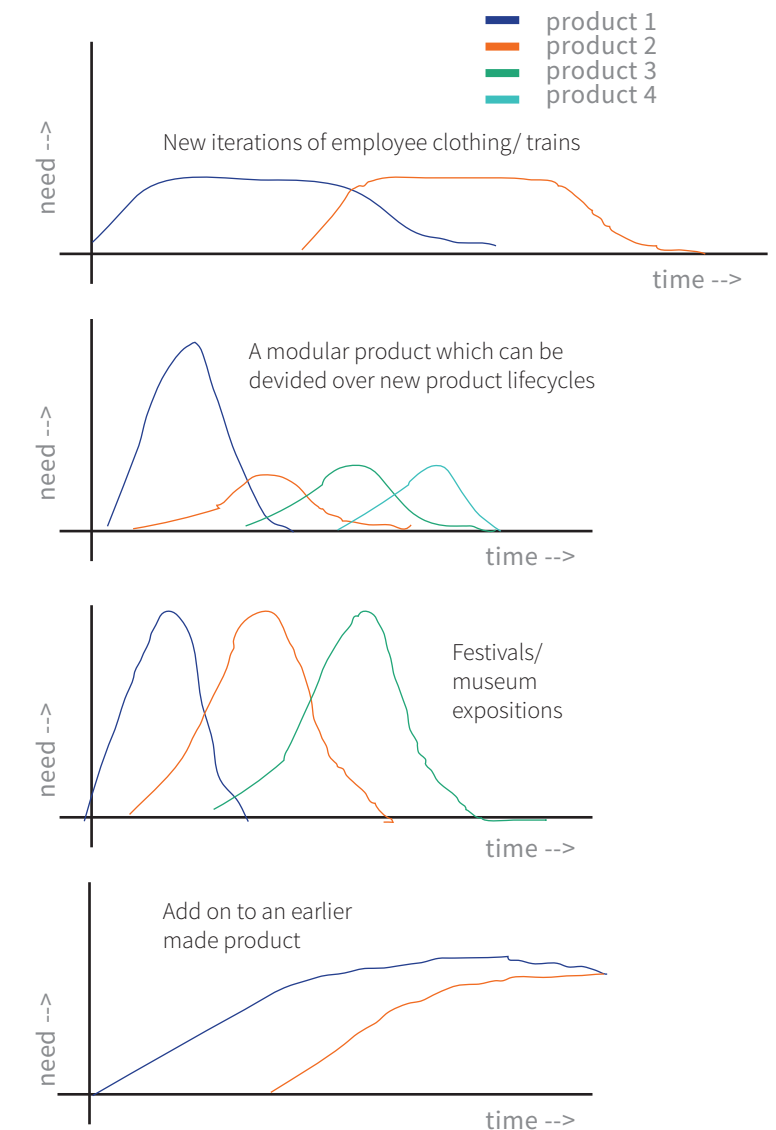


Figure 18. hypothetical graphs illustrating: predicting patterns of need over time

Flexibility in product design

A new way of looking at products is needed: products as a changing system over time

Concluding from chapter 1 and the interview results 1: to deal with complexity is to deal with a connected network of subsystems. With a modular product, we can start to see the product itself as a system, where sub-layers change over time.

Example of a chair: core of the product is based on fixed ergonomic measurements, while the look and feel of the back and seat can be changed much more quickly to fulfill the demand of the public.

“I always want to make sure my client is the happy ambassador of my brand. When a table comes back I have the chance to adapt the table with minimal effort to the client’s new needs.”

Design Agency - C39

Layers of change: predicting which parts of the product changes quicker and which ones stay the same over a longer time. Seeing a product as a changing system over time is seen in architecture as well: Layers of change in architecture (Simmonds, Ian 2000). A system is a combination of parts, influenced by external factors:

There is no whole system without an interconnection of its parts and there is no whole system without an environment.”

Figure 19. (Ansari, 2019)

The shape/ modular ability of particular Diving masks makes it easier to adapt the mask for another purpose. During the Corona crisis Designers and Students adjust the masks to be fit as Medical Oxygen masks to provide an answer to the lack of masks during the crisis.

Figure 20. (decathlon, 2020) (airwave, z.d.)



AIR WAVE

2.4 Result 2 - Hindering and Stimulating Factors

This section describes Result 2 from the interviews in detail: “General repurpose insights: hindering and stimulating factors“. At the end of this chapter these insights are summarized together with Result 1 from the interviews: “Designers’ Perspective”.

All quotes from the interviews were gathered and analyzed to find the most hindering and stimulating factors in applying Repurpose.

With ‘transcribing and conventional content analysis’ 11 categories were found which were divided in 4 main themes:

Theme 1: Holistic view on circularity

A. Recycling & Reuse vs Repurpose

Theme 2: Conceptualization

B. Product Value/ Need for a second product

C. Design methods & Role of the designer

Theme 3: Embodiment

D. Standardization vs Innovation

E. Product and Material Quality

F. Flexibility in Hardware

G. Demand and Supply

Theme 4: Strategies & logistics

H. Location & Transport

I. Finances and business model

J. PR/Promotion, communication and image

K. Knowledge (gap)/ sharing community

Theme: Holistic view on circularity

This theme is a summary of the quotes in category A: Recycling & Reuse versus Repurpose. This shows what factors are mostly mentioned which hinder and stimulate Repurpose in general. The quotes in this category reflect how participants view, Design for Repurpose, Repurpose driven design (see chapter 1) and Repurpose compared to the 9R’s circularity rules. Their perspective naturally influences how they would approach a transition to a circular economy.

Summary: The quotes in this category show that Repurpose is not always seen to be the best solution in a specific context. It is often unclear when and how to apply Repurpose because a clear method and definition are missing (Sustainability and Circularity are sometimes mixed up).

It was mentioned that there can be unintended effects in Repurpose, such as extra added material use within the first product to enable a transition to the second product, without actually comparing this quantity of extra material with the actual virgin material use of a new second product.

Products are seen as a fixed end goal which disappear of view when brought to market. It is difficult to oversee a long-term timeline when products change over time.

Repurpose is often solely seen as a method to turn waste of 1 single product completely into 1 other single product. This might not show all the possibilities of applying Repurpose to Designers.

Furthermore, when companies want to start a circular product-service-system, they often get demotivated. They often don’t know where to start when Circularity is new to them. Circularity also asks for finding expertise and a unifying solution across multiple domains. This is more difficult for smaller companies, where various product development and distribution phases are fragmented over various companies.

Conclusion: A clear set of guidelines should inspire to see the possibilities of Repurpose, by showing what, when (not) and how to Repurpose. A tool is needed to see a product not merely as a fixed end goal, but as a changing product over time.

Theme 2: Conceptualization

This theme is a summary of the quotes in category B. Product Value / need for a second product, and C. Role of the designer (& design methods).

Summary: Companies/designers seem to struggle to find a second valuable product opportunity, either in Design for Repurpose as in Repurpose from waste products. Searching for solutions in other domains is sometimes seen as a large investment or risk, partly because of their own specific domain knowledge around which they have built their solid business case. Their existing focus and method to get 1 high quality product to the market (with a specific PvE), withholds them, naturally, from thinking outside the box.

Other companies who do invest, seem to find out that the first step towards circular design is easier than they thought because existing design skills can be applied. However, they do struggle to find new partners or product opportunities which can give them a second product cause, which is of the same or higher quality and value as their existing products and business model.

Conclusion: There is a need for a 'toolset':

- A creative tool to find new valuable product opportunities, which make investing in a circular design manageable and viable.
- A phased plan to think more and more outside of the box (to find unexpected opportunities), but with a clear and familiar starting point.
- A focus shift is needed in design practice to a more iterative one, to turn the uncertainties of becoming circular into certain opportunities.

Theme 3: Embodiment

This is a summary of the quotes in category C. Design methods (and role of the designer), D. Standardization versus Innovation , E. Product and Material Quality, F. Flexibility in Hardware

Summary: Companies /designers seem to have sufficient capable tools to tackle Repurpose.

Predictability of future requirements

A current hinder in Repurpose is having to design for a long time frame, which is difficult to predict.

There are two directions:

1. *Flexibility, modularity, multi-functional*
Embracing uncertainty by make your product hardware "flexible". Often mentioned methods were modularity and multifunctional products.
2. *Standardization*
Searching for products, modules, components and functionality which are uniform across various domains. An insight is that companies / designers need help to view products differently: a product does not only have a function as a whole, but can be a system consisting of various sub-system of which its functionalities can be utilized separately if needed.

The interviews also showed that 2nd hand materials are valued less than the material quality actually still deliver. A product at EoL is also quickly considered as waste, while consumers' product quality valuation is for 70% based on visual perception.

As companies / designers aim to emphasize certainty when they invest in new opportunities. Especially when they are asked to imagine how to manage a circular product-service-system.

Some clear characteristics should be:
1. maintaining and having control over material quality through multiple lifecycles and 2. preparing for efficient throughput

from product 1 to 2 to reduce costs and or feedstock problems.

There are certain geometries and product modifications or treatments which facilitate this, making these more valuable in a circular/ Repurpose economy.

Conclusion: A creative 'design toolset' is needed to assist in playing with the boundaries and characteristics of a product to match 2 product designs, while focused methods are needed to incorporate certainty and simplicity within circular innovative product design (reducing risk, complexity and costs).

Theme 4: Strategies & logistics

This is a summary of the quotes in category G. Demand and Supply, H. Location and Transport, I. Finances and Business models, J. PR/Promotion, communication and image, K. knowledge (gap)/ sharing community,

Summary: Within this thema certain hinders currently prevent a company/designer from investing in a circular product design. First, the scale, brand and control over the supply chain influence the playing field of a company. When an investment is too different from what the company/designer already does, it is seen as setting up a new company department, while circularity asks for a holistic design approach across multiple domains. Therefore it is important to find or align among 3, being the initiating company, producer and designer when doing a circular investment. Then the responsibility and costs become manageable because they aren't carried by solely one.

For companies/ designers who are one of these 3 and who are operating individually, it is difficult to find a Supplier matching their demand, or vice versa. Also for product companies having all of these internally, it is difficult to find a demand for their supply of

EoL products and parts, or to get the whole company to aligned to one goal.

Initiatives such as corporate start-ups have a higher chance to succeed, since budget, core decisions, ambition and an open mindset to change come together. Furthermore the current supply chain, logistics, economic systems are based on a linear economy, so they aren't stimulating, but hindering Repurpose design.

Conclusion: Companies/ designers need promotion/communication methods to find partners towards a circular economy which fit with their own company, and need methods to cooperate more closely/ openly across domains. I expect that Design Guidelines following from the themes conceptualisation and embodiment will be the first step in solving strategy and logistic problems, since a company will only step over the threshold to become circular when it sees opportunities to benefit from.

2.5 Summary of interview Results

This sections summarizes the results from the qualitative interviews divided in 'General results' and 'results from the perspective of Designers'.

Summary of "General results"

Holistic view on Circularity

We think a clear set of guidelines should inspire to see the possibilities of Repurpose and will show what, when (not) and how to Repurpose.

Conceptualization

There is a need for a creative 'tool' that addresses 'product opportunities/Search Areas to find new valuable product opportunities, which make investing in a circular design manageable and viable. There is a need for a phased plan to think more 'out-of-the-box' to find unexpected opportunities but with a clear and familiar starting point. Uncertainties of becoming circular can be turned into certain opportunities.

Embodiment in design

A creative tool 'Design for Change' is needed to play with the boundaries and characteristics of a product to match future designs. Design Guidelines are needed to incorporate certainty and simplicity towards subsequent products (reducing risk, complexity and costs).

Strategies and logistics

Companies / designers need communication methods to find new circular partners and need methods to cooperate more openly across domains. Furthermore new circular resources and activities need to be adopted. However, a company will only step over the threshold to become circular when it sees opportunities to benefit from. This means it is important to find a future product opportunity first.

Summary of results from the perspective of designers

Repurpose in Practice

Hindering factors with applying Repurpose in practice, by designers:

Product design is focused on finding out user demand first. What companies currently do wrong in Repurpose is:

- Starting point is material focus (waste): finding opportunities and designing from technical boundaries (& hidden value); prevent technical waste boundaries.

- Currently business models are based on what the client or consumer desires in the first iteration of the product: fulfilling needs creates revenue: circular design should also focus on fulfilling needs to create revenue.

Maintaining the value over multiple use iterations requires that the perspective of the designers should change to iterative products as a system need.

Designers already have the skills necessary to design for complex and wicked problems such as circular economy. They just need guidance to know where to start and to know how to tackle the problem efficiently and effectively: a toolset of guidelines and approach is needed.

Dealing with time means dealing with uncertainty

Embrace certainty: start from existing product, infrastructure, skills, users...; predict (research on) future demand: increase certainty.

Embrace uncertainty: embed flexibility in/ during product design to cope in advance with likely future requirements.

Certainty versus Uncertainty

Uncertainty

Perception of companies / designers: it is complex to design for future products. It either requires a restart of the Design process or a compromise in the design of current and future products.

Recommended: change in perspective on Repurpose

Embracing certainty

- Designers and companies should think of their existing infrastructure & capabilities as a starting point for finding future needs (next products) to prevent unbounded scope (creating focus and a logical goal in the repurpose design project).

Embracing uncertainty

- Change will happen. Nothing stops the designer of appointing / design reusable parts anyways (to harvest value) and becoming more agile for future unforeseen changes -> flexibility in product design.
- Change has a level of predictability of which patterns could be made (fig. 21 for a sketch). With pattern prediction uncertainty can be reduced.

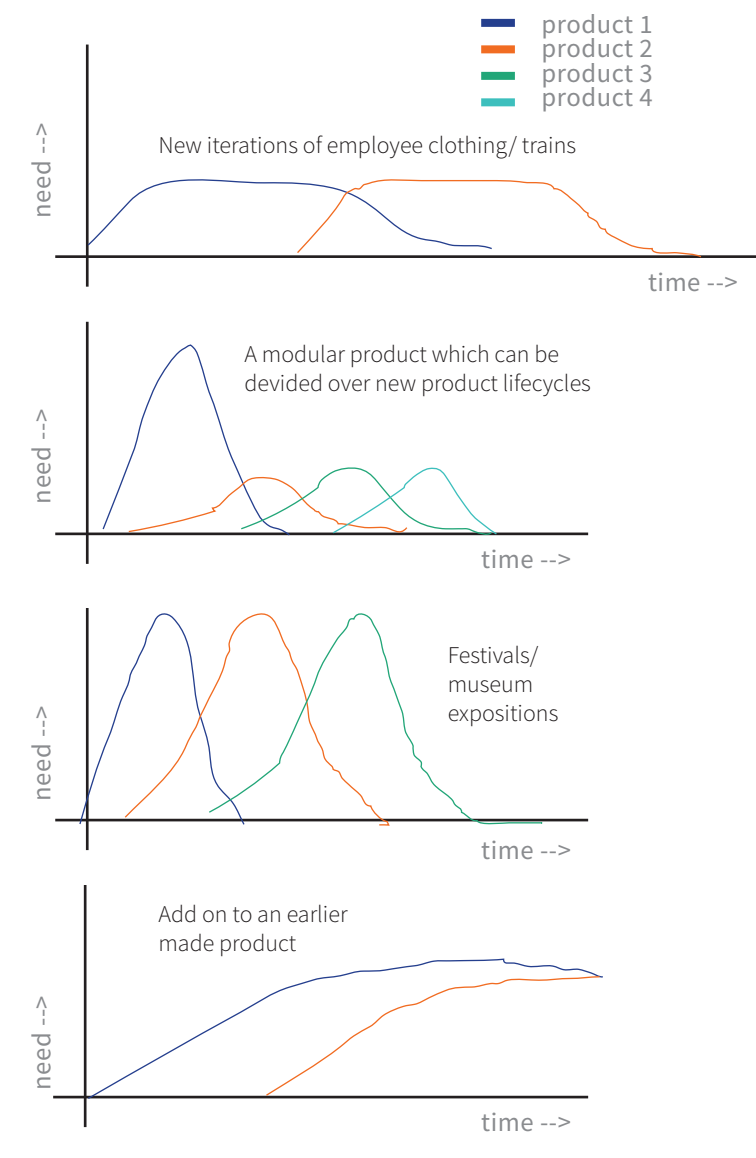


Figure 21. hypothetical graphs illustrating: predicting patterns of need over time

2.6 Conclusion

From interviews with 9 design companies (connected to the HvA Repurpose project and consortium) (Hogeschool van Amsterdam, 2019) it becomes clear that designers need a change in perspective: current linear thinking makes it difficult to see products as “changing systems over time” (theme holistic view on circularity from the interview results). Such a perspective is necessary for Circular product design. In addition, the interviews show that designers need a clear, familiar, and realistic goal, to minimize the risks and scope the Repurpose project. Although designers have the skillset to address circularity issues, without a clear goal to benefit from, companies simply won’t invest in key resources and activities which are required for reuse. Therefore the following chapters focus on the themes Conceptualisation and Embodiment.

As Repurposability indeed turns out to have an unclear definition and designers need more experience with designing product parts for reuse it is difficult to know where to start. Examples of past cases and the interview questions about Repurpose, inspired designers to mention ways in which they would address Repurpose, leading to a first list of essential design actions for Repurpose. This and insights about how designers work (see chapter 1) show that designers would be able to design reusable products and parts.

Overall, the study shows that Designers need to a clear plan of how to approach Design for Repurpose and specific Design Guidelines for optimizing the Repurposability of their product part.

The following chapter describes how this study results in a toolset consisting of:

- a Process to find clear future product opportunities, subsequent to the current product,
- specific “Design for Change” guidelines, where the first and subsequent product are redesigned to increase the possibility to reuse parts.

The quotes in these pages give a first view on the content of the toolset.

“I think it asks us to look at products from a new perspective: What kind of needs are there in the same market apart from what we know?”

Design Company - B30.1

“If I would have known this beforehand I would have made this product differently from the start and ask myself the question: what else can I make of this?”

Design Agency - A1.Fx4.11, A1.Fx3.3, A1.N3

“A floor is dirty after people walk over it for many years, but there is high quality below the dirt. Reused products still have high quality but this is value is often not seen.”

Comapny - N7

“Next time I will take functional requirements into account already while I purchase materials, so much earlier!”

Company - A1.N3

“What really changes in a chair over time? The length of someones back almost does not, so the ergonomic measurements in a chair also don’t.”

Design Agency - F1.A45, F1.A12

“We need to make material quality visible, why not a quality label?”

Producer - FcW – 36

“I would repeat the same type of interfaces throughout the product, like LEGO does.”

Design Company -A11

“when there is an emotional band, and the product becomes obsolete, users don’t like to throw away their product.”

DesignCompany - B22

In one project I used a flat flexible material which I could bend into a 3D shape with low effort. So, we need to find quick & clever adjustments.

Design Agency - Fx4.1, Fx4.2

3 A NEW DESIGN APPROACH

*Stimulating factors for Design for Repurpose,
captured in a Design Approach & Guidelines*

3.1 Introduction

Guidelines & Tools

A phased plan is needed to close the gap between the companies first product (supply) and a second product case (demand) (link to previous chapter). This can be done best before the 1st product's lifecycle, with creative iterations. (Source from quotes: (Fx1.3) (Fx3.2)(C9), (Fx4.11) (Fx1.9) (Fx3.3) (Fx1.8))

During the interviews companies and designers mentioned hindering factors linked to the conceptualization and embodiment phases of the design process. From the previous chapter it is concluded that there is a need for a 'tool' that supports finding and realizing future ideas for the Repurposed product while coping with a changing set of requirements over product life cycles.

Aim of this chapter: describe how Design Guidelines are incorporated in the existing design process. As such it serves as a 'tool' to handle those 'hindering and stimulating factors'.

It is a first attempt to try to apply Repurpose within the workflow of designers.

In short:

- **Part 1: STARTING POINT**
Guideline: Know when to change, know what you have and predict future change
A clear and familiar starting point is needed to come up with viable, feasible and desirable new product ideas later on
- **Part 2 PRODUCT OPPORTUNITIES**
Guideline: Find future product opportunities
Search, with the aid of 'Search Areas' in various directions for opportunities of future products. The aim is to increase certainty by predicting what products are needed at the moment that product '1' becomes obsolete.
- **Part 3 DESIGN FOR CHANGE**
Guideline: Design for Change – embrace uncertainty
The aim of this guideline is to redesign the product in such a way that a significant part of the product can be reused in subsequent product(s). This is done by taking 'Reuse in a future product' as a design requirement for each part of the product. As such 'uncertainty of change' is changed into 'change is certainty'. The result is a flexible product that can cope with changing requirements during the product life cycle over time.

3.2 From interview results to guidelines

Method

Various iterations of a brainstorm and discussion together with interviewee 2, with the aim to find a set of guidelines stimulating Repurpose for designers in their regular workflow.

Creating guidelines

Chapter 2 resulted in the discovered stimulating and hindering factors for Repurpose, from interviews with designers and design companies. From this, guidelines were created with the method “Insight Statements: Key Themes are identified and then to translate into opportunities for design.” (IDEO, z.d.).

Then more in depth brainstorm questions or statements were identified for each theme with the aim to inspire designers to think outside the box. This was done by selecting inspiring and clear Repurpose cases and approaches from the interviews and the 80+ case analysis (see chapter1) to imagine in what useful ways the themes could be interpreted.

Why “design“ guidelines

Within the interview various statements were mentioned about the role of the designer and which methods are applied during the general design process (see chapter 2).

These statements clarified that designers typically apply Design Thinking (idea-prototype-test-iterations) to solve complex problems. On the other hand, they have several ideas to apply Circular Design however they do not apply it during the Design Process yet because of the hindering factors mentioned in the previous chapter (Bender, 2020).

Therefore I used the Design Thinking process to give structure to the design guidelines, corresponding to the phases in the design process (Roozenburg & Eekels, 1998).

3.3 ‘Design for Repurpose Guidelines’ explained

3.3.1 phase 1 - starting point

Know when to change, know what you have and predict future change

1A. KNOW WHEN TO CHANGE

Have a clear timeline and use-cycle of your current product

Rational

During the current design process a product is often seen as fixed end goal because it is created for one use-cycle. Changing the perspective to a product which changes over various use-cycles can be difficult, because a changing set of requirements must be taken into account. A timeline (see fig. 22) starting with the first concrete and specific product definition followed by envisioned possible use-cycles helps to oversee and predict future changes.

Implications

Determine phases the current product goes through, including details about ownership, location/context and activities happening around the product.

Think of a general timeline and fill in the further possible use-cycles. The transition towards a second product should start when the first product becomes obsolete.

Actions

- Create a product timeline.
- Fill in the use-cycles of the current product (the product could be used several times, for example through 2nd hand sales).
- Fill in when the End-Of-Life happens of the current product.
- Answer the following questions to fill in details about the product:
 - Who owns the products various moments in time and to what extend?
 - Where is the product at various moments in time?
 - What happens around the product in various phases of the product’s lifetime?

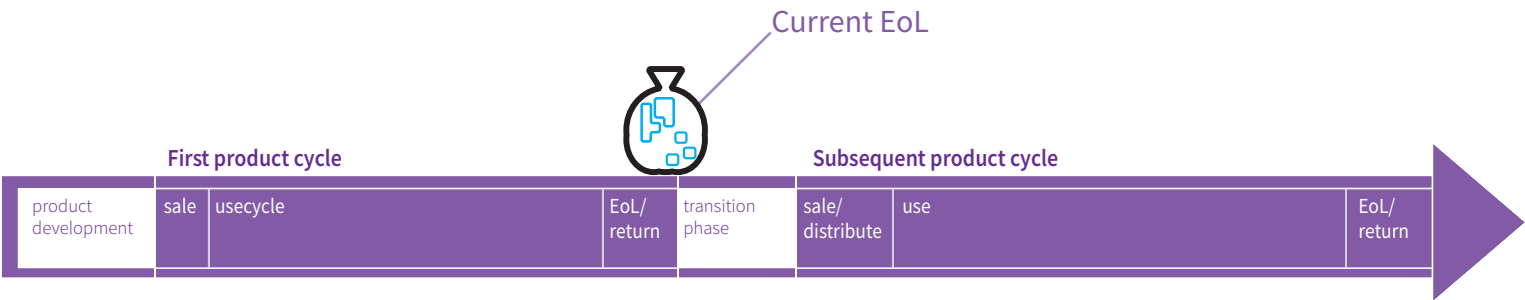


Figure 22. A timeline of two subsequent products helps to envision possible use-cycles and helps to oversee and predict future changes.

