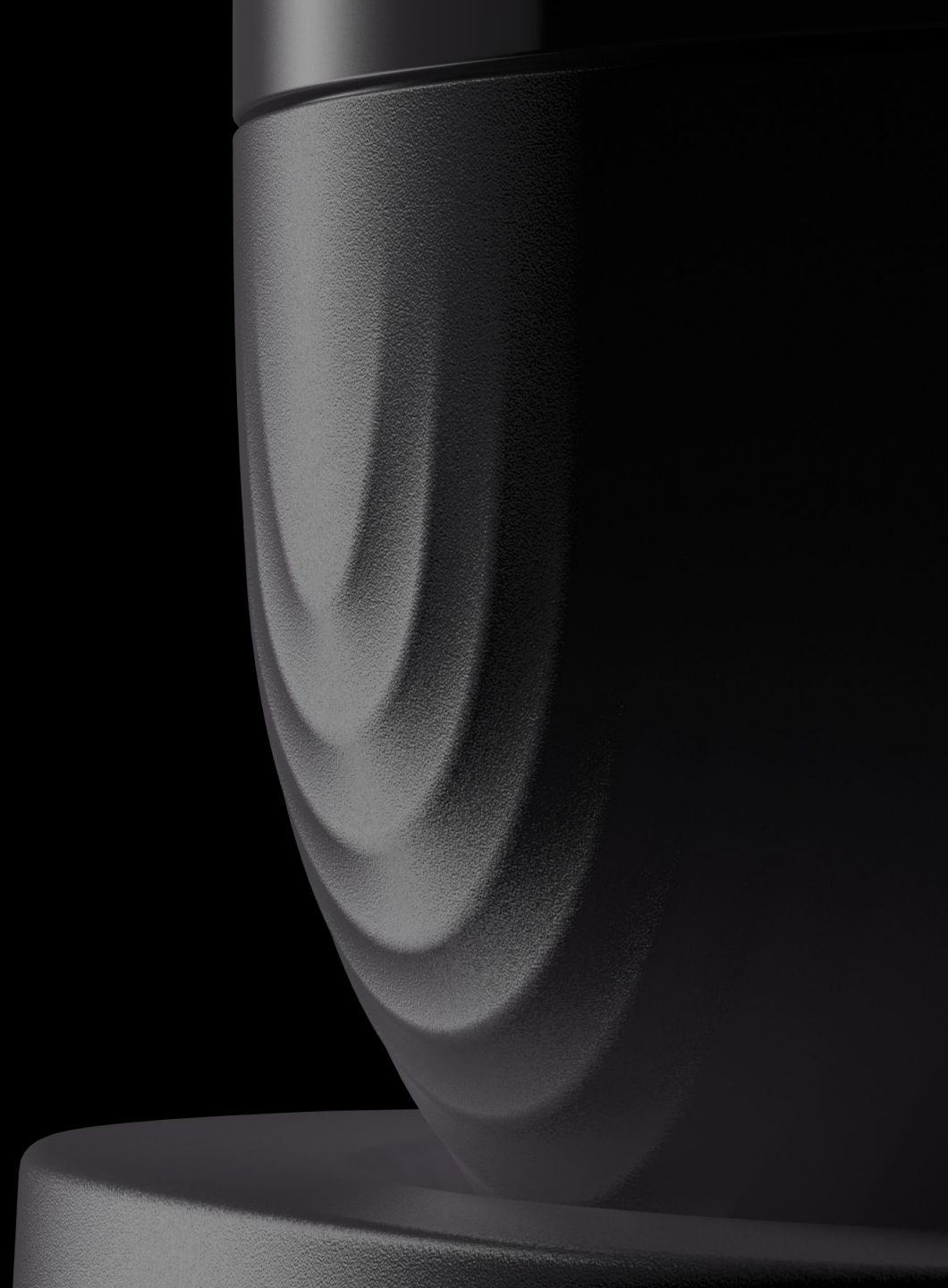
accenture

Designing Sustainable North Stars

A guide to design sustainable products



Version

1.0

/ First published version of the document

This design guide is meant to be a dynamic and constantly evolving document. It will be updated over time, based on feedback provided by readers, new processes and tools developed, and new insights collected on the topic of **sustainable design.**

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Designing physical products for the Digital age.

Industrial Design embedded in Accenture

By combining our expertise in data, digital, and physical product design, **we can help our clients to reimagine their products and create exceptional customer experiences that drive growth and competitiveness.**

Our multidisciplinary approach is human centric and sustainability embedded, to ensure that every aspect of the product is carefully considered, **from its design and engineering to its sourcing, manufacturing, and servicing.**

One goal, many disciplines

The power of multidisciplinary expertise

Sustainability presents a complex challenge, one that demands a multifaceted strategy. To truly tackle this challenge, we understand the necessity of approaching it from diverse viewpoints. At Accenture, we've embraced this need for a comprehensive perspective, recognizing the essential role of diverse expertise across the Sustainable Value Chain. Our commitment extends beyond rhetoric; it's ingrained in our methodology. By bringing together a spectrum of specialists across strategy, innovation, design, engineering, supply chain, and beyond, we amplify the impact of our efforts. This collective effort underscores our commitment to not just envisioning, but actively creating a sustainable future.

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Introduction

A compass, a beacon, a call to action

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Preface

In an era where innovation and technology continue to shape our world, the imperative for sustainability has never been more pressing. As designers and engineers, we stand at the crossroads of this evolution, bearing both the responsibility and the opportunity to drive positive change. Our journey has been one of continuous learning, a journey that has revealed the profound impact our decisions can have on the environment, society, and business.

As we reflect on the path we've traversed, it's evident that the landscape of sustainable design is ever-shifting, marked by new challenges and discoveries. This realization has only fueled our determination to adapt, evolve, and expand our understanding. Our growth is not solitary but collective, a growth that transcends our individual capacities. We are firm believers that the trajectory toward a harmonious future for people, the planet, and businesses can only be achieved by empowering a broader community of designers and engineers.

The creation of this comprehensive documentation stands as a testament to this belief. It is not merely a static repository of knowledge; rather, it is a dynamic tool designed to embolden and enlighten those who seek to make a difference through their work. At its core, this document is a guiding light, illuminating the intricate path of sustainable product design.

Within these pages, you will find a meticulous blueprint—a step-by-step approach that demystifies the complexities of sustainable product development. But this documentation is more than a procedural manual. It delves into the theoretical bedrock that underpins sustainable design, providing a thorough understanding of the principles that guide our decisions. It opens doors to process knowledge that empowers us to bridge the gap between ideation and implementation.

Preface

Yet theory alone is insufficient. Our endeavor extends to equipping you with tangible tools and methods—practical instruments that transform concepts into reality. We understand that a holistic approach is necessary, one that encompasses every facet of the design journey. As such, this document is enriched by a case study on a baby monitor to show how an electronic product can be completely redesigned for sustainability.

This is an invitation to embark on a transformative expedition. It's an acknowledgment that the path to sustainability is not a solitary one. It's a call to action—for designers, engineers, and innovators to unite in a shared purpose. As custodians of creation, we hold the power to mold a world that is both cutting-edge and conscientious, innovative and environmentally attuned. In the pages that follow, we offer not just knowledge but a compass—a compass that orients us toward ethical innovation, responsible progress, and a future that benefits all. May this documentation serve as a beacon, guiding us all toward a tomorrow where ingenuity harmonizes with sustainability, and where our collective efforts manifest in a world we can be proud to pass on.

Together, we step forward into a realm of limitless possibilities, armed with the insights within this documentation. The journey is yours to take, and the destination is a better future for all.

Teun van Wetten
Design Director & Head of Sustainability

Sustainability

Goes beyond product.

Sustainable design goes beyond product. It requires a holistic, end-to-end approach, which considers also user experience and system level aspects.

Requires time, transitions, hence planning.

Truly sustainable solutions often requires important changes at product-, user experience- and system level. These cannot be achieved overnight. Developing a long-term transition roadmap is often necessary. To do so, we must first envision what the end goal is, a North Star, to then scope short- and medium-term incremental steps that will lead us there.

Is too complex to be tackled all in one.

Designing for sustainability involves addressing wicked problems, which are very difficult to tackle from only one perspective. The “first-principles” thinking approach can greatly help to deconstruct the overall problem in smaller research questions that ensure we are tackling the topic in a holistic way.

Beyond product

Sustainable products is not just about products

Sustainability is a complex topic, because it is systemic by nature. Sustainable solutions, of any kind, cannot be developed by tackling only one side of the problem; solutions must be developed in a holistic way, by considering system, user and product.

Our solution is not truly sustainable if:

The product does not enable sustainability by design

The user is not interested in using the solution or enable sustainable behavior

The system does not allow the user to use the solution in a sustainable way

This complex and systemic nature makes sustainability one of the key topics where we can showcase holistic, end to end, cross competence design approaches, where we don't only look at engineering solutions (e.g., design for disassembly), but also at user experience (e.g., design for behavior change) and systemic ones (e.g., value chain optimization).

A new approach

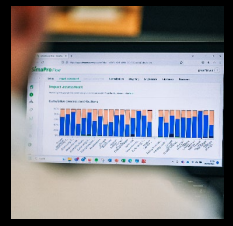
The Sustainable North Star approach

In this design guide we thoroughly documented a new approach, which we called the Sustainable North Star. Below you can find the key steps of this new process.

Click on the images below to jump to specific chapters of this document.

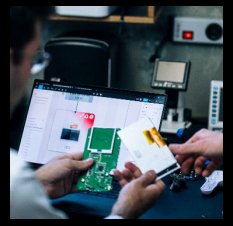
The Approach

Value Chain Mapping



Life Cycle Assessment

User Research



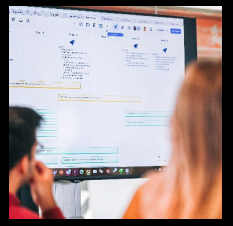
Circular Product Assessment

Future scanning

Product Journey Mapping

Ideation & Concept Selection

The North Star



The Roadmap

02

The approach

A Sustainable North Star

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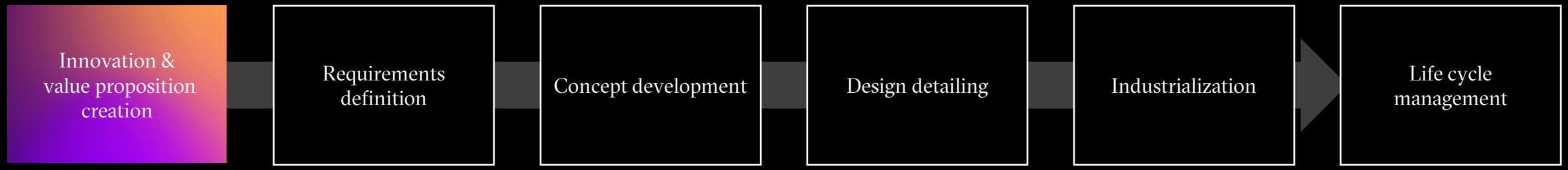
The importance of front-end innovation

The beginning of the innovation process is where the biggest impact can be achieved

The end-to-end product development process involves many different steps, processes and stakeholders. A circular development process is even more complex, because it involves additional life cycle management activities. The first step of this long value chain is pivotal to promote truly sustainable solutions. In this initial phase, there is freedom to explore completely new propositions; new ways of solving core user needs in more sustainable and profitable ways. This is the phase where new concept directions can be proposed. These overall directions are more and more difficult to change later in the process. For these reasons, front-end innovation is the best phase where to implement the Sustainable North Star approach.



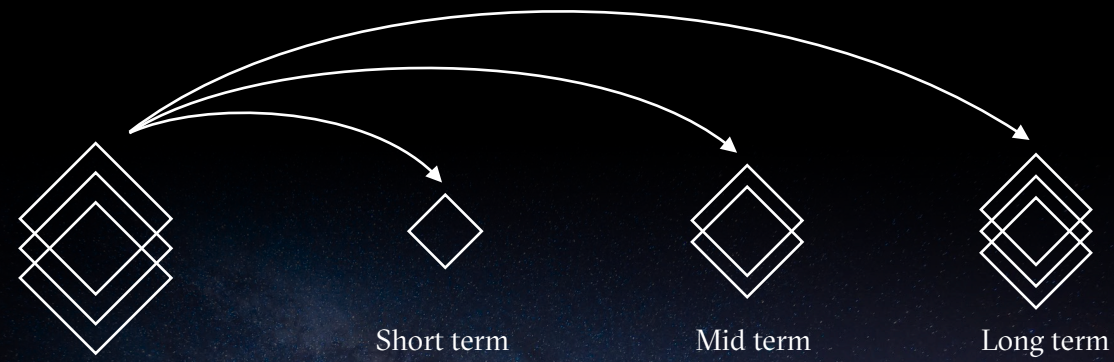
The North Star approach

The importance of defining a clear end goal

Truly sustainable solutions can be very different from today's reality: they usually require important and drastic changes at the product, user behavior and system level. For this reason, they cannot be achieved overnight.

A transition, sometimes spanning over many years, is needed to spread investments and risks, by developing and testing incremental solutions. This transitional approach allows to learn, validate and adapt solutions over time, to finally reach the ideal end scenario.

A key element to apply this transitional approach is to define a long-term goal: a Sustainable North Star. By setting a clear and concrete long-term goal, we can define a transition roadmap, where we can plan de-risking activities which build on top of each other over the years. Without a North Star, there is the big risk of focusing on just small incremental solutions, which are not building towards any real end goal. Furthermore, these incremental solutions might completely miss tackling core sustainable challenges and opportunities. Counterintuitively, by applying the North Star approach, we might end up identifying solutions which will determine a higher environmental impact in the short term, while bringing big benefits in the long run.



We start from the end

We define the most sustainable scenario for a product.

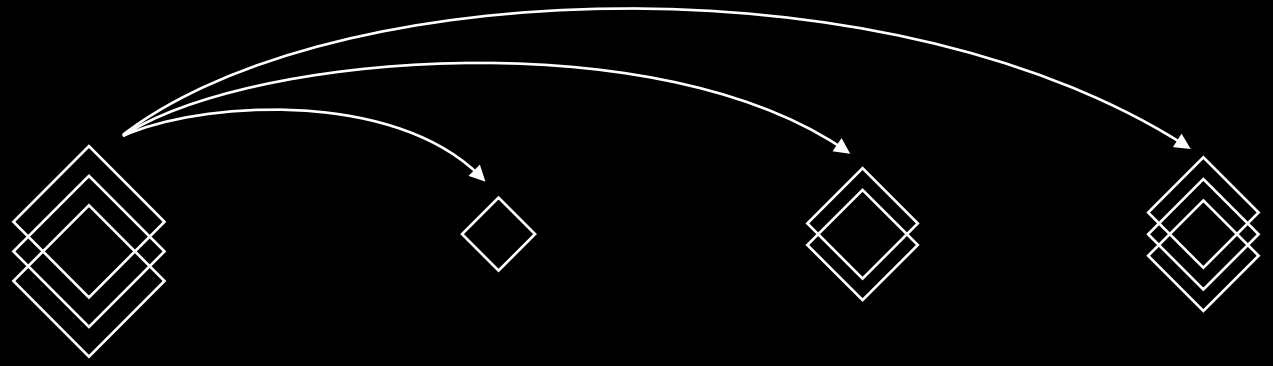
We reverse engineer our North Star in an implementation roadmap

We define what must be done in the short, mid- and long term to achieve the North Star.

The North Star approach

Example from the industry

A good example of the application of the North Star approach, even if not necessarily sustainability focused, is Tesla. They defined a long-term goal: a fully autonomous vehicle. Based on this end goal, they defined a development roadmap, which involved in the short-term equipping vehicles with extra sensors and electronics, not meant for the primary functions of their first-generation vehicle, but to collect data and train the computer vision based autonomous driving system which was implemented generations after.



A fully autonomous vehicle

Short term
Equipping vehicles with additional sensors and electronics to collect data and train vision models in the cloud

Mid term
Refinement of camera array and gradual sensors removal when reliability of vision models is high enough

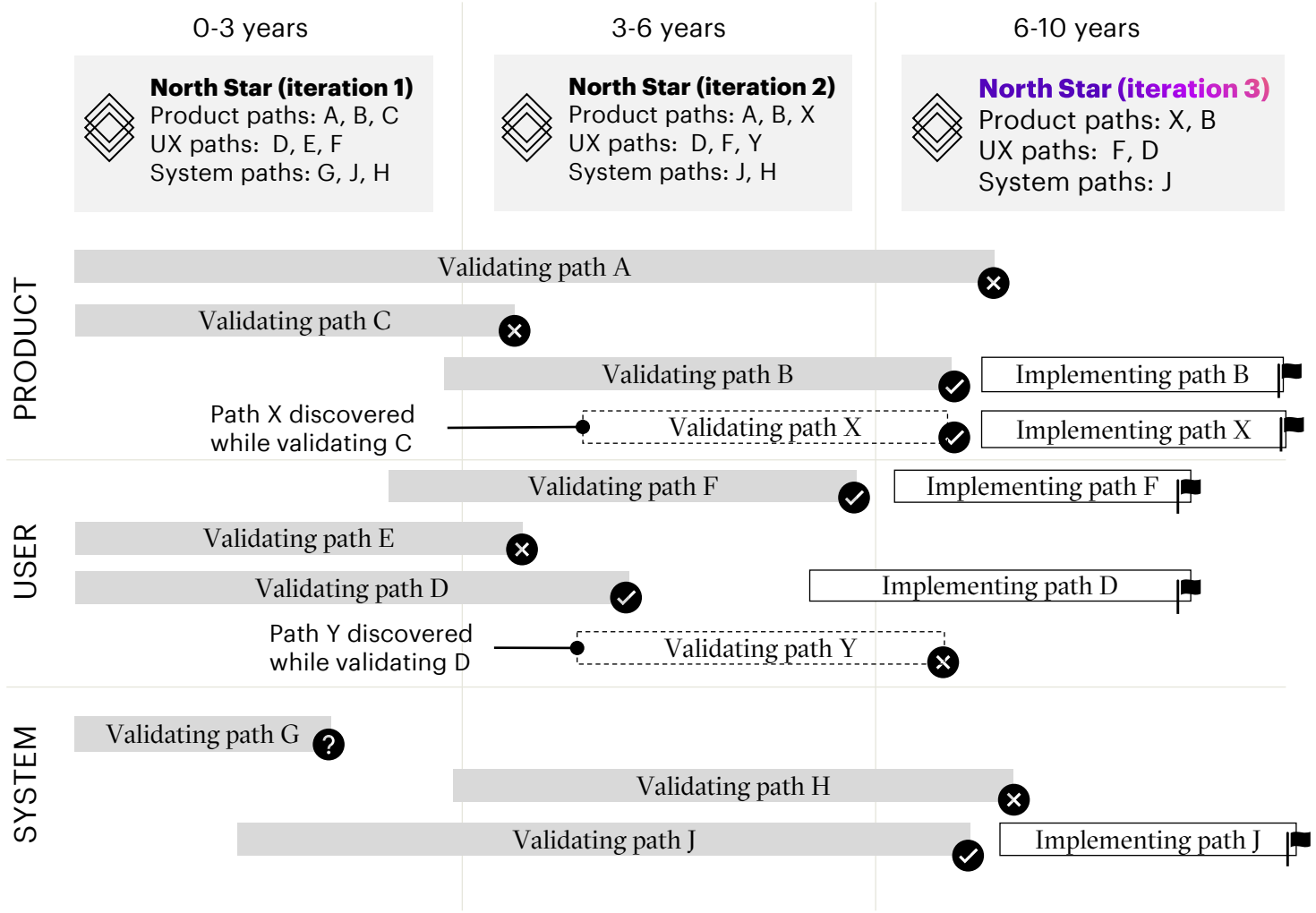
Long term
A fully vision based autonomous vehicle

The North Star approach

A clear, but still moving target

There is no silver bullet in sustainability. We are dealing with a complex group of value chain stakeholders. These span from investors, to suppliers, logistic partners, but most importantly the end user. A North Star should set a clear overall direction. However, since it describes a long-term future goal, it cannot be too specific and absolute. Testing and iteration is key.

The North Star should describe a set of alternative paths, all going towards the same overall direction. These alternative paths account for the great level of uncertainty determined by setting a direction so far ahead in time. Alternative paths can be set at the product, user experience and system level. Activities planned in the transition roadmap should be aimed at exploring and validating these different paths. By testing different paths, over time we exclude paths found to be not viable, we evolve them in something new or we discover completely new paths that we ignored at the start of the transition. This way, the North Star direction is continuously refined, corrected and scoped over time, building on learnings collected throughout the transition.

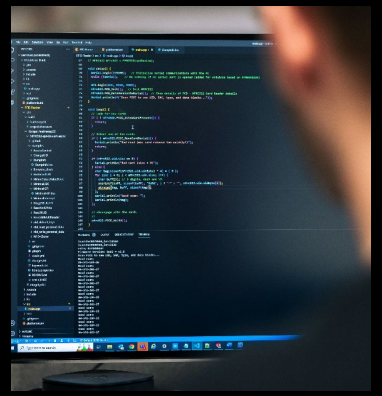


Actionable innovation

The power of making things tangible

The main risk of a traditional North Star approach is that, since most of the focus is on long term scenarios, outcomes might feel abstract and not actionable. This is often detrimental to creating consensus among different stakeholders in a company and agreeing on real commitments towards the long-term vision.