1B. KNOW WHAT YOU HAVE

Design from a clear and familiar starting point

Rational

In chapter 1 became clear that companies (see 80+ case analysis) need a clear 2nd product goal, to prevent unsuccessful Repurpose innovations. The aim of this guideline is to define various Search Areas for finding new and logical product opportunities later on. Repurpose is new concept for many companies and therefore can be challenging and be a risk (see H.2: Repurpose in practice interviews). However, a **familiar starting point** reduces time/costs to adopt new skills and knowledge. It is advised to choose a starting point like an existing product from the company’s portfolio or a product similar to this one. In this way the company makes use of what is already available like skills, infrastructure, facilities and brand.

Implications

- 1. **Stay close to your existing infrastructure & capabilities:** Gather information about the current product, user and brand.
- 2. **Identify and focus on the most valuable parts of the current brand and product:**
 - a. Understand your users’ current connection & experience to the product
 - b. Understand how the brand stands out
 - c. Determine the functional structure of the product
 - d. Understand which parts are valuable of the current product, and what are the most important brand aspects and what the user needs

“developing a product too far away from what I’m currently doing just means setting up a new company”
Design agency - T 14, V24

Actions

- 1. Existing infrastructure & capabilities:
 - a. Gather saved files from an earlier project and/ or perform new user research (personas/ scenarios/ experience). Revisit or create a user persona and scenarios, map the user’s connection points in the earlier created roadmap
 - b. Map the current brand value. Revisit your brand experience and market insights through brand analysis and a product benchmark.
 - c. Create a functional structure of the product:
 - Divide the current product in system, module & component levels
 - Determine the valuable functions, working and mechanisms (a function fulfils a user need directly or indirectly).
 - d. Map the most valuable components, parts and functions within the functional overview (which are often reused in other products) (for your brand) (by specific durable/strong characteristics)
- 2. Map the most important brand aspects and user needs

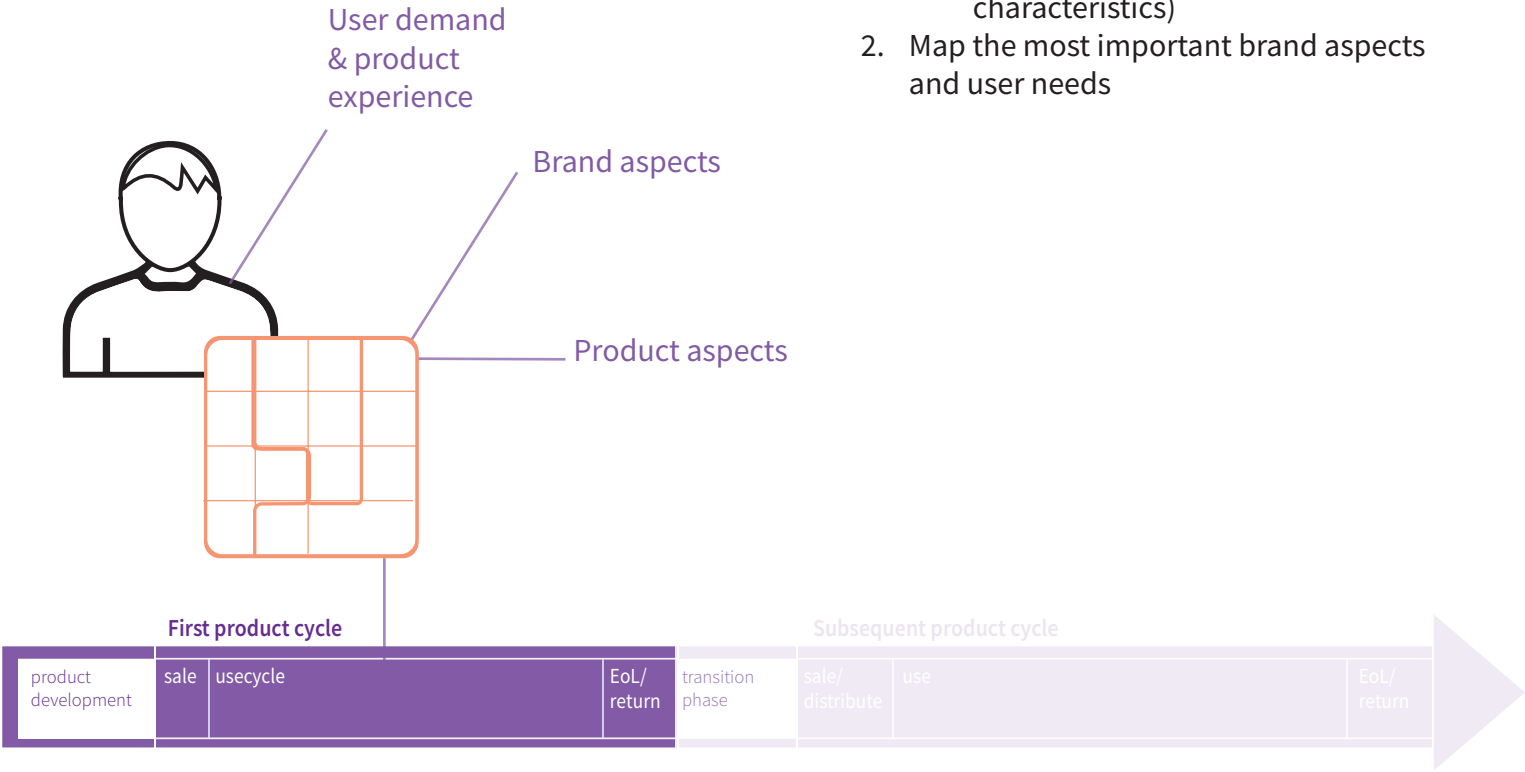


Figure 23. First focus on the current product, as essential aspects of the current product are a basis for the subsequent product. Pinpoint which aspects create the current value proposition

1C. PREDICT FUTURE CHANGE

Give guidance in brainstorm for future product opportunities
Embracing certainty: predict which products are needed at the time of obsolescence of product 1.

Rational

By having a justified view on future product opportunities one can foresee if the current product’s modules and functions are also usable in upcoming products. For designers this could be taken into account when designing the modules, parts and functions of the first product. As such, a demand for reuse in a subsequent product does not come as a ‘surprise’ and Repurpose becomes part of the first design of the product use cycles. It is hard to predict the future but not hard to do research on the future.

Implications

- 1. Research future trends and changes in the brand, market and new users
- 2. Create a future brand and product strategy which address how brand & user might react on future changes

Actions

- 1. Map the future changes and needs in the form of future trends the earlier created roadmap.
- 2. Map future strategies: create short sentence descriptions & mood boards/ themes according to the future vision

3.3.2 phase 2 - product opportunities

2. ‘SEARCH AREAS’ BRAINSTORM

Explore your starting point with the search areas to find new product ideas

Rational

In chapter 1 it became clear that companies (see 80+ case analysis) need a clear 2nd product goal to prevent Repurpose innovations that do not lead to significant demand. The found Search Areas serve as a focus point during brainstorming for a second product opportunity.

This guideline aims to help designers to find viable, desired, and feasible product opportunity of which product parts can be exchanged with the current product.

Implications

A clear description is needed how to find new product opportunities. This guideline comes with the approach “Search Area directions” which helps designers to “think out of the box” to find new product opportunities which aren’t immediately clear.

Actions

Gather the future predictions of the most valuable aspects in the roadmap

- a. Do various short brainstorm iterations to find second product opportunities (iterative approach, build up inspiration in steps).
- b. Do various short brainstorm sessions help to come up with a creative, open minded, set of ideas, in various directions. Some Search Areas will be more suitable for specific contexts, so not all Search Areas are mandatory to brainstorm with, but each search area can serve as an eye opener. Each search area contains a set of brainstorm questions.
- c. Finally select product ideas which are most viable, desired, and feasible. Don’t limit the brainstorm too much by the 1st product’s specific components as a redesign will happen.
- d. Tinker by disassembling the product by hand & reassembly by quick prototyping: find a subsequent product opportunity

- e. Compare the current product to the subsequent product ideas, but see the product functions separate from the current products’ solutions: Don’t limit the brainstorm too much by the 1st specific components as a redesign will happen)
- f. Switching back & forth between product 1 and the ideas for product 2 to find the best match. Assess the ideas by comparing them with product 1 and based on the criteria:
 - with as many of the same components as possible
 - which the user needs at the first products’ EoL
 - with the same emotional value
 - with the same construction behaviour
 - with the least complexity (to assemble)
 - which complies with the future themes

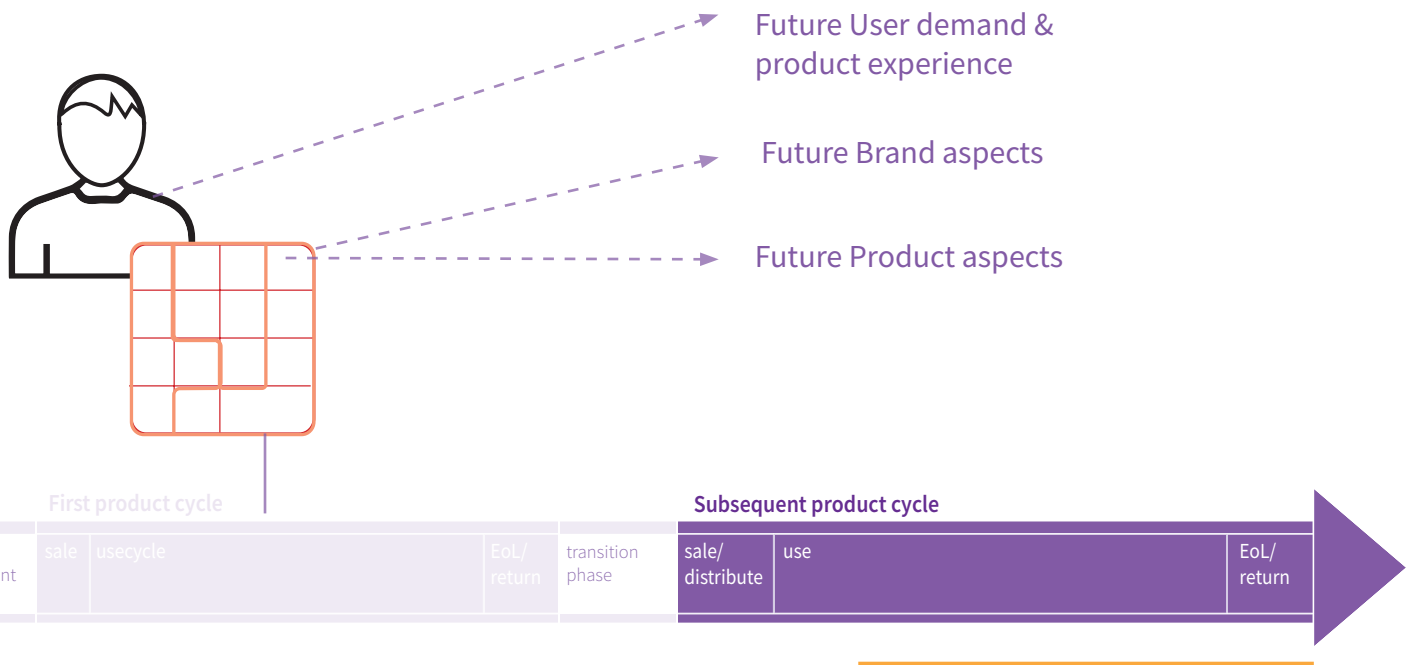


Figure 24. Valuable product aspects help to predict a subsequent value proposition

SEARCH AREAS

Here the ‘Search Areas’ are described, fitting with Design Guidelines 2. (see the previous page) which inspires and helps designers to “think out of the box” to find new product opportunities which aren’t immediately clear.

TIME BOUNDED USERS/PRODUCTS– use the future user demand as a starting point

The aim of TIME BOUNDED USERS/PRODUCTS is to find a product fitting with the future demand of the current product’s user. The starting point is information of that user. Try to predict if and how this demand will be changed at the moment of End of Life of the first product.

- Which events are likely to occur over time (life events, seasons, age, etc.)?
- Who is the user and who can become one?
- What other products are related to the above questions?

CONTEXT/ LOCATION NEEDS – find new products closely related to the current context

The aim of CONTEXT/LOCATION NEEDS is to find a product close to an already familiar field to the company.

- How will the product context change over time? Research future changes in society.
- Where is the product? What other products are used in this location?
- What other products are necessary at the EoL of product 1?

ECONOMIC VALUE – maintain economic value over the subsequent products

The aim of ECONOMIC VALUE is to minimize the economic value loss in the transition towards a subsequent product.

- Which products have the same value in terms of economic value/ money?

CURRENT BRAND – strengthen the brand experience in the future or make use of market gaps

The aim of CURRENT BRAND is to find a product fitting with the already established aspects of the brand.

- What type of brand experience do I have/ how can I exploit that over time?
- What other products could I expand my product portfolio with?
- What other products fit with my future brand?

RECOGNITION - amplify the value of recognition between the two products, as a special product line feature

The aim of RECOGNITION is to establish a strong connection in product experience between the subsequent products, as a special feature of the future product and in some cases to show the circular aspect of the product.

- What current product elements are very recognizable/ have a special feature?
- How can I use recognizable parts of the current product in a new product?

SIMILARITIES IN FUNCTIONALITY - Find products with common functionality

The aim of SIMILARITIES IN FUNCTIONALITY is to find low-hanging fruit by reusing valuable parts of the product which are already there in another way.

- What is the value/quality of the current product modules and in what other products/ways can these be used? In what way is the current product multifunctional?
- What functions can my product deliver? What are valuable modules, components, materials in the current product?
- In what other location/ contexts/ markets are similar products used?
- In what other location/ contexts/ markets are similar product modules used?

EMOTIONAL VALUE – use the power of emotional value to connect the future user as well

The aim of EMOTIONAL VALUE is to establish a strong user-product connection for the subsequent product, by extending the experience which is already there.

- Does the current user have a strong emotional experience/ value with the current product?
- Are there products which capture the same emotional value as the current product?

FIXED/ FLEXIBLE – brainstorming with a changing product in mind

The aim of FIXED/FLEXIBLE is to make use of predictable changes and strengths of the current product, at the right time. Standardized parts can be applied more easily in future use cycles as they are more likely to be used. Flexible parts can be special features of a product.

- Which product modules/ components stay the same over time?
- Can you predict when which product modules are likely to change?
- What would the current product look like if it would be sold in the future?
- What is the value/ quality of the standard product modules and in what other products/ ways/ contexts/ locations/ markets can these be applied?

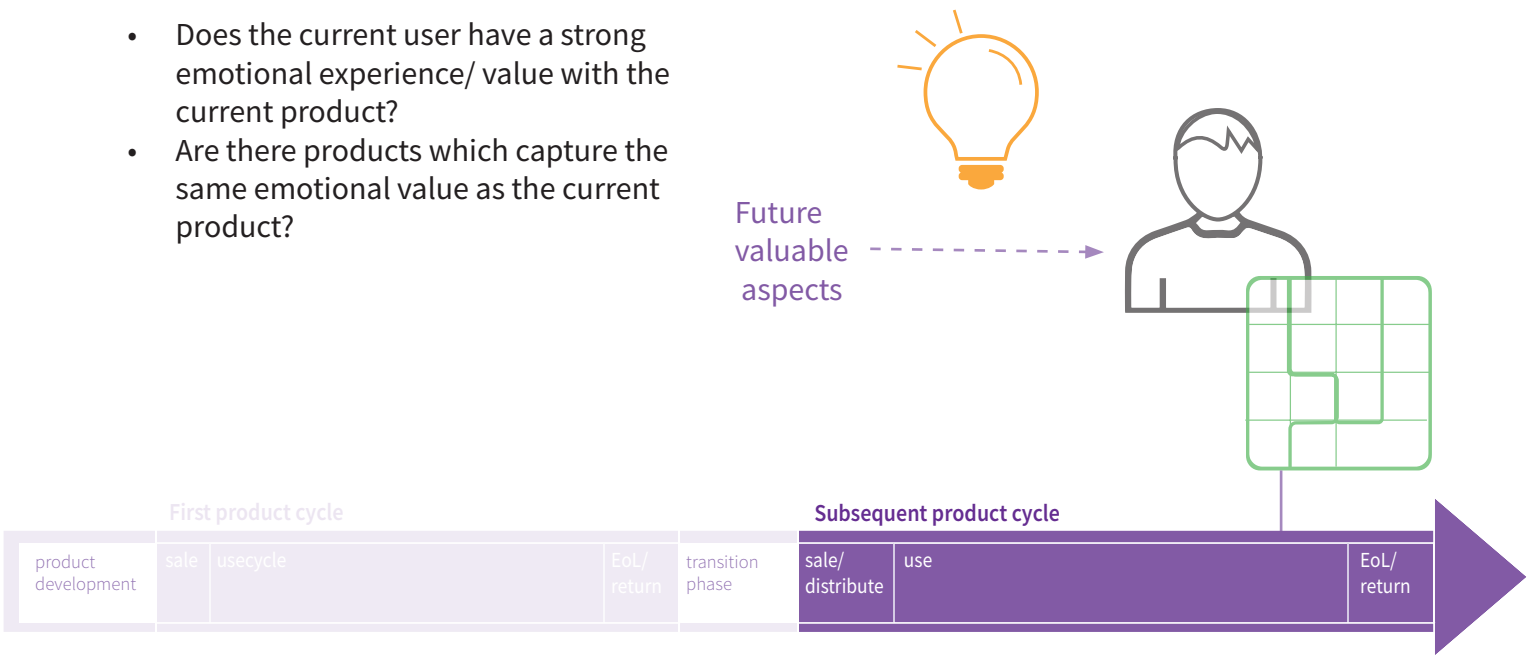


Figure 25. Within Phase 2 of the design approach the search areas (described on this page) and the future valuable aspects (as a result from Phase 1) can be used to generate ideas for the subsequent product .

3.3.3 phase 3 - Design for Change

Rational

After having made the choice for next product opportunity design guidelines are necessary to guarantee an effective and efficient transition from product 1 towards the next product. By applying this special set of guidelines in the design of the first product, valuable modules and components can be reassembled in a subsequent product. This is done through **Embrace uncertainty**: by a redesign of the current product, a flexible product is created which can change according the changing set of requirements over time.

Implications

Make it possible to ‘iteratively compare’ the first product with subsequent products in such a way that design changes can be applied on part, function, module and the system of the product.

Actions

- Use the 2nd product choice, functional structure of the current product and the current’s product disassembly as a starting point.
- First select similar valuable functions.
- Check if the products have similar embodiment solutions, modules and components.
- Apply the following Design Guidelines while switching back and forth between the current and subsequent product(s).
- Find out how the products modules, components and construction need to change for reuse.

3A. APPLY MODULARITY

Create functional modules & generic connections

Rational

To reuse functional modules and generic connections in subsequent products with minimal change. Make sure the product consists of separable functional modules and generic connections. A company should eventually be able to re-assemble the current product into the subsequent product.

Implications

- Find out what the dependencies and similarities are between parts within and between products. This helps to understand which modules and separations need to be made with product parts.
- Do a functional decomposition to detect valuable modules, components, and connections.
- **Analyze part reusability** (durable, modular, etc.)
- Determine how parts and interfaces should change to enable reuse in subsequent products
- To make generic connections fit to varying modules (to various shapes and locations), an adaptable interface between a generic connection (module) and a module x is necessary.

Actions

- Disassemble the current product
- Compare product parts and modules with the future product
- Redesign parts for reusability
- Functional analysis: Determine which valuable functional modules are used in the first and second product as well – make these easily separable first, before creating more modularity within the modules itself.
- Rearrange parts in a ‘quick & dirty’ prototype
- Modularity/ Repurposability analysis – Find out which existing (internal) connections prevent separation of modules.
- Determine which dependencies and similarities exist between components within the existing product
- Increase reusability/ Repurposability: adapt, redesign, repeat, add, and remove parts to increase the amount of parts which can be reused directly in the second product.

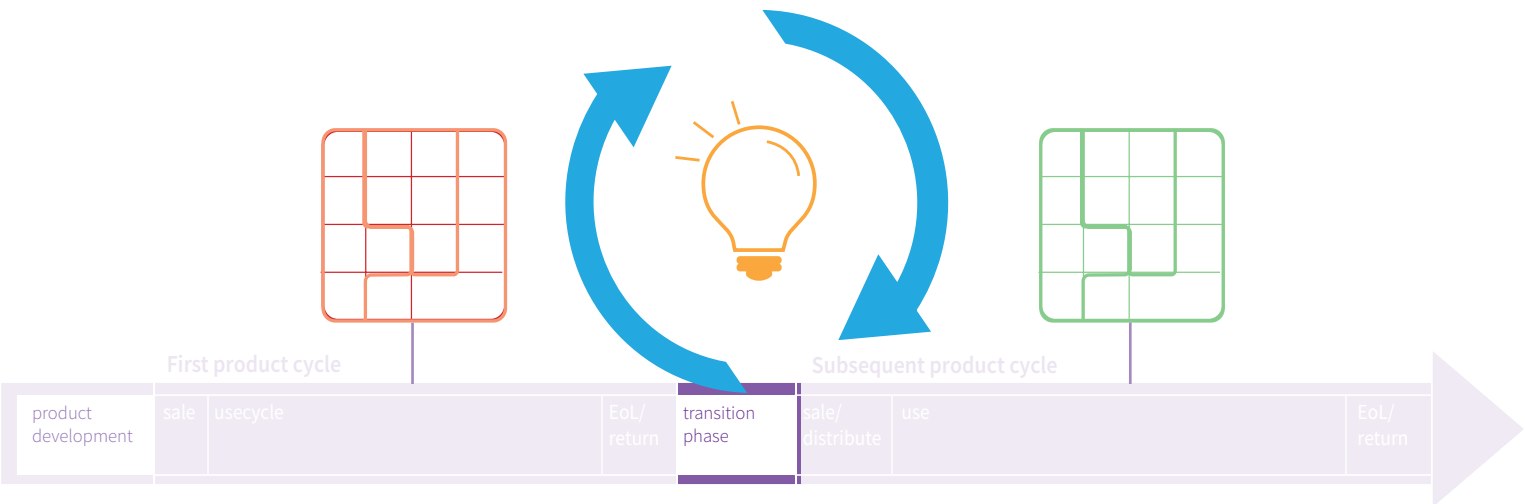


Figure 26. The last 5 guidelines (3A to 3E) focus on ideating and designing for product part exchange.

3B. QUALITY PERCEPTION

influence what is perceived to influence quality perception

Rational

Quality is a perception? The main aim in Repurpose is to maintain quality / value over multiple use cycles. However, from the interviews it became clear that 70% of the quality comes from aesthetics. Other aspects could be durability, such as experienced product failure. Therefore, other qualities (material, construction, and functional quality) are more difficult to see than aesthetic experience. For example, a product with dirt and visible wear, could be perceived as old, while it still operates as new. Furthermore, aesthetics are most likely to change quickly over time, due to a faster changing demand.

Implications

- Apply more “timeless” aesthetics on components which can be used for many use cycles. Limit the amount of specific applied colours/ aesthetics unless they are “timeless”.
- When applying specific short-lasting aesthetics, apply these primarily on short-lasting / temporary components.
- Prevent visible wear on materials and finishes because this makes the product look less valuable than it probably is.
- Consider using 2nd hand and recycled materials, components and modules where parts are not visible. Parts which are not visible do not need to be optimized for aesthetics.
- Since the demand for aesthetics changes more quickly than other types of qualities, make parts fulfilling these aesthetic demands separable from parts which do not fulfill this demand.
- Use aesthetics to amplify the most important/ valuable functional qualities

Actions

- Highlight long lasting components/ modules in the product’s functional structure
- Highlight short lasting components/ modules in the product’s functional structure
- Highlight high valuable components/ modules in the product’s functional structure
- Apply neutral/ timeless aspects of the brand’s aesthetics on long lasting components
- Apply durable finish on long-lasting components
- Make long-lasting components separable from short-lasting components

3C. SIMPLE FORM

Keep it simple in geometric shapes. Keep it basic to prevent irreversible adjustments

Rational

“Basic” & “simple” shapes are easier to apply again in a different product configuration in the future. Simple modules, components and constructions are easier to comprehend and therefore it is easier to envision them in another configuration, system, product. However, some specific shapes are generically applied (see guideline “standardization”).