Our approach to this challenge is what we call “actionable innovation”: pushing innovation forward by creating real functioning proof of concepts of future innovation and fast iteration cycles. Of course, since we are designing something that will only reach the market in 10-15 years from now, we might not be able to already use the end technologies that we expect to be available in a later stage. However, we can still develop credible proof of principles that can mimic the functions, features and experience that the North Star concept is supposed to achieve. In multiple occasions this approach proved to be very effective in convincing stakeholders about very future oriented concepts and creating common agreement on directions to pursuit. Having something tangible on the table of discussion is always helpful, even just to be a trigger for discussion and identifying exactly what different stakeholders like or don’t like about the idea that is pushed forward.



Designing from First Principles

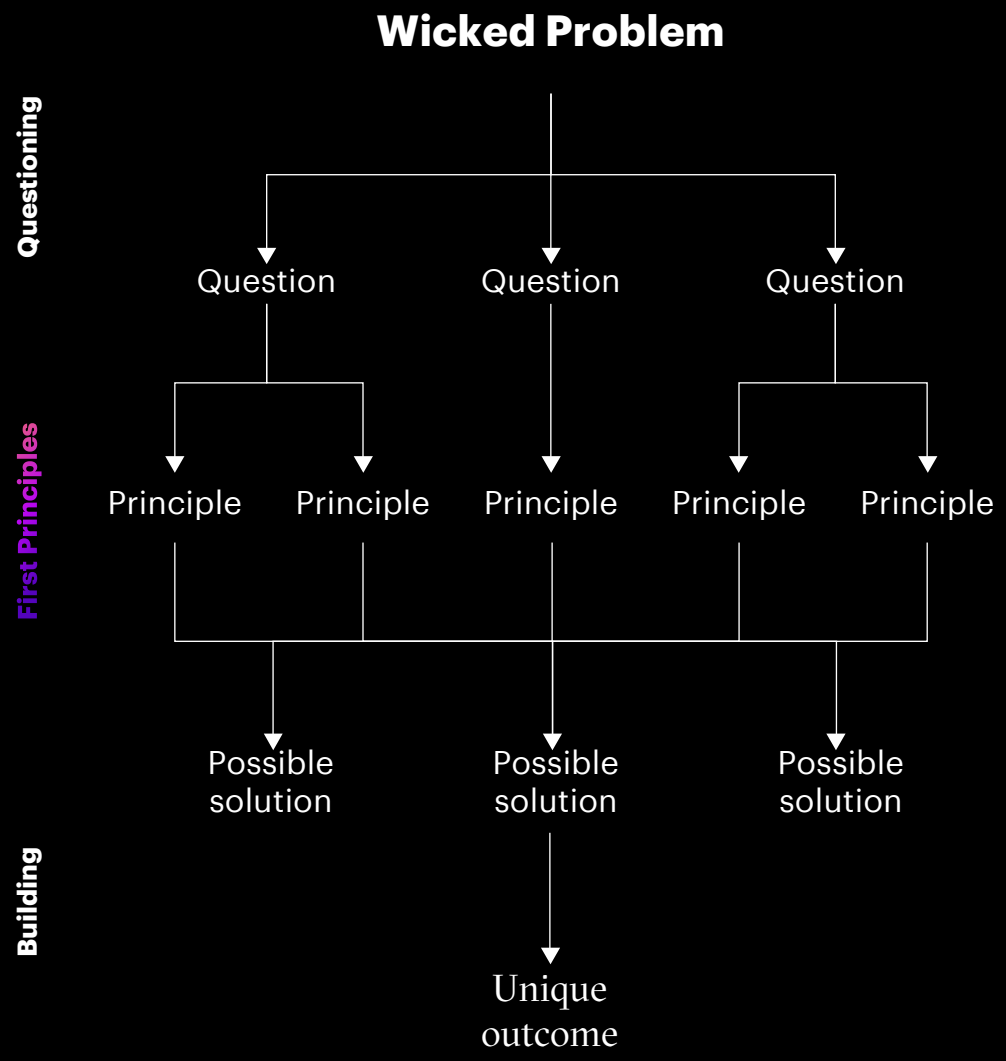
How to tackle the complexity of sustainability

When designing for sustainability, one of the biggest risks is jumping straight into solution mode or relying on misleading silver bullets.

It is very common to hear before a project even starts people say: “It should be repairable of course” or “Modularity is a must!”. General models, like the 9R model or the butterfly diagram are good starting points to identify and prioritize possible strategies to make our product more sustainable. However, they are simplified models, which do not consider product and context specific challenges and opportunities that might make a strategy more relevant over another. Defining sustainable strategies for our products by following pre-concepts, high level frameworks and assumptions about the system, product and user, is extremely dangerous. It can steer a project, or even a company's entire strategy, in the completely wrong direction.

There is no silver bullet in sustainability: the best sustainable strategy for a product is the one that satisfies value chain stakeholders requirements and needs at the lowest, if not positive, impact on ecological ceiling and societal foundation.

To identify this strategy, we must ensure we have the right data and insights to holistically look at the problem and make thoughtful and educated decisions.
The first-principles thinking approach can help to break down complex topics, like sustainability, into smaller research questions, easier to manage and address. By investigating each fundamental question, objective truths can be identified, called First Principles.



Designing from First Principles

Fundamental questions to define a Sustainable North Star

This approach is composed by three main phases:

1. Questioning: break down the problem into a set of questions you need to answer to build a solution

2. First Principles: investigate and identify First Principles for each of your questions

3. Building: generate solutions based on the First Principles identified

Depending on the type of system, product, and user you are dealing with, the set of questions (the fundamental questions) you need to investigate before defining sustainable solutions may vary.

However, there is a set of questions that need to be investigated in most cases, regardless of the nature of the product you are focusing on. These can be grouped in 4 categories: Environmental impact, User needs, Value proposition and Future trends. These are four key ingredients that must be embedded in your end solution, to make it truly sustainable, needed by the user and wanted by the user. Furthermore, since we are defining a North Star, which will probably reach the market in 10-15 years from now, we must consider how future needs, use scenario and technology might evolve.

Environmental impact

- What does the current value chain look like?
- What are the key environmental hotspots of the current solution?
- What does the current user journey look like?
- How does the user dispose the product?
- What are the main reasons for disposal and product end of life?
- How are current products designed against circular strategies?

User needs

- What product features does the user believe they need to serve their needs?
- What are the actual core user needs that the product is trying to solve?

Value proposition

- What features is the user currently looking for during purchase decision making?
- Does the user consider sustainability during the purchase decision? If not, what can be done to change that?
- Is the user willing to buy pre-owned (second-hand and/or refurbished) products? If not, what can be done to change that?
- Is the user willing to pay to repair the product if it breaks? If not, what can be done to change that?
- Is the user willing to rent the product? If not, what can be done to change that?

Future Trends

- What will the future use environment and use experience look like?
- What are the technological trends for the product you are focusing on?
- What future technologies could be used to make the product more sustainable?

Methodologies

Methodologies to investigate fundamental questions

There are 5 methodologies/processes that can greatly help in investigating and answering fundamental questions before developing solutions. Each of them is meant to help with answering one or more fundamental questions, across the 4 main categories: environment, user, proposition, and future.

1

Value Chain Mapping

Visual representation of the entire value chain, from production to end of life, to be fed to the Life Cycle Assessment (LCA)

2

Life Cycle Assessment

The LCA is a quantitative assessment of the environmental impact of the entire product life cycle

3

User Research

Qualitative and quantitative research to collect key insights from users

4

Circular Product Assessment

Assessment of current products on the market to understand current design challenges and opportunities

5

Future Scanning

Trend analysis of future societal and technological changes which can determine an evolution in user needs and/or new opportunities for sustainable innovation

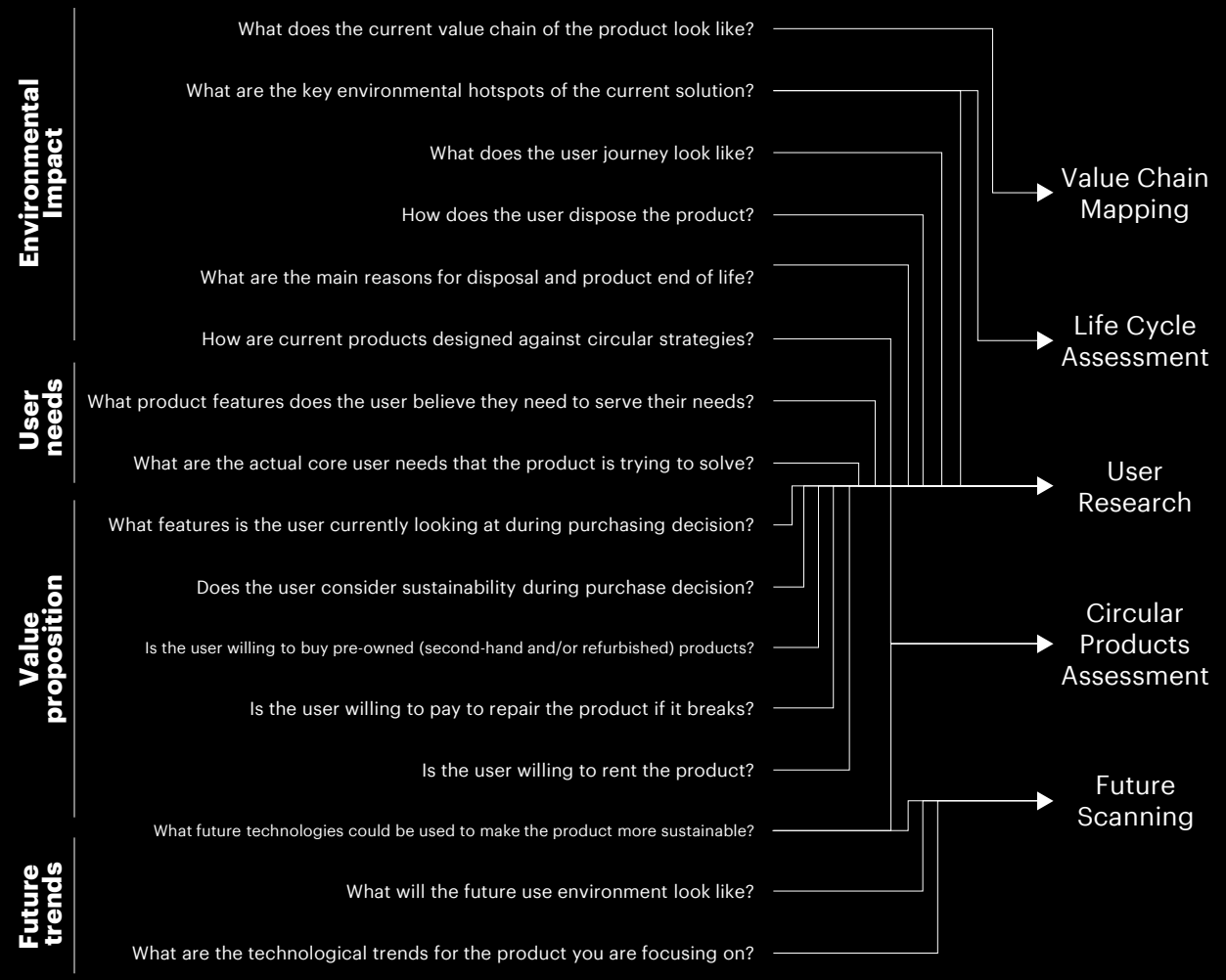
Methodologies

Investigating fundamental questions through different methodologies

To identify comprehensive answers to one fundamental question we often need to use and combine different methodologies. For instance, to carry out an LCA, the value chain of the product must be known, and this can be done using Value Chain Mapping.

Using different methodologies to answer the same fundamental question also helps to "question the question" and to address it from different directions. For instance, current user behavior at end of life is also an important input to calculate the LCA of the current product. However, user research and circular product assessment can help us to look beyond what is happening today and understand why it is happening. For instance, there could be very different reasons why the user stops using the product after X years: the product might not be needed anymore, or the product is subject to fast trends, or the product might not be repairable if it breaks. So, while the average product lifespan might be the same number of years, the reasons determining end of life might be extremely different from each other. Each of these three scenarios require a very different type of solution.

As shown on the right, user research in particular, is essential to investigate many fundamental questions.



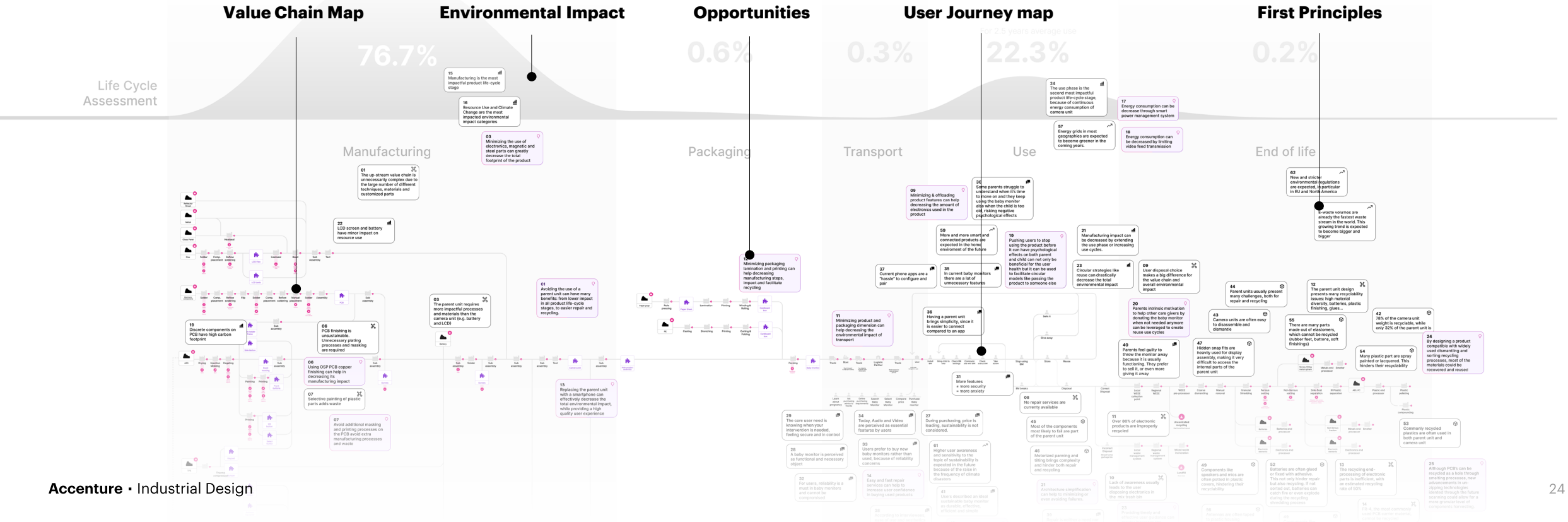
Synthesizing

Synthesizing First Principles throughout Product Journey Mapping

Product Journey Mapping is a potent tool to combine all First Principles in one overview, which can be used to spark ideation and solutions development.

Product Journey Mapping allows to:

- Visualize entire value chain of the product, from production supply chain, to use and end of life
- Visualize the environmental impact of each life cycle phase, calculated using LCA
- Combine user journey mapping with value chain and LCA
- Map all First Principles and design opportunities identified based on the different research methods used

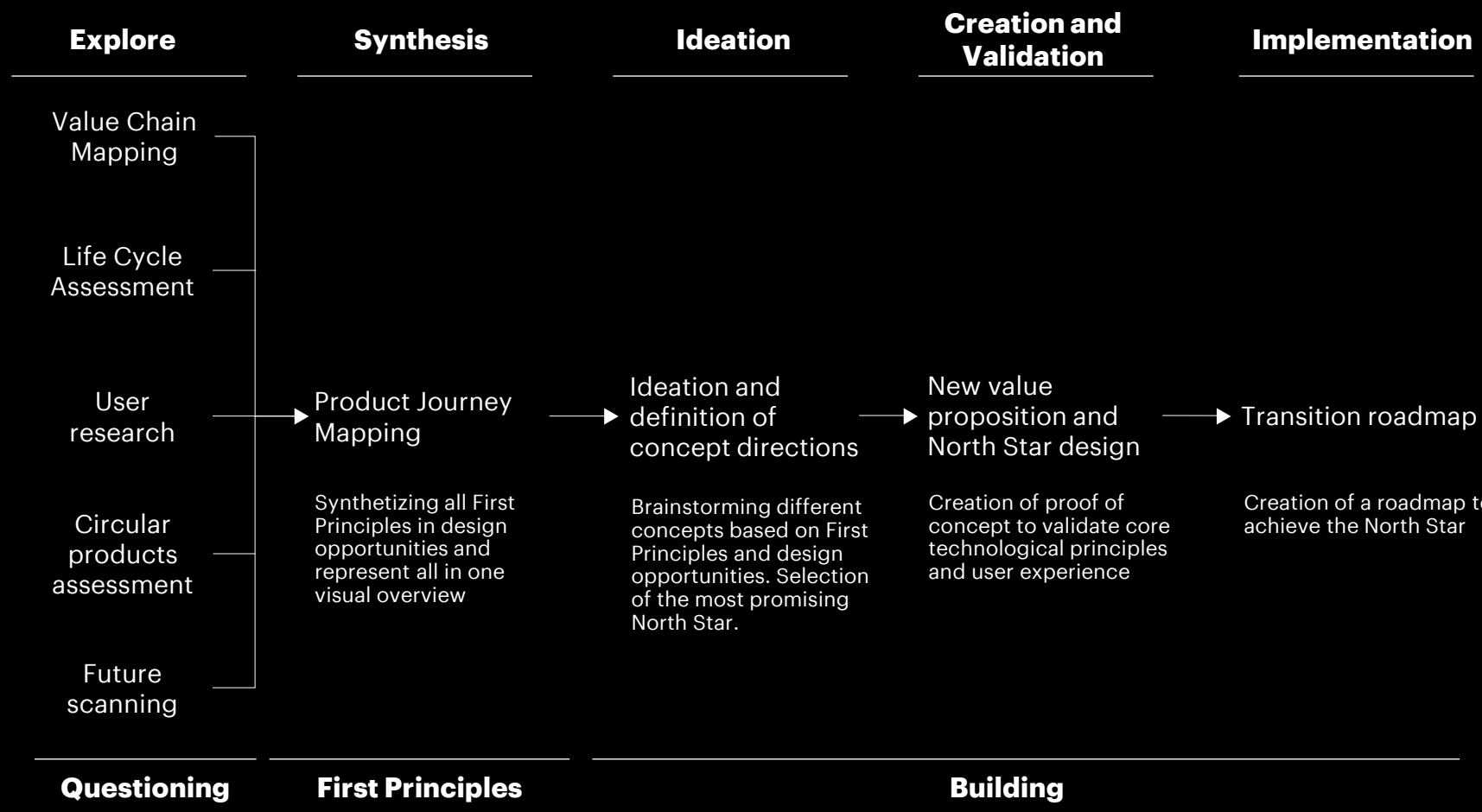


The Sustainable North Star approach

One holistic approach

The Sustainable North Star approach is the result of combing:

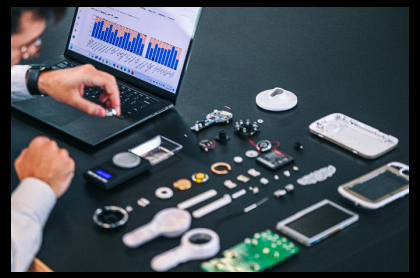
- The traditional North Star approach
- The First Principles thinking approach
- 6 key methodologies: User Research, Value Chain Mapping, Life Cycle Assessment, Circular Product Assessment, Future Scanning, Product Journey Mapping
- The traditional design process: discover, design, develop and deliver
- The creation of tangible proof of concepts



The team

A diverse group, a common goal

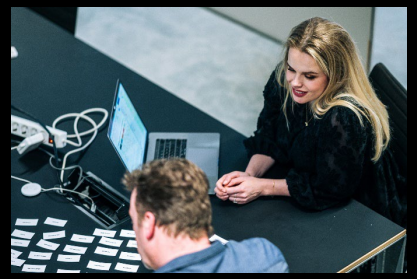
Because of the diversity of topics tackled through this approach, it is necessary to create a diverse team of experts.
This allows to combine different expertise and capabilities in one single process.



Life Cycle Assessment

Scope: Identifying the environmental hotspots of the current solutions.

Activities: Collecting data, creating a model and carrying out the Life Cycle Assessment of the current solution to identify where the highest impact lies.



User Research

Scope: Identifying the core user needs that the current solution is trying to solve and the key challenges and opportunities at the level of user experience and behavior.

Activities: User interviews, data scraping, literature research.

User Experience

Scope: Creating new innovative experiences which solve the core user needs in a new, sustainable way.

Activities: Assessing the user experience of current solutions, concepts ideation, physical design, digital design, service design.

Engineering

Scope: Creating feasible and viable solutions which solve the core user needs in a new, sustainable way.

Activities: Assessing the engineering of current solutions, closely work together with the User Experience team to ideate new solutions, identify new technology directors and develop feasible and viable engineering solutions.

System Design

Scope: Bringing together different value chain stakeholders and create new system solutions to solve the core user needs

Activities: Mapping the current value chain, identify key value loss hotspots, develop new system solutions and service blueprint.

03

The case study

An unusual end of life reason

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Baby monitors

Applying the Sustainable North Star approach

To show how to practically apply the Sustainable North Star approach, we picked a specific, popular baby monitor, with common features, to be redesigned. Baby monitors represent an interesting case study, because:

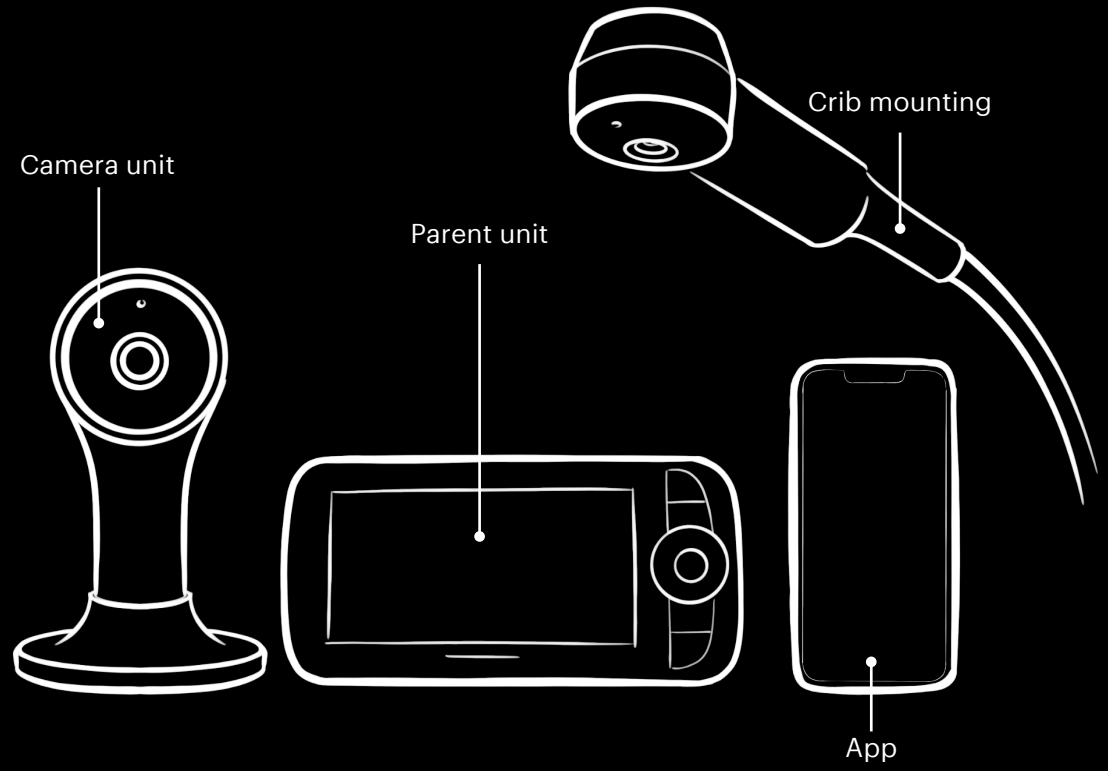
Their useful life is often determined by the growth of the baby: once the baby is between 2 and 4 years old, baby monitors are not needed anymore.

It's a growing market, with 32 million units produced a year; therefore, a growing e-waste problem.

The manufacturing cost of these devices is relatively low, making it challenging to implement sustainable solutions in the short term.

It is a product that has reason to exist. It is not an unnecessary gadget that could easily be avoided in the first place.

This case study was done without involving any manufacturer, to ensure full disclosure of any detail about the process. Naturally, this brought some challenges at the level of information and data availability. Although the process is based on many assumptions, it is a good example to showcase the overall process. Therefore, the focus of the reader should not be on the validity of the developed concept, but rather on the process used to get there.



The above image represents the chosen baby monitor to redesign, it integrates common, popular features: camera unit, parent unit, crib mounting accessories and an app. The brand and model will not be shared in this report.

Baby monitor categories

Baby monitors can be grouped in 4 main categories

Audio

- No video
- Automatic activation when noise is detected
- Light alerts when noise is detected
- Two-way talking
- Extra features: lullabies, night lights and temperature sensor

Non-WiFi video monitors

- All features of audio
- Video feed to parent unit
- Camera unit and parent unit
- Radio-frequency based (limited range but faster and easier pairing than WiFi models)
- No internet
- No app
- Noise and movement alerts
- Night vision
- Wall mounting
- Lullabies
- Room temperature sensor

WiFi video monitors

- All features of Non-Wifi video monitors, except for Radio-frequency based connection
- WiFi dependent
- Remote functionalities and notifications if smartphone and monitor have internet connection
- More extensive UI and features (e.g., more detailed monitoring information)
- Advanced features: motorized and remote panning/tilting, breathing pattern monitoring

Wearables

- This category is usually paired with a WiFi video monitor.
- The wearable brings extra monitoring features: baby temperature, heartbeat, oxygen level, precise movement monitoring, advanced growth tracking

Exploration

04

Value Chain Mapping

Tracking the current system

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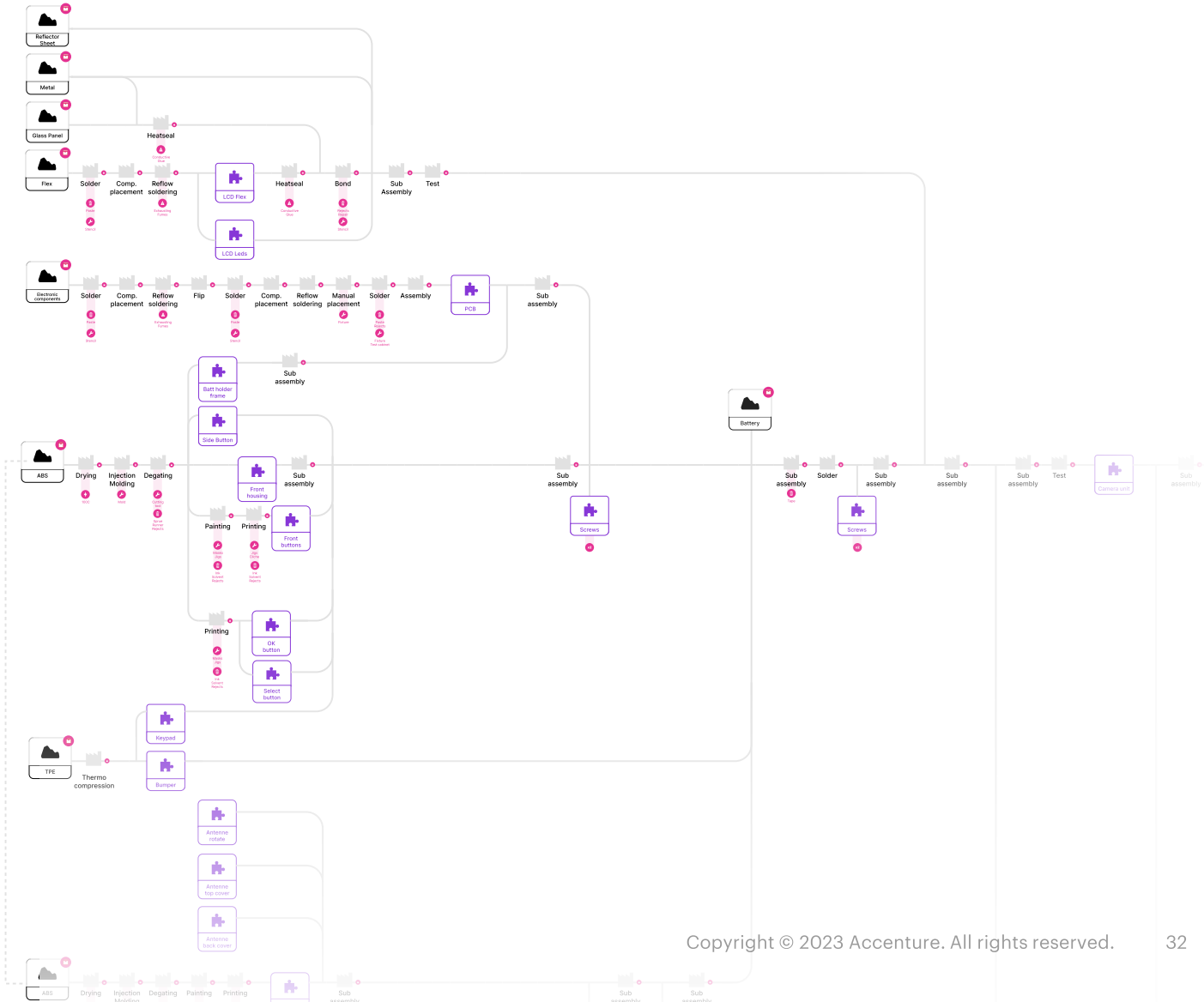
Value Chain Mapping

Tracking the current system

Value Chain Mapping is a method used to identify and understand all steps and processes that define the journey of a product. It creates value by providing a better context of the product and/or service and responsible stakeholders. Additionally, a good value map takes all life stages into account, resulting in a holistic overview which is essential for proper implementation of sustainable practices.

In this project the Value Chain Mapping activities were focused on the up- and down-stream value chain. The 'middle chain', namely the user journey, was investigated separately with user research. The combination of the Value Chain Map and the user journey is the Product Journey Map, which will be presented in chapter 9 as a synthesis tool. In a traditional project we would investigate the Value Chain Map together with value chain stakeholders during collaborative sessions. In this case, we based it mostly on in-house expertise and literature. Furthermore, the map created in this project starts from main materials and/or components and does not investigate raw extraction and production. This is because real value chain stakeholders were not involved and information on such an early-stage value chain is difficult to retrieve and often unreliable. The Dutch market was considered to build this example.

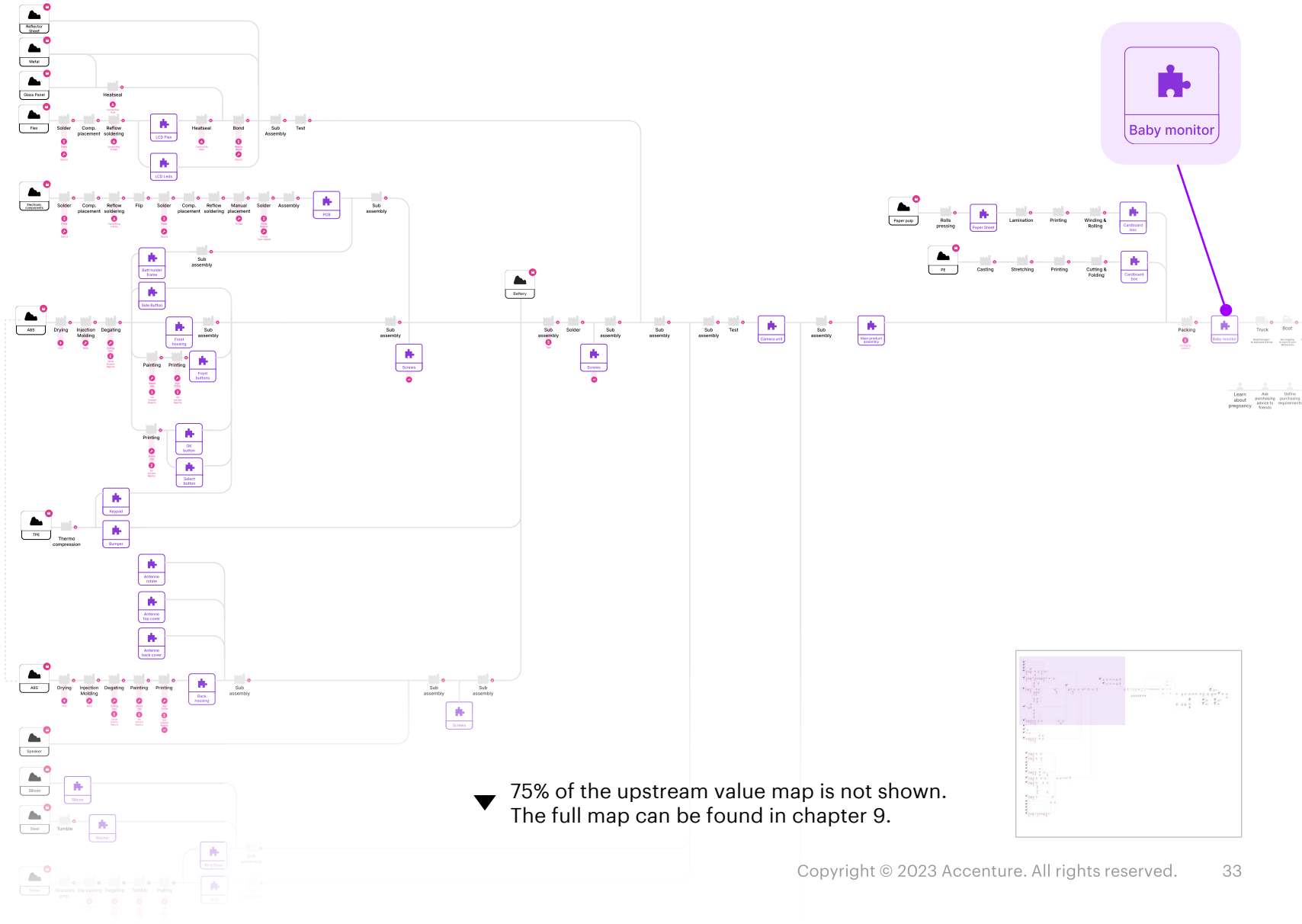


Value Chain Mapping

Upstream

The image on the right shows only about 25% of the total upstream Value Chain Map. It consists of materials, manufacturing processes and components that, when combined, form the complete baby monitor seen on the right of the visual.

The upstream Value Chain Map of the baby monitor was based on in-house knowledge and desk research. It shows an extremely intricate system of interdependent components and production processes: the fact that the image on the right only shows about 25% of the total upstream Value Chain Map further emphasizes that the current value chain is unnecessarily complex. The main contributing factors are the lack of standardized parts and tools, the use of multiple modules, multiple finishing processes and suboptimal PCB design.



75% of the upstream value map is not shown.
The full map can be found in chapter 9.

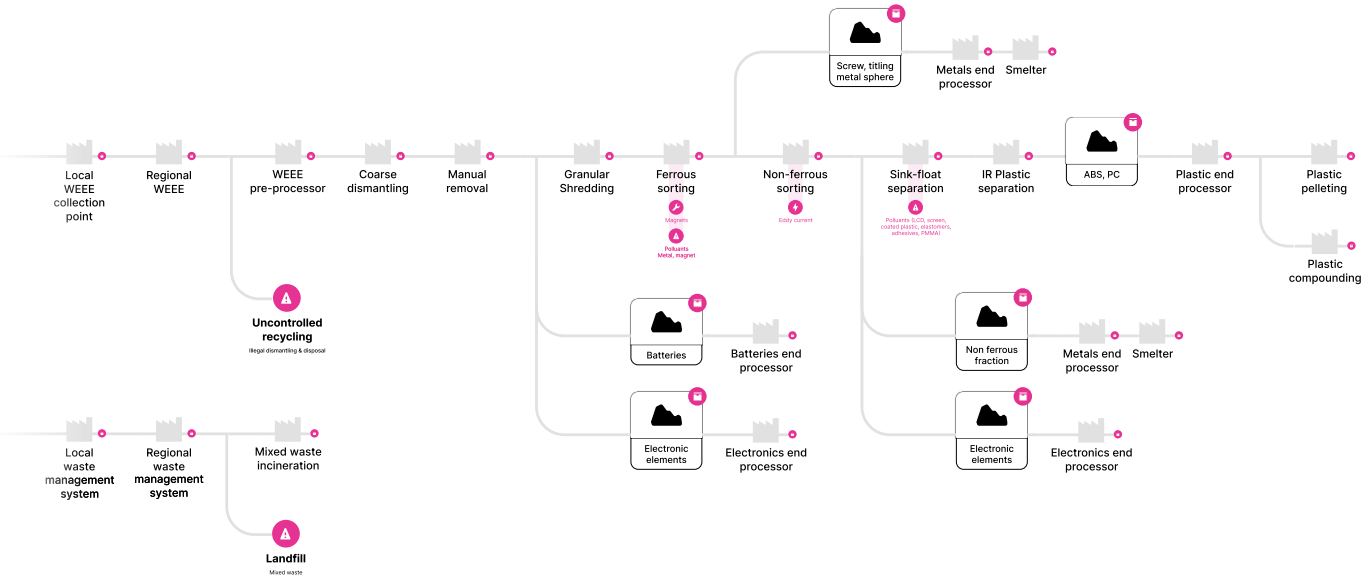
Value Chain Mapping

Downstream

The downstream Value Chain Map shows all steps from the disposal of the baby monitor to the recycling and/or incineration of material. As for the upstream, materials, processes and components make up the map, but in this case favorable and unfavorable practices are highlighted as well.

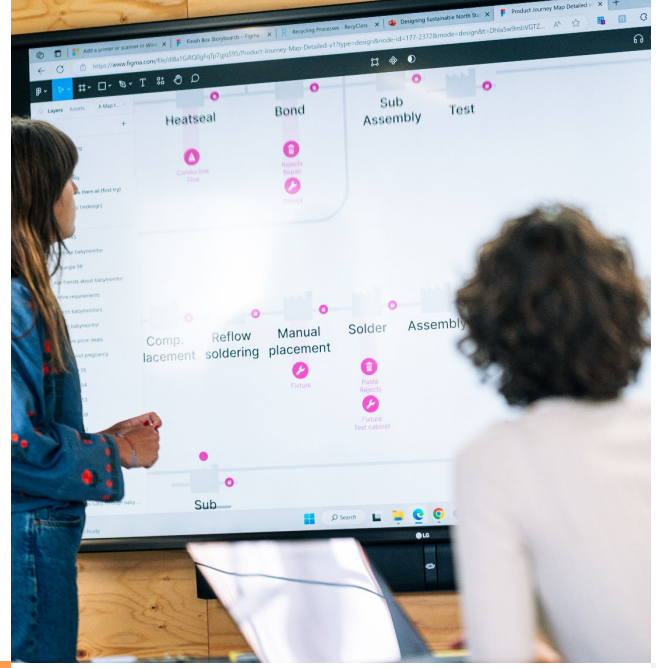
The downstream Value Chain Map of the baby monitor was also based on extensive in-house knowledge and desk research. A key insight shown is that different End of Life scenarios can take place. User disposal choice makes a big difference: the product could be stored in a drawer (typical user behavior with electronics), it could be disposed incorrectly in a general waste bin, or it could be properly disposed in an e-waste collection point. Even if properly disposed, data shows that more than 80% of e-waste end up improperly disposed in developing countries, with major environmental consequences. In the best disposal scenario, many different waste managers are necessary to effectively process all the different components and materials. Additionally, a part of the waste stream ends up in landfills or being incinerated. Combined with the other uncontrolled processes, we assume that this results in a high loss of material value.

Something else that catches the eye is that there are no repair or refurbishment services to prolong the baby monitor's life, resulting in more value losses.



First Principles from Value Chain Mapping

△ Upstream ▽ Downstream



01.

The up-stream value chain is unnecessarily complex

The Value Chain Map shows an unnecessarily complex supply chain due to the large number of different techniques, materials and customized parts that are used for this product.

02.

Lack of standardized parts and tools determine inefficiencies

Custom tools and inefficient molding processes with significant in-process waste are used due to many unstandardized mechanical parts. Examples are small lightguides and spray-painted buttons.

03.

The parent unit requires more impactful processes and materials than the camera unit

Making two physical devices (the monitor and parent unit) results in a doubled amount of production processes. The parent unit in particular presents more complex processes, and it includes materials and parts that require impactful processes (e.g., battery and LCD).

04.

PCB is not optimized for material efficiency

Every chip has a package and lead frame that add weight and impacts material use. The PCB's size, layer count, finishing (extra plating) and copper usage are bigger than necessary.

05.

High processes diversity with many specific waste streams

There are many process steps, each with their own waste-streams which are often not considered in the LCA due to the lack of precise datasets. The number of unnecessary processes is significant.

First Principles from the Value Chain Map

06.

PCB finishing is unsustainable

The choice of finishing of the PCB is not the most environmentally friendly: unnecessary plating processes and masking are required.

07.

Selective painting of plastic parts adds waste

Many parts are selectively painted which requires additional plastic parts for masking. These can only be used 3-5 times creating a waste stream on top of the inefficient spray-painting process. Typically, there is 80-90% overspray for a selectively painted part.

08.

No repair services available

The downstream Value Chain Map shows that there are no repair or refurbishment services available as of now, resulting in value losses.