Implications

- Divide too specific/organic shapes in easier to reuse basic geometric shapes, unless these specific shapes are used abundantly throughout the industry and the products’ market
- Prevent specific adjustments which are impossible or difficult to reverse

Actions

- Use fasteners which do not require holes were possible
- Apply basic geometric shapes when these parts need to be reused

3D. STANDARDISATION

Seek standardisation available in industry

Rational

Standardized parts used in industry are usually more quickly and easily available and in large quantities. Standardized parts usually have a lower cost because of the “economy of scale” principle, so the cost also is expected to be reduced when a part is applied multiple times within and between products. Finally, when an investment fails due to unforeseen situations causing product parts to become obsolete before use. For example, when it turns out a future product opportunity does not come true, standardized parts are more easily sold and reused again.

Implications

- Puzzle with standardized shapes and sizes already available in industry
- Copy solutions for generic functions, throughout the product and between the subsequent products
- Copy adaptable product solutions for similar functions, throughout the product and between the subsequent products

Actions

- Highlight generic and similar functions within the functional products’ structures
- Check if similar design solutions can be applied

3E. EFFICIENT TRANSITION

Easy to (dis)assemble. Reduce remanufacturing/ refurbishment production effort and costs during transition.

Rational

The product should be designed in such a way that it takes the least amount of effort to transition from the first to the subsequent product. The different process phases of transition are roughly:

1. Quality check,
2. Disassembly of the first product,
3. Cleaning, Refurbishment and Remanufacturing to maintain and improve quality,
4. Reassembly, into subsequent product,
5. Quality check.

To get as easily and most cost-effective through this process, the product and its parts should be designed for disassembly and reassembly, made to last multiple use cycles with minimal wear, and must be as easily, effectively and efficiently cleansed, (if necessary) refurbished and remanufactured. *Before the transition phase, return of the product is required and after product distribution is needed.

Efficient transition is often mentioned as a hindering factor in Repurpose Driven Design, and therefore often mentioned as a reason not to apply repurpose. The main reason is: in past Repurpose projects (see chapter 2) products are not specifically designed for reuse beforehand, but products are Repurposed which already after product EoL.

Implications

- Apply design for disassembly & reassembly steps, so the product can easily be adapted
- Reduce the possibility of wear and tear, by creating more long-lasting modules, reducing the chance that refurbishment/remanufacturing of product parts is necessary during transition.
- The product should be easy to clean to save time and energy
- Reduce the amount of costs (energy, time, material) in refurbishment, and remanufacturing steps.

Actions

- Apply long-lasting materials, finishes and mechanisms
- Prevent shapes in which, and materials and texture on which, dirt can get stuck or is difficult to remove. Isolate mechanisms in closed off spaces so dirt cannot influence the mechanism performance.
- With design for disassembly a few factors influence the ease of disassembly & reassembly :
 1. The amount of steps to execute,
 2. The effort to execute each step,
 3. The time cost per step and of the procedure as a whole,
 4. Understandability of each step and the procedure as a whole.

Apply the following guidelines to improve the ease of disassembly (Vezzoli & Springer, London, 2018, p. 193) (ceguide, 2018):

- **Design with modules** To divide the product into easily separable and manipulable sub-assemblies and to minimize the amount of disassembly & reassembly steps. Reduce complexity of disassembly by making components have fewer hierarchically dependent connections. Prioritize the disassembly of parts with a higher economic value, those that have easily damageable components and those that are more quickly subject to change.
- **Fasteners:** Minimize the overall number of fasteners: aim for only fastening components once. Prevent irreversible fasteners, such as glues or rivets. Apply easy to handle and similar fasteners (which require a minimal variety in tools). Apply fasteners which can be quickly unfastened.
- **Shape:** Avoid difficult to handle components. Aim for applying symmetrical components. Build “instructions” into the product to reduce the learning curve of the disassembly and to make the order of disassembly obvious. Design accessible and recognizable openings for dismantling joints. Find more in depth steps in source (Vezzoli & Springer, London, 2018, p. 193) (ceguide, 2018).

3.4 Conclusion

Guidelines & Tools

This chapter described the toolset, consisting of an approach and guidelines to find product opportunities and Design Guidelines to make a product and its parts more fit for Repurpose. In short:

- Searching for new product opportunities in the future: change will happen and some changes can be ‘predicted’ by research
- Starting point: analyze existing infrastructure & capabilities
- Search for and select a second product opportunity in the future
- Make products parts easily exchangeable

However, does it work? Is it measurable to what extent the ‘Design for Change’ guidelines actually lead to improved Repurposability?

Within the following 2 chapters the guidelines are tested with a design case. Mainly it will be looked into if these guidelines indeed result in a valuable subsequent product opportunity and if the redesign will lead to a significant amount (‘80%’) of reused parts. This will be calculated with a ‘Repurposability Factor’ which measures the result of ‘Redesign for Change’.



Figure 27. The proposed Design Approach in this chapter consists of 3 phases, shown in the above graphic.

4 DESIGN CASE PHASE 1 & 2: PRODUCT OPPORTUNITY

4.1 Introduction

In previous chapter a new design approach and ‘toolset’ is described, to address Repurpose in a design process.

In this chapter a part of the Design ‘toolset’ is tested by applying phase 1 and 2 (see fig. 28) in a Case Study (see fig. 29) . The eventual goal of phase 1 and 2 is to select a subsequent product, in which the current product can be transformed after the current product’s end of life. The subsequent product is found by analysing valuable aspects of the current product and predicting how these valuable aspects have evolved (as described in chapter 3). Chapter 5 describes a Product Redesign, the process of applying phase 3 “Design for Change” with the case.

Figure 28.
In this chapter
phase 1 and 2 of the
Design Approach
will be tested



Design Case

One of the partners in the HVA consortium, the design agency Springtime, was asked for a product design case which they would like to see redesigned to become repurposable. The chosen design case is the ‘Mutsy IGO Stroller’ (see fig. 29). The stroller was released to market approximately 10 years ago (see use cycle analysis in chapter 5). This makes it possible to obtain a 2nd hand version of the stroller for analysis.

There are two points of interest for Repurpose in this stroller, linked to the search areas:

1. The stroller is parts of an emotional user experience.
2. The product has a construction with multiple basic components.



Figure 29. The Mutsy Igo Stroller is the Design Case on which the Design Approach will be tested (Mutsy & Springtime, z.d.)

4.2 Design Case Approach

Phase 1 and 2 of the Design case is described on the next pages follow the following structure (also illustrated with fig. 30).

Phase 1 and 2 of the guidelines:

1. **Know when to change** – have a clear timeline and use-cycle of your current product
 - Business models: current lifecycle --> possible future lifecycles
2. **Know what you have** – design from a clear and familiar starting point
 - **Valuable user aspects**
User (persona, scenarios, survey, product experience, other products --> most important user needs highlighted, most valuable user experience highlighted
 - **Valuable brand and business aspects**
 - Brands (brand triangle, market insights, product benchmark --> most valuable brand aspects
 - Business aspects are described with the guideline: Know when to Change.

- **Valuable Functions: Functional Structure**
Product functional structure --> most valuable functions & modules highlighted
- 3. **Future prediction**
 - **Timeline Mind map** - Mapped future user within the timeline
 - **Future trends** --> determine future needs --> short sentence descriptions of future strategies = **future themes** (Mood boards)

Brainstorming for product opportunities: Guidelines Part 2

The results from guideline 1 will be used together with guideline 2.

Idea generation

1. Brainstorm by brand & user analysis
2. Brainstorm based on the functional structure
3. Tinkering by disassembling the Mutsy stroller by hand

Result: Selected Product Opportunity

Idea selection
Final choice

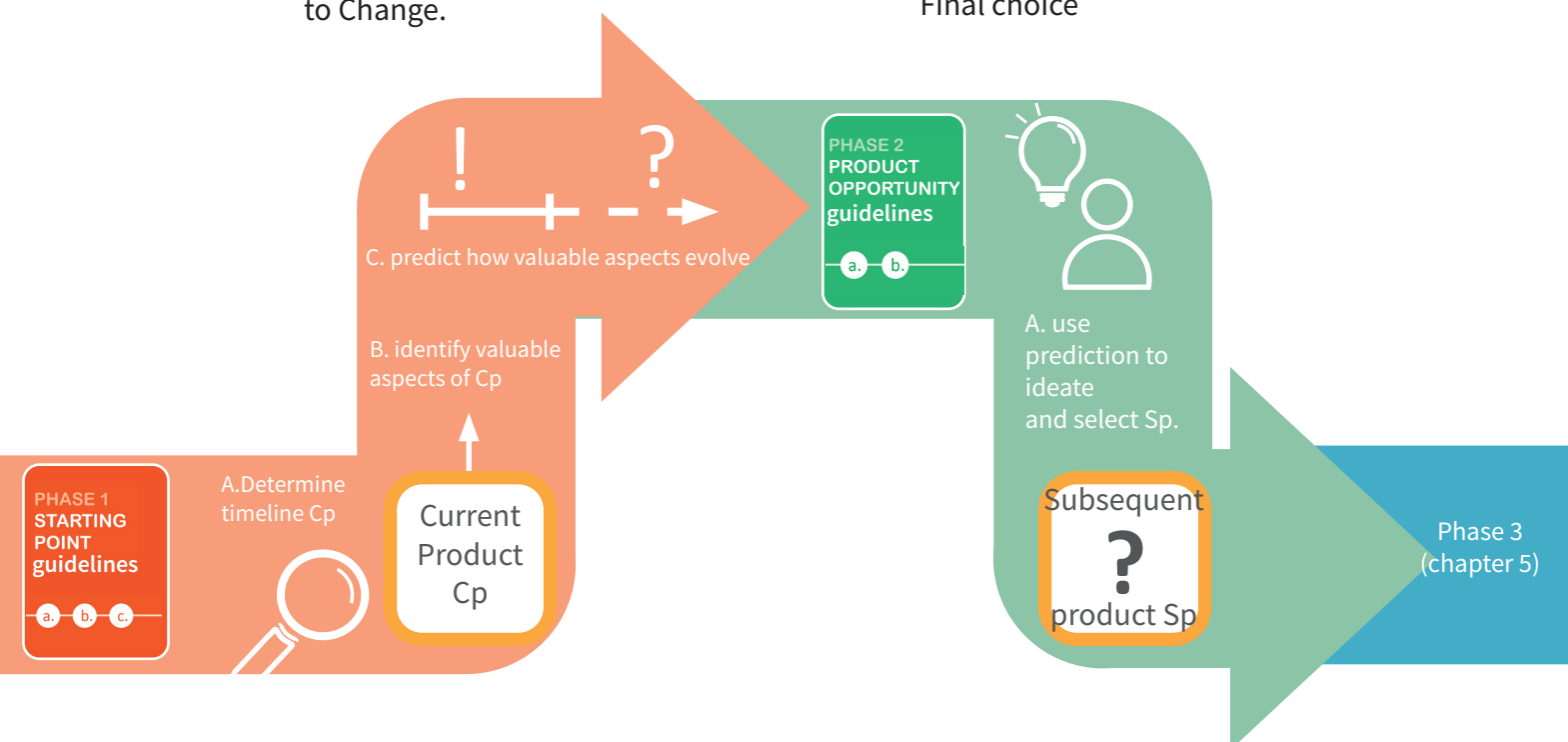


Figure 30. Illustration of the Process of guidelines phase 1 (red) and phase 2 (green)

4.3 Results of Phase 1

The various valuable aspects of the current product and for future product will be described in paragraph 4.3 which will eventually provide focus in a brainstorm for the subsequent product in paragraph 4.4.

GUIDELINE 1A.

KNOW WHEN TO CHANGE

Valuable aspects of the current's product timeline & marketing strategy

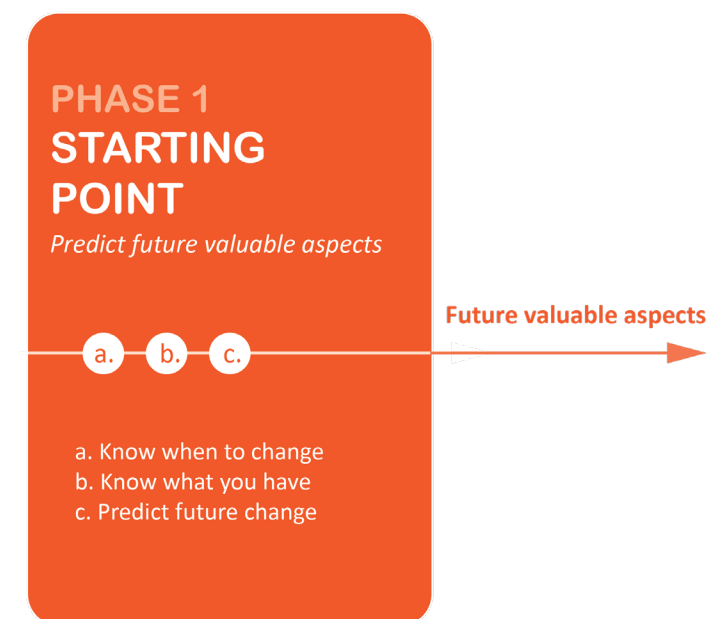


Figure 31. Overview of guidelines Phase 1

Product Lifecycles

In fig. 32 the different lifecycle phases of the current product is shown, which consists of a combination of market and benchmark research insights.

The current product has a typical linear process, in which the product is not in direct control of the company after sale.

A circular lifecycle has a different set of requirements. In this paragraph is described how the current product's valuable aspects evolve over time and how these might contribute to a future envisioned repurpose lifecycle for a subsequent product. The valuable aspects help to scope this Repurpose Project. The new strategy will be reflected upon in see chapter 6.

Project Scope

Marketing Strategy

A clear and familiar starting point is needed (see chapter 2 and 3) as Repurpose is a new terrain for most companies, increasing the investment costs and risks. The following marketing strategy is chosen to scope this design project: ‘Product Development’, a strategy in which “the company sells a new product to an existing customer” (see fig. 33.a). For Design for Repurpose this means the current product will be adapted for the same user, i.e. resulting in an extension of the current user connection.

Diversification, a marketing strategy in which a product is developed for a second user and or market, does provide a larger set of opportunities for subsequent products (see

figure 33.b and 33.c). However, this might mean to invest in researching a new market and/or user. So unless the company does not already have knowledge and skills for multiple markets, the marketing strategy ‘Product Development’ is the only familiar starting point.(van Boeijen, A.G.C., et. al. 2020 ,Rev. ed.).

Start of subsequent product usecycle

The following valuable aspects from current product’s usecycle determine the starting point for usecycle of the subsequent product (Mutsy, 2020a):

- The subsequent product should fit with the user 4 years after the stroller is bought as the stroller becomes obsolete after 4 year.
- The user group of the subsequent product is therefore: parents with a child of approximately 4 years old.

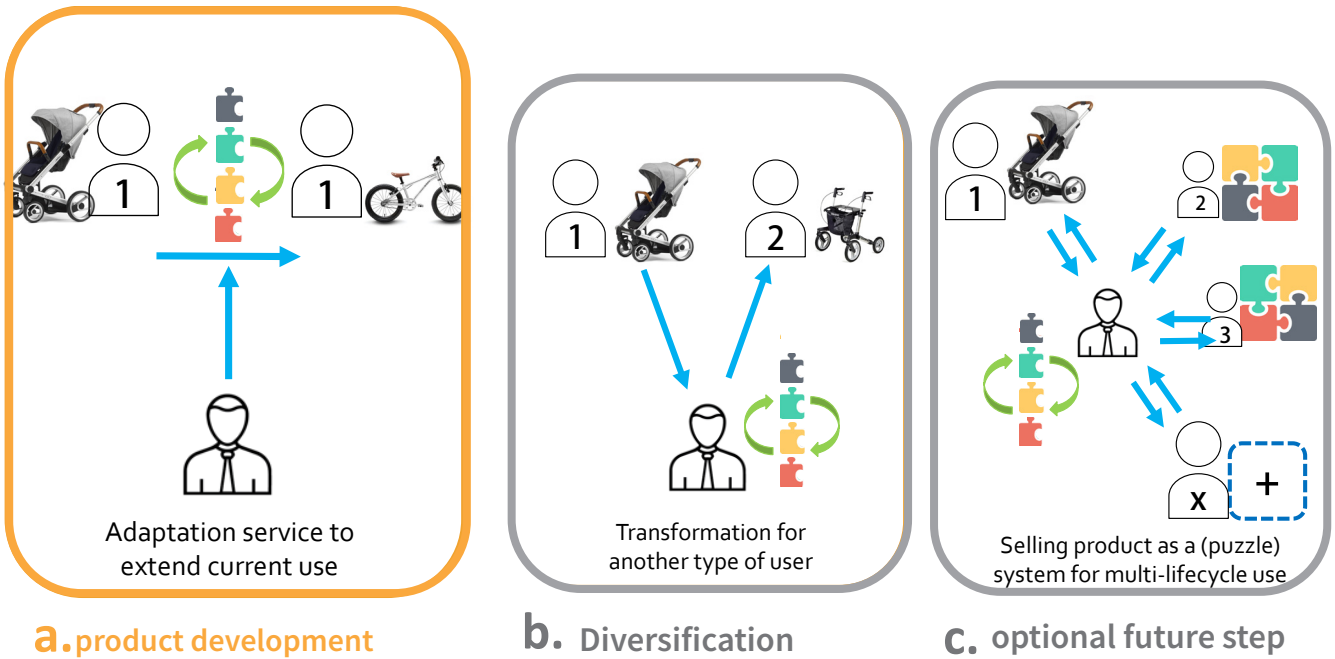


Figure 33. Chosen circular distribution model, i.e. marketing strategy a., to reduce the Design Projects’ scope. Legend:

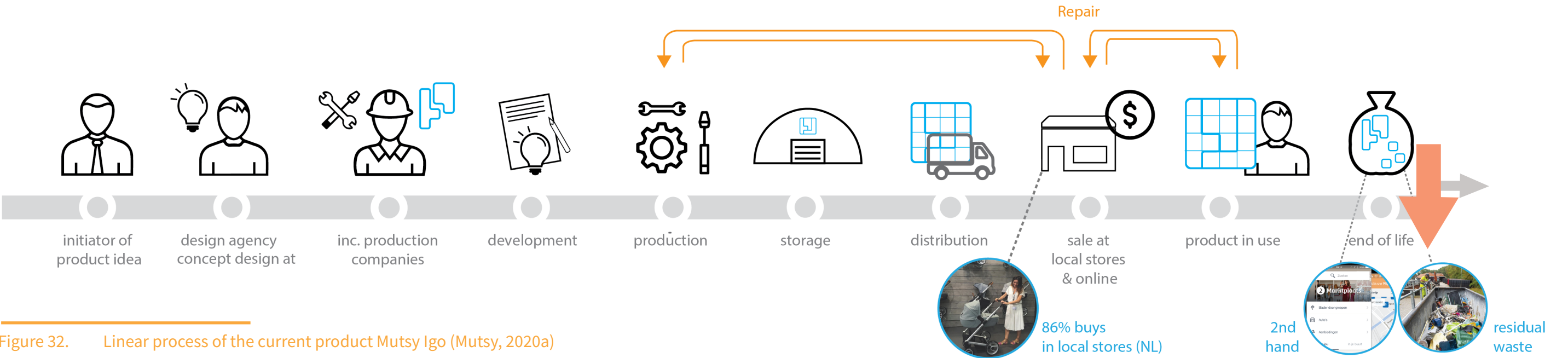


Figure 32. Linear process of the current product Mutsy Igo (Mutsy, 2020a)

Valuable Sale & EoL aspects

Some valuable aspects are found within the user and desk research which aren't yet included in the Design guidelines: within the transition current distribution channels which users value could be used for a product return (see fig. 32 and 34):

- Both subsequent products can be introduced at the same time in the store, as users like to try out products extensively before buying.
- Expert service within or around the store is highly valued by users, so product exchange at the product store or an exchange service through employees of the store is more logical than a rebuild toolkit which would require the users to reassemble the stroller themselves. This asks for more requirements, e.g. easy and safe reassembly. A service where the user can view reassembly altogether might not fit with a user who values safe products.
- At EoL most of the products end on a landfill and few are sold on the 2nd hand market (approximately 14%) (WIJ monitor, 2019). A careful first assumption can be made that the future circular market is not yet saturated by the 2nd hand market. From the conducted user interviews the main reason for selling became clear: apart from a few scratches the stroller works well so it still contains economic value users can get back. A careful conclusion is that willingness to return a package depends on the value users get in return.

GUIDELINE 1B.

KNOW WHAT YOU HAVE

Valuable brand, user and product aspects

Valuable brand aspect

Various research directions were performed, such as a brand analysis and a product and price benchmark on various brands (see price benchmark in the appendices) (WIJmonitor, 2019). It can be concluded that the current personality, purpose and positioning of Mutsy is valuable as it is long-lasting. Neutral colours and durable materials and shapes from approximately 10 years ago are still maintained in the newest product, with high sales figures (WIJmonitor, 2019) (also see chapter 5 use cycle analysis). **Brand preference, forms, colours and shapes** are the main attributes on which users choose their product. Users want to reflect their style and envisioned parenthood. In chapter 5 is tested if how and if these brand attributes can be maintained in the subsequent product.

The valuable brand aspects are used for the future trends prediction.

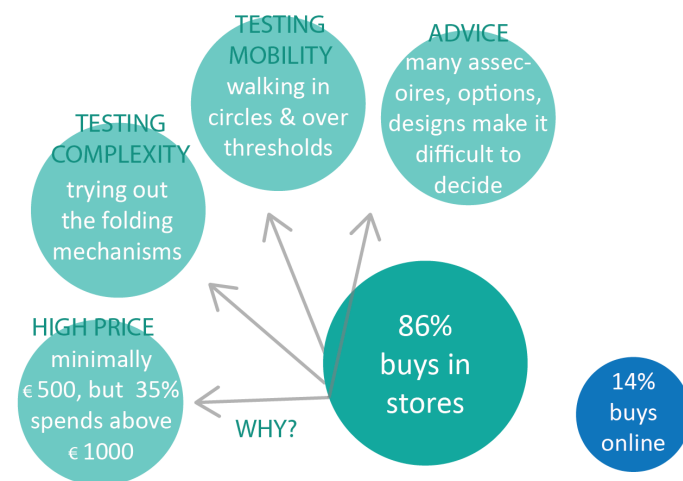


Figure 34. Data of Dutch parents buying strollers (2012 - 2017) (WIJmonitor, 2019)

Valuable product aspects: Functional Structure

By disassembly (see fig. 35) a function structure was created in which the most valuable functions & modules are highlighted. Fig. 36 shows the functional structure of the stroller's main system. This image shows the functionality, material element, the type of operation per part and the relation between these parts.

The functional structure is based on the methods "Lifecycle" & "Functional structure" (Roozenburg & Eekels, 1998) (TU Delft IO, z.d.).

Subsystems of the current product are also included in the function structure, see appendices)

The most valuable functions in this system are: **carrying, keeping the baby in one place, folding in and out, mobility** (rolling/moving), and pushing (portability). The corresponding product parts are **Seat/Carrier, the Push Bar the Bottom Frame, and a Large Hinge**.