09.

User disposal choice makes a big difference

The product could be stored in a drawer (typical user behavior with electronics), it could be disposed incorrectly in a general waste bin, or it could be properly disposed in an e-waste collection point.

10.

Lack of awareness = mix trash bin

Lack of awareness about how to properly dispose e-waste is an important issue. Many users dispose electronics in the home mix waste bin. These end up in landfill or incinerated depending on the geography.

11.

Over 80% of electronic products are improperly recycled

Even if properly disposed, data shows that more than 80% of e-waste end up improperly disposed in developing countries, with major environmental consequences.

12.

The parent unit design presents many recyclability issues

The high material diversity makes sorting complex. Batteries and LCD's requires selective sorting, and their recyclability is low in many geographies. Plastic finishings like painting and lacquering hinder recyclability. Use of glues and adhesive hinder liberation during shredding. Thermosets used for buttons cannot be recycled.

13.

The recycling end-processing of electronic parts is inefficient

Although possible, the recycling of PCB's and other electronics elements has lower recovery rates compared to common plastics and metals. End processes are often energy intensive and requires use of heavy chemicals.

14.

FR-4 cannot be recycled

FR-4, one of the most common carrier materials for PCB's, is not only carbon intensive to produce, but it is difficult to recycle as well, since it is a glass-reinforced epoxy laminate material.

05

Life Cycle Assessment

Identifying where the biggest impact lies

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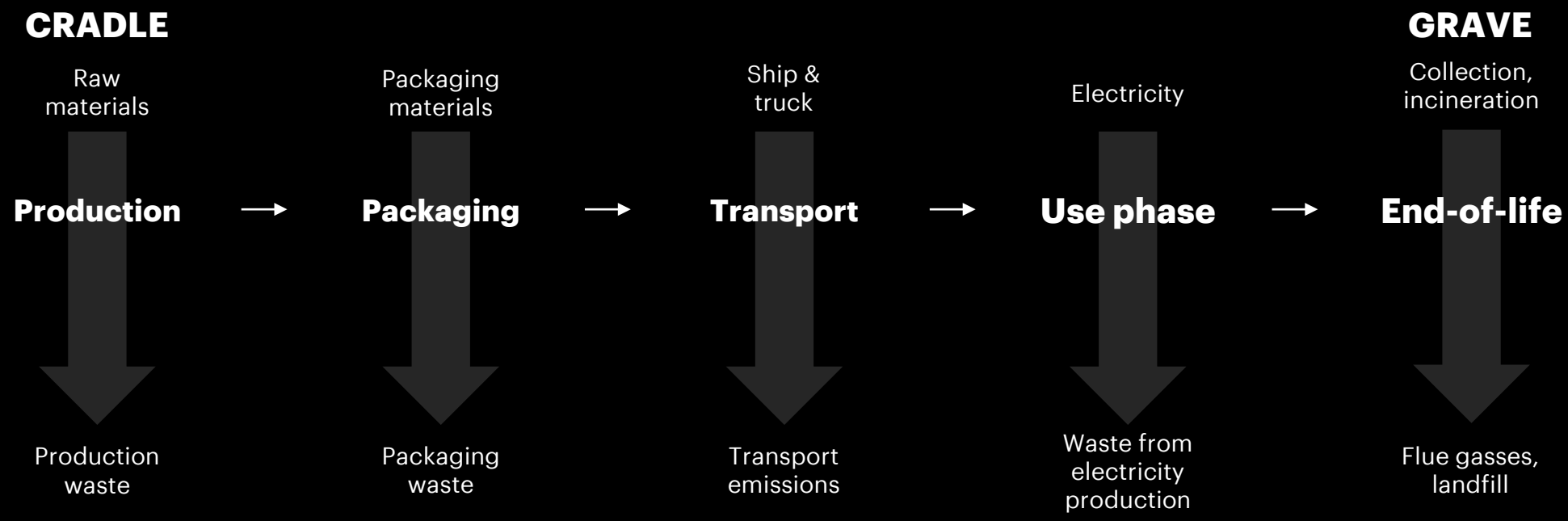
Life Cycle Assessment

Making environmental impact measurable

A Life Cycle Assessment (LCA) is a systematic approach used to evaluate the environmental impact of a product, process or a service throughout its entire life cycle. It takes into account all life stages, from the extraction of raw materials, through production and use, to end-of-life. Impact is measured over several categories, such as ozone depletion, climate change and acidification.



Life Cycle Assessment setup

Making the baby monitor's impact measurable

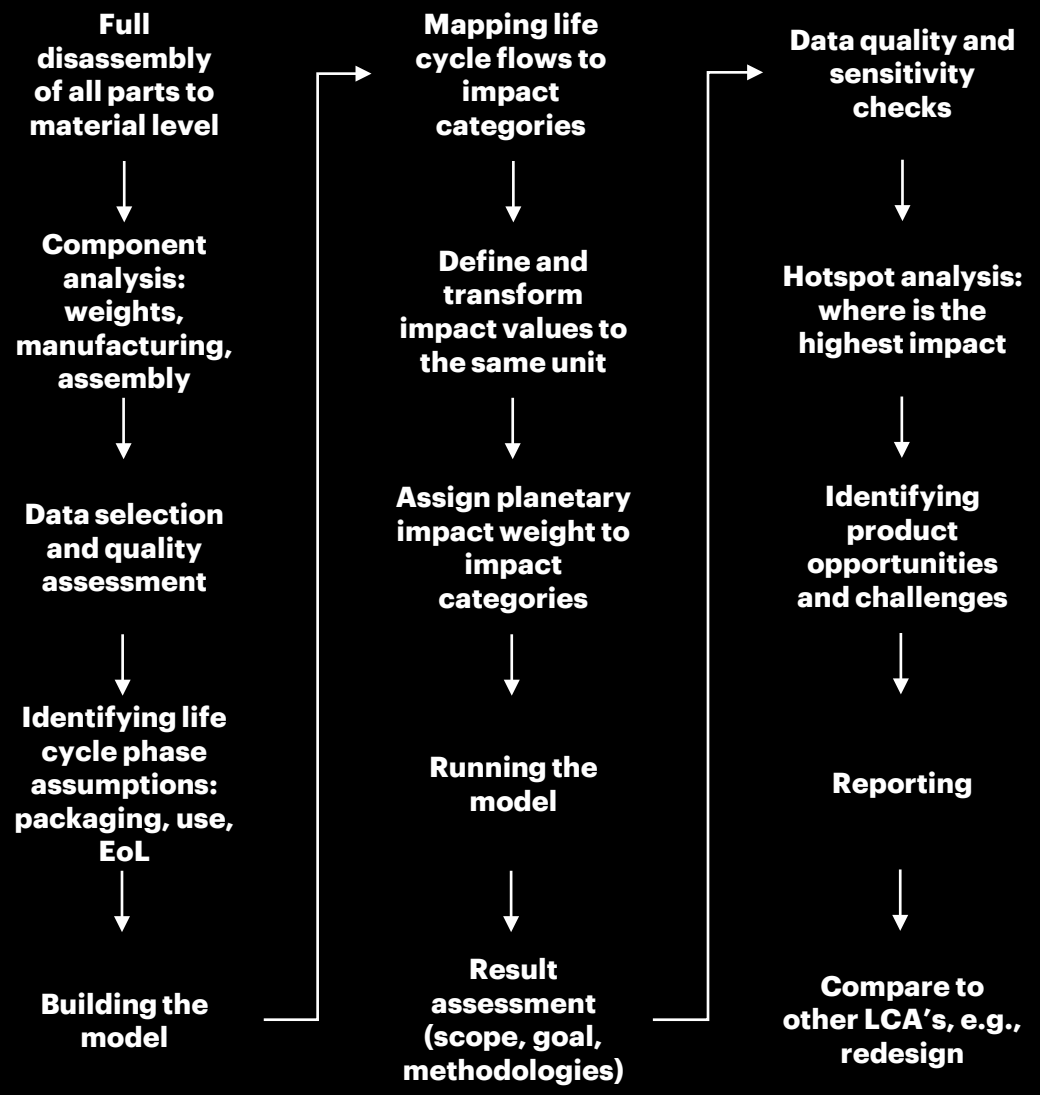
In this project an LCA was performed to find the environmental hotspots of a specific baby monitor, so that these could be taken into account during the redesign process. The LCA was performed by LCA experts' part of Accenture Strategy & Consulting. The process consisted of the following steps:

Product life cycle data collection
Gather all information about the different life cycle steps of the product. Additional information about materials used, specific components, proprietary manufacturing methods, consumer use assumptions, typical end-of-life treatments, etc.

Flow categorization
All in-and outflows specific to some processes in the life cycle need to be mapped on specific impact categories, dictated by the standards used. Examples of these categories are water use, resource depletion, climate change, etc. Each impact results is expressed in one specific unit, such as m^3 water, kg Sb equivalent depleted or kg CO_2 equivalent.

Category normalization
To bring all categories to a base on which all impact categories can be compared, they need to be set to one and the same unit. This is done by a process called normalization.

Category weighting
Not all impact categories have the same result on the planet in its current situation. Some categories are more urgent to tackle than others. To be able to make a final impact assessment, the categories need to be weighted.



Life Cycle Assessment setup

Impact assessment of the baby monitor

Inventory results are associated to environmental impact categories and indicators. This is done in 3 steps:

Flow categorization

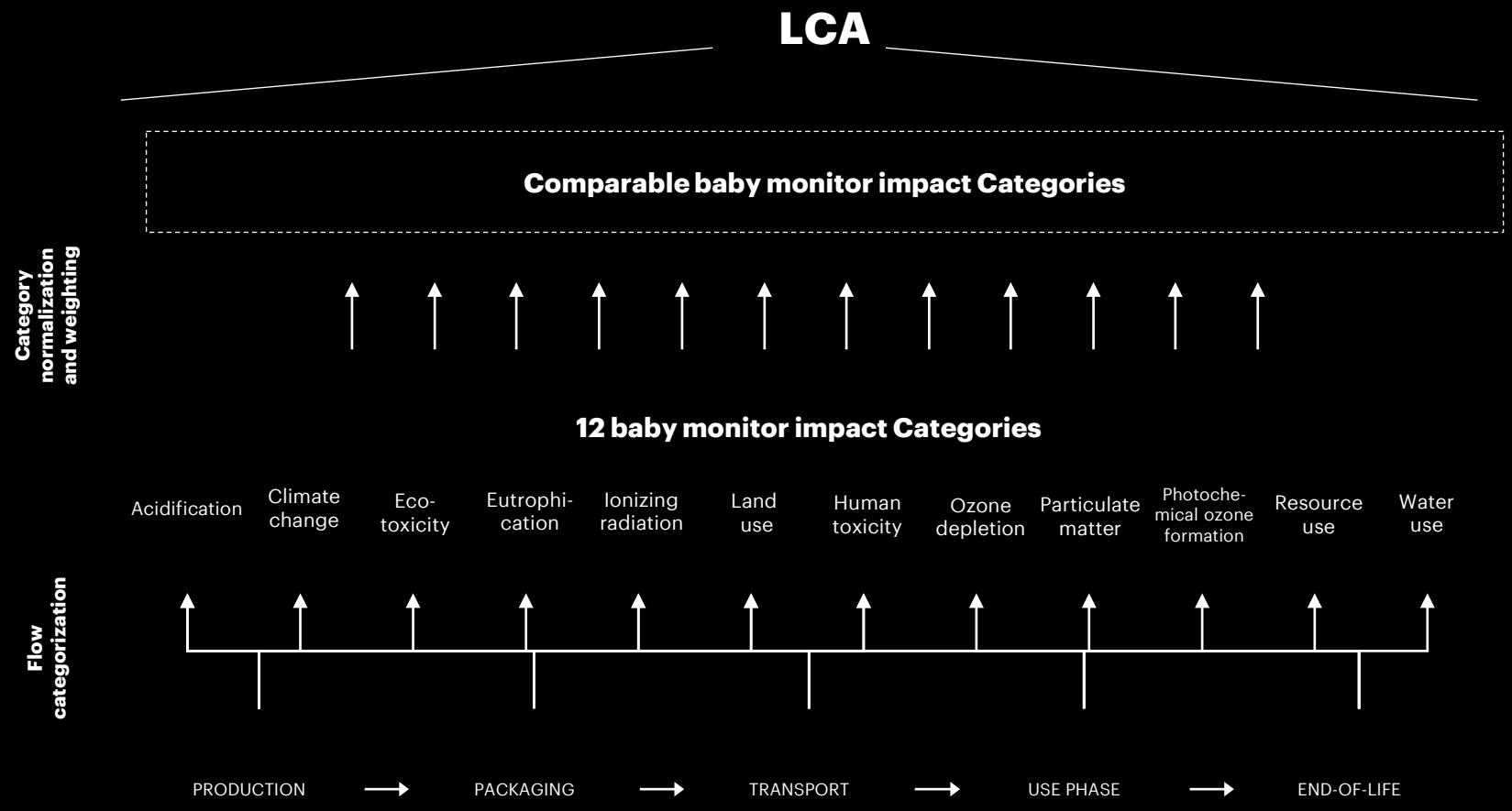
Mapping all mass- and energy flows of the product lifetime into their relevant impact categories. In case of the baby monitor this resulted in 12 comparable impact categories shown in the image to the right.

Category normalization

Impact categories are expressed in a specific unit. To make categories comparable, they need to be normalized. For example, in the case of eutrophication the units mol N-eq, kg PO_4-eq and kg N-eq were normalized to a comparable unit.

Category weighting

Not all impact categories have the same result on the planet in its current situation. Weighting categories leads to one uniform impact.



Life Cycle Assessment assumptions

Filling knowledge gaps

Due to the demonstrative nature of this project, a significant portion of secondary data was utilized such as average industry information, publicly available research, or datasets. Use of secondary data inherently includes some assumptions to be made, they are as follows:

Production

Assembly performed in 1 facility

Manual assembly methods

Components manufactured separately

PCB mounting: surface mounting

Electronic components purchased at 1 supplier

Packaging

Cardboard box packaging

Modules individually wrapped in plastic

Auxiliaries include charger and plug

Packaging is recycled

Transport

Lorry transport to Shanghai port

Shipping to Rotterdam port

Small truck transport to retailer

Use phase

Netherlands electricity grid consumption

Average power consumption estimates based on direct measurements.

Sensoric activation to activity

Majority of time spend in passive mode

2 years active use

1 year phase-out half-time use

End-of-Life

Battery manually separated before shredding

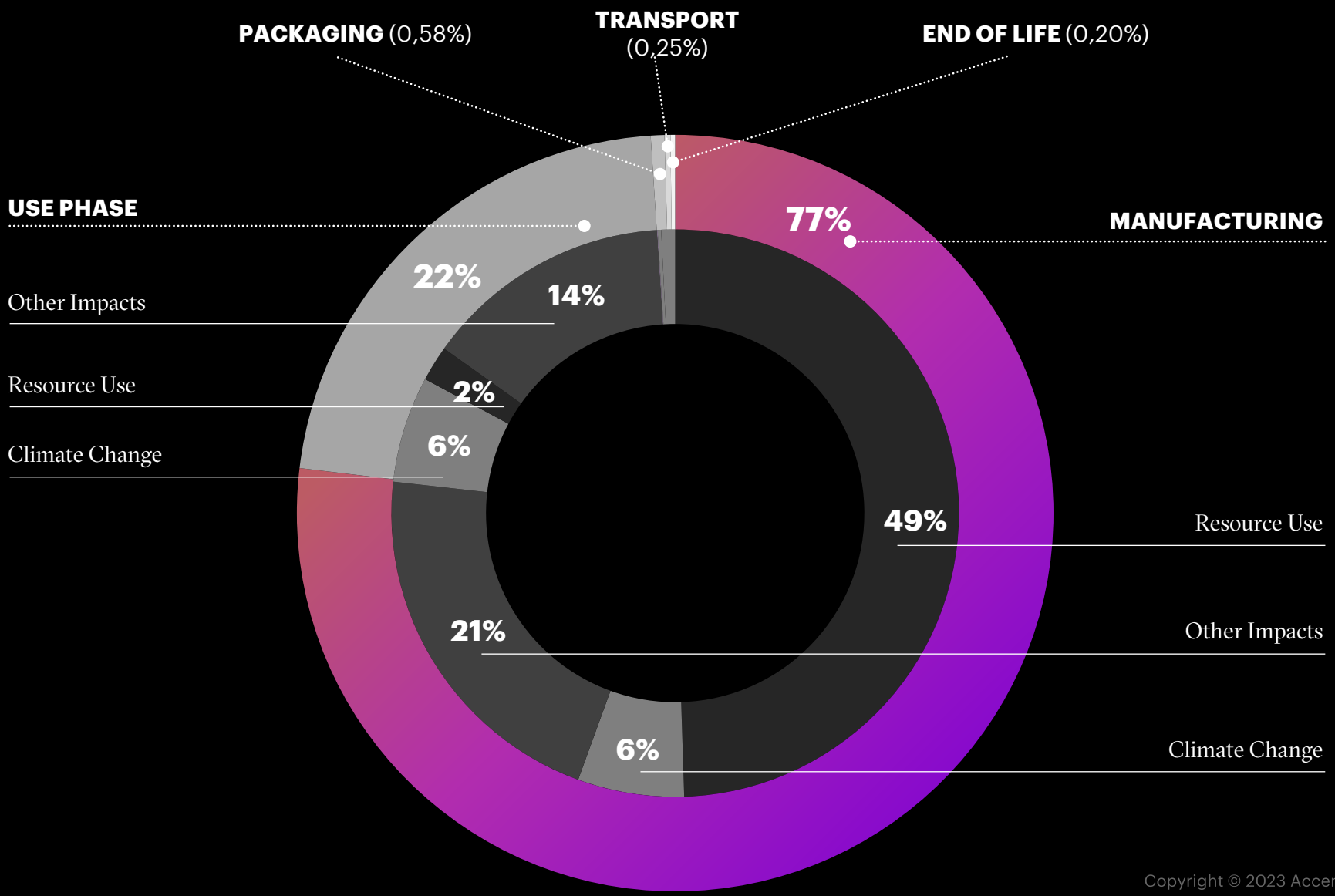
Battery treated separately

Manual dismantling & sorting

25% of electronics recycled

Life Cycle Assessment Results

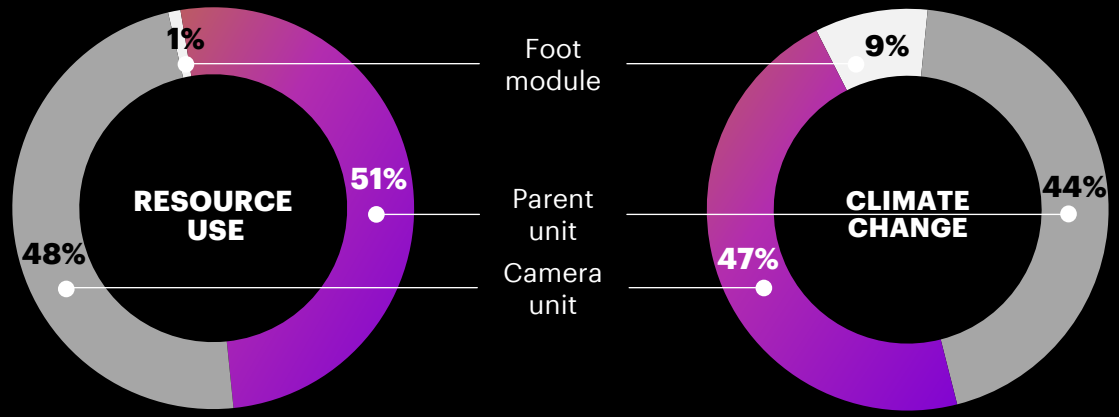
Key insights



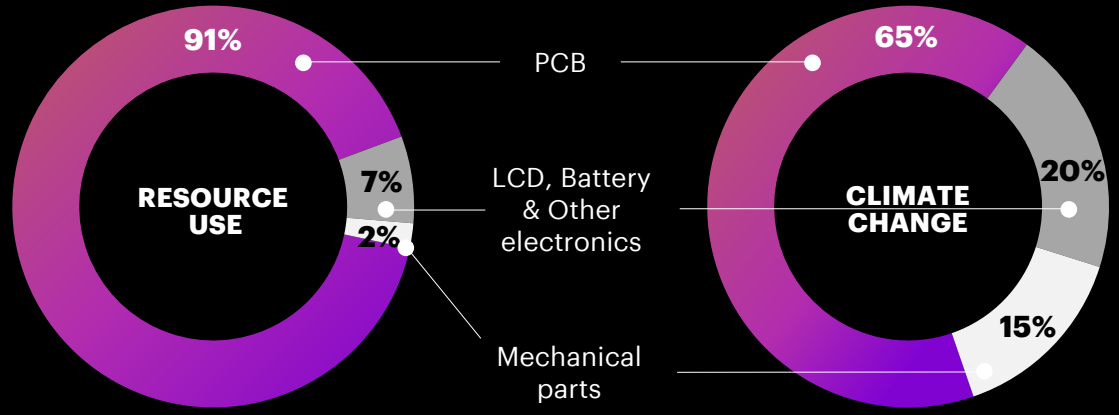
Life Cycle Assessment results

Key insights

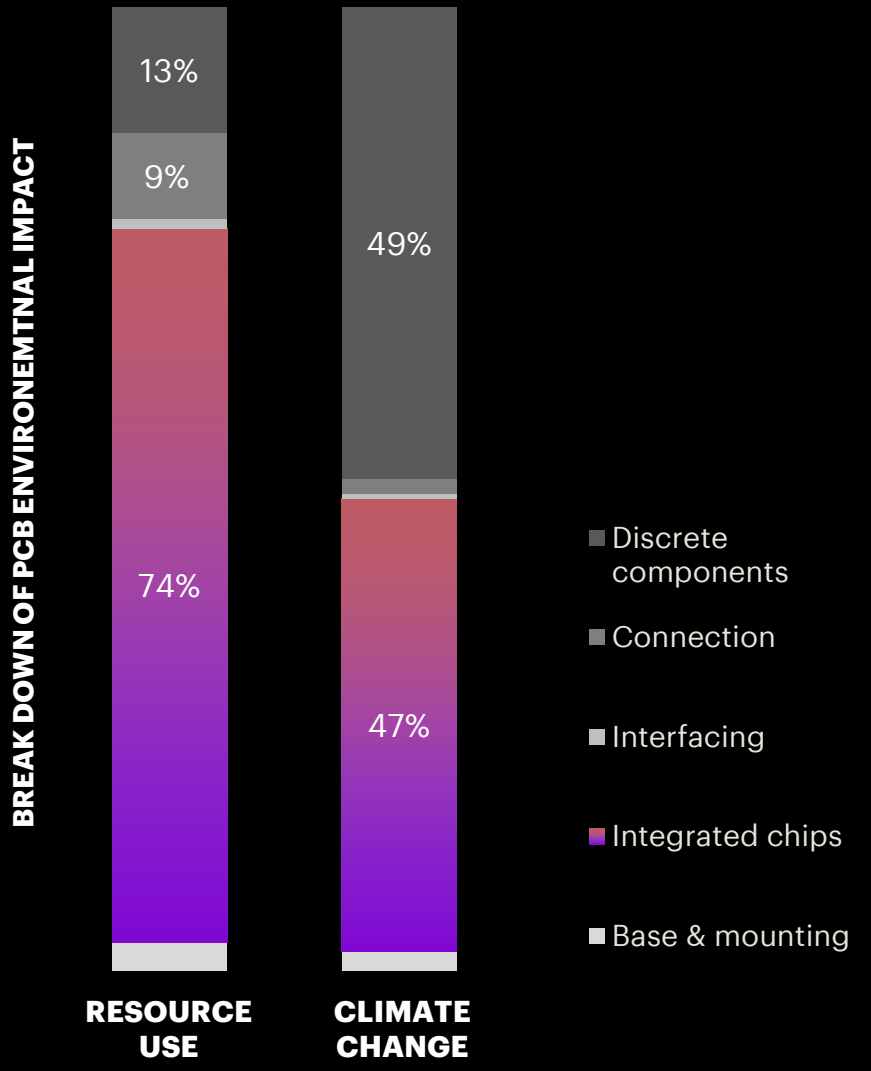
MAIN MODULES



COMPONENTS



BREAK DOWN OF PCB ENVIRONEMTNAL IMPACT



First Principles from Life Cycle Assessment

15.

Manufacturing is the most impactful product life-cycle stage

The manufacturing phase emerges as the primary driver of environmental impact across all stages of the life cycle analysis.

16.

Resource Use and Climate Change are the most impacted environmental impact categories

Out of the 28 investigated impact categories, climate change and adiabatic resource depletion emerge as the two most significant factors exerting the heaviest impact on the overall results.

17.

Electronic components have the biggest impact

The manufacturing phase is notably affected by the presence of electronics components, resulting in a substantial impact.

18.

Integrated chips on PCB have highest impact on resource use

Discrete components form the highest impact on climate change, integrated chips are a close second. Additionally, integrated chips have the highest impact on resource use compared to other PCB electronics.

19.

Discrete components have high carbon footprint

Discrete components, encompassing transistors, conductors, and inductors, stand out with a high carbon footprint, significantly impacting climate change. However, they exhibit a favorable characteristic of low resource depletion, demanding relatively fewer raw materials during their production and life cycle.

First Principles from Life Cycle Assessment

20.

Mechanical components have lesser environmental impact compared to electronics

Mechanical components demonstrate a comparatively lower environmental impact compared to their electronic counterparts.

21.

Manufacturing impact can be decreased by extending the use phase or increasing use cycles

Extending the use phase effectively leads to a reduction in the dominant impact of the manufacturing phase, as the environmental burden associated with manufacturing gets distributed over a longer period.

22.

LCD screen and battery have minor impact on resource use

The LCD screen and battery unit exhibit a relatively lower impact in terms of resource usage compared to other electronic components. However, their contribution to climate-related concerns remains a significant consideration.

23.

Circular strategies can drastically decrease the total environmental impact

The end-of-life stage plays a crucial role, particularly concerning resource allocation and its potential to significantly enhance the ecological design of the product. Strategies like reuse or recycling can initiate a new cycle for product and materials.

24.

The use phase is the second most impactful product life-cycle stage

After manufacturing, the use phase shows high energy usage, with turning on of the camera and transmitting video feed costing the most energy. This is also because most users leave the camera unit always connected to the main.

25.

The PCB has the highest environmental impact of all components

Of all components (PCB, LCD, battery, other electronics and the mechanical parts), the PCB has the biggest impact on both resource use and climate change.

26.

The parent unit has the highest impact on Resource Use of all modules

Compared to the camera unit, the parent unit has the highest impact on resource use.

06

User research

Bringing in the user perspective

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User research

Different methodologies to bring in the user perspective

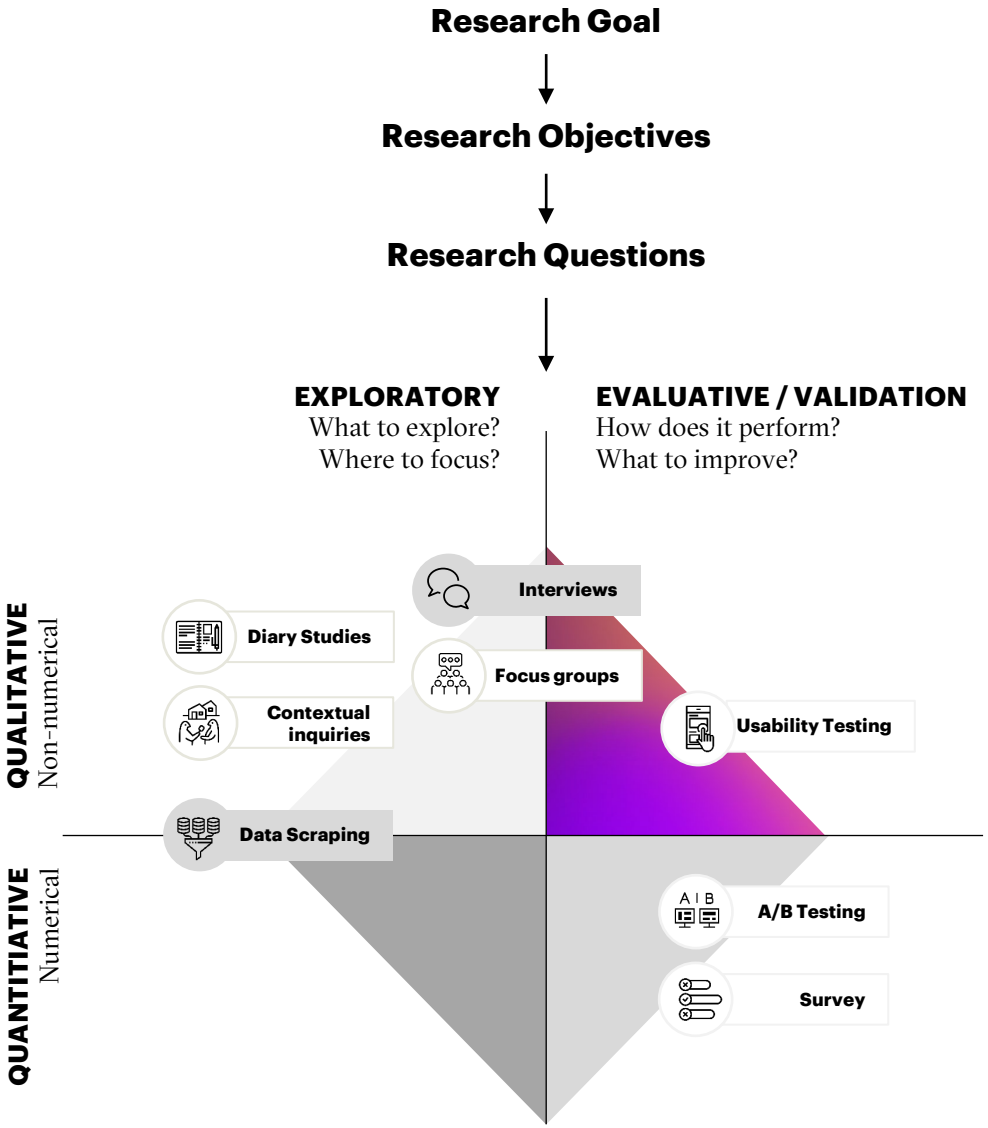
To develop a solution which is not only sustainable, but also desirable for the user, it is vital to take a user centered design approach that includes user research. User research is meant to uncover the users' perspective, and understand the users' pains, and gains regarding a product or service.

Before carrying out any research it is important to start with defining a clear research goal, questions you want to answer and objectives you want to reach. Together with the sample group and timeline, these elements will influence what type of methods to choose to carry out the research.

- **Research goal:** describes what the aim of the research is, as part of a project
- **Research objectives:** describes what we aim to obtain through the research
- **Research questions:** overarching questions need to be answered in order to achieve the research objectives

There are different types of ways to collect data in research: qualitative (non-numerical) or quantitative (numerical). Typically, qualitative research provides us depth in answers (e.g., why do people make certain choices). Whereas quantitative research shows the breadth of the data (e.g., what choices are made most often). By first using a qualitative research approach, we can uncover detailed insights among a smaller group of people. By using quantitative research afterwards we can identify if this resonates with a bigger group of people.

Three main research methods were used in this project. This allowed to uncover different types of insights: User interviews, Aspect-based sentiment analysis and a Literature research.



User research

User interviews

The research objective was understanding core user needs, purchase reasons, and disposal/end of use reasons and behavior. Furthermore, it was also investigated what type of elements influence sustainability perception, the willingness to invest in a more sustainable baby monitor and to extend the product life.

Setup
Two types of samples were recruited: one that had recently purchased a baby monitor (focus on purchase decisions) and one that had stopped using a baby monitor in the last 5 years (focus on end-of-life). Interviews were carried out with a total of 16 participants.

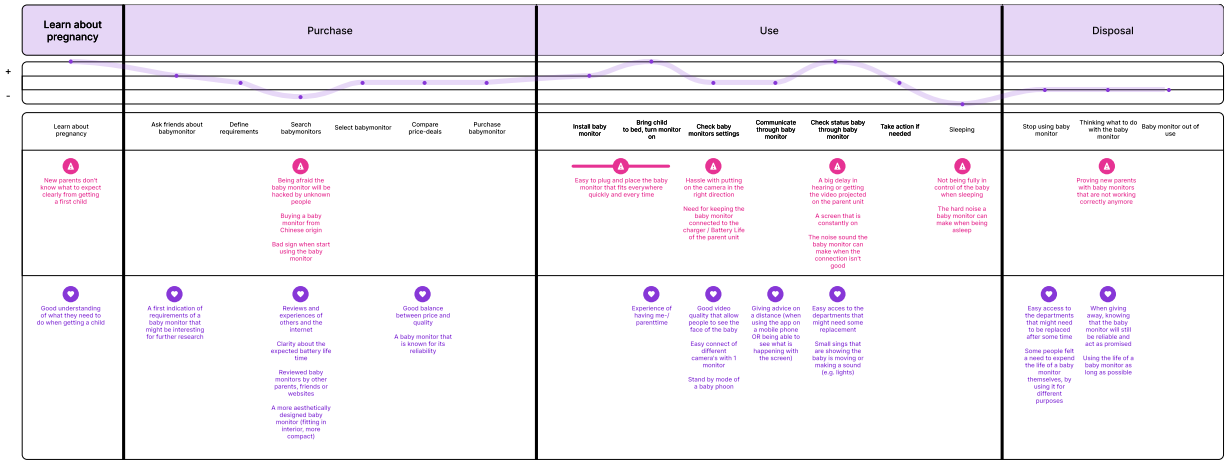
Research tools
During the user's interview:

- *The UX curve* was used to evaluate the experience with the product over a long period of time.
- *The Geneva Emotion Wheel* was used to evaluate an experience for a participant based on emotion.
- *Product Reaction Cards* were used to ask participants to pick cards best describing the experience and the perception of a product/service.

After the interviews:

- *Condens* was used to structure and analyze user research data, and share findings.
- *User Journey* was used to visualize the findings into activities, experiences (positive and negative), pains and gains, quotes and design suggestions.

User interviews



User Journey

User research

User Interviews process

Group 1

8 users that recently purchased a baby monitor

- *Purchasing journey*
- *Reasoning of buying baby monitor*
- *Evolution of experience and average usage of current baby monitor*
- *Understanding sustainability perception (on baby monitors)*

Group 2

8 users that stopped using a baby monitor in the last 5 years

- *Evolution of experience and average usage of used baby monitor*
- *Understanding end of use/life reasons*
- *Understanding current state of the baby monitor*
- *Understanding sustainability perception (on baby monitors)*

Prepare the interviews

Define a framework for the research by completing the Research Plan Canvas

Recruit participants that fit the sample groups

Do the interviews

Introduce the participant to the overarching topic of the research

Start interviewing based on the prepared set up

Tag and cluster the data

Tag the transcriptions of each participants based on relevant subjects

Cluster the data based on the tags and find overarching themes

Gather insights from the data

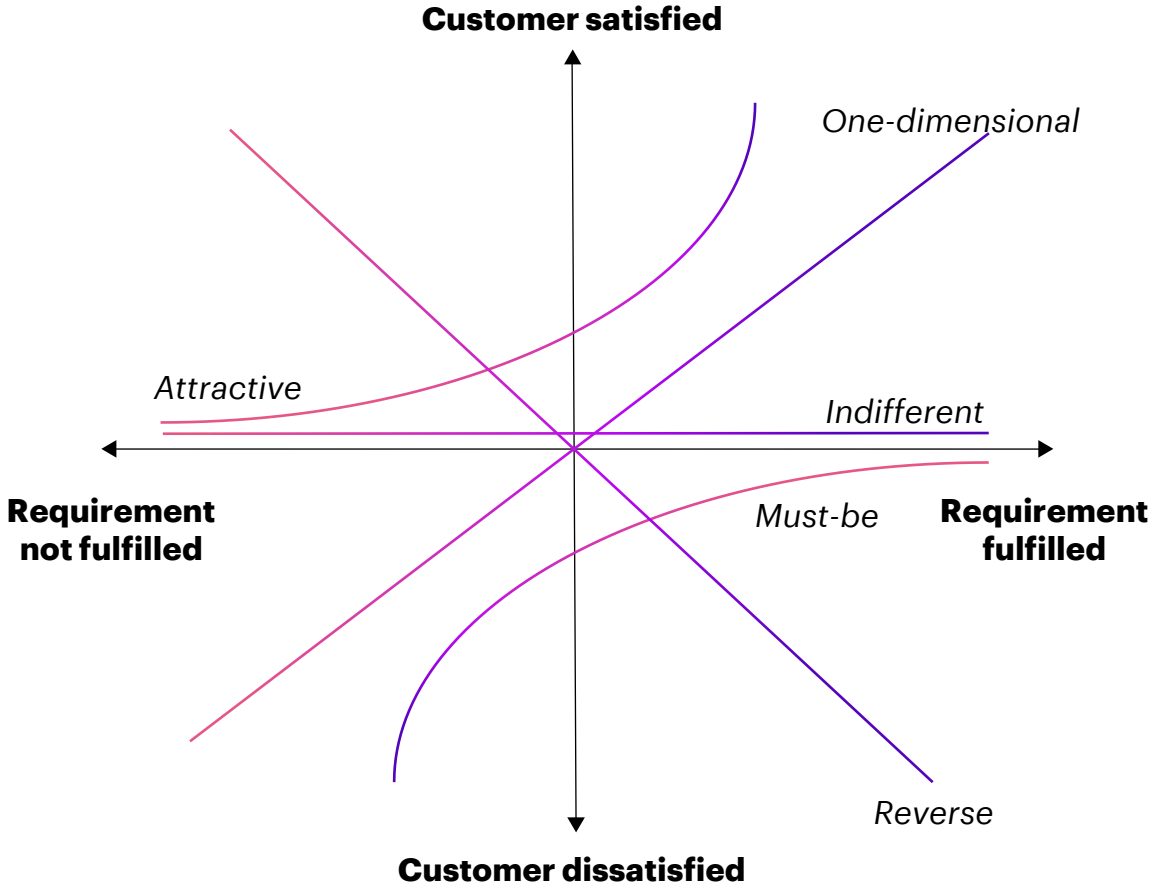
Define First Principles from all the data collected and clustered

User research

Aspect-based sentiment analysis (ABSA)

The objective was identifying which product features are most dominant when a user purchases a baby monitor, understanding how baby monitor users evaluate these dominant product features and identify if and how some users use the product other than for monitoring their baby.

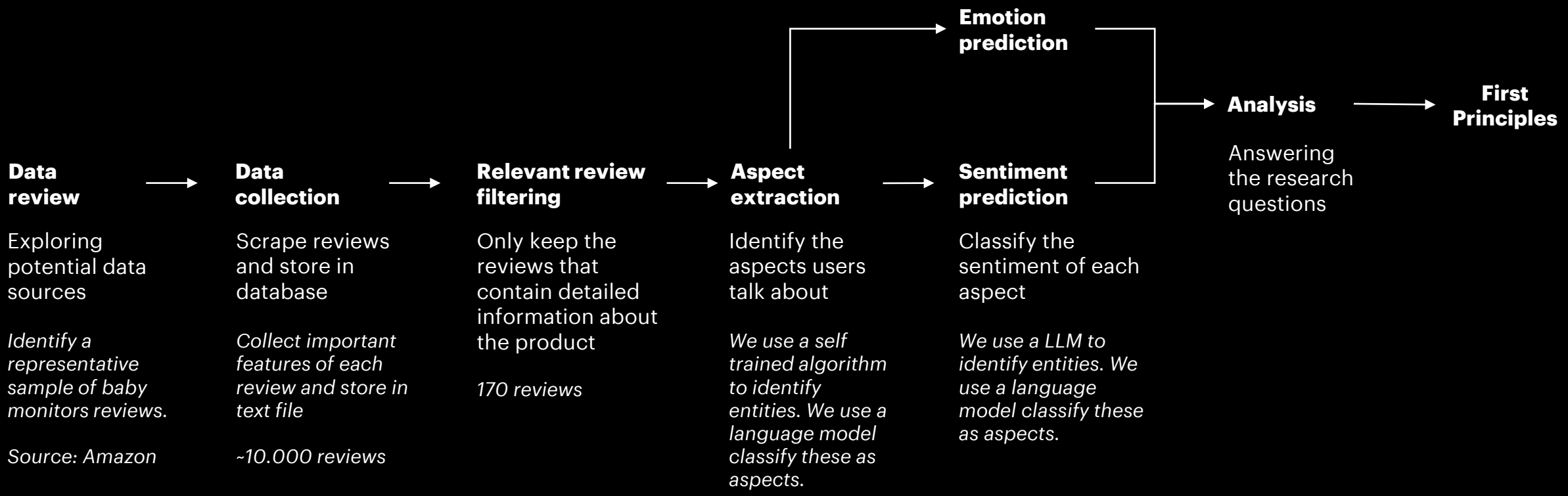
By leveraging ABSA, we scraped and analyzed baby monitor online reviews to identify key features valued by users and evaluate their satisfaction levels. These reviews can come from different sources. For this project we focused on amazon.com. A Python script was used to collect the information and further elaborating the data collected. We performed an aspect-based sentiment analysis to discover the objective and subjective features of importance to the end-user.
These were mapped using the KANO model, an approach to prioritizing features based on the degree to which they are likely to satisfy customers. Features are grouped in attractive, must-be, one-dimensional, indifferent.
Harnessing the power of user reviews through ABSA reveal important insights into consumer needs and preferences, enabling product developers to make data-driven decisions and optimize their designs accordingly. However, this analysis focuses on identifying what users wants/look for in current solutions, rather than what they actually need. Therefore, insights must be carefully considered when creating solutions that go beyond the current way of solving user needs.



The Kano Model is an approach to prioritizing features on a product roadmap based on the degree to which they are likely to satisfy customers.