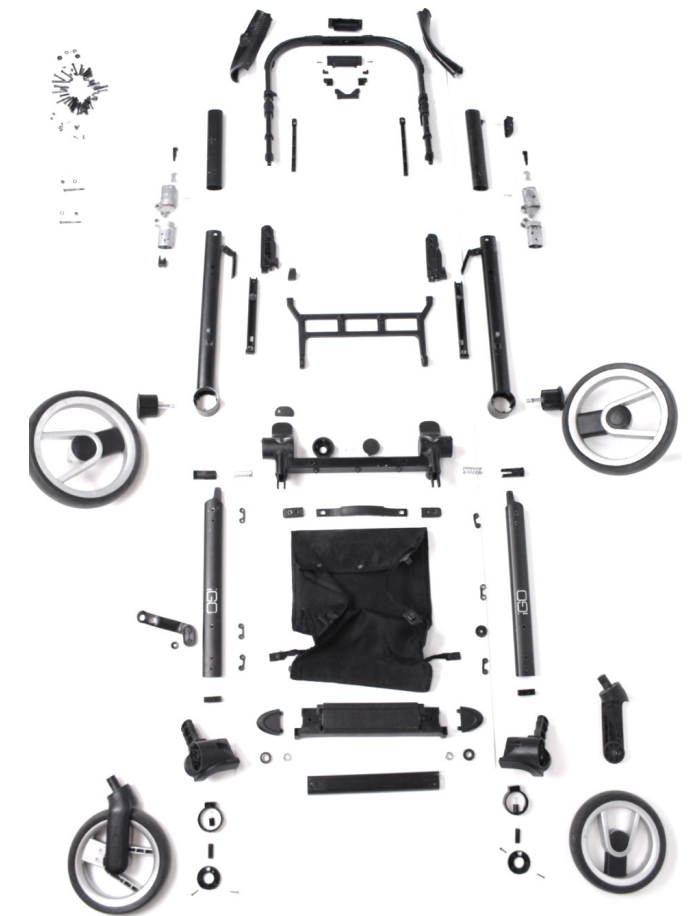


Figure 35. Frame disassembly used to create a functional structure of the current product, see fig. 36 and chapter 5

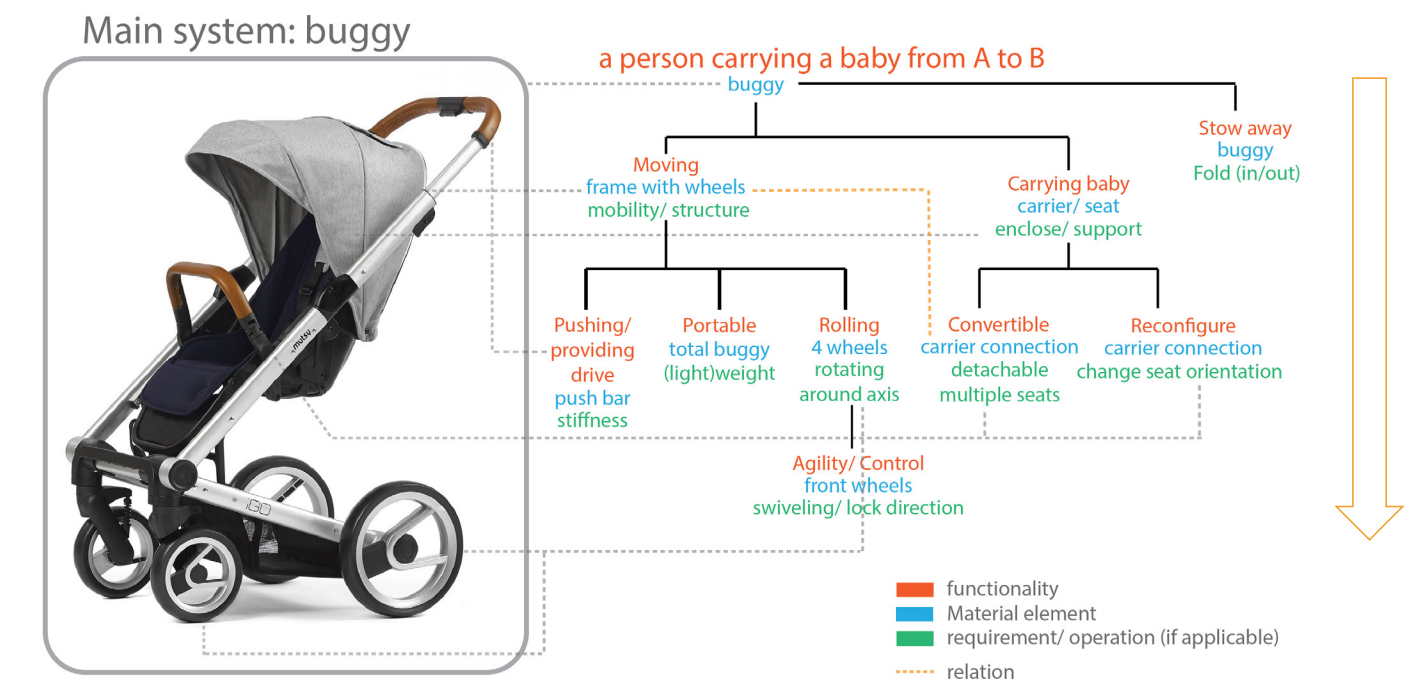


Figure 36. Functional structure of the main system of the current product (Amazon & Mutsy, 2019)

Valuable user aspects

Online desk research (following vlogs , blogs, social media and forums) and a user survey were conducted, leading to:

- personas reflecting 2 user types
- set of user scenarios and trends

This includes an understanding of the users’ experience with the stroller and related products (see appendices for the personas) (see fig. 37).

The most important user values in using this product with their baby are: **taking care, giving comfort, keeping safe, having relaxed and fun time and being mobile.**

Managing activities and care can be a challenge. However, as the babies grow older round the clock feeding and care is not necessary anymore leaving more time for play and fun activities. Still, managing products, time and planning is demanding, which makes **“ease of use” and “mobility”** important product aspects. Parents are very involved in doing **fun activities** and their **child’s learning process**. This is especially the case during the next big life event: the baby’s first school, which happens at the time of C1’s EoL (see fig. 38).

The above aspects of this **life event** and the users’ strong **emotional involvement** are important valuable aspects in the search for a subsequent product.

GUIDELINE 1C.
PREDICT FUTURE CHANGE

- Give guidance in brainstorm for future product opportunities

Future prediction

The valuable user, brand and product experience aspects were combined in a set of trends. The method Trend Foresights (Boeijen et al., 2014) was used to create 3 future trends, taking place at the subsequent product use cycle (see fig.38):

- Save & healthy care
- Practical tools
- Serious play

Collages were made of the future user trends and corresponding future user scenarios and needs. This is used as a starting point in brainstorming for future product opportunities.

It would be a pre if the subsequent product supports the most important future valuable aspects which are that users want to spend **relaxed and fun offline time together and want practical tools**, as a counterpart to busy lives.



Figure 37. User data from youtube vlogs reflect the main concerns parents have during the first 4 years of bringing up a baby: doing fun activities together with family and friends and spending time on round the clock. (Global Baby, 2016, 03:15–05:21) (DE BELLINGAs, 2018, 03:15–05:21) (Travel Mama Anna Von, 2017, 03:15–05:21)(But First, Coffee, 2018, 03:15–05:21)(Sannie Verhoeven, 2018, 03:15–05:21)(Emily Faith, 2019, 03:15–05:21)(Morgan Bylund, 2019, 03:15–05:21)

Figure 38. The predicted future trends and activities during the subsequent product’s usecycle (totalwomenscycling, 2014) (twitter, 2017) (active-walker, 2020) (Mercure, 2020)

4.4 Results Phase 2

GUIDELINE 2

‘SEARCH AREA’ BRAINSTORM

In this paragraph the starting point is explored by use of the search areas to find new product ideas of the subsequent product (see fig. 39).



Figure 39. Overview of guidelines Phase 2

Idea generation

The insights from Guidelines Part 1 and the search areas were used as input in the following 3 brainstorms:

1. Brainstorm by future trends, scenarios and needs
2. Brainstorm based on the functional structure.
3. Tinkering by disassembling the Mutsy stroller by hand (see fig. 40 and 41)

The future valuable aspects correspond most with the following search areas :

- Time bounded users
- Emotional band
- Similarities in functionality.

As the 'search areas' were already known before phase 1, they provided focus and inspiration for finding the most valuable aspects. The three brainstorms were all helpful in creating new product ideas. Tinkering by hand created most flow in the process as one can 'build' and 'tweak with' new product ideas right away. Using a specific technique can be determined by preference.

Idea selection

A large set of ideas was generated. First the ideas were quickly classified based on how many parts and modules were corresponding with the Mutsy stroller. Some parts, which for example included motoric elements, were not included in the selection because they are too different in economic value compared to the stroller. Ideas which did not classify in any of the future trends were excluded from the selection. After that the ideas in the top ten percent of the similarity classification are selected and evaluated by the "Weighted Objectives method" (see fig. 43) (van Boeijen, A.G.C., et. al. 2020 ,Rev. ed.).

Criteria for selection are chosen based on important search areas and guidelines. Emotional value for example is important because the experience of getting a baby creates a strong emotional connection. Applying the criteria: "same components", "construction behaviour" and "ease to assemble" reduces the design effort needed in applying the design guidelines part 3 "Design for Change".



Figure 40. One of the used methods which helped the brainstorm was Tinkering by hand



Figure 41. One of the used methods which helped the brainstorm was Tinkering by hand



+	+	++	+	-	+	+	0	+	9
+	-	+	++	+	+	+	++	0	8
-	+	-	++	++	+	+	-	-	2
++	0	+	+	0	+	0	++	-	6
+	-	+	0	-	++	0	++	+	5
0	0	-	++	+	+	++	-	-	3
++	0	+	++	++	++	++	+	-	10
+	0	+	++	++	++	++	0	-	9
user need at EoL	same economic value	same emotional value	same components	same construction behavior	Ease to assemble	practical tools	serious play	Save & healthy care	Total

(Handicare Rollators, 2020) (Pinterest Erna Uys collection, z.d.) (Decathlon, 2020b)
(Decathlon Inesis, 2020) (M-wave, 2020) (ilovespeelgoed, 2020) (The Boba G3 Carrier, 2013)
(Ikea LT, 2020)

Final idea choice

The final selected idea is a handcart (see fig.44). Although this product does not have exactly the same economic value, it seems to be used way more frequently than the other high scoring concepts as it is often mentioned within user research (both the survey as online desk research).

This handcart has the highest score within the Weighted Objectives table: mainly it has many similar components, a similar construction and fits with the emotional product experience of the current product. There is strong and logical connection between the subsequent products, as the handcart fulfils a part of the valuable aspects the stroller has, its use is focused on a more independent child and the activities a user is more likely to do after current product’s EoL.

The most important valuable aspects of this product are:

- Spending relaxed and fun offline time together
- Practical tools:
 - Being mobile
 - Carrying stuff/ keeping the child in one place
 - The potential to fold the product in and out

The handcart consists of similar parts as the stroller. The handcart, seen in an abstract way, consists of simple geometric shapes, so various embodiment solutions might be possible. In chapter 5, a redesign is made of the subsequent products to find the best embodiment design solution which makes part exchange possible.

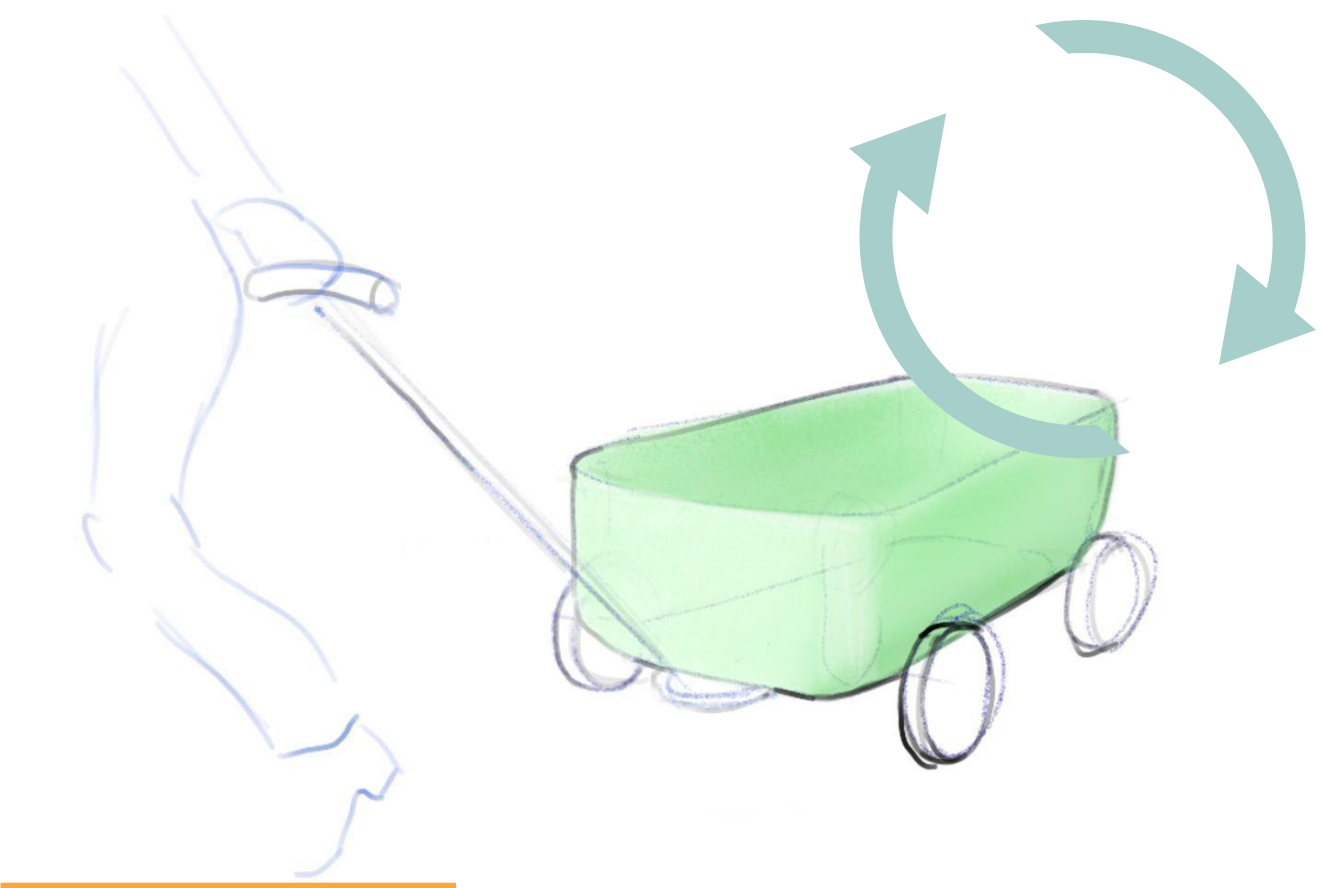


Figure 44. The found product opportunity for the subsequent product a handcart

5

DESIGN CASE PHASE 3: DESIGN FOR CHANGE

Testing phase 3 of the guidelines in practice with a case study of Mutsy strollers: increasing efficiency and effectiveness during product transition.

5.1 Introduction

In this chapter, Phase 3 (“Design for Change”) of the Design for Repurpose approach is tested (see fig. 68 and 45). The “Design for Change” guidelines focus on designing in such a way that components can be exchanged between two products and therefore improve Repurposability of the first product. This chapter reports on applying the Design Guidelines in practice showing the steps of the design process. Ultimately, the chapter provides an answer to one of the main research questions:

Is the Repurposability Rate improved by applying the Design Guidelines Part 3: Design for Change?

The starting point for this chapter is the Mutsy Stroller case, earlier described in chapter 4. The second product opportunity (the handcart) is found with applying the first part of the guidelines, described in chapter 4.

By using an existing stroller design the difference between the “traditional practice of product design” and the new Design Guidelines can be illustrated and reflected upon. The difference can be calculated by means of the Repurposability Rate with the expectation that Design for Change improves Repurposability.

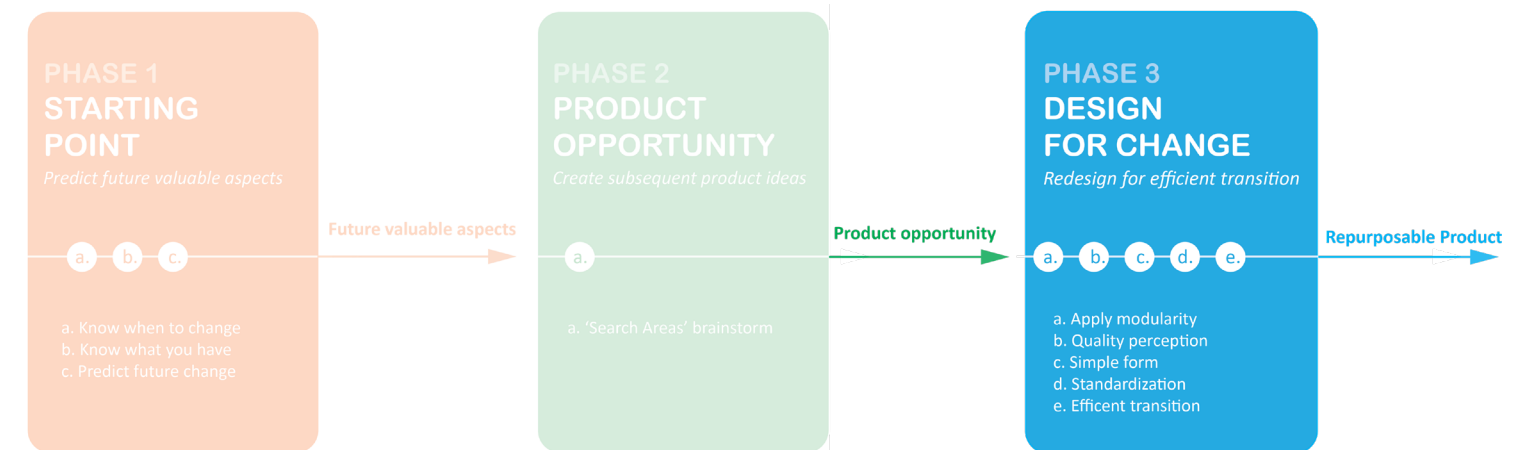


Figure 45. This chapter tests Phase 3 of the design guidelines. The image shows an overview of all the phases of the design guidelines, with Phase 3 highlighted.

5.2 Design Case Approach

Design process

This chapter shows first which minimal steps are necessary to enable a functioning second product. The guidelines are applied to test if and how the Mutsy stroller can be transformed to a handcart. By applying various design methods and prototyping techniques is found out which design steps are necessary to apply the guidelines. In chapter 6 is shortly evaluated if these methods are effective.

Within this case, there were no old information and 3D files available of the product. Therefore a first analysis had to be made of the construction and lifetime, which was done through obtaining two second-hand Mutsy Igo strollers, respectively from 2010 and 2014. The advantage of taking an existing stroller design is that the approach in this chapter can focus on applying and testing the guidelines instead of designing a whole stroller.

The following steps are applied:

1. Finding reusable components and functions through decomposition of the second hand stroller and analysing:
 - The functional structure at system level: highlighting valuable functions on valuable components/ modules
 - Product Modularity current and future product
 - Main corresponding functional modules
 - Possibility to dis- and re-assemble
 - use-cycle analysis
2. Various iterations of Rapid Prototyping to: Explore and improve the reusability of parts and applying the guidelines
3. Calculating the Repurposability factor

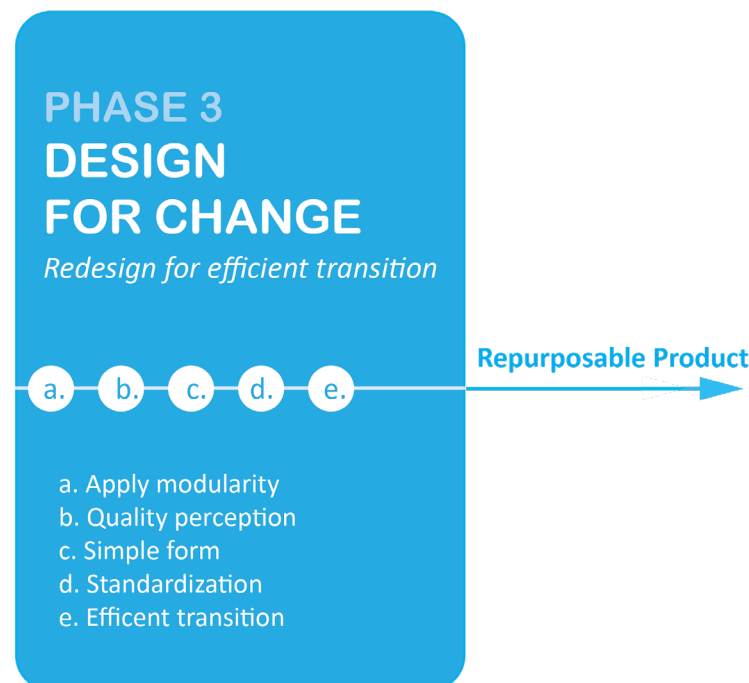


Figure 46. a. (left page) and b. (right page): The “Design for Change” guidelines are tested by redesigning the Mutsy Igo stroller with the aim to make its parts reusable in the handcart, the found product opportunity of chapter 4: a handcart. (Amazon & Mutsy, 2019)

Aim: Repurposability factor

Quantitative research is conducted to understand what the effect is of the applied ‘Design for Change’ guidelines on the product’s Repurposability Rate. A Repurposability Rate is calculated based on the result (product analysis and redesign) of the Design Case’s product: the “Mutsy Igo” stroller. At the end of this chapter the calculations are further explained. To conclude on the effectiveness of the ‘Design for Change’ guidelines, the Repurposability Rate from before and after the Redesign will be compared (see fig 68).

As defined in chapter 1, Design for Repurpose is defined as “reusing parts from a product for another product with a different function”. When looking at realistic reuse of product parts, there are not many mass production examples of repurposed products available, but there are examples of the recycling of cars: in 2017, 88 % of parts and materials, of scrapped passenger cars and light goods vehicles was recycled (ec.europa, 2020).

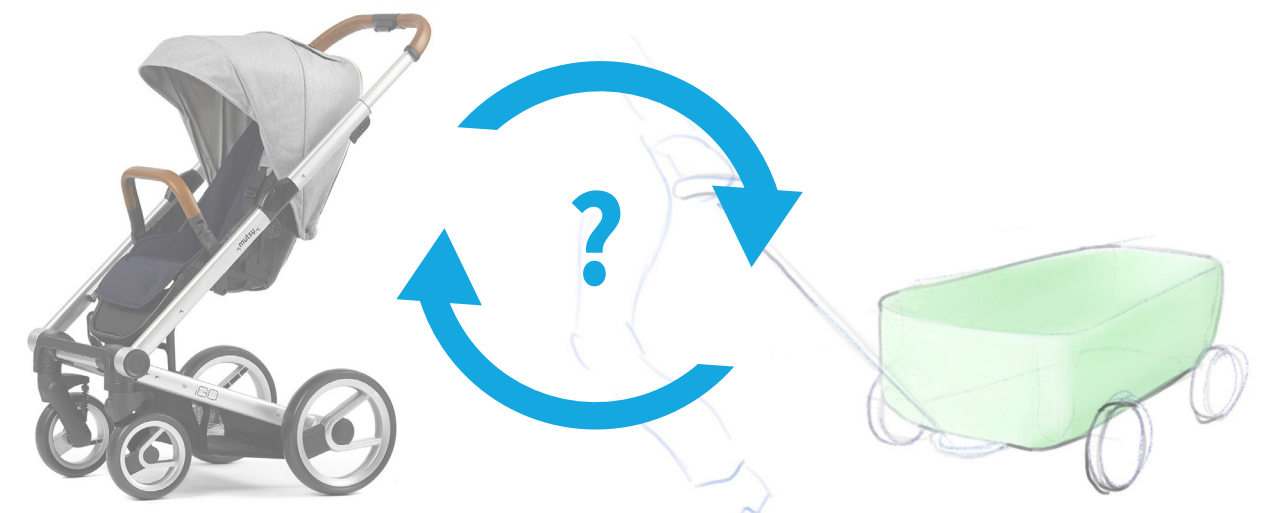
To efficiently come to a repurposed product in this Design Case in the limited available time, a target is set to redesign 80% of the stroller. The purpose of this study is not to reach this target per se but to see if significant benefits can be achieved by applying the Design for Change guidelines.

This would be a positive outcome of the test, showing that the guidelines work as intended, however since the design guidelines and approach are tested for the first time, necessary improvements are expected.

Table of the Repurposability factor

Table (see fig.69) shows the redesigned parts, grouped per module of the original stroller design.

Each part has a certain Repurposability Rate, indicating what percentage of a part can be directly reused in the subsequent product. Comparing the total product Repurposability Rate before and after the redesign shows what effect the “Design for Change” guidelines have on the product’s Repurposability.



5.3 Result 1 - Prototyping & Disassembly

Testing the guidelines in “Design for Change”

Functional decomposition & module division

The functional structure from chapter 4 is mapped with the functional structure of the hand card. Various hand cart models were analysed in a product benchmark (see fig. 47). Through quick construction: sketches corresponding functional modules were looked for. Through sketching (see fig. 48 and 49) similar modules were found within the stroller as the handcar: a Pull Bar, a Bottom (rolling) Frame, a carrier (box) and other tubes to support and fold the construction. This leads to the first prototype (see fig. 51)

Figure 47. A Jipfish stroller us for comparison with the stroller's functional structure and embodiment solutions (Jipfish, 2018)

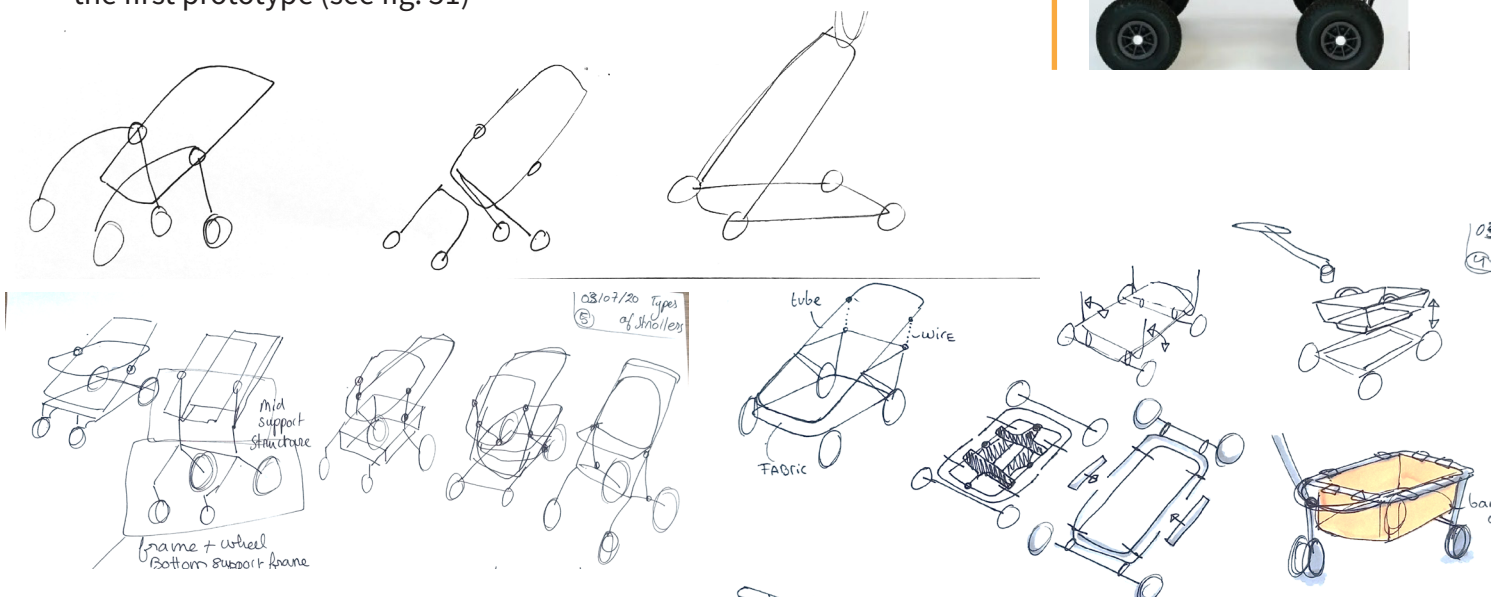


Figure 49. Various sketches to find matching embodiment solutions

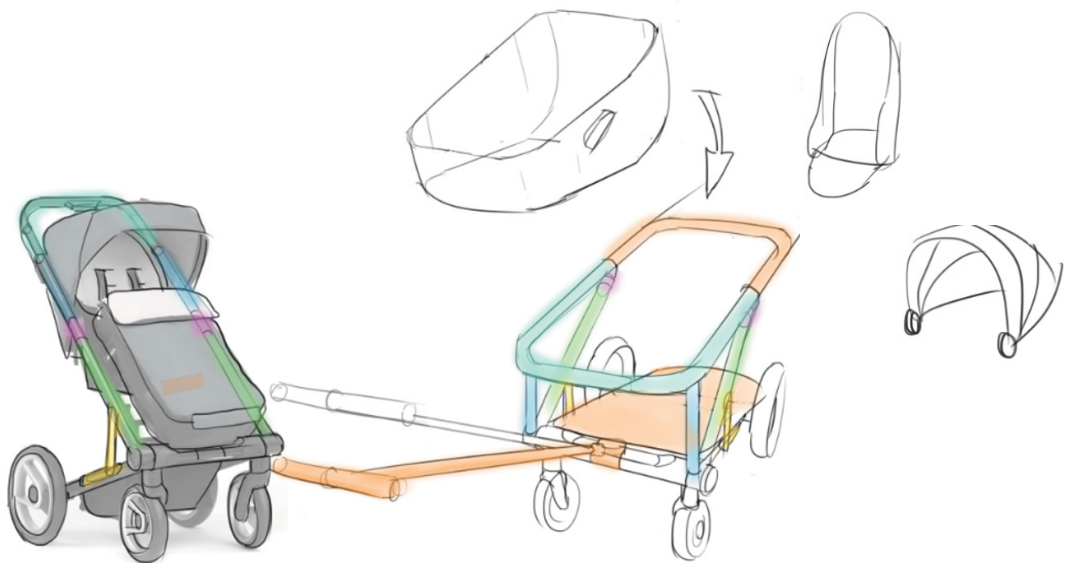
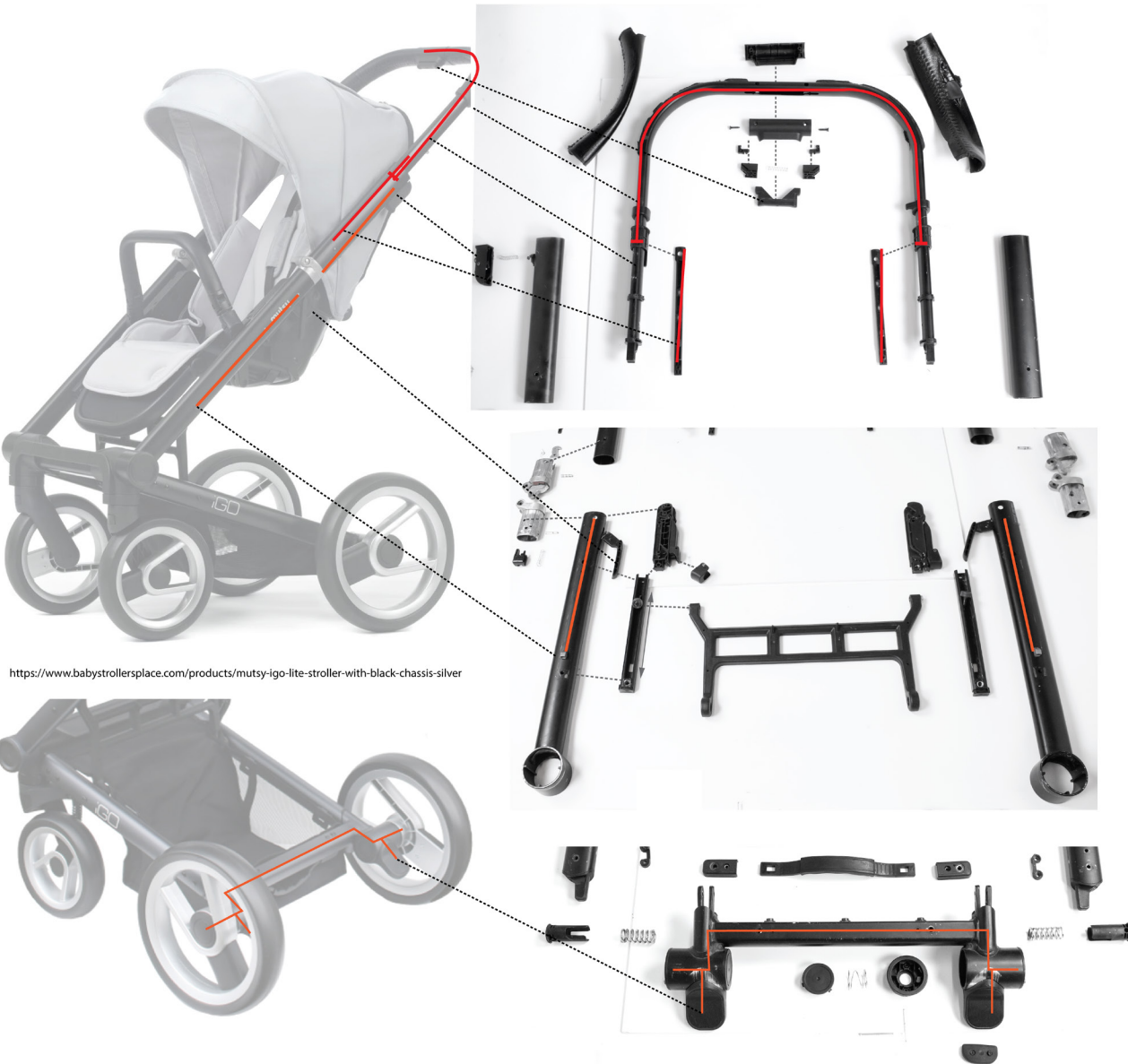


Figure 48. A first iteration of finding matches between modules



Product disassembly and analysis of modularity

By disassembling the stroller steps where found which made it difficult to dis- and re-assemble, such as welded rivets, many screws which had to be drilled out and internal connections between various modules and parts. A definition of modularity was discovered through the axiomatic design method (Gu et al., 2004, p. 541) (Suh, 1998, p. 202) (Suh, 1998, p. 202)

Figure 50. Analysed internal connections to see which modules and components prevent modularity in the current product (Mutsy & babystrollersplace, 2020)

(Gershenson et al., 2003, p. 298) (see fig. 50), which helped to further understand the balance between the amount of modules and connections within a construction, based on the functional requirements of a product. (Vezzoli & Springer, London, 2018, p. 193)(ceguide, 2018)

Redesign by prototyping

The next step is to use the previously found match between functionalities of both products. Through iterative rapid prototyping iterations the transition & reusability of parts were explored. A prototyping plan was made based on the ID-cards methods (Loughborough University Design School & MIT, z.d.).

Various prototypes were made in the following order:

1. Finding the modules through a quick and dirty prototypes with foam and toothpicks (see fig. 51)
2. Check if the first idea of modules and reassembly is correct in a 3D model and perform a few new found module iterations in 3D (see fig. 51).
3. A few simple redesigned connection modules/ components were printed and used to reassemble a second hand stroller into a hand cart (see fig. 52) This serves as a proof of concept: a few key components can be used to

reassemble the stroller components into a handcart and back. Method used: 'functional model' and 'assembly model' (Loughborough University Design School & MIT, z.d.). (Roozenburg & Eekels, 1998) (Boeijen et al., 2014) (van Boeijen, A.G.C., et. al. 2020, Rev. ed.) (Suh, 1998, p. 202) (Gu et al., 2004, p. 541) (Gershenson et al., 2004, p. 46) (Gershenson et al., 2003, p. 298)

4. Redesign of a few main elements to show how these key elements need to change by 3D printing (see fig. 53). Prototyping method determined with 'Design development model' (Loughborough University Design School & MIT, z.d.).
5. Further detailing and optimizing through iterations by applying the Design for Change guidelines on the whole product in a 3D model.



Figure 52. Proof of concept: a few key components can be used to reassemble the stroller components into a handcart and back.

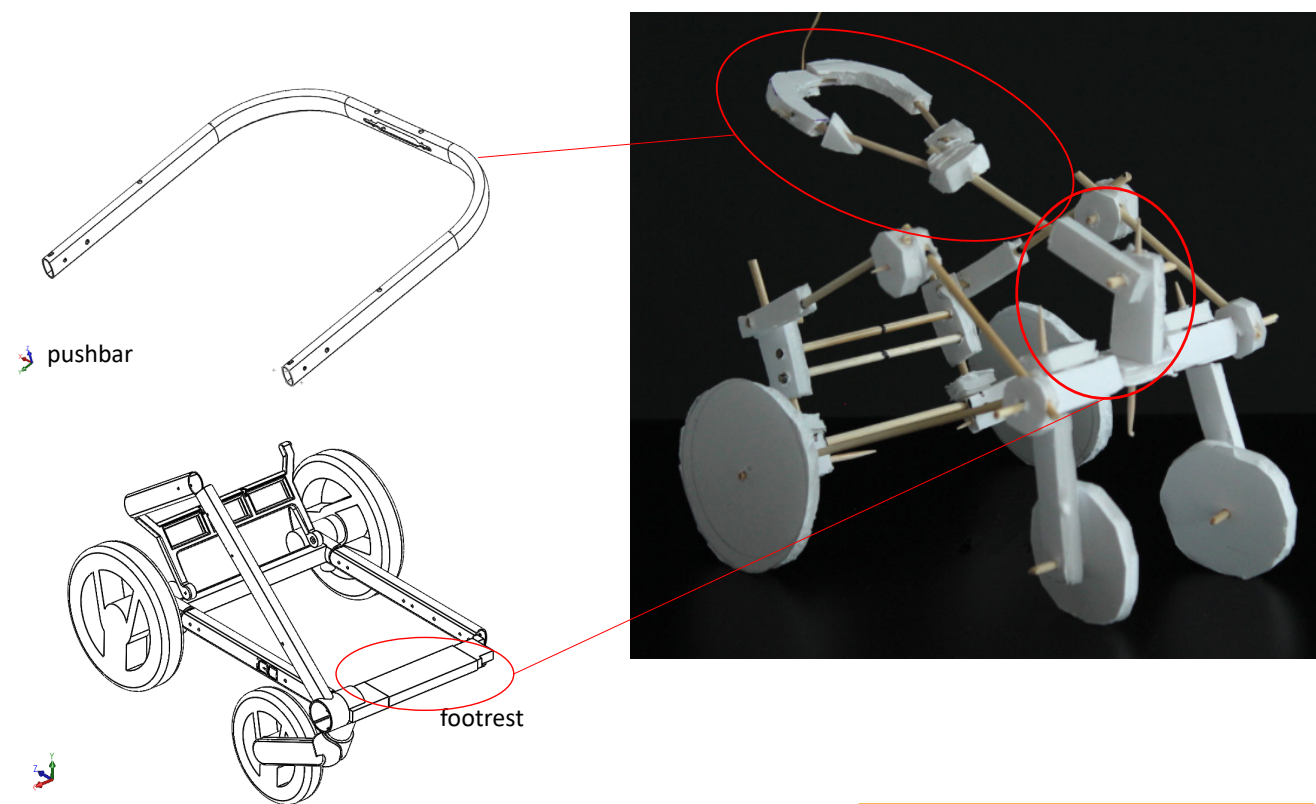


Figure 51. Finding modules - iterations through the use of quick prototyping and 3D modelling

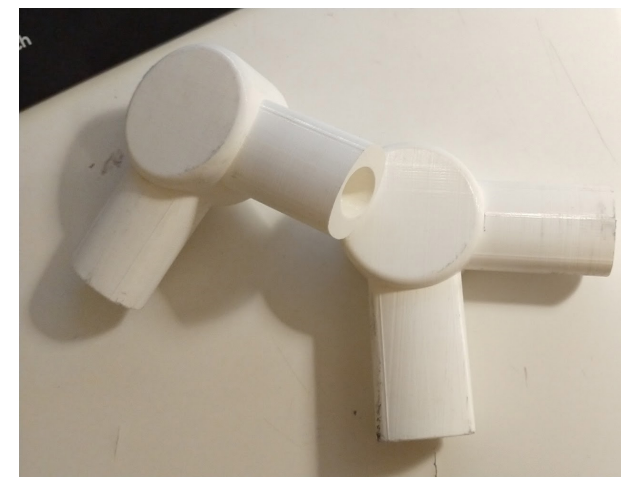


Figure 53. Development of key components for the reassembly from a stroller into a handcart and vice versa

Use-cycle analysis:

A use-cycle analysis is done to find out if components are durable enough for reuse (close to new) after one use cycle. When parts are not durable enough, an extra redesign step is needed. The durability is determined by observation and production knowledge use cycle lifetime analysis of each type of produced part. (Tempelman et al., 2014) (Thompson, 2007).

In the table fig. 56 the use-cycle lifetime is described per production techniques used in the various components. The percentage of reusable components is based on the analysis of 2 strollers. Stroller A is from 2012 and stroller B is from 2014 (a sticker on the products showed a year). Both strollers are expected to have had 2 use cycles, since one use cycle has a maximum of 4 years (see market analysis in chapter 4).

Damage per component-material type per stroller is noted in the below table. The table shows if additional steps are needed before the reuse phase. A prediction of the lifetime is made, based on the state of the strollers:

see fig 56 and the legend:

- **LOW**= lasts one use cycle or less, has significant wear. Sustains major damage or quality cannot be guaranteed after one use cycle. A redesign (RD) is needed if the component is reused more than one lifecycle.
- **MEDIUM** = completes one use cycle with some damage, might be suitable for multiple use cycles. Sustains some damage during normal use, excessive use might cause failure/out-of-spec performance.
- **HIGH** = lasts more than one lifecycle with minimal to no wear. Is difficult to break by users, does not sustain damage or only minor.

Stroller A is kept in a much better condition than stroller B. This shows there is a certain insecurity with predicting the stroller component’s lifetime. Therefore, the products need to go through quality control after return.

Conclusion

According to this analysis the stroller can be used minimally for 2 use-cycles before some wear is starting to show. The fabrics, basket, imitation leather and the positioning component might need to be replaced after 1 use-cycle already. These need a redesign first. The plastic rain covers, and tires should be made from a more resilient material, but the shape can stay the same considering merely the use-cycle analysis. The metal tubes need a different finish to reduce visible wear. See next overview of outcome per part in table fig. 56.



Figure 55. Two examples of parts from the second hand strollers’ disassembly. The top image shows the still good quality part of the seat’s cap. The bottom image shows dirt which got stuck in a mechanical part of the seat.

Component type based on production technique	State stroller A	State stroller B	need for cleaning/ refurbishment/ replacing at transition	Prediction of 1 use cycle	Redesign step
metal tubes with a black finish	Dirt, minor scratches, where aluminum layer under black paint becomes visible	Dirt, larger scratches, where aluminum layer under black paint becomes visible	Cleaning. Scratches that occur might easily be refurbished/remanufactured, depending on the material finish	MEDIUM to HIGH – parts are still functioning after multiple use cycles in both strollers	(RD) Redesign: change to a more long-lasting finish, or the same finish as the base material.
Injection molded plastic with metal inserts	Dirt, some difficult to see scratches	Dirt, some difficult to see scratches	Cleaning	HIGH – parts are still functioning after multiple use cycles in both strollers	No redesign to improve quality over lifetime
Injection molded plastic positioning components & buttons	Dirt	Dirt in between the mechanisms causes reduced ease of use	Intense cleaning	MEDIUM to HIGH - apart from dirt, parts are long—lasting	No redesign to improve quality over lifetime
Injection molded plastic fastener	Dirt	A crack	Minor cleaning or replaced when broken	LOW - Might break within one use cycle	(RD) Redesign: a different shape or material to prevent breaking
Die-cast aluminum	Minor dirt	Minor dirt, difficult to see scratches	Minor cleaning	HIGH – parts are still functioning after multiple use cycles in both strollers	No redesign to improve quality over lifetime
Imitation leather	Damaged: worn	Damaged: worn, some parts of the imitation leather fell off.	Replace	LOW – in the current state the product doesn’t last one use cycle	(RD) Redesign: use of real leather or higher quality imitation leather.
Textile cushions and covers	Minor stains on the fabric	Colors are faded, stains on the fabric	Depending on how the user deals with the product: cleansing or replace	LOW to MEDIUM	(RD) Redesign: use of long-lasting colors. A stronger/ more resilient type of fabric which stains less quickly
Plastic rain covers	As good as new	Colored stains in the plastic	Depending on how the user deals with the product: cleansing or replace	LOW to MEDIUM	(RD) Redesign: Use of a plastic which does not stain.
Tires (rubber or air tires)	Foam tires have visible wear and have become more flat. Some air tires have a leak.	“	Cleanse or possibly replace	MEDIUM to LONG Air tires are less long-lasting than foam tires, but have more visible wear.	(RD) Redesign: Use of a plastic which does not stain.
Basket Polyester fabrics and a PTU board inside	Not present	Some broken connection points, is partly worn.	replace	MEDIUM Fabric basket connections and material aren’t long lasting	(RD) Redesign: The basket should be designed with more durable shape/materials

Figure 56. use cycle lifetime analysis of each type of produced part. (Tempelman et al., 2014) (Thompson, 2007)

5.4 Result 2 - the Guidelines Applied

Main Redesign Changes

Applying the guidelines led to the following main redesign steps and increased reusability. Before redesigning a 3D model was made of the current product, see fig. 57)

- Various modules became reusable in one go (see green parts in the hand cart) except for a few additional parts (see purple parts in the hand cart) and a few not reusable parts (see red parts in the stroller).
- Components could be standardized were necessary by:
 - Holes are reduced when these hindered necessary standardization of a component (when these holes were not necessary in the subsequent product, therefore reducing the components' value at transition). This was mainly possible by placing connections within generic connections or by replacing these connections with reversible fasteners.
 - Copying parts were functionality overlapped
 - Separating specific components into basic geometrical shapes and including new connections
 - Creating generic parts with an adaptable core (generic connections) could be applied in different locations/ situations/context within each product and in both subsequent products.
- Sometimes specific parts have a large value in one of the subsequent products. Simplifying parts should not be the end goal.
- Adding and removing parts seems to be inevitable, but these can be reduced in size by applying the guidelines.
 - A few functional parts are necessary in the subsequent product, because functions don't overlap, such as buttons to adjust the push bar's height and the sliders.
 - A few connection modules needed to be added because several tube lengths were not identical within the subsequent products. This shows that dimensions and sizes are the most difficult to match up between subsequent products, but when parts are standardized, smaller connection modules or components with generic interfaces can be added instead of replacing larger components or modules with new components or modules.
- Between main modules the connections should be as simple as possible. Applying simplification over the whole construction makes it easier for designers to create reusable modules. A product-benchmark can be done for both subsequent products, to find simple construction solutions.
- Some parts which are not necessary anymore or parts which need to be added at the moment of transition, are not hindering other functionalities in the subsequent or previous product. It is assumed that it is better to keep these parts in the other product, because this reduces extra re-assembly steps and production or new parts.

- In the end, the parts which are most replaced at transition are the interface/ connection parts, which are also the smallest parts. Therefore, applying the guidelines lead to a reduction of material to be replaced at the moment of transition.
- On system level, one module consisting of several parts was redesigned consisting of several parts, in order to have a higher level of reuse of other parts, leading to a higher Repurposability Factor. This was done through: redesign of the push bar, repositioning of the slider, leaving out the internal complex wire construction, repositioning the seat connectors, leaving out hooks which leads to more generic parts

Not included in the Redesign:

Several parts are not taken into account in the redesign, so require extra attention in future iterations.:

- The design guidelines were not applied on the foot muff and rain covers due to limitations in time in the project. Recommended is to prototype these to find if the right dimensions can be found for both products. The foot muff could be applied in the basket of the hand cart for comfort but needs to become larger. The question is if changing the foot muff really weighs out the benefits of comfort. The rain covers should become more geometrical to fit in the hand cart as side covers and should be separable in flat pieces of fabric.
- However, although the foot muff and the rain cover are not part of the

Legend, for fig 57,

- severe redesign
- direct reuse
- minor adjustments

This legend corresponds with the reusability table fig. 69.