User research

Aspect-based sentiment analysis process



First Principles from User research

Interviews Literature ABSA

27.

During purchasing, price is leading, sustainability is not considered

Price and reliability are the key purchasing decision factors. Sustainability is currently not considered during purchase. Sustainability on its own is not a sufficiently strong value driver in the short and mid-term.

28.

A baby monitor is perceived as functional and as a must have

A baby monitor is seen as a must have. User wants to be sure it works; they need to know if the baby needs help and go to the room only when really needed.

29.

The core user needs: knowing when parental support is needed, feeling secure and in control

These are the core user needs that users are trying to fulfill by purchasing a baby monitor.

Parents are looking for something that notifies them when they need to intervene. Less functional and more emotional needs are feeling reassured, safe and in control.

30.

Some parents struggle to understand when it's time to move on

Some parents struggle to stop using their baby monitor, because they get used to the sense of control it provides. Checking the video too often or using the product after the child is 4 years old can lead to psychological consequences on the self confidence of both parents, who don't feel ready to stop monitoring, and the children, who above the age of 4 are self aware enough to understand someone is spying on them.

31.

Excess of features and monitoring data can lead to anxiety and stress.

Having many features does not necessarily make the user feel more secure, but could lead to feeling more anxious, and makes it more difficult to stop using the product when it is time to move on.

First Principles from the user research

32.

Reliability is a must and cannot be compromised

The product and the notifications must be accurate and reliable. Key features that are a must-have are reliable, wide range signal reception and parent unit battery life.

33.

Users prefer to buy new baby monitors rather than used

Users wants to be sure the product works. All participants interviewed purchased a new baby monitor; they did not consider second hand or refurbished.

34.

Today, both audio and video are essential features

Audio is seen as essential, because it is often the main trigger to check on the baby. Video is seen as supplementary, but still important, to avoid false alarms and go to the baby only if something is actually happening.

35.

In current baby monitors there are a lot of unnecessary features

Lullabies, speakers, room temperature session, zoom, panning and tilting, nightlights and other room sensors were indicated as barely used and unnecessary.

36.

Having a parent unit brings simplicity

Users don't find the parent unit essential, but they like how easy it is to connect it and to have an extra device dedicated to the baby monitor function.

37.

Current phone apps are a "hassle"

Phone apps are often difficult/time consuming to set up, since the creation of an account is needed and the connection between device and smartphone is sometimes lagging.
It was mentioned that notifications were too many and not precise enough.

38.

Ease of use and aesthetics can be improved

In general, interviewees found that many baby monitor apps UI are difficult to use and configure. Products aesthetics should also be improved: although the priority is proper functioning, baby monitors are generally perceived as ugly. People would like a more minimal design that fits with their interior.

39.

Repair is neither a need nor a wish

The end of use of the product is not determined by breakage, but by unuse. Almost no interviewees encountered issues with their baby monitor (repair was not needed). However, people indicated that they would not be willing to spend to repair the product if it broke. Buying second hand was seen as more attractive than repair. Parent unit charging port issues was the main failure found through ABSA.

40.

Giving it away rather than throwing it away

At end of use, the product is most of the time still fully functioning. It is perceived as a waste to throw it away. Most of the interviewees tried to give it away to someone they knew or to sell it. However, giving it away for free was indicated to provide a better feeling and was the preferred option (low cost, helping someone)

41.

Durable, effective, efficient and simple

This is how most interviewees described what they perceive as a sustainable baby monitor: "it should last a long time, it should work as promised, it should be efficient in material and energy use, its design should be simple: it should only include the most relevant features and it should be easy to use (no irrelevant buttons etc.)"

07

Circular Products Assessment

Understanding today to define tomorrow

Table of Content

Circular Products Assessment

The importance of looking back

Assessing current products is essential to identify challenges and opportunities to be tackled in a new design. After all, those who cannot remember the past are condemned to repeat it.

Insights from the assessment of multiple products, including competitors', are not only essential to fully understand how others tried to solve similar design and engineering challenges, but they are very effective triggers for ideation and creation of new concepts. There are two aspects in particular which are extremely interesting to assess:

Design for Disassembly. This is a very important design strategy, since it is necessary to enable multiple sustainable strategies (e.g., repair, refurbishment, parts recovery). It mostly focuses on analyzing disassembly sequences, types of connectors and tools required to disassemble a product in a non-destructive way.

Design for Dismantling. This design strategy is essential to enable recycling. Contrary to disassembly, it focuses on destructive operations. Assessing dismantling brings the focus on different aspects compared to disassembly, like material types, combinations, finishing, and design for mechanical dismantling.

These two topics share many commonalities, but also many differences, and they are both essential to achieve circularity. For this reason, by taking them into account during the research phase, they can help with collecting interesting learnings to be considered during the redesign.

Products selection

- Direct competitors
- Products presenting interesting features/solutions
- Most successful products on the market
- A range of samples that reflect differences in product categories

↓

Disassembly assessment

- Priority parts identification for disassembly
- Ease of disassembly assessment using Disassembly Mapping
- Documenting of all disassembly operations (notes/pictures)

↓

Dismantling assessment

- Priority parts identification for dismantling
- Dismantling of all parts up until single materials level
- Parts weighting and material composition identification
- Disassembly Mapping
- Recyclability calculator tool to estimate recyclable fraction weight

↓

First Principles

Key learnings from both disassembly and dismantling assessment, including key contradictions.

Circular products assessment

Design for Disassembly

Design for disassembly is a key design strategy, since it enables multiple sustainable strategies, like repair, refurbishment and parts recovery. It usually focuses on manual and non-destructive operations.

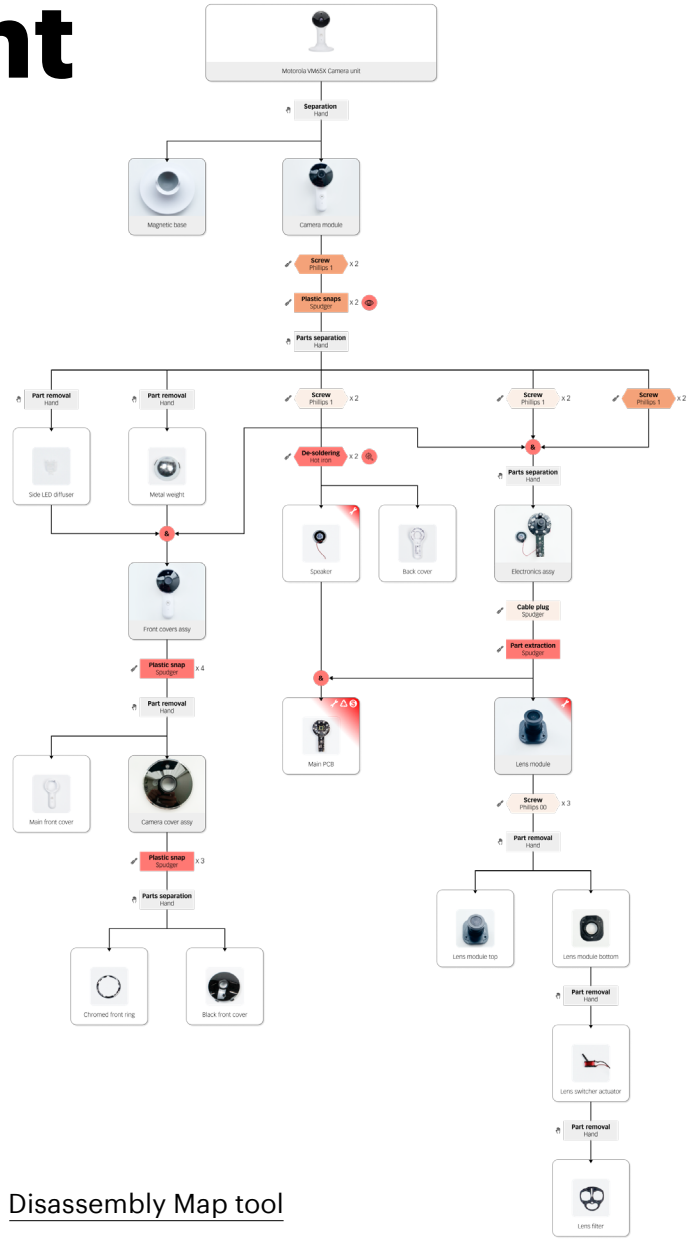
Our design for disassembly assessment process is based on the latest standards, labeling systems and regulations that were released in multiple countries since 2020 (e.g. EN45554, French Repair Index, EU Ecodesign directive for smartphone and tablets).

Identifying priority parts. Priority parts are those with the highest relevance to enable a specific sustainability strategy.

- For repair, these are those parts with the highest likelihood of failure; they can be identified using manufacturer field call rates, cost of non quality reports, consumer association statistics, consumer reviews through ABSA.
- For refurbishment, priority parts are those most likely to need replacement for functional and aesthetic reasons before being able to sell the product to a new user.
- For parts harvesting, priority parts are those with the most fragile supply chain and highest embedded economic value.

Key priority parts for the camera unit are the main PCB and the pan and tilt mechanism. For the parent unit: the charging port, battery, plastic display cover, LCD and main PCB. Covers are priority parts for cosmetic refurbishment.

Architecture mapping. The ease of disassembly of priority parts can be assessed using the Disassembly Map. This is a tool which helps visualizing product's components, disassembly steps/depth, fastener reusability/ reversibility and necessary type of tools. The Disassembly Map allows to visually represent key disassembly challenges and compare different product architectures.



Disassembly Map tool

Circular products assessment

Design for Dismantling

Contrary to disassembly, design for dismantling focuses on mostly automated and destructive processes commonly used to recycle electronics.

Electronics recycling is regulated in the EU by the WEEE directive. There are collection systems in all EU countries and specialized recyclers, which work with mostly fully automated sorting, shredding and compounding processes. Our design for dismantling assessment is based on learnings and insights collected from multiple e-waste recyclers. These are mostly EU based; datasets on e-waste recycling in other regions are still very limited. Our assessment is based on 19 design guidelines, describing:

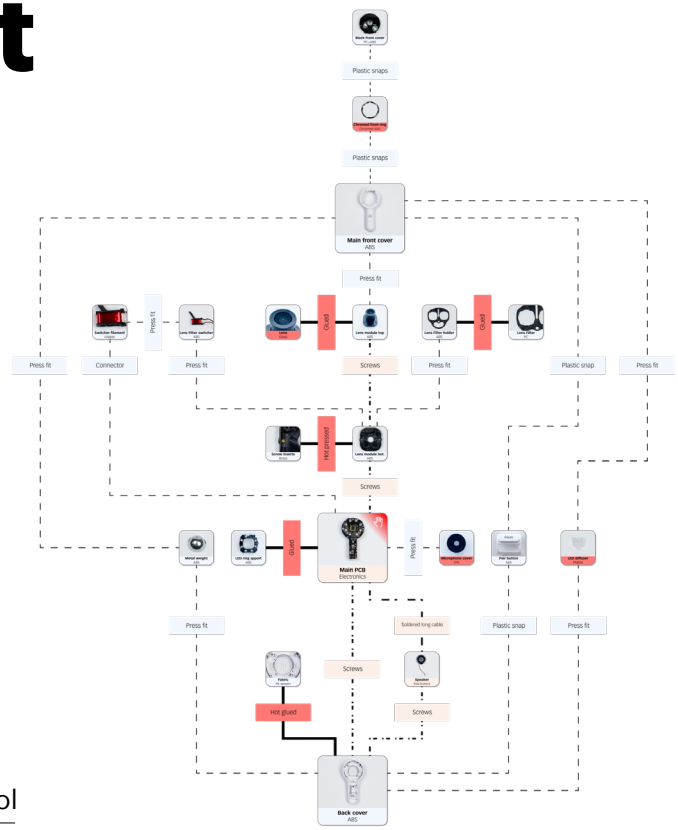
- Avoidance of hazardous substances
- Easy access and removal of hazardous or polluting components
- Recyclable materials
- Material combinations and connections that allow liberation

This assessment is usually done after focusing on disassembly. In this case the focus is less on analyzing disassembly procedures and more on weight, material composition and type of fasteners and interfaces between different parts. All parts are dismantled until a single material level. Then they are weighed, and material composition is identified.

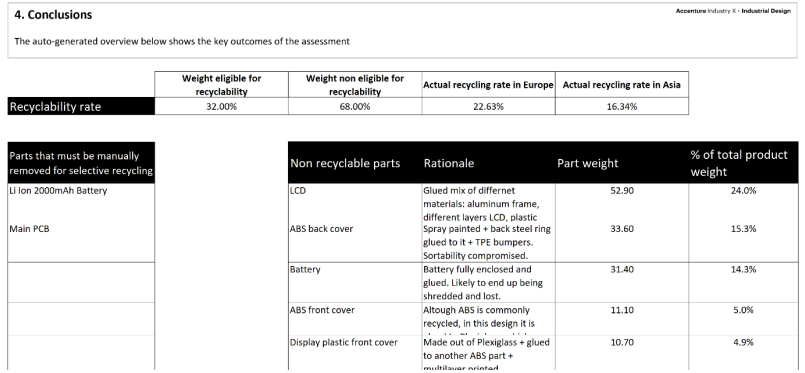
Dismantling Map. This is a similar tool to the Disassembly Map, but it focuses on visually representing those aspects impacting dismantling. Priority parts in this case are:

- Parts that are hazardous or polluting or require selective treatment. For a baby monitor, these are the PCB's, LCD and battery.
- Parts with the highest weight. For a baby monitor, these are the PCB's, battery, LCD and main plastic parts.

Recyclability calculator. This tool can be used to calculate the recyclable fraction of the total product weight, by calculating the weight of those parts that can be easily recycled by a professional e-waste recycler.



Dismantling Map tool



4. Conclusions

Accenture Industry X · Industrial Design

The auto-generated overview below shows the key outcomes of the assessment

	Weight eligible for recyclability	Weight non eligible for recyclability	Actual recycling rate in Europe	Actual recycling rate in Asia
Recyclability rate	32.00%	68.00%	22.63%	16.34%

Parts that must be manually removed for selective recycling	Non recyclable parts	Rationale	Part weight	% of total product weight
Li Ion 2000mAh Battery	LCD	Glued mix of differnet materials: aluminum frame, different layers LCD, plastic	52.90	24.0%
Main PCB	ABS back cover	Spray painted + back steel ring glued to it + TPE bumpers. Sortability compromised.	33.60	15.3%
	Battery	Battery fully enclosed and glued. Likely to end up being shredded and lost.	31.40	14.3%
	ABS front cover	Altough ABS is commonly recycled, in this design it is	11.10	5.0%
	Display plastic front cover	Made out of Plexiglass + glued to another ABS part + multilayer printed	10.70	4.9%

Recyclability calculator

First Principles from Product assessment

Disassembly Dismantling

42.

78% of the camera unit weight is recyclable, while only 32% of the parent unit is

In most products assessed, the camera unit usually presents a simple design, with a high recyclability rate. On the other hand, parent units always present a low recyclability rate, due to glued parts, LCD's, batteries and coatings on polymers which hinder their recyclability.

43.

Camera units are often easy to disassemble and dismantle

Camera units usually present very simple architectures, composed by plastic covers and a main PCB. The disassembly and dismantling was often found to be easy and intuitive.

44.

Parent units present many challenges, both for repair and recycling

All the parent units analyzed presented many challenges for both repair and recycling. For instance, a higher presence of glue components, hidden connectors and a higher number of parts likely to fail during average use. On the other hand, camera units usually present a much simpler architecture, with much less challenges.

45.

Most of the parts most likely to fail are part of the parent unit

While the failure likelihood of the parts used in the camera unit is expected to be low, most failures and risk of breakage are expected in the parent unit. This is because, while the camera unit is stationary, the parent unit is carried around. It can be dropped, it contains a battery, and it has to be repeatedly charged during the product life. Parts like display, battery and charging ports would definitely need replacement if circular strategies are implemented.

46.

Motorized panning and tilting brings complexity

Motorized pan- and tilt mechanisms require a lot of extra parts compared to simple manual ones. This not only can increase the likelihood of failure, but it also makes disassembly more complex. Electronics become more enclosed and difficult to liberate during shredding.

First Principles from product assessment

47.

Hidden snap fits heavily used for display assembly

In all parent units, disassembly of the display is required to access all internal parts. Its disassembly is often complex because of the use of hidden snap fits, difficult to unfasten in a non-destructive way, and the use of glue/adhesives.

48.

Standard chargers used in most models

Most products assessed use standard changers. Most of them were standard 10W USB-A to micro-USB chargers, while others are already adopting USB C. This makes it easy to find replacement parts if needed.

49.

Many potted components, problematic for recycling

Although many reversible connectors were used, speakers and mics were often potted in the plastic housing in both camera unit and parent unit. This is a problem for both recycling and repair.

50.

Glued displays are difficult to repair and recycle.

In most analyzed units, the display used in the parent unit is often glued to its external front plastic cover, making it challenging to disassemble and replace.

51.

Many reversible connectors and common screws

In most products assessed, only common screws were used. Reversible connectors were used to connect electronic components like speakers, mics, displays and batteries.

52.

Batteries are often glued, making it difficult to remove before shredding, creating safety risks

In all products that were assessed, the parent unit batteries were always glued or fixed using adhesives. If not sorted out, batteries can catch fire or explode during the recycling shredding process.

53.

Commonly recycled plastics are often used

Most products use ABS, PC, PC-ABS, HIPS. All commonly recycled.

54.

A lot of spray painting and lacquering, which hinder recyclability

Many products present finishing on the plastic parts that compromises recycling. This is the case with spray painting and lacquering.

55.

Many non recyclable elastomers

Most products presented many elastomeric parts: rubber feet, buttons on parent unit, finishing on hard plastic for soft touch. These are non-recyclable.

56.

Antennas often taped to plastic housing

Adhesive is often used to attach the antennas to the plastic housing, making them difficult to remove for proper recycling.

08

Future Scanning

A glimpse of the future

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Future Scanning

Understanding the future before designing for it

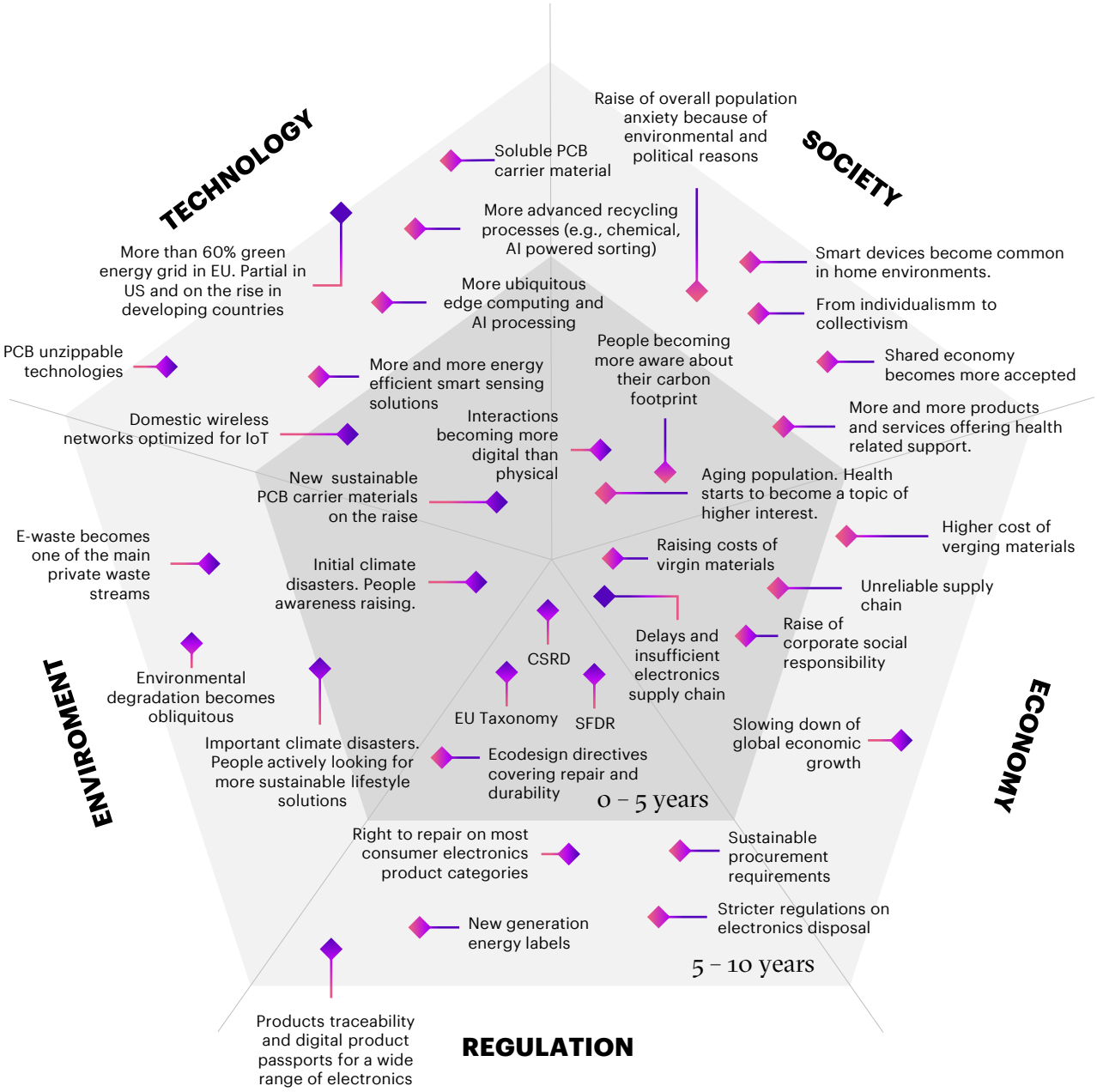
Designing a North Star means that we are designing a product for a future society and economy. It is important to investigate and consider trends that might lead to different ways of living, new technology opportunities to decrease environmental impact, new economical phenomena and changes in regulations and environment.