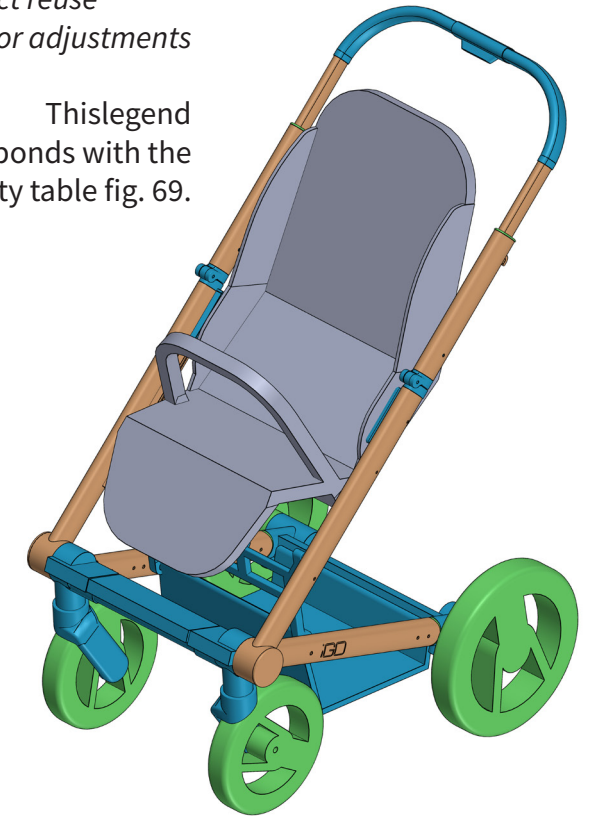


Figure 57. A made 3D model of the original stroller. The colour code shows the severity with which each part is redesigned (see conclusion at the end of this chapter).

new 3D model, it is considered that Redesign for Change is still possible. An assumption is made with respect of reusability. See the table of the Repurposability Factor (fig. 69 and 70).

- The design guidelines were also not applied on the seat and carrier (only on the connection module), because these might be reused another time because of the high quality. The fabrics used are of a very specific shape or have a small size and might not be usable for more than one use cycles. Also for these parts Redesign for Change is considered feasible and as such an assumption is made with respect of reusability (See the table of the Repurposability Factor). In case of redesign then several new interface parts can be developed which fit between the seat/hood module, the top frame tubes and the generic connection modules.

Redesign steps per guideline

The following pages discuss which main “Repurpose” problems were found and the redesign of the different modules and components per each “Design for Change Guideline. (see fig. 58 and 59 for execution of this guideline applied on the Design Case redesign)

GUIDELINE 3A.

Apply modularity

- Main function is grouped in a module
- Shared functions (between products) are grouped in a module
- Connections (modules) are made adaptable --> a generic module is used multiple times in the system
- Some non-reusable components/modules had to be redesigned to not interfere with reusable components/modules
- With the use of interfaces: updating of generic components does not mean updating the whole product: when the interface on the generic component side stays the same, the generic components can still be reused.

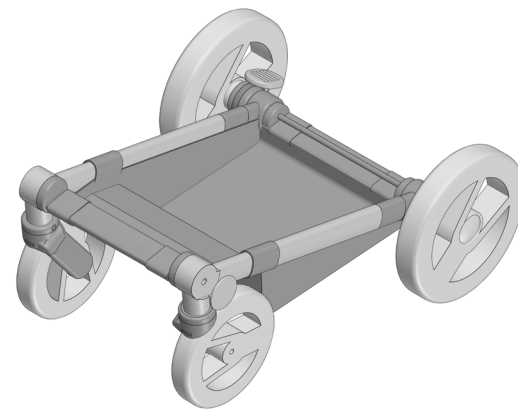


Figure 58. The main function “rolling” is grouped in 1 module and can be reused as a whole.

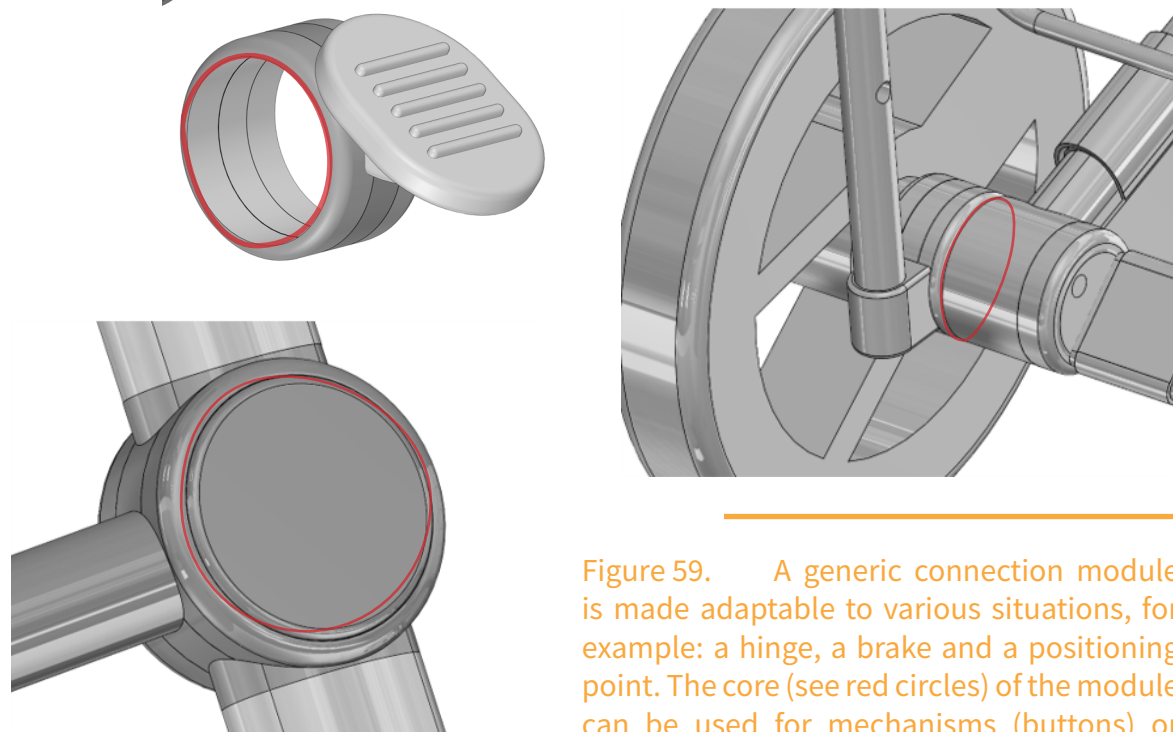


Figure 59. A generic connection module is made adaptable to various situations, for example: a hinge, a brake and a positioning point. The core (see red circles) of the module can be used for mechanisms (buttons) or positioning.

GUIDELINE 3B.

Simple form

- Amount of connections reduced between modules by applying generic connections
- Complexity moved within modules to simplify components (removed holes + specific shapes tubes)
- Specific/organic shapes were divided into geometric shapes to make them reusable
- Simple overall construction helps to reduce connection points between modules.

(see fig. 60 and 61 for execution of this guideline applied on the Design Case redesign)

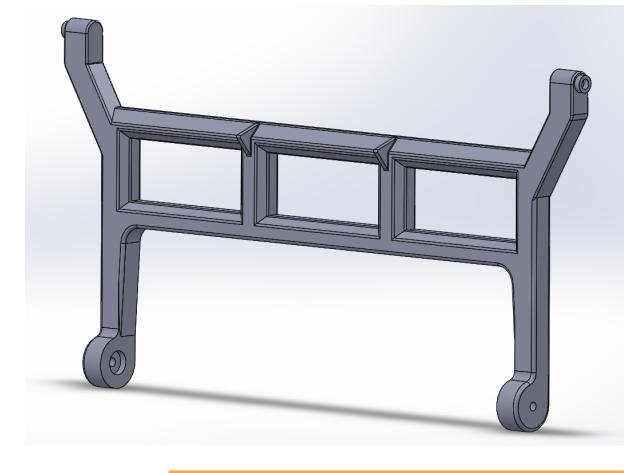


Figure 61. An specific shape in the stroller before redesign

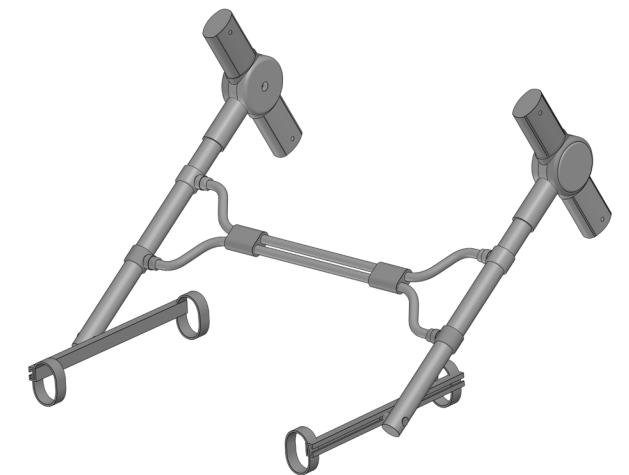


Figure 60. Organic shape before redesign becomes a module full of basic components are r the redesign, which can be seperately reused into the hand cart

GUIDELINE 3C. Standardization

- Specific shapes were divided into generic reusable component
- One type of interface connection module is created – which is repeated within the product, but can also be reused between modules
- 5 type of tubes are used, of which 2 types more often – the possibility to apply various interfaces on a generic connection module, enables use of various tubes. Standardization does not have to be applied through all parts for a product to be reusable.
- Applied guideline simple form increased the amount of generic components

(see fig. 62 for execution of this guideline applied on the Design Case redesign)

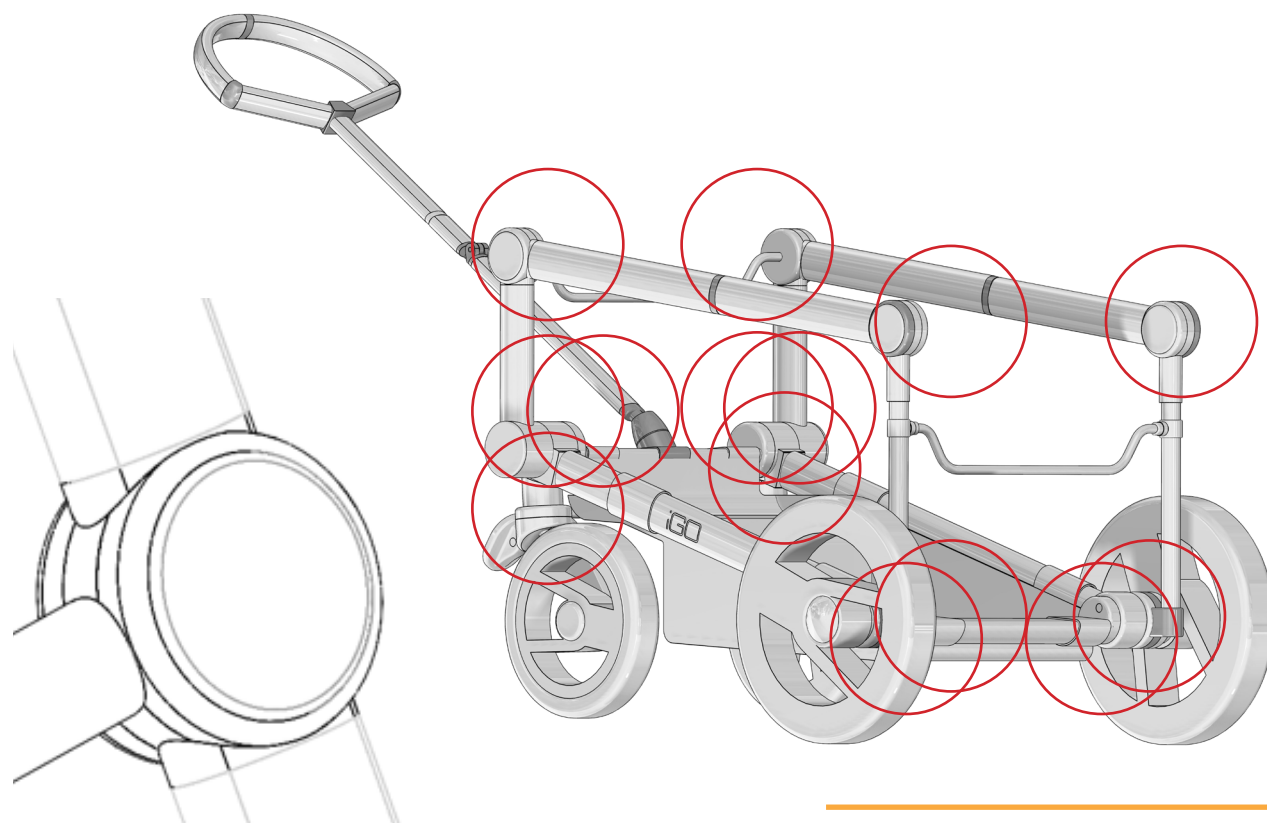


Figure 62. A generic connection module is repeated through the whole product

GUIDELINE 3D. Efficient transition

- Applying the other guidelines increased the ease of (dis)assembly and reduces the amount of irreversible production steps
- Increase the use of long-lasting materials and finishes to reduce the chance of component rejection (which would increase costs) during transition
- More detailed design for disassembly steps need to be assessed and improved in upcoming iterations: reducing complexity, high effort and amount of disassembly steps, applying generic tools and fasteners, building instruction steps into the product, use of irreversible fasteners, increase modules where there are reused groups).
- The ease of cleaning/ refurbishment of the product need to be assessed and improved in upcoming iterations.

(see fig. 63 and 64 for execution of this guideline applied on the Design Case redesign)

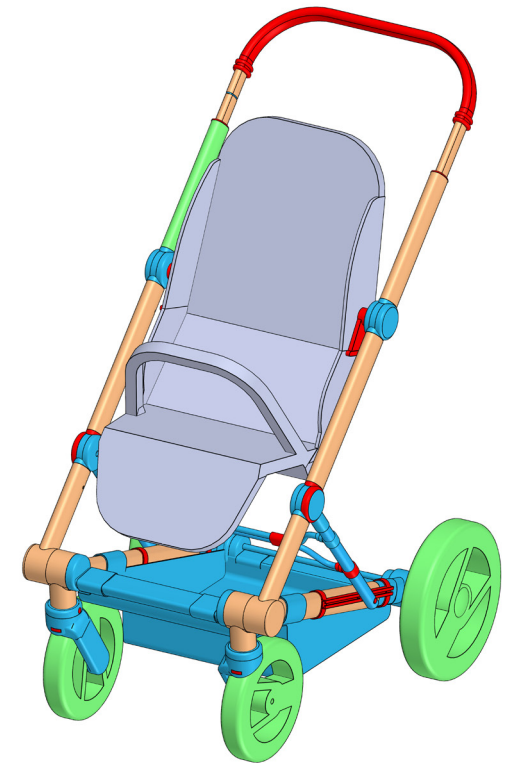


Figure 63. Dividing the product in separate modules increases part reusability. See legend with fig. 57, plus the non-reusable parts are coloured red



Figure 64. Many parts had to be broken or damaged for the disassembly of the Stroller before Redesign

GUIDELINE 3D.**Quality perception**

- Placed specific colours only on the more temporary parts: cushions, textiles, flexible interfaces within connections.
- Placed recognizable colours on the product to communicate the special repurposed appearance.
- Applied a material finish which shows less wear: aluminum coloured finish on aluminum components
- The already neutral long-lasting appearance, is retained.
- A new iteration is needed to increase some materials' use cycle lifetime, such as with textiles and rain-cover plastics.

(see fig. 65. for execution of this guideline applied on the Design Case redesign)



Figure 65. The applied neutral colours in the final design iteration to increase the chance on long-term use of durable parts. See the guideline quality perception.

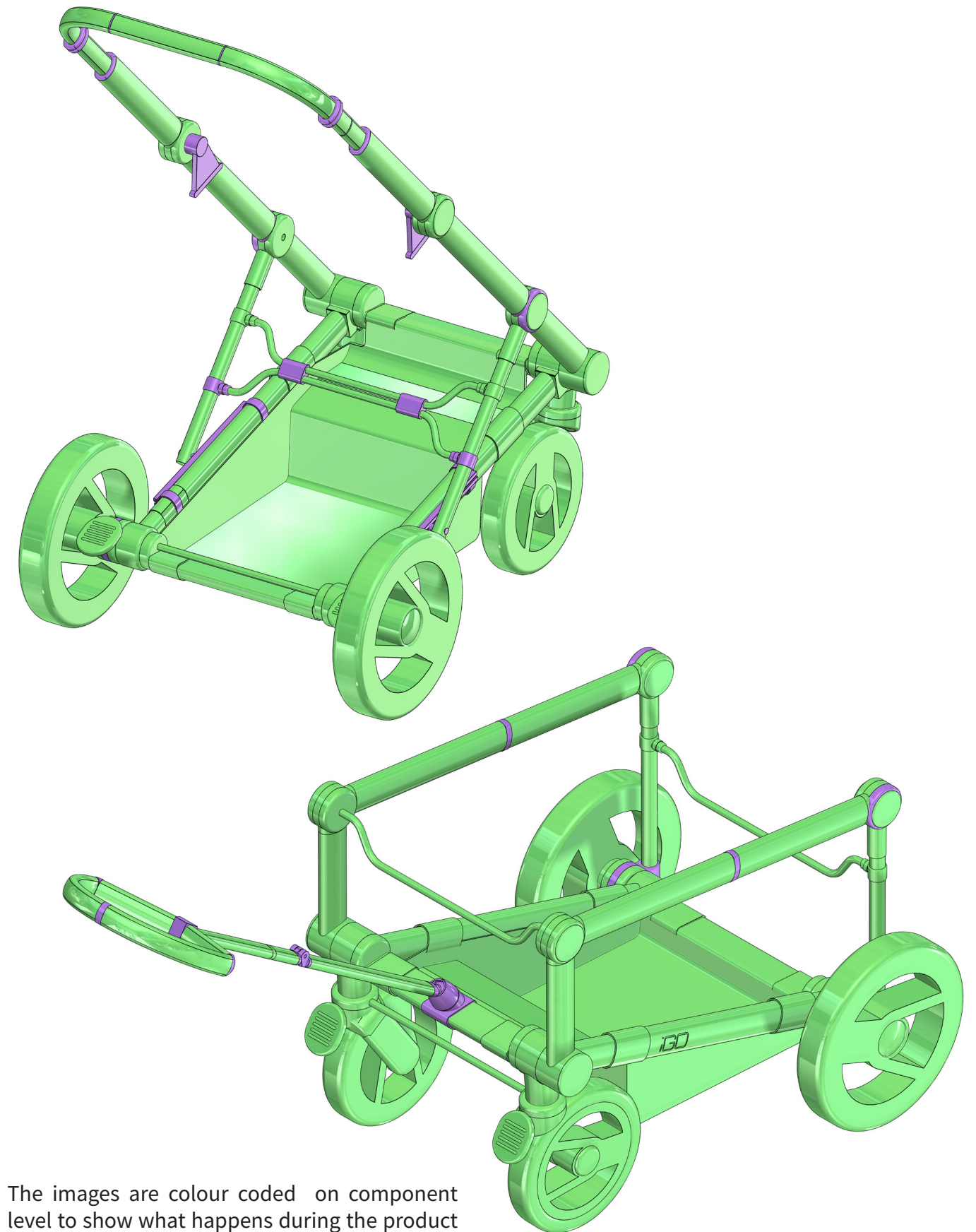
5.5 Conclusion - Repurposability Rate

Result of Redesign

By applying the guidelines specific redesign steps were applied to make product parts reusable. These are explained on the previous pages. On this page Figure 66 shows the complete redesign of the stroller and handcart. Figure 67 shows which parts are corresponding with the other product, which parts are not reusable and which parts need to be added to the handcart. This is reflected through the Repurposability Rate which is discussed on the subsequent pages.



Figure 66. Final stroller and handcart design, achieved by applying the “Design for Change” guidelines

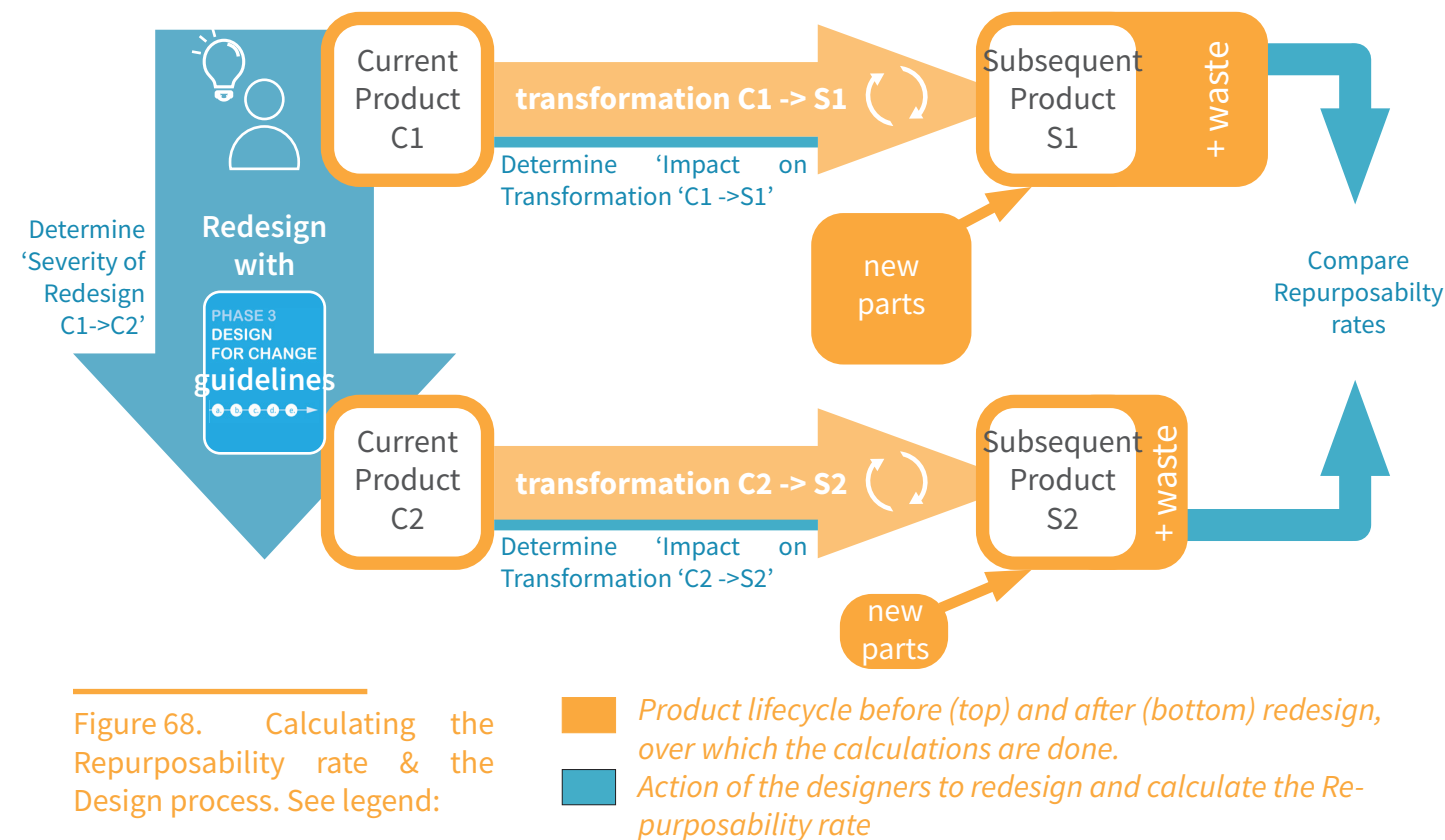


The images are colour coded on component level to show what happens during the product transition:

- - reused parts
- - non-reused and added parts

Figure 67. Showing the exchangeable parts of the current product (top image) to subsequent product (below image) over the transition after the design guidelines are applied

Approach: calculating the Repurposability rate



The Design Case consists of two starting points, as explained in fig. 68:

1. An existing product C1 that was designed without considering a Subsequent Product S1, in other words the Design Guidelines were not applied when realizing Product C1.
 2. An existing product C2 that was designed while taking into account a Subsequent Product S2 by applying the Design Guidelines when realizing Product C2.
- The effort it takes to design C2 should be extra 'investment', expressed as 'Severity of Redesign C1->C2'.