Future scanning is an important step in our process, to identify possible future challenges, but also opportunities. Our North Star should take these future scenarios into account. There are many ways of doing future scanning; however, it is mostly based on:

1. Identifying macro topic categories which are relevant for the aim of the project
2. Carrying out extensive desk and literature research and/or interviewing a big sample of experts/users

For this project, five key macro topics were identified:

- **Technology**. It is important to identify new technologies which could positively or negatively impact the environmental impact of the North Star.
- **Society**. Focusing on macro perspective (e.g., macro trends like health) and micro perspective, closer to the scope of the project (future of home living).
- **Economy**. Economical changes (e.g., supply chain reliable) are important enablers of new economical models, like circularity.
- **Regulatory**. Changes in this macro topic have already shown to be strong drivers for sustainable change (e.g., EU Green Deal).
- **Environment**. Expected more visible changes at climate level will keep increasing people awareness about the importance of more sustainable consumption.



First Principles from Future scanning

57.

Greener energy grids

Based on the EU renewable energy targets, Baiden's administration plans, the constantly decreasing costs of solar PV, and reports from the IEA, it is clear that the energy grid will become greener in the coming 10 years, with agreed targets of 55% by 2030 for EU. China is also heavily increasing their renewables, despite still financing big coal-based energy projects.

58.

New technologies for more sustainable PCB production and recovery

Two promising technology trends that could contribute to less carbon intensive and more circular electronics have been identified:

- Less carbon intensive and soluble carrier materials (alternative to FR-4), from Jiva®
- Unzippable PCB technology, which allows to non-destructively disconnect single components from the main board, from In2Tec®

59.

The future home environment is smart

The fast raise of smart home assistance, a bigger and bigger ecosystem of smart devices and the development of new standards like Matter and Thread show a clear trend towards a widespread use and increasing acceptance of smart devices in everyday home living.

60.

Focus on mental and psychological heath

Although the aging population trend has been going on for quite some time in fully developed country, this is expanding to other developing countries, which are reaching full development and modern lifestyle. This trend has brought special attention to health. The Covid-19 pandemic further accelerated this phenomena, expanding it to mental health as well. More and more consumer electronics companies are embedding health in their propositions.

61.

Bigger climate disasters = higher user awareness and sensitivity

2022 and 2023 have shown the first worldwide alarming and visible signs of climate change. Western countries are becoming affected as developing ones. This is rapidly raising the awareness and sensitivity of consumers towards the importance of more conscious lifestyle decisions.

First Principles from future scanning

62.

New and stricter environmental regulations

Many markets, in particular EU and North America, have announced and started to release stricter and stricter environmental policies. These are expected to have an important impact on the way manufactures do business: from reporting, to product development, procurement and traceability.

63.

Higher cost of natural resources

Pandemic, climate change and raising political tensions are speeding up supply chain issues and the raise of natural resources pricing. While recovery models, like parts harvesting and urban mining were hardly profitable in the last decade, they are now becoming more and more strategically important to avoid dangerous price fluctuation and dependence from politically unstable/opponent regions.

64.

Increasing e-waste volumes

In 2023, e-waste is already the fastest waste stream in the world. This trend is expected to keep increasing, since electronics is being embedded in more and more commonly used products. A strong example is single use vaping devices, which contain batteries and PCB's, often thrown directly in the biosphere or in mix home trash bins (leading to fires and explosions).

65.

More ubiquitous edge computing and AI processing

Hardware developed by companies like Mythic® and Hailo® allows to perform inference on device, reducing the latency, bandwidth requirements and power consumption compared to centralized cloud solutions. Whilst enabling more intelligent and adaptive applications that can leverage local data and context-awareness.

66.

Wireless networks optimized for IoT

As the demand for IoT devices grows, new wireless networks optimized for IoT are being developed with higher speed, lower latency, higher capacity and better reliability than previous generations of cellular and wireless networks. Meanwhile, interoperability is improved through the development of standards and protocols for IoT devices, such as Matter. These technologies enable the distribution and repurposing of the functionality of devices, creating new possibilities and opportunities for innovation and efficiency.

Synthesis and Ideation

09

Product Journey Map

Synthetizing complexity
in one single overview

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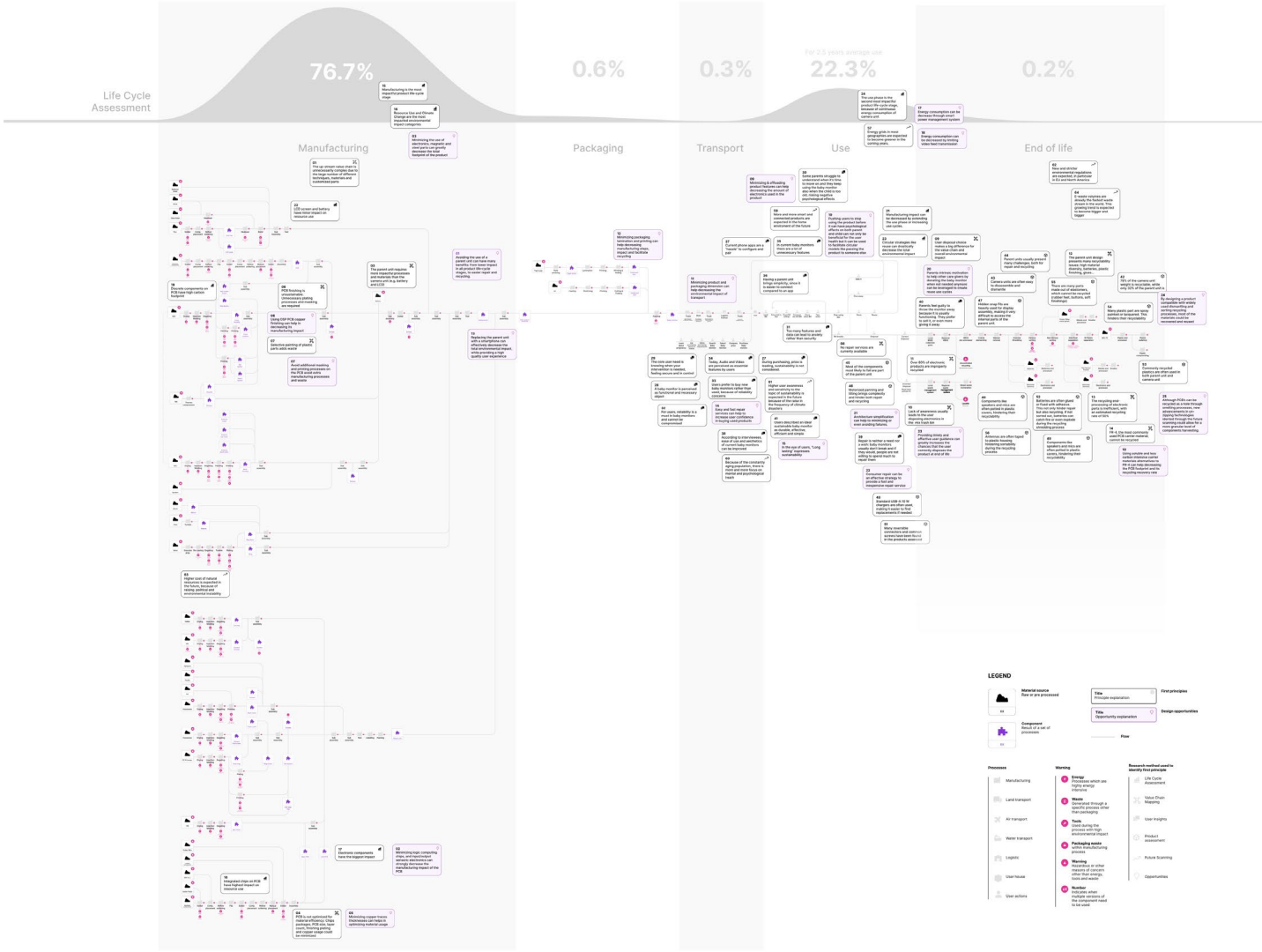
Product Journey Mapping

Combining all research outcomes in one overview

The Product Journey Map is a tool that allows to visually combine the key insights collected using the different research methodologies previously presented. The Journey is split in 5 phases: manufacturing, packaging, *transport, use and end of life. At the top, the normalized environmental* impact of the product in the different life cycle phases is indicated. This allows to immediately spot which phase is currently determining the highest impact.



In the case of the baby monitor, manufacturing and use are the most impactful phases, with an impact of respectively of around 77% and 22%. Beneath the LCA data, the steps of the journey of the product are visualized. These steps are determined by combining the insights form Value Chain Mapping and User Journey Mapping (created based on the user interviews).

First Principles identified through the 5 research methods presented earlier, are mapped throughout the map. The map is used as a synthesis tool, by going through all First Principles and product journey and by identifying design opportunities. These opportunities are then used as input for ideation session, when defining the North Star.

Key design opportunities

01.

Avoiding the use of a parent unit

The parent unit contains a big PCB, LCD and Battery. These are not only the main contributor to the environmental impact of the product, but they are also the parts with the highest likelihood of failure and most complex recyclability. The LCA shows that the parent unit accounts for 51% of resource use and 44% of climate change over the total baby monitor kit.

02.

Minimizing logic computing chips, and input/output sensoric electronics

Computing chips and input/output sensoric electronics and their mounting (soldering) are the components of a PCB with the highest impact. By selecting a technology solution that minimize its use, the overall impact of the product can be minimized as well.

03.

Minimizing the use of electronics, magnetic and steel parts

Electronics, magnetic and steel parts are key environmental impact contributors. By minimizing or avoiding their use, the overall impact can be decreased.

04.

Minimizing PCB layers and size

By minimizing the number of layers of a PCB, the etching of copper, which creates wastewater and other chemical waste, is also minimized. However, this has to be in balance with minimizing the overall PCB size, since FR-4, the most common carrier material for printed circuit boards, is also carbon intensive and cannot be easily recycled.

05.

Minimizing copper traces thicknesses

Avoiding over dimensioning of copper traces thickness allows to optimize the use of natural resources and reduce waste in processing.

Key design opportunities

06.

Using OSP PCB copper finishing

Using OSP finishing, and avoiding other forms of plating like Au, Tn, Sn/Pb, allows to avoid additional processing, to reduce resources used, and to reduce process waste.

07.

Avoid additional masking and printing processes on the PCB

Avoiding additional process, like additional silkscreen, screen printing, inks and solvents allows to avoid additional production materials, fixtures, equipment and related materials.

08.

Using integrated packages, System On Chips

The use of integrated circuits and multi chip modules (SOM's) is beneficial as every chip has a package and lead frame that adds weight and impacts the LCA significantly. Using less components will help to simplify the PCB and reduce the size and layer count.

09.

Minimizing & offloading product features

Many features in current baby monitors are not used at all. Others are barely used. This has also an impact on the level of user anxiety. By prioritizing only those features necessary to answer core user needs, electronics can be minimized. This could also be achieved by offloading some functions to other smart devices.

10.

Using less carbon intensive carrier materials

FR-4 is the most widely used carrier material. It is carbon intensive and cannot be easily recycled. From the future scanning alternative materials, less carbon intensive and dissolvable at end of life were identified.

11.

Minimizing product and packaging dimension

Product and packaging dimension optimization can allow to decrease environmental impact for transport. This becomes even more important when back and forth shipping is needed to enable circular business models.

12.

Minimizing packaging lamination and printing

Printing and laminating packaging has a high impact on the overall packaging production, and it can hinder recycling at end of life.

13.

Replacing the parent unit with a smartphone

From the user interviews, users seems to be open to the idea of using a smartphone instead of an extra device. However, the pairing and configuration must be intuitive, fast and reliable in the long term. This could avoid having an extra device, therefore decreasing the overall impact.

14.

Easy and fast repair to increase confidence in used products

From user interviews it was found that users don't feel comfortable to buy a second-hand baby monitor, since they want to make sure they buy something reliable. A fast and simple repair service is a must to increase confidence and lure users to buy pre-owned products.

15.

"Long lasting" expresses sustainability

Based on the user interviews, people perceive a sustainable baby monitor as "long lasting". This is a key feature required to ensure people perceive the product as sustainable

Key design opportunities

16.

Leveraging a technical life that outlasts a single use cycle

Based on user interviews and data scraping, it was found that baby monitors last longer than their average use. This can be leveraged by creating an engaging experience which allows to reuse/repurpose the device after its first use cycle.

17.

Decreasing energy consumption through smart power management

Energy consumption accounts for 22% of the total environmental impact. The product assessed had a high power consumption even in stand-by. Based on the interview, the user always leaves the camera unit connected to the main.

18.

Decreasing energy consumption through limited video feed transmission

Video feed transmission from camera unit to parent unit is the operation that requires the highest energy consumption in the current design. By removing the video feed from the user experience, power consumption can be descreased.

19.

Helping parents while triggering divestment and circularity

Some parents struggle to understand when it is time to stop using the baby monitor. By developing an enjoyable and engaging divestment experience, the user can be triggered and guided to give the product a second life or to understand how to properly dispose it.

20.

Leveraging intrinsic motivation to help other parents

Interviewees explained that giving away the unused baby monitor to another parent is what they prefer the most. It makes them feel like they are helping someone else and not wasting a product which is still fully functioning. This can be leveraged to create a new use loop.

21.

Architecture complexity minimization to avoid failures

Secondary features, like motorized pan and tilt requires additional parts (mechanical and electronics), increasing the likelihood of failure and the complexity in both disassembly and dismantling. By focusing on core features and by simplifying architecture, failures can be also minimized.

22.

Consumer repair to provide fast and inexpensive repair services

Easy and fast repair is a must to increase user acceptance of pre-owned units. Shipping spare parts directly to users and intuitive repair operations is a key strategy for a fast and inexpensive operation. To be consumer proof, the repair must not only be fast and simple, but also safe, intuitive and mistake proof.

23.

Providing timely and effective user guidance about proper disposal

Many people are not aware about how an electronic product should be properly disposed. Providing clearer and more accessible information at the right point in the user journey can greatly increase the chance that a product is reused or properly disposed.

24.

Optimizing for dismantling

By designing a product to be compatible with widely used dismantling and sorting recycling processes, most of the materials could be recovered. This means minimizing material diversity, using materials widely recycled, avoiding finishings and fasteners that hinder liberation and sorting, avoiding the use of hazardous or selective sorting parts (e.g., LCD's, Batteries, big capacitors).

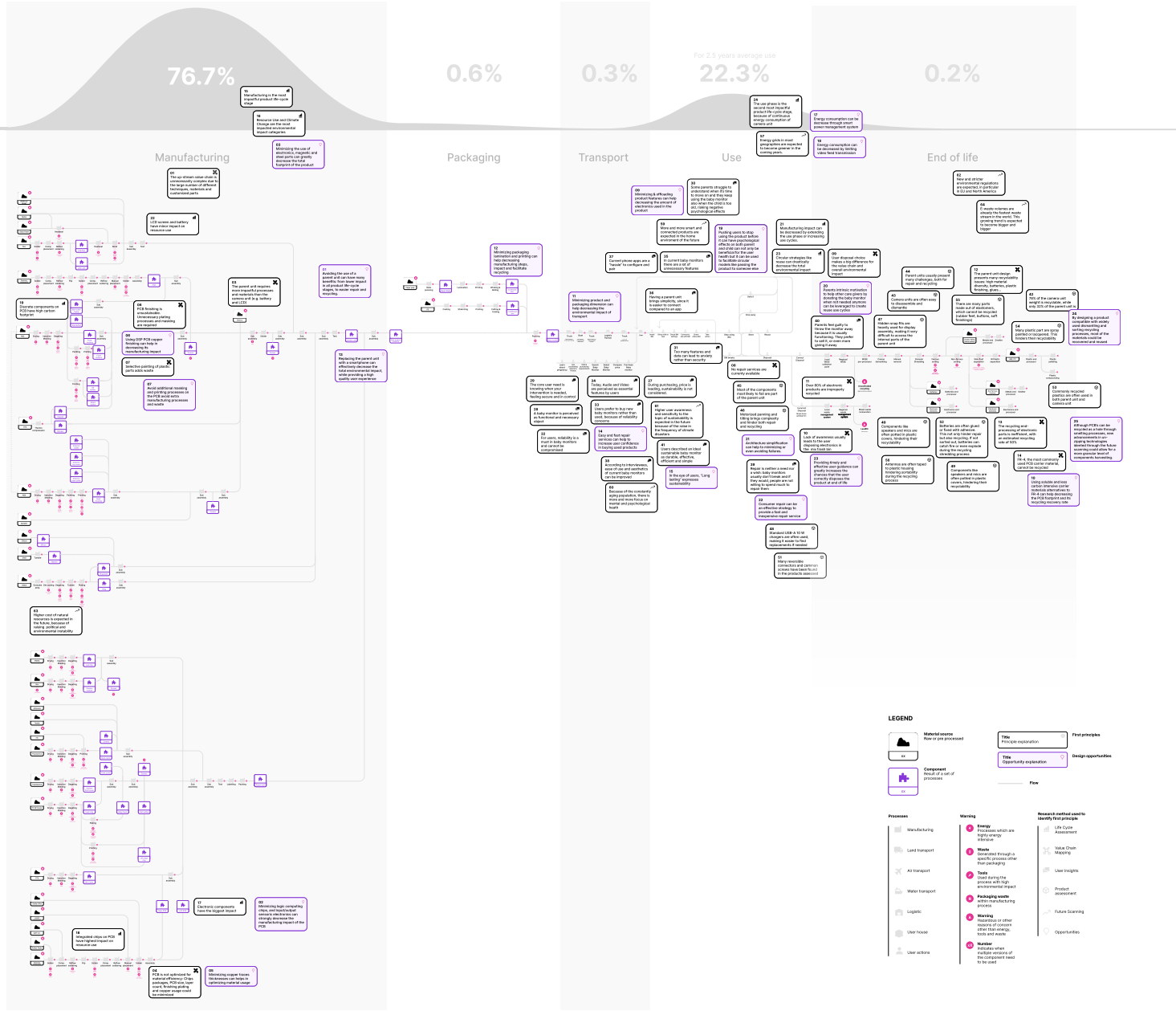
25.

Using unzippable technologies

Although PCB's can be recycled as a whole through smelting processes, new advancements in unzipping technologies identified through Future scanning would allow for a more granular level of components harvesting and sorting. This would allow to decrease the impact of recycling end-processing and create higher quality secondary raw flows.

Product Journey Map

Zoom in to see in more detail



10

Ideation & concept selection

Exploring different paths

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Ideation

Giving shape to ideas

Ideation is a pivotal phase in the Sustainable North Star process: it marks the beginning of creating tangible solutions based on the findings of the previous phases. By using the Product Journey Map as main input, brainstorming and ideation were carried out to define a North Star. This is done with a multi-disciplinary group, which includes designers, engineers, researchers and strategists, enabling them to give shape to ideas with different perspectives in mind.

The Product Journey Map is used as a trigger for initial discussion; First Principles identified might be different compared to what people expected at the start of the process, making this an important moment to share considerations among the team.

An effective way to brainstorm with a big and diverse group is to split the group in smaller teams, while maintaining diversity in the group compositions.

To collect a broad spectrum of ideas, different “How might we” questions can be derived from the 66 First Principles and 25 design opportunities identified during research, and assigned to different teams, to avoid too much overlap in the type of generated ideas.

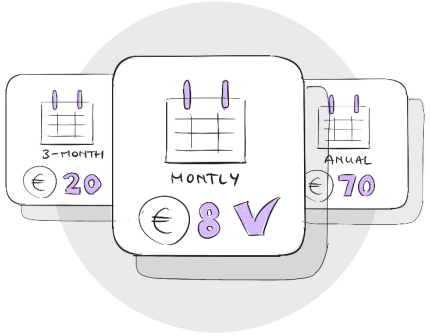
At the end of the session, each team presents their ideas, including the benefits they see for user, planet and business.

System level concepts

Different directions

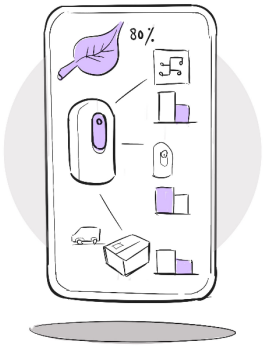
System level concepts, including service design ideas, have been split from product level ones, since they could be independently implemented in the final selected design direction. Naturally, specific product level solutions might need to be integrated to enable the system level concepts.