For each starting point (C1 and C2) the impact on transformation is determined to design the Subsequent Product.

The impact is expressed as 'Impact on Transformation C1->S1' and 'Impact on Transformation C2->S2'. For both trajectories, the Repurposability Rates are calculated for the whole Product and compared.

Apart from the difference in Repurposability Rate, it is likely that there is a difference in residual waste and amount of new parts that the subsequent Product requires. The more the Subsequent Product resembles the Current Product (influenced by the Search Area guidelines) and the more the Design for Change Guidelines are successful, the lower the figures of waste and the number of new parts will be.

Since parts and modules are different in size and material, the weight is included within the Repurposability rate. This gives an indication about material reuse in transition to the subsequent product: how much material is reusable, how much material is non-reusable, and additionally to the Repurposability Rate, how much material needs to be added.

The 'Severity of Redesign' is based on the design approach in this chapter, which resulted in a 3D model of the original stroller, a 3D model of the redesigned stroller and a 3D model of the designed handcart. Not all parts of the stroller could be redesigned, because of limited time.

Legend table fig. 69.

Table rows from left to right:

- **Product part name**, grouped per main module name
- **Function reusability (rating)**, showing if the function from product 1 is also needed in the subsequent product, apart from the redesign and apart from what type of redesign is necessary before reuse is possible.
 - V Function is reused in subsequent product
 - X Function is not reused in subsequent product
 - R Complete Redesign of part before the part can be reused
 - S Small adjustments and minor changes are necessary before the part can be reused.
 - ? Redesign and reuse estimated. More design iterations needed to know if function can be reused.
- **Redesign steps**, explanation of the adjustments to the old stroller until the part became reusable in the subsequent product
- **Severity of redesign C1->C2 (rating)**, per product part, a number between 0 and 5, based on what Redesign steps were necessary. See explanation of each number in the below table fig 54. The table x describes in the 4th column which redesign steps were executed. The severity of the needed redesign was estimated to give.

Severity of Redesign	S - small adjustments	S - Minor changes in shape	R - full redesign	Added part after transition
0 to 5	Detailed adjustments such as reduction of holes, a different material finish, etc.	The overall shape stays the same, some parts of the overall shape are completely redesigned.	A full redesign is needed as nothing of the original part design fits in the new product.	There is no redesign as the part does not exist in the original product
0				
1				
2				
3				
4				
5				

Fig. 54

- **Impact on transformation C1->S1 (%) & C2->S2 (%)**, an indication of how much of each product part can be directly reused in the subsequent product. The redesign steps lead to a 100% Repurposability Rate in this table row, unless the product part is partly non-reusable in the subsequent product leading to a lower Repurposability Rate. C1->S1 shows the Repurposability rate per part of the original stroller, C2->S2 shows the Repurposability rate per part of redesigned stroller.
- **Partweight(g)**, obtained by weighing the original product parts' and by measuring the weight in the 1:1 SolidWorks model (which is based on part volume and density of the assigned material).
- **Reused weight per part before redesign (g)**, calculated by combining the product weight and 'Part Repurposability Rate before Redesign'.
- **Reused weight per part after redesign (g)**, calculated by combining the product weight and 'Part Repurposability Rate after Redesign'.

Legend, for fig. 69,

- Module group
- Repurposed parts
- Parts not Repurposed (function is not necessary in subsequent product)
- Estimation of Repurposability (parts not included in the first redesign iteration)
- Part incorporated within another part, after Redesign

product part name	function reusability	redesign steps	Severity of Impact on			part weight (g)	reused weight per part before redesign (g)	reused weight per part after redesign (g)	
			Redesign C1 --> C2 (rating)	transform ation C1 --> S1 (%)	Impact on transformation C2 --> S2 (%)				
Module Push Bar									
sub-module Adjustment button	X R	0	full redesign, different location, makes reusability of sub-module Metal Frame possible,. Part itself is not reused. Redesign step because of reusability of other parts.		4,5	0	91,22	0	0
sub-module Metal Frame	V S	60	holes reduced, cut in separate pieces, replaced 2 small connection components at reuse, added 3 small connection parts with redesign		2	95	456,81	274,086	433,9695
sub-module Leather strip	X R	0	redesign: the parts can't be glued, the parts need a reversable fastener, such as zippers. Part not reused because not needed for future product. Redesign step because of reusability of other parts.		3	0	74,94	0	0
Module Top Frame									
sub-module Small Hinge	V S R	10	full redesign, same rotation axis and location, increased complexity, created generic connection module		4,5	100	995,56	99,556	995,56
component Metal Frame top	V S	80	holes reduced, 1 added connection component at reuse		1	100	270,74	216,592	270,74
sub-module build in safeguard button	V R	x	Full redesign,reduced part: incoorporated in generic module small hinge, slide button became push button.		4,5	x	x	x	
sub-module Unlocking Button for seat/ carrier	V R	x	Full redesign, reduced part,lock for seat incoorporated into seat-carrier attachment points. Push button brought closer to the mechanism location.		4,5	x	x	x	
sub-module seat-carrier Attachment Points	X R	0	Full redesign: fitting interface to generic connection module large hinge, different location. Redesign step because of reusability of other parts.		4	0	154,6	0	0
sub-module slider	X S	0	Incoorporated in large hinge modle, different location. Redesign step because of reusability of other parts.		2,5	0	150,6	0	0
sub-module Chassis unlocking button	V R	10	Full redesign, created a generic connection module of Large Hinge, squeesh button became push button		4,5	85	78,94	7,894	67,099
sub-module Metal Frame rotation	V S R	50	redesign, same shape, increased complexity, cut in separate pieces, reduced holes, created generic connection module		2,5	100	668,44	334,22	668,44
Module Bottom Frame									
sub-module Front Frame	V R	30	redesign, reduced components, reduced complexity, reduced holes, generic connection applied		3,5	100	781,28	234,384	781,28
component Metal side tube	V S	80	holes reduced		1	100	581,17	464,936	581,17
sub-module Back Frame (inc. brake & rear wheel connection)	V R	20	full redesign, made generic, divided into geometric shapes/ seperate modules, reduced holes, added 2 generic connection modules		4	90	887,44	177,488	798,696
sub-module Rear Wheel	V S	70	Release button from sub-module Back Frame moved to this module, same brake mechanism		1,5	100	1472,72	1030,904	1472,72
sub-module Front Wheel (inc.front wheel connection)	V R	30	Front wheel connection seperated per function, brake mechanism added, interface for brake added, added generic connection module		3,5	98	1522,84	456,852	1492,3832
sub-module basket	V S R	40	redesign, stiff basket material, same basic shape, enlarged area, increased amount of seperable and generic components		3	100	983,58	393,432	983,58

product part name	function reusability	redesign steps	Severity of Impact on			part weight (g)	reused weight per part before redesign (g)	reused weight per part after redesign (g)	
			Redesign C1 --> C2 (rating)	transform ation C1 --> S1 (%)	Impact on transformation C2 --> S2 (%)				
Module Large Hinge									
Module Large Hinge	V R	10	Full redesign,divided into geometric shapes/ separate components, generic connection module added, change in size, change in rotation interface, increased holes. 2 clasps and 4 small connection components not reusable		4,5	90	328,18	32,818	295,362
Module seat and carrier									
sub-module plastic seat	? S R	10	Might be reused as a whole in another stroller becaue of quite high quality (see use-time), might not be reused. Redesign is less likely		4,5	80	2400	240	1920
sub-module seat sun screen	? S	50	Not yet applied in 3D model: small adaptations, added interface to fit to generic connection module, added connection to top tubes		2,5	100	500	250	500
component seat-cushion	?	20	Not reused, too specific requirements & shape to be able to be reusable.		4	80	550	110	440
component foot-muff	? S R	30	Not yet applied in 3D model: Small adjustment, made a little bit larger, adding different zippers, not sure if the original requirements are still fulfilled		3,5	100	780	234	780
sub-module carrier & textile cover	n.a.	30	n.a. because you only use one seat type at a time. The carrier basked might be used in another stroller (see use-time) because of high quality. Also, the carrier has a much quicker use-cycle than the seat.		3,5	50	3400	1020	1700
Module rain-covers									
component raincover A for seat	? R	30	Not yet applied in 3D model: redesign, created a less thight fit by changing the specific shape to more geometric shapes, divided in seperable straight parts.		3,5	90	232	69,6	208,8
component raincover B for carrier	? R	30	Not yet applied in 3D model: redesign created a less thight fit by changing the specific shape to more geometric shapes, divided in seperable straight parts. - The carrier rain cover might be applied in another stroller, because it has a much quicker use-cycle than the seat.		3,5	50	232	69,6	116

Figure 69. Overview of redesign adjustments on part or module level , to calculate Repurposability rate: figure 70)
See legend on previous page

Test	total product weight	Repurposability rate, whole product before redesign (%)	Repurposability rate of the whole product after redesign (%)	Increase in repurposability rate (%)
Included/excluded parts	(g)			
A. Result from test excluding parts which were not redesigned	9499	30	93	63
B. Result from test including parts which were not redesigned	17514	16	50	34
C. Result from test including an estimation on the redesign of the earlier not included parts.	17514	16	83	66

Figure 70. Repurposability rate before and after the redesign, calculated by us of table figure 69.

Legend table fig 70, each Repurposability result (A., B., C.) the following information is shown:

- **Total Product weight (g)**, The difference in weight before and after redesign is marginal in this Design Case.
- **Repurposability Rate of the whole product before redesign (%)**, shows how much material of the whole original stroller can be repurposed. This is calculated by adding up the ‘Reused weight per part before redesign’ and dividing this by the total weight of the designed stroller.
- **Repurposability Rate of the whole product after redesign (%)**, shows how much material of the whole redesigned stroller can be repurposed. This is calculated by adding up all the ‘Reused weight per part after redesign’ and dividing this by the “Total Product weight”.
- **Increase in Repurposability rate (%)**, A comparison of the Repurposability rate before and after the redesign reflecting the effect of applying the “Design for Change guidelines”.

Intial Aim

The aim of the Repurposability Rate is to show how much more Repurposable the product became by applying the Design for Change guidelines. The goal is to have at least 80% of the stroller Repurposed after the redesign. The Repurposability Rate before the redesign is also calculated to show how much impact the current design changes have had.

See the overview of changed parts in the above table (fig. 69) which shows the effect on the Repurposability Rate before (3D model in fig. 57) and after (3D models in fig. 66 and 67) applying the Design for Change Guidelines. Answering the question that was raised for this case study:

Is the Repurposability Rate improved by applying the Design Guidelines
Part 3: Design for Change?

Repurposability Rate before and after Redesign

The Repurposability Rate has significantly increased with:

- 34% for the total Product when considering all Product parts even if they were not Redesigned (and thus become waste). See result B in fig 70.
- 63%, considering only the parts that were reused in the new Product, not considering parts that were not Redesigned at all. This only shows the effect on Repurposability for the parts that were subjected to Design Guidelines. See result A in fig 70.
- 66%, including an estimate for parts that become only reusable after an extra Redesign. The parts that are considered here are most difficult to Redesign and were not essential for the new product. In particular, the seat and carrier (part of the non-redesigned parts), each 3,5 kilos, cannot be used simultaneously in the stroller, and each seems to be long-lasting (see use-cycle analysis). Therefore, these might be reused in another stroller, in another use cycle. See result C in table fig 70.

Additional parts

Additional parts after transition seem to be inevitable, as not all functionality overlaps between two different products. These are not included in the Repurposability factor, since these parts aren’t part of the initial product. The Repurposability Rate of additional parts therefore depends on a subsequent product cycle of a repurposed handcart. However, the additional product parts do influence the investment cost (see product reflection in chapter 6)

Recommendation

Given that:

- Exercising the case was constrained by time and there was a learning curve, only a limited number of iterations could be done.
- Some of the parts were not redesigned, such as the foot muff, rain cover, seat and carrier. A careful estimate has been made regarding the reuse.

It is expected that a second iteration on the design of the hand-cart and on the use of the Design for Change Guidelines, the Repurposability Rate could be further increased.

6 CONCLUSION, EVALUATION & RECOMMENDATIONS

*Assessing the feasibility, viability and desirability
of the Design Case Study and of the Guidelines.
Providing an answer on the research questions.*

6.1 Introduction

In this chapter the overall experience of this project, the Mutsy Stroller case, is evaluated. It follows the three phases of the study (see fig 71):



Figure 71. Overview of the applied guidelines and approach on the Mutsy Igo design case. See chapter 3 for a full explanation of the guidelines

Chapter approach

Experience of each of the phases is evaluated separately within this chapter, leading to specific recommendations for a phase. A part of these recommendations is used to create a final Product Reflection and an iteration upon the guidelines. Finally, a conclusion is given to the Research Questions.

Then, to give Designers a start, the report ends with a practical manual to apply the guidelines.

6.2.1 Evaluation & Recommendations for Phase 1: ‘Starting Point’

Summary of phase 1

Phase 1 consists of three guidelines (see fig. 72):

- a. Know when to change: set up a product timeline
- b. Know what you have: gather info about the current product, user & brand and highlight valuable aspects
- c. Predict future change: Create future product strategies to guide later brainstorm on future product opportunities

The goal of these guidelines is to identify the most valuable product aspects and to understand how these could evolve towards a possible future product. The aim is to have a clear and familiar starting point to design a new product opportunity.



Figure 72. Overview of phase 1

Evaluation & recommendations

The overall process of Phase 1 was too extensive and ineffective, leading to too many ideas and a future prediction which became too broad. A more focused and practical approach is needed to find valuable future product aspects, quickly and easily. In the following text the 3 guidelines are evaluated in more detail.

1a. Know when to change – set up a product timeline

Evaluation of results

- I. Before starting, information of the current product was not available. Starting from scratch was time-consuming. It is important to know where to look first to prevent too broad analysis.
- II. Making a timeline worked well: it gave a clear overview of the existing product-service-system. However, the timeline should be simple, to maintain an overview and to prevent a too extensive analysis.
- III. The rest of the process needs more focus (see reflection on guidelines 1b, 1c and 2). This can be done by putting more focus

- on the envisioned EoL moment of the first product through the entire process, so by having more control by the timeline.
- IV. Valuable market aspects were identified, which initially were not part of the guidelines. It has proven to be convenient to scope the project (e.g.: single user versus multiple users).
- V. The business model aspects were not extensively addressed in the guidelines. To determine the viability of the new product and the viability of the followed approach, this is clearly an essential topic.

Recommended improvements

- I. A “grocery” list of what information is necessary to start
Before starting a clear list is needed of what information needs to be gathered which could speed up the process.
- II. Using a visual template (see explanation 1B) as a ‘worksheet’
The worksheet shows, amongst other, a simple timeline which should be used during the execution of the rest of the guidelines. As such, one has continuously the subsequent product in mind which will be introduced at the 1st product’s EoL.
- III. Create focus to prevent a too extensive research
First mark a draft of the product aspects in the worksheet, to know what product aspects to further research.

- IV. Incorporate a marketing strategy reflection to scope the project.
Choose the scope of the project in the first Phases of the approach. This gives focus and control on the project.
- V. Validate the Business Model
To determine the viability of the new product and approach, the business model should be investigated: Does the extra effort of applying the approach and the addition of new parts give a better business case than a traditional product design?
(ellenmacarthurfoundation, z.d.)(Boeijen et al., 2014)(van Boeijen, A.G.C., et. al. 2020 ,Rev. ed.)(Haffmans & Gelder, 2020)(Gedeon, 2019)

1b. Know what you have – gather info about current product, user, brand, highlight valuable aspects

Evaluation of results

I. The analysis in this Phase was too extensive, not very efficient and not very effective. It took much more time than anticipated, lead to too many, not very useful ideas into the next phase of the project. This needs to be more controlled and more efficient. The tool should help the designer to mark the valuable aspects quickly (user, brand, product/function, market/sales) .

II. The followed approach was a rather theoretical, analytical method while a more practical approach would likely reveal obvious valuable aspects more naturally. By ‘acting out’ scenarios with the product, talking with users and tinkering with the product parts, the valuable product aspects became obvious. Value is appeared to be best found by intuition.

A more practical approach makes the approach more desirable to apply. Nevertheless the tool helps to see the values from different perspectives on the product.

III. The guidelines recommend starting from the familiar starting point being the current product. This gives more control, scope and focus. However, although I choose relatively early the market strategy to bound the scope, the guidelines inspire to look broader to product opportunities also usable for other users and other markets. This led to a very large amount of ideas stimulated by the Search Areas. In my case it appeared to be a too broad scope and most of the ideas addressed other users or markets which were ultimately **not considered to be viable**.

Perhaps the cause of this is that the chosen most valuable aspects are directly linked to the current user while a lot of the ideas did not have this direct connection. It trapped me into a too broad analytical scope by also looking in other markets and users. This appeared **not to be very feasible** in this Design Case as the most valuable aspect was only applicable for the current user (‘emotional value’).

Recommended improvements

- **A more efficient & practical approach**
A visual ‘worksheet’ and a mind-map could help to quickly highlight valuable product aspects (see example in the manual).
- **Deduct from the various perspectives, like ‘experience in use’, ‘functional value’, ‘location’, ‘economic value’, ...)** the values of the product. This approach should be emphasized in the guidelines. The first analysis feeds a mind map onto which the most value aspects can be marked.
- **Only the most valuable aspects should lead to the future prediction**
The current tool is to be adjusted with more guidance, visible in the manual and in the worksheet.

1c. Predict future change - Create product strategy to feed brainstorm on product opportunities

Evaluation of results

I. **Current future prediction method is unclear: add specific future prediction methods.**

In the Case Study the method ‘Trend Foresight’ was used to predict future user trends. The future trends found were not as useful since they were too general.

However, more prediction methods exist which might fit better with predicting future product opportunities. During the process it was decided to not apply other specific methods than Trend Foresight because these would require going through another learning curve while there was limited time.

II. **Current future prediction phase is too theoretical. Replace by more practical methods.**

The future product opportunity was found

within the Search Areas: ‘time users’, ‘emotional value’ and ‘similarities in functionality’. Practical approach worked well: tinkering with the second-hand product and the product parts (making it easier to sympathize with user scenarios), a user survey and personas (online desk research). Brand analysis and applying global trends on the personas were experienced as being too theoretical and too broad.

III. **Too broad analysis for future trends - instead, let valuable aspects lead the future.**

The guidelines should focus less on current valuable aspects, and more on long-term future valuable aspects. The timeline and product EoL should be used as a main theme in these guidelines, to concentrate mainly on the future.

Recommended improvements

I. **Existing future prediction methods & valuable aspects lead future prediction only.**

Various existing methods can be used to go quickly from existing valuable aspects to future valuable aspects (in this case ‘future user needs’, ‘VIP’, ‘design road-mapping’, ‘SWOT’ (Boeijen et al., 2014)(van Boeijen, A.G.C., et. al. 2020 ,Rev. ed.).

Trend Foresight can be used but valuable aspects need to be clearly determined first (see evaluations of Phase 1b.).

Further research is recommended to find out which methods fit best with the guideline of future prediction.

II. **A visual template, worksheet and workshop make the method more practical;**

A visual template helps in maintaining overview over the most valuable aspects & the main points in the future prediction, because the limited space in a template forces the user to write down the most important insights. This can be applied in a workshop with Designers to make the approach more ‘hands on’ and focused on most important aspects and the workflow of the Design for Repurposability approach.

6.2.2 Evaluation & Recommendations for Phase 2: ‘Product Opportunity’

Summary of phase 2

- One guideline is applied (see fig. 73):
- a. Find the next product opportunity – Explore the starting point with Search Areas

The goal of this guideline is to find a feasible, viable and desirable future product opportunity. In Phase 3, ‘Design for Change’ the chosen product is designed, by a redesign of the first product.

Evaluation & recommendations

The overall process of part 2 was successful, but also quite extensive: a product choice was found, but too many ideas were generated. This was partly because there was not enough focus in Phase 1, preparing the input for Phase 2. Besides that, there is some overlap between the guidelines in Phase 1 and within the Search Areas tools. Furthermore, an extra Phase is recommended to validate the product choice before starting with Phase 3.



Figure 73. Overview of phase 2.

Guideline 2A. Find the next product opportunity – Explore the starting point with Search Areas

Evaluation of results

- I. Phase 2 was successful
 - a Product opportunity is found, fitting with the initial user and the product EoL time.
- II. Too many ideas were generated in the brainstorm phase:
 - a. Partly because too much input came from Phase 1. Only future valuable aspects should lead the brainstorm; see also the evaluation of Phase 1.
 - b. Partly, there is some overlap between the guidelines in Phase 1 and the Search Areas which made it quite unclear what to focus on.

- III. Validation step misses regarding ‘Desirability, Viability and Feasibility’.
The outcome of this phase is a chosen Product Opportunity which should be validated regarding Desirability, Viability and Feasibility before going into Phase 3: “Design for Change”. Initially the reflection was positioned at the end of Phase 3 only.
- IV. Applying the ‘Weighted Objective’ method helped with chosen a product opportunity.
The aspects on which the product choice can be made are not clearly specified within the guidelines but could be tested against earlier identified essential valuable aspects.

Recommended improvements

- I. Reduce the amount of Search Areas
Doubles between Phase 1 and 2 are reduced. Some of the guidelines show a perspective on value, which could be incorporated within Phase 1. The Search Area titles should focus on future.
 - ‘Recognition’ is an aspect of the emotional value Search Area, so recognition should be addressed within ‘emotional value’.
 - ‘Fixed/flexible product components’ is more a way of thinking than an inspiring brainstorm area. ‘Economic value’ is more a check for a ‘viable product opportunity’. It is applied in the weighted objective (as well).
 - Change ‘Current Brand’ into ‘Future Brand’. Although ‘Current Brand’ seems redundant, looking into the Brand Aspects could inspiring for the future brand. Hence the rename.

The most valuable aspect on which the product idea is based, can give focus in validating this Phase.

- III. Extra validation moment regarding “Desirability, Viability and Feasibility”
It is recommended to reflect on the Desirability, Viability and Feasibility before going into Phase 3: “Design for Change”. The product choice is actually a long-term investment as it extends the product. Therefore, the product choice should be validated before more definitive decisions are made during product redesign in Phase 3. The Product Choice could be validated by a user test, as the most valuable aspects are emotional value and product experience. This would give insight into aspects like Desirability and Viability. (ellenmacarthurfoundation, z.d.)(Boeijen et al., 2014)(van Boeijen, A.G.C., et. al. 2020 ,Rev. ed.)(Haffmans & Gelder, 2020)(Gedeon, 2019)

- II. Add a clear set of aspects to choose between the products from the brainstorm: like ‘weighted objectives’, ‘desirability’, ‘viability’ and ‘feasibility’.

- IV. Divide Phase 2 into 3 guidelines for more structure in the guidelines, into:
 - a. Brainstorm with Search Areas
 - b. Weighted choice
 - c. Validate the product choice

6.2.3 Evaluation & Recommendations for Phase 3: ‘Design for Change’

Summary of phase 3

In Phase 3, “Design for Change” the following Guidelines were applied (see fig. 74):

- a. **Apply modularity** – create functional modules & generic connections
- b. **Quality Perception** - Influence what is visible to influence quality perception
- c. **Simple Form** - Keep it simple and basic in geometric shapes, to prevent irreversible adjustments
- d. **Standardization** – Seek standardization available in industry
- e. **Efficient Transition** - Easy to (dis) assemble, reduce remanufacturing & refurbishment of product efforts and costs during transition.

The goal of the ‘Design for Change’ guidelines is to increase the Repurposability Rate of the product by redesigning the current product. A high Repurposability Rate means that modules and components can be exchanged effectively and efficiently between two products.

Evaluation & recommendations

The overall process of part 3 was successful,; the Repurposability rate increased significantly, but the process was also time-consuming. There are two main reason: 1. There is a learning curve in applying the current design guidelines, 2. It seems to be not an easy process to generalize over two designs.

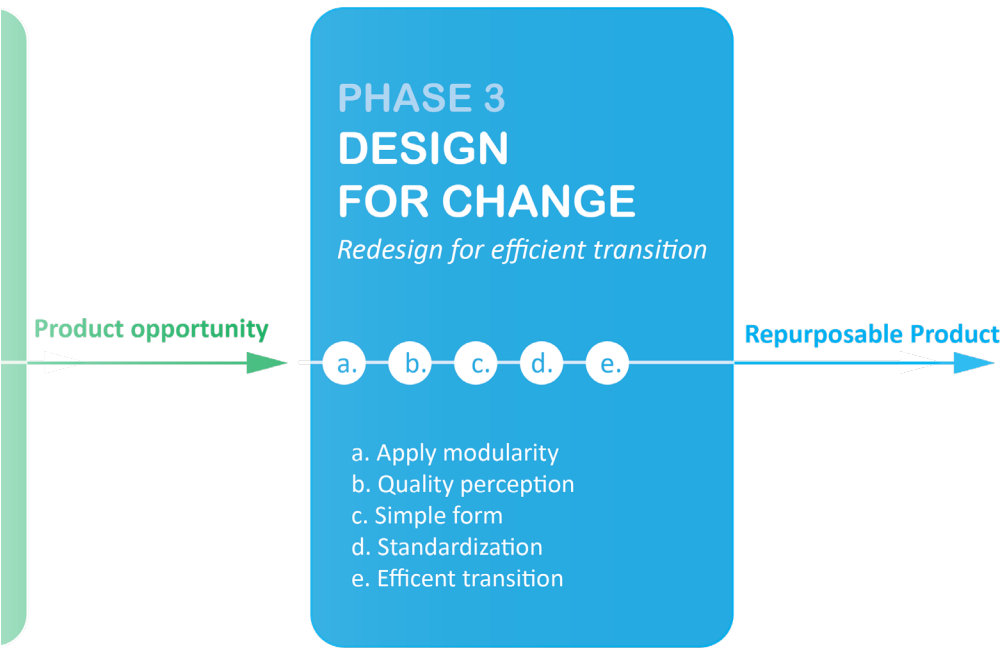


Figure 74. Overview of phase 3, see chapter 3

Guidelines 3.A t/m 3.E

Evaluation of results

I. Although time consuming, applying the guidelines increased the Repurposability Rate. An increase is achieved in the Repurposability Rate of 30% to 70%.

The guidelines were quite time consuming: not all parts were redesigned so more redesign iterations are needed. However, the guidelines could also become more efficient when the learning curve is reduced: the guidelines are still in development. This can be improved by putting more emphasis on the essential part of the guidelines, which were discovered in the Case study.

Furthermore the question arises if these guidelines are by nature difficult: repurpose requires a different perspective in designing, or perhaps seen as an additional set of requirements: ‘Generalize parts across products’.

II. Repurposability Rate of 100% seems not feasible

At last, it seems inevitable that some parts stay non-reusable and some parts need to be added during transition to the subsequent product: a Repurposability Rate of 100% means that all parts can be reused. As such, a Repurposability Rate of 100% (or near 100%) seems not feasible.

III. Simple Form and Applying Modularity is a ‘Means to an End’, not a goal in itself

By applying the guidelines “Simple form” and “Applying Modularity modules were created for main matching requirements between the 2 products. The initial guidelines imply that the main goal is to create modules and simple shapes, but they are actually a ‘Means to an End’.

‘Simple form’ was initially added because it prevents specific shapes and adjustments which have a high chance of not fitting in many other situations other than fitting with the current product. However, as Phase 2 from the guidelines results in a specific chosen product, simplification of components is only necessary when it contributes to specific generic modules; in other words, it is not logical to put design effort in simplifying each part.

‘Modularity’: creating as many modules as possible is not the main goal. Transforming one product as efficiently and effectively into a second product means the amount and difficulty of dis-and re-assembly steps reduces.

This means the guidelines should emphasize on creating a simple construction: match and

generalize across modules.

IV. Adaptability versus standardization

Reusable, generic modules are not only reached by standardization. There is still room for specific shapes within Repurposing by creating by designing adaptable modules can be placed in/onto various locations of generic modules and as such resulting in a specific shape. Therefore, generic adaptable modules should be the main focus of this guideline instead of standardization.

In the Case study it was found out that by applying 'Adaptability' onto a generic module, it could to be placed in various standard configurations: 1-3 modules can be placed and rotated around an axis and there the core allows for 1-2 modules to be attached the side of the connection module. Condition: all varying components have a generic interface which fits the connection module's interface.

V. The guideline 'Efficient Transition' was not fully applied due to limited time.

Other guidelines contribute to this guideline, such as reducing irreversible fasteners and increasing modules which can be reused as a whole. However, more design iterations should be done to test if this guideline in particular is easy to apply and whether it is effective.

VI. Not all 'Non reused parts' are subjected to all the Guidelines, such as Quality Perception.

Parts that are not reused and which are considered as temporary detailed parts (e.g. leather strip) are not subjected to some of the Guidelines as the contribution of these parts to the increase of Repurposability is considered low. As such, the case study learned that the order of Design Guidelines

should be according 'design main parts first' before addressing the details.

VII. The order & focus of the guidelines matters

It is 'natural' to focus on discovering the construction & essential modules first, then focus on connection parts between modules, then focus on disassembly, reassembly and lastly focus on details: design for cleaning, materials & finish.

VIII. Approach should be simple and more practical

To make the Guidelines more desirable, effective and feasible emphasis should be on hands-on and low learning curve.

- a. Prototype to quickly find matching modules.
- b. Apply disassembly to find elementary simple functions and strive for freedom in creation. For example: use 2nd hand products.

IX. Repurpose might be more costly in the short term, benefits come on the long term.

As more effort is done when redesigning for Repurpose (taking multiple products, personas and business model requirements into account as well as the transformation from first to next products) questions might arise regarding 'Return on Investment' and thus about willingness to invest. Considering the reuse of parts and prevention of waste, the benefits are obtained on the long run.

Recommended improvements

I. Emphasize Modularity for efficient & effective transformation to subsequent products

The guidelines 'Applying Modularity' and 'Simple Shape' will put more emphasis on designing generic modules across subsequent products.

II. Adjust guidelines: Increase reuse by making generic modules specific by means of adapters

To make connections between several generic modules, adaptable interfaces will make generic modules more reusable. Create generic modules which can be adapted to various configurations if the same type of functionality is occurring multiple times but slightly different. Examples of common variations are variation in angles around an axis, rotating around an axis, fasteners, buttons, etc. Interfaces on these modules take care of supporting these variations.

III. Change the order and titles of the Design for Change Guidelines

1. Matching modules
2. Simple construction & shape
3. Generic: standardization & adaptability
4. Efficient transition
5. Quality perception

IV. Introduce an extra validation step

- Introduce a validation step at the end of "Design for Change":
 - Determine long term Economical benefits
 - Measure expected 'demand' for subsequent products

6.2.4 Summary of Recommendations per guideline

The main changes, based on the evaluation, to the Design approach and Guidelines are described here in short. The recommendations are partly incorporated in a final version of the manual in the appendices.

Phase 1

1. Overall, the timeline should be used more prominently when applying the guidelines to create more focus on the future.
2. Practical methods should be incorporated in the guidelines, to make finding valuable aspects and doing a future prediction more efficient and effective.
3. Incorporate a Marketing strategy to scope the project early
4. Check on applicable Business Model to validate viability of the approach and outcome as early as possible: does the extra effort weight up to the result.
5. Feasibility, Viability and Desirability: the current setup of Part 1 is not viable nor desirable: Designers will experience it as too time-consuming and the outcome is not easily applied in Phase 2 (brainstorm for Product Opportunity)

Phase 2

1. Future prediction guided by valuable aspects only
2. Amount of Search Areas reduced leading to a more effective brainstorm
3. Validation of future prediction
4. More hierarchy/structure in the guidelines by added guidelines

Phase 3

1. Emphasize module over component redesign
2. Adjust the guidelines, to emphasis simplicity in construction and generic adaptable modules
3. Changed order of the guidelines
4. Introduce validation step

6.3 Product reflection

Here an evaluation on feasibility, desirability and viability of the product redesign is described as an outcome from the Design Case.

Feasibility

- Phase 3 (Design for Change) of the Design Approach concentrate on making product parts easily and exchangeable between the subsequent products to minimize transition efforts.

The design case shows an increase in Repurposability rate, however the guidelines need improvement to have time left in the design process to design the details of the embodiment design (see reflection on guidelines). It is recommended:

1. More Repurpose design iterations should be done to test the guidelines further.
 2. The product result should be tested on feasibility regarding existing Key partners, Key resources and Key activities of the Company.
- The design guidelines helped to get a good view on the future product experience and what aspects are valuable in this experience for the user. Based on this, mood boards were created for a fitting aesthetic design. However, due to time constraints (see guideline reflection) the aesthetics need to be designed further in a future design iteration. The Design Case shows that the aesthetics of the current and subsequent product fit with the brand. This proves that specific brand shapes can be maintained through a repurpose project.

Specific colours and materials can also be maintained, but mostly because these already have a neutral (thus long-lasting) appearance.

Concluding from the Design Case the appearance of the product is influenced by the Design for Change guidelines because:

- Connection parts stand out because they have become larger due combining complexity at one place,
- The 'Quality perception' guideline hasn't been applied completely; it advises for application of specific colours and shapes for specific parts and long-lasting materials and finishes.

User research and design iterations might be needed accordingly.

Desirability

Considering the current research and design steps, the proposed products will fulfil the user needs:

- The current customer segment corresponds largely with the future customer segment; the products EoL corresponds to the next phase of the child which requires other needs (after 4 years).
- The current distribution channel and customer communications are highly valued by the current customer. Expertise service and try out at the store is highly valued, reflecting their emotional involvement with the product (searching for a product experience reflecting their envisioned parenthood) as well as the willingness to pay for high quality (a durable, safe and functional product). This service is advised to be extended for product return.

However, there are a few challenges to tackle:

- Although several users mentioned their need for the subsequent product (handcart) it is not completely validated that this

result in enough users to buy a handcart at EoL of the current product. As the whole value proposition depends on this future need, the future prediction in Phase 1 of the guidelines should be emphasized more in the overall design approach and validation steps should clarify how and if users are willing to pay for a later product in time.

- In contrast to the Circular model the Repurposable model adds aspects like Time and Product Transition. During the life time of the current product it should be tested that the need for the subsequent product still exists. A active customer relationship with the company from the moment of sale would help, leading to questions like:
 - How will customers be reminded that the product can be repurposed after 4 years?
 - (How) do customers need to get accustomed to the return of Products at EoL?

Viability

What do customers expect to gain? In research from chapter 4 was found that users sell their stroller on the second-hand market mainly as an investment. Will buying the handcart beforehand be an investment? What will customers get in return: discount on the handcart based on the quality of the stroller when returned?

Is this possible for the company to offer the handcart at a lower price?

In theory it would be more efficient to redesign an existing product for transformation in 2 products than to start a separate design process for a new product, because companies can build upon their existing key partners, key activities and key resources as they are dealing with a very similar value proposition as their original product (amongst other the same user and product parts). On the other hand extra investments are needed:

- Onetime costs to redesign the product into a durable and Repurposable product.
- Investments for product return, quality check, product reassembly, stock observation and communications and maintaining long-term customer relationship.

However, the short-term investment costs to set up new tasks and resources might be too large threshold, unless long-term profits can be proven beforehand. Do the design efforts outweigh the savings in product parts, and does it lead to a stronger user connection with the brand? And in case the stroller is not sold again as a handcart: is it possible to resell standardized parts back to suppliers?

Type of revenue could be based on the validation of future user need:

- Who is willing to make the long-term investment: the customer or the company? Validation tests during the Design Process could provide answers. Will the user decide at the sale or at EoL of the current Product if they want to have the stroller transitioned to a handcart? A decision at moment of sale means the customer needs to invest in a future product but the company knows beforehand if the future transition will happen. A decision at EoL implies that the user clearly expresses need at the time of EoL however at design time of the current and second product the company is not sure if the investments will lead to profit. More user tests are needed to understand the future revenue stream.
- Lease: a classic long-life derivative (Haffmans & Gelder, 2020)
 - In Lease models the customer pays a monthly fee for maintenance of the product.
 - Tests performed by Bugaboo shows a few benefits and concerns:
 - Some users felt less responsible, causing a reduce in product quality at return and a higher repair rate,
 - In some cases, there were problems with the monthly payments while Bugaboo couldn't stop the product usage.
 - A new user group was indeed

attracted to use the Lease model: it could lead to lower cost for the consumer as economy-of-scale benefits of the company could be returned to the consumer as well. The benefits for the company might consist of the profit of selling and reusing returned products (parts).

- A Lease model increases Customer Relationship and the contract time could correspond to the EoL time of the product. The return of the product would be a good moment to offer the transition. The monthly fee of the of the Lease contract could encompass the cost of transition.

Impression of Investment cost versus financial and material benefits

The following starting figures are assumed:

- Extra design effort of Designers to consider a subsequent product: 1 month (22 days) (assuming approximately 1 week extra user research, 2 weeks extra validation according toolset, 2 week extra design effort)
- Average cost of a Designer per hour: 85 EUR; workday of 8 hours (productdesignstudios, 2019)
- Reuse of Product parts: 72% (based on outcome of test case – see chapter 5): 12 out of 16 parts can be reused.
- Cost to design a part: 3 days per part

Doing the calculation for the Case Study:

Financial view:

- Extra design cost for addressing Repurposability: 22 days * 8 hour * 85 EUR = EUR 14960
- Design saving for 12 reused parts = 12 parts * 3 days * 8 hour * 85 EUR = EUR 24480
- Overall design savings: 24480-14960= EUR 9520

Material view, based on weight

- 93% of the total redesigned stroller (see chapter 5) can be reused in the stroller. The weight of the stroller is 9,5 kg, the weight of the hand cart is 9,8 kg.
- 93% material savings of 9.5 kg = 8.8 kg.

6.4 Answers to Research Questions

Main research questions

The two **Main Research Questions** defined in chapter 0, Introduction, are:

How should Repurpose be defined so it can be effectively applied to maintain value over multiple use cycles?

What guidance is needed to make Repurposable Products feasible, viable and desirable from a Designer point of view?

During this case the following **Sub Research Questions** were raised:

- How should Repurpose be defined?
- How can Designers be stimulated and helped to incorporate Design for Repurpose in their workflow?
- What guidance do companies need, to apply design for repurpose?
- Which process needs to be followed to Design a Repurposable product?
- What are the experiences when applying guidelines for 'Design for Repurpose' on a practical case and can the effects be measured?

Answers to sub research questions

How should Repurpose be defined?

In contrast to existing definition of Repurpose, it seems to be more beneficial to immediately consider future products during the design of the first product. The expectation is that the reuse of product parts (Repurposability Rate) will increase.

Proposes definition:

Incorporate infinite re-use of product parts, during the design of the first product, to maintain as much value as possible over time.

How can Designers be stimulated and helped to incorporate Design for Repurpose in their workflow?

It becomes clear that designers need to change perspective: current linear thinking and systems does not help designers in thinking of products as “changing system over time”. On the other hand, designers need a clear and familiar goal to design, to minimize the risks and scope of a project. Therefore the study shows that Designers need a clear plan of how to approach Design for Repurpose and specific Design Guidelines for optimizing the Repurposability of their product part. The study results in a toolset consisting of a process to find clear future product opportunities and specific Design for Change guidelines.

Which process needs to be followed to Design a Repurposable product?

A process of 3 phases is recommended:

1. “Starting point aims” to find certain opportunities in the future to design for and to minimize risks, by highlighting essential valuable aspects of the current product.
2. “Product Opportunity” aims to guide the designer from evolved valuable aspects towards 1 chosen product opportunity in which the current product can be repurposed. The search areas within this phase aim to inspire how value of a current product can be extended towards the future.
3. “Design for Change” aims at redesigning the subsequent products and parts for efficient and effective part transition into the subsequent usecycle.

What are the experiences when applying guidelines for 'Design for Repurpose' on a practical case and can the effects be measured?

Applying the Guidelines as prescribed are experienced as very time consuming and theoretical and have a rather broad scope. The outcome of the case is that the approach is adjusted to be more practical, intuitive and more concentrated on a single product as soon as possible. This will lead to more flow and desirability in the design process.

Future prediction is very important and needs emphasis and extra validation steps within the guidelines. To truly create a circular proposition, business model canvas should be used across current and future products.

Answer to main research question

What is needed to make Repurposable Products feasible, viable and desirable from a Designer point of view?

During this study a toolset is proposed to assist Designers in designing Repurposable products. A practical case was performed to test the feasibility, viability and desirability of the toolset.

It shows that the proposed toolset has some issues regarding effectiveness and efficiency: too theoretical, too time consuming and unclear; thus costly.

Based on the test improvements were made to the toolset to make it more practical and easier to comprehend, more concentrated on essential steps. As such, it should be feasible to incorporate this in the workflow of the Designer.

Last but not least, the test case showed a measurable increase of the Repurposability Rate; however, two Design for Change guidelines were not fully applied and extra iterations could be done to optimize the Repurposability Rate. Putting effort and time to address this, influences the economical results however it would be a matter of optimization for this Design Case.

Regarding the Desirability of the future Product the toolset is improved to apply several extra validation steps during the process amongst other to validate if the future user has a need for the future product (ellenmacarthurfoundation, z.d.). For the test case, the future Product Hand Cart has not been validated with future users.

6.5 Final version of ‘Design Approach & Guidelines’



Figure 76. The final version of the design approach and guidelines, shown in 3 phases. Changes seen in this image: the order of some of the guidelines has changed, some new guidelines are added (2.b, 3a, 3b, 3c) or changed and validation steps are added. ‘Recipe’ worksheets and cards are made with a description of the above steps and ‘Search Area’s’.

Changes to the Design Approach

A practical case study of a redesign of the Mutsy IGO Stroller, provided by Springtime, was performed to test feasibility, viability, and desirability of the design approach. With this the final changes were made to the guidelines, see fig. to.

- The proposed toolset has some issues regarding effectiveness and efficiency: the guidelines were adjusted to be more practical, intuitive, easier to comprehend and with more focus on essential Repurpose design steps. The result is a more feasible Design Approach to incorporate this in the workflow of the Designer.
- Prototyping is incorporated in the guidelines: how to generalize modules across subsequent products, simplify overall construction while maintaining specific brand shapes.
- Extra validation steps were added in the process to further validate the future user demand (as this is an essential step to develop a circular value propositions) and to validate the Redesign method as a Circular business model see fig.

With fig. 76 and 77 the changes and added templates are illustrated. Additionally to these figures, ‘recipe’ worksheets and cards are made with a description of the above steps and ‘Search Area’s’.

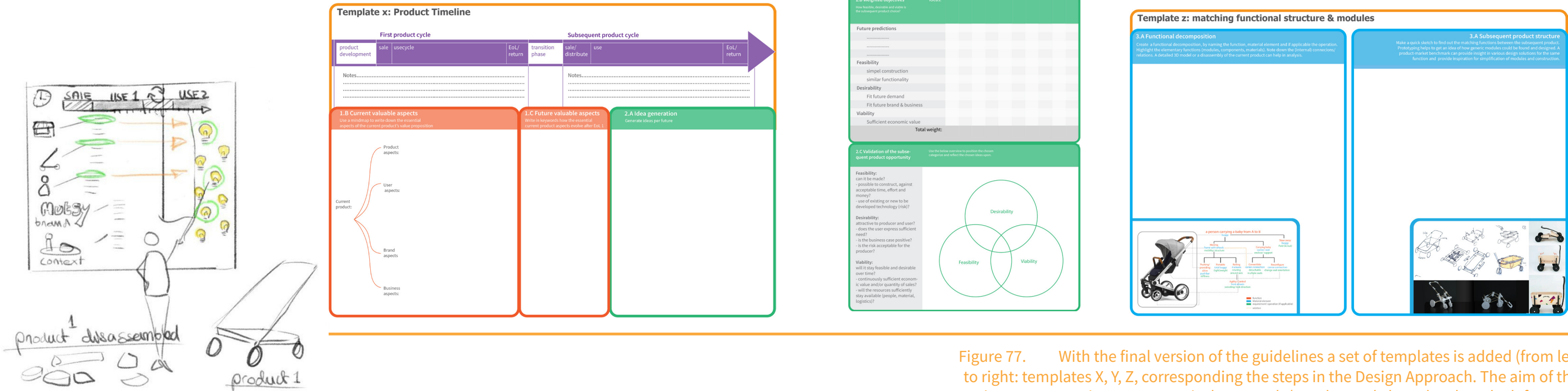


Figure 77. With the final version of the guidelines a set of templates is added (from left to right: templates X, Y, Z, corresponding the steps in the Design Approach. The aim of the improvements is a more practical approach (see the workshop sketch at the left page).

6.6 Personal Reflection

Here I reflect upon the personal learning goals as described in the project brief (see appendices).

- **Goal 0: Learning from a circularity project**

I learned more about circularity than I had imagined beforehand. Although I knew it was challenging the literature research and interview results showed the existing repurpose definition is vague and not well adopted. This made the research results very broad which in turn made it more difficult to come to essential conclusions and insights. Could this be prevented? Being part of the HvA consortium had its advantages and disadvantages. It gave the opportunity to discuss and validate ideas with many different people (such as during workshops and pitch sessions at the HvA) and a chance to visit and talk to many designers in the field. This was a fun and great learning experience. On the other hand managing so many contacts, especially about such a broad topic, is challenging and time consuming. I was eager to go for the many opportunities but this definitely made clear to me that time is often limited and therefore how important it is to prioritize what (not) to do earlier on.

In the end I definitely understand the hindering and stimulating factors of (design for) circularity better before. A positive side-effect to this goal: interviews with designers and the holistic design approach of this project gave me a better understanding of how design decisions are made in the field.

- **Goal 3: Focus on technical/embodiment aspects instead of the fuzzy front end**
Through doing the project it became clear that this was much more about the fuzzy front end than I was anticipated. Nevertheless in phase 3 of the Design Case I was able to focus much more on the technical/embodiment design process and I discovered I enjoyed this and making prototypes a lot. I definitely touched upon **goal 2** as well in this phase (improving my knowledge about production techniques).
- Within this phase I was able to practice quick & fun design steps, to become better at following a “hunch” & quickly making/drawing ideas (**goal 5**). In Phase 3 of the Design Case helped me to let go of some fear to create: in the end of the project I quickly draw out ideas more and I am more eager to start making. This also showed me making helps to intuitively and quickly find essential insights.
- In Phase 1 of the Design Case was less in line with goal 5. My focus was very theoretical and I had difficulty to see through the large amount of results from the research phase (see fig 0.b). Besides additional circumstances I’ve learned something very important through this whole project: to create more structure and hierarchy in my work and to become better at finding essentials. The broad scope of this project forced me to do so. In the end it made tasks in general easier and more fun because adding structure and hierarchy increases simplicity and focus in planning and communication.

3/4th of this project took place during corona measures and partly a lockdown. It made me realise how important it is for energy, motivation and workflow to have structure in the day and to frequently talk with others, go outside and have a change of workplace. The lockdown started during phase 1 of the project and affected the project: 1. The joint effort of analysing the interview outcomes and creating the guidelines became more difficult: A draft of the guidelines was created together, but due to a lockdown the results of 9 interviews were further analysed separately. 2. Spending time in one space for a large part of the day and moving a lot less didn’t help to be creative and practical. The latter three things (and the earlier discussed lack of structure) are reflected in Phase 1 of the design process: it took more time and the outcomes are less focused and useful than Phase 2 and 3.

- Furthermore it was not possible to obtain files of the current product of the Design Case (such as 3D models and user research). Therefore the analysis in Phase 1 of the Design Case was quite time-consuming. On the other hand I’ve spent more time practising 3D modelling.
- **Goal 1 and 4** were touched upon through the holistic nature of the project: gaining more knowledge about material supply stream and applying earlier skills such as creating visuals stakeholder/ user research, sketching and prototyping skills. In hindsight, the other goals had a higher priority than applying skills I’ve learned before.

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