Concept 1



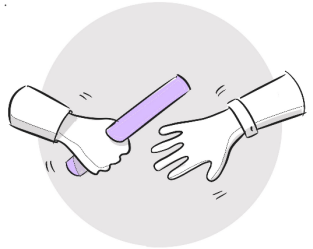
Subscription based model, where the parent rents the device by paying a monthly fee. Any service and support cost is included in the monthly subscription.

Concept 2



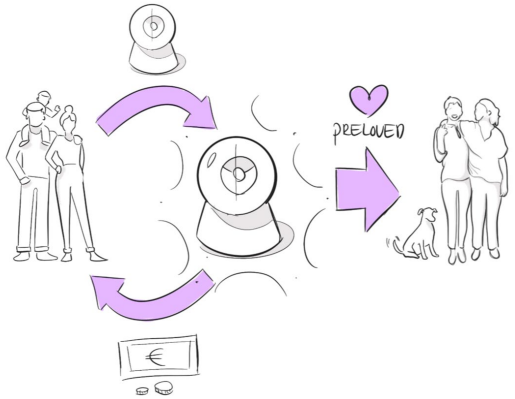
Configuration service, which allows consumers to build their own solution. Users are made aware of the environmental impact of the product configuration they are choosing, attracting them towards the most efficient one.

Concept 3



Platform to pass the baby monitor to the next parent, when no longer needed. The service could be local, with more direct interaction between users, or more automated (more similar to an online sale platform)

Concept 4



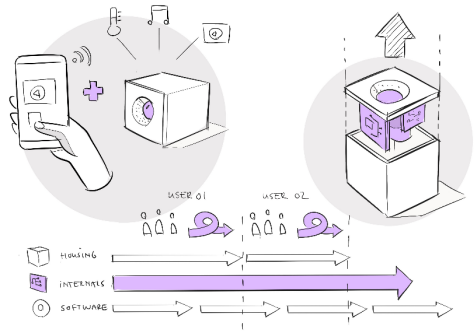
Pay back scheme to collect the monitor, refurbish it and resell it as preloved product.

Product level concepts

Different directions

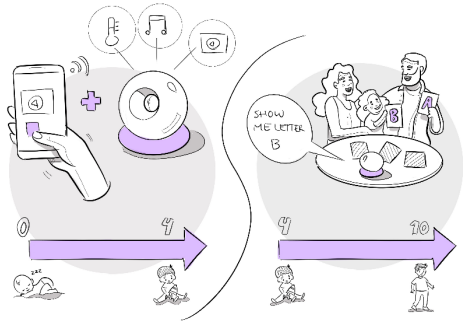
Based on their nature, ideas can be clustered in concepts directions, which are then further refined.
Benefits and challenges are detailed out and used to select the best concept direction to further explore.

Concept 1



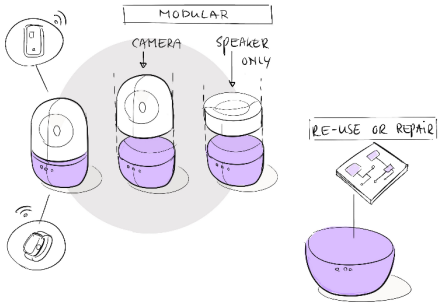
Video baby monitor fully optimized for material use reduction, power consumption reduction, refurbishment and upgradability.

Concept 2



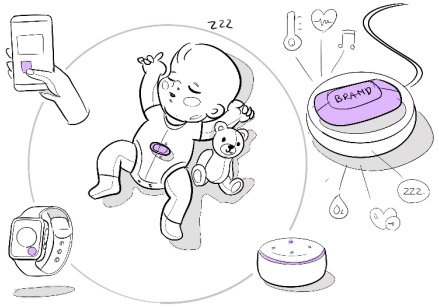
Design that evolves over time, following the growth of the baby and their evolving needs. The same hardware can be reused for different purposes.

Concept 3



Modular design, that allows users to purchase only the modules they really need, or to add more over time. Information and notification overload is replaced by a “subtle notification experience”, where the user is notified only if really needed, through different smart devices.

Concept 4



Wearable sensor, which can fulfill the core user needs without using a camera and in a compact form factor. Hence, minimizing materials and transpiration impact. Offloading of secondary functions, which cannot be achieved with a wearable to smart home devices.

Selected concept direction

Defining an overall direction

The selected direction combines the key benefits of different concepts developed during the brainstorm. When defining a North Star, it is important to define a clear overall direction, while still proposing alternative paths to be further explored and validated in the short- and mid term. Below the key paths defined for product, user and system are presented.

Product paths

P.1 Design for disassembly and dismantling

P.2 Sufficient tech

P.3 Smart home offloading

P.4 Power consumption optimization

P.5 Lower carbon PCB

P.6 Unzippable PCB

UX paths

UX.1 Subtle and reassuring notification experience

UX. 2 Optimized divestment experience

System paths

S.1 Preloved resale platform

S.2 Industrial refurbishment and resale

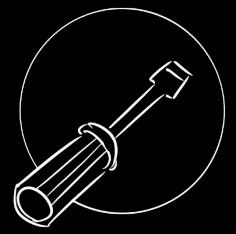
S.3 Subscription based model

The overall North Star direction:

"A connected, sufficient and subtle smart sensing solution, where the end of the journey is as important as its begin"

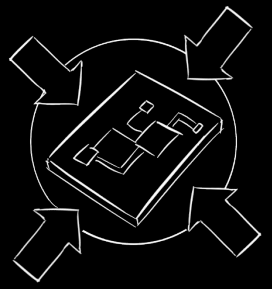
Selected concept direction

Product paths



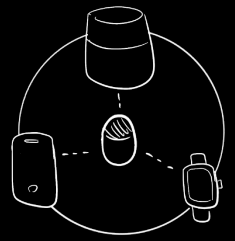
P.1 Design for consumer disassembly and dismantling

Design for Disassembly is a core design enabler for most end-of-life value retention strategies, such as repair, refurbishment and parts recovery. It is a necessary path to explore and implement any of these possible long-term strategies. Furthermore, future repair regulations are expected, and being able to easily repair the product is essential to promote trust in pre-owned. By combining design for disassembly and dismantling, we ensure that the architecture we develop fits also the last of the circular loops: recycling.



P.2 Sufficient technology

The amount of hardware, in particular electronics, is minimized by implementing smart sensing technologies which monitor only the strictly necessary parameters to achieve the main core user need that the product is meant for: detect if the child is in a situation that requires the parent's intervention.

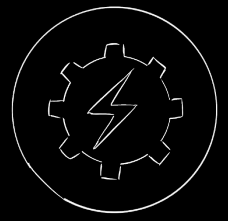


P.3 Offloading of non-essential functions to smart home devices

Based on the future scanning insights, we expect that the use of smart and connected devices in the home environment will keep increasing. This is a great opportunity to offload some of those secondary, but still appreciated, functionalities to other devices which will often already be present in people's homes.

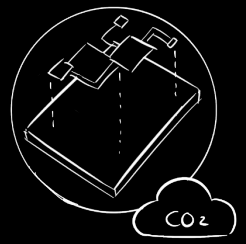
Selected concept direction

Product paths



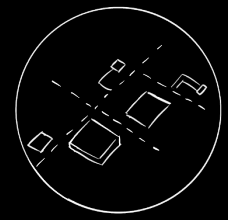
P.4 Energy consumption optimization

The use phase is the second most impactful life cycle phase of the current baby monitor. Power consumption is the key driver of this impact. Based on the Future Scanning, we expect power grids to become more and more green; however, this will remain an important hotspot to address. By investigating smart power management logic and low power consumption sensing technologies, we can minimize the environmental impact of the product during use phase as much as possible.



P.5 Lower carbon PCB carrier material

The LCA shows that the manufacturing phase is the most impactful of the entire product life cycle. The key hotspot contributing to this impact is the production of the PCB. From the recyclability assessment, we see that the recyclable weight of PCB's often does not go above 50%, because of the non-recyclable FR4 material used as carrier. This material is also carbon intensive to produce. Future scanning pointed us towards innovative technological alternatives. Although these are still developing and not ready for full scale production, they are a path worth exploring.



P.6 Unzippable PCB technologies

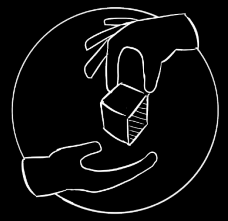
Similar considerations apply to the components used on the PCB: being able to more easily separate components from a PCB at EoL could potentially allow for micro harvesting or higher recycling yields. This would indirectly decrease the environmental impact of the production of the PCB, by promoting the market to reuse and recycle components and/or materials. Currently, unzippable PCB technology, identified thanks to the future scanning, has a low technology readiness level. However, it is a path worth investigating since it might bring big benefits in the long term.

Selected concept direction

User Experience paths

UX.1 Subtle and reassuring notification experience

Through user interviews we found out that false alarms are quite common with current baby monitors: a notification is sent every time noise or movement is sensed, even in those cases where parent's intervention is not really needed. This is one of the main reasons why people today are moving to video baby monitors: they can check through the video if the child actually needs help. By designing a new, more reliable, precise and reassuring notification experience we can achieve a more subtle system, less stressful for the parents and that does not necessarily need a video signal. Avoiding video signal also means avoiding a parent unit and decreasing power consumption during use.



UX.2 Optimized divestment experience

Giving up the sense of security provided by a baby monitor is sometimes difficult for parents. This can lead parents to use the baby monitor longer than is advised, risking behavioral and psychological disorders for both child and parent. Designing an optimized user experience can help the parent divest from the product. But what to do next? These optimized divestment experiences guide the user towards different end of life options: from passing the device to another user in need ("Preloved platform"), to using the product for a different purpose, to sending the product back for refurbishment and resale, to guiding the user to dispose of the product correctly.

Selected concept direction

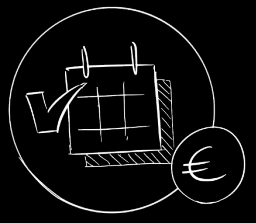
System paths

S.1 Preloved resale platform

Through the interviews, we found out that parents often feel uncomfortable with throwing away the baby monitor, since in most cases it is still fully functioning. Multiple interviewees indicated that what they try and prefer doing is to give it away to someone they know in need (e.g., a friend that has recently become parent). The “Preloved platform” is a peer-to-peer exchange-based resale platform. When a user does not need the baby monitor anymore, they can offer it to others. The system automatically link offer and demand. When a new user decides to buy preloved through the main website, the previous user receives a notification, shipping label and box directly at home. They can then ship it directly to the new user. There is no industrial repossessing in between.

S.2 Industrial refurbishment and resale

An industrial refurbishment step in between users is of course also an option. While this option allows for higher quality control, it increases refurbishing processes costs: multiple shipping, refurbishment infrastructure, labor, refurbishment processes. It is too early to select already which option should be chosen between peer-to-peer exchange and industrial refurbishment. Therefore, the design of the North Star should be able to enable both. Pilots and user studies should be planned in the roadmap to identify the best solution.



S.3 Subscription based model

The solution could be offered also through subscription model. This is an interesting model for this type of industry, where products are used for a short period and there is no strong emotional attachment to them (mostly functional purpose). As for industrial refurbishment, it is too early to make a final decision about the end business model. Therefore, this is an option to be further explored through pilots and user studies that should be part of the final roadmap.

The solution

11

The North Star

A clear long-term vision

Table of Content

A holistic design implementation

System, user, product

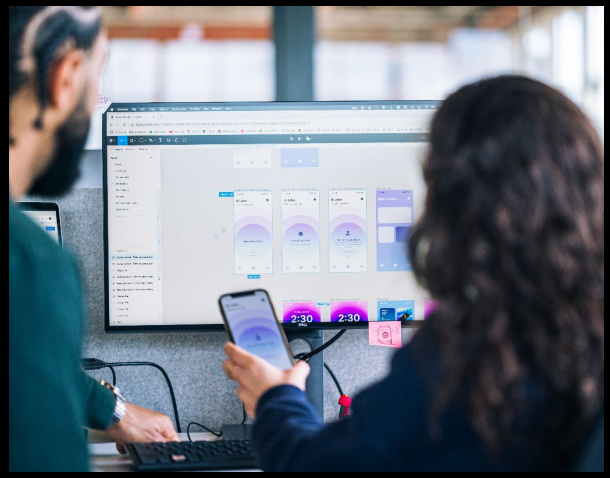
The North Star represents the intersection point between system, user and product. For this reason, we develop it through and a holistic and iterative process. System design, product design, digital experience, mechanical engineering and electrical engineering teams work side by side to bring to life a combined solution.

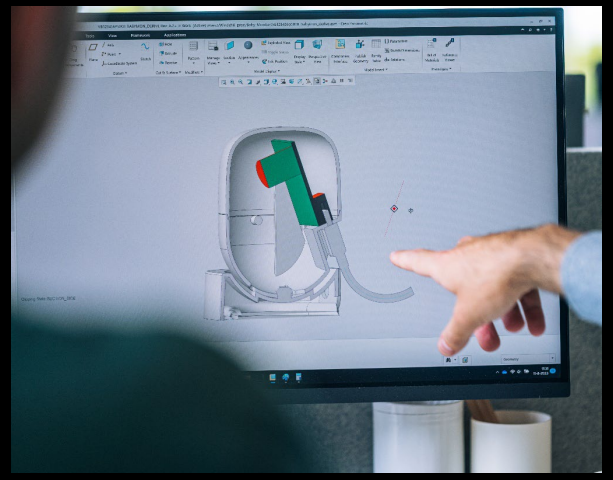
The system design team develops completely new user experiences, by considering the entire value chain and its stakeholders. The outcome is a new way of using and experiencing products, aligned with core user needs and intrinsically more sustainable. New business and service models which take into account user, planet and business.

The mechanical engineering team focuses on identifying technical solutions to enable sustainable strategies like repair and recycling. The goal is to find solutions which are not only enabling sustainability, but that are also feasible, viable and reliable.

While the design team defines a brand personality and design language for the physical product, the digital team develops the virtual design identity and experience. Here the goal is to address topics like aesthetics and physical durability; but also designing something desirable and convenient.

The electronics team is the one that explores new technology horizons. New smart solutions which allow to satisfy core user needs in completely new ways. Solutions which are not only sustainable, but that have the potential to create innovative competitive differentiation.





A holistic design implementation

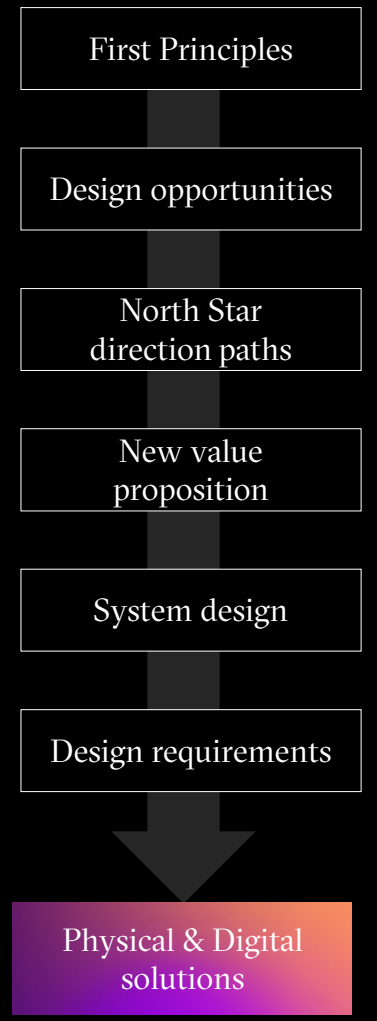
From First Principles to final North Star design

During the exploaration phase we identified 66 First Principles, synthetized into 25 design opportunities. These have been translated into 11 North Star direction paths, which are now used to develop a completely new value proposition.

This new value proposition creates value for user, planet and business in an organic way: sustainability might not show prominently, but it is integral part of it. This is the key for a successful North Star, not based on marketing or regulatory push, but on core user needs:

it does not look sustainable, it simply is.

Once a clear value proposition is defined, it can be translated into the design of a new system and service. In turn, this can be translated into design requirements, which are used to create physical and digital solutions.



A new proposition

Bliss: from a spy camera to a trusted companion

A trusted companion

A solution based on trust, where you don't need a camera to spy on your baby.
It monitors only what is really needed to reliably know when your intervention is required.

to assist you and your baby

A solution that does not only focus on your baby, but also on you, by supporting you throughout the first phase of your parenting journey.

on the journey

A solution which guide you from the beginning till the end of its use.

from their first nap till your full confidence!

A solution which helps you understand when it is time to move on and say goodbye.

A healthier relation with you child

From using a spying device to using a trusted support solution, which alerts you only when needed and helps you understand when it is time to move on (to stop using the product).

Paths

UX.1 UX.2 S.1

A real support in stressful moments

Parenting presents already many stressful situations. Bliss should not add to it. It calls your attention only if needed, and it let you rest as much as possible. You can fully rely on its advanced monitoring system.

Paths

P.1 UX.1

It simply works: nothing more, nothing less

A smart sensing solution optimized to provide the highest reliability while allowing for the most efficient use of resources. Designed around the true user needs. Nothing more, nothing less. To donate a sustainable future to your child.

Paths

P.2 P.3 P.4 P.4 S.3

A meaningful end: helping someone else begin

Instead of throwing a perfectly working product away, or store it in a drawer, Bliss gives you the opportunity to do a nice action towards another parent, by passing it on to another person in need.

Paths

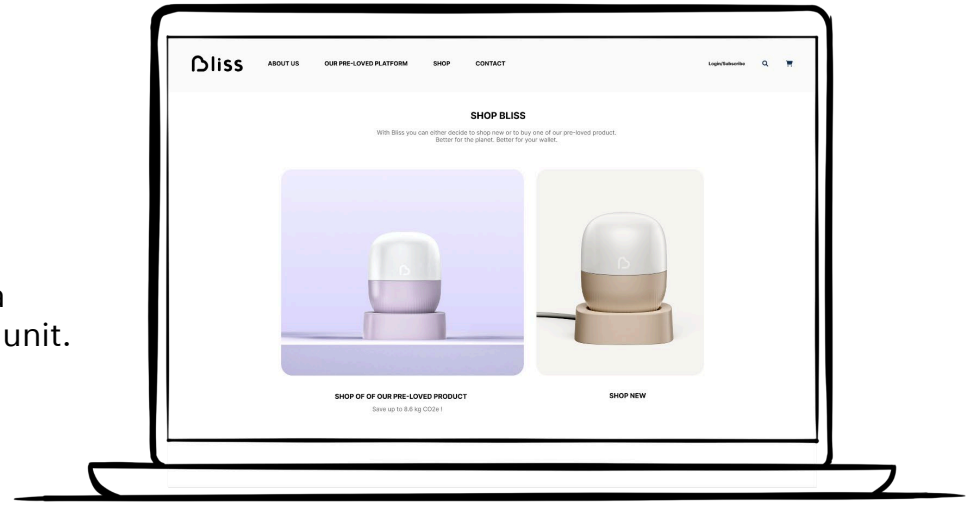
P.1 P.5 P.6 UX.2 S.1 S.2 S.3

A new proposition

A new user experience, as desirable as sustainable

1.
The journey starts from the manufacture website, which highlights the key benefits of Bliss value proposition “More reliable than traditional video baby monitors, less stress, more sustainable"

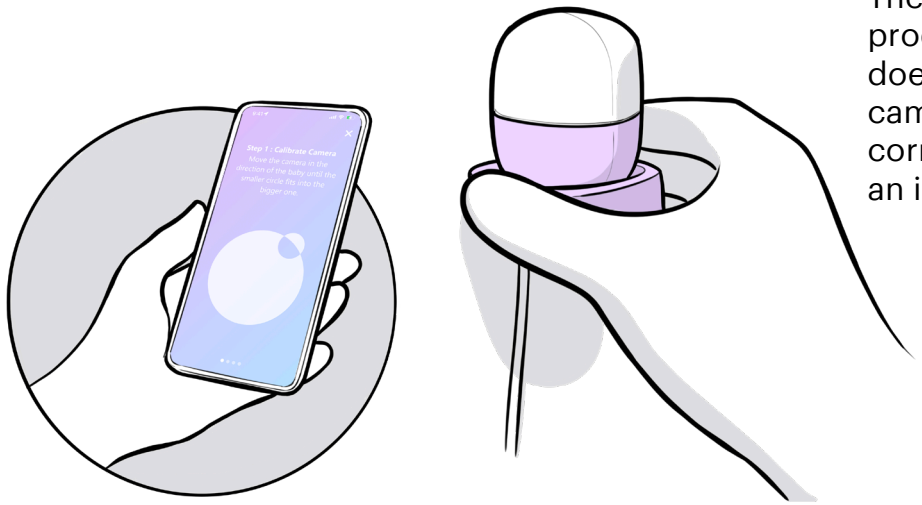
2.
In the store page, the website suggests the option of buying a preloved Bliss instead of a new unit.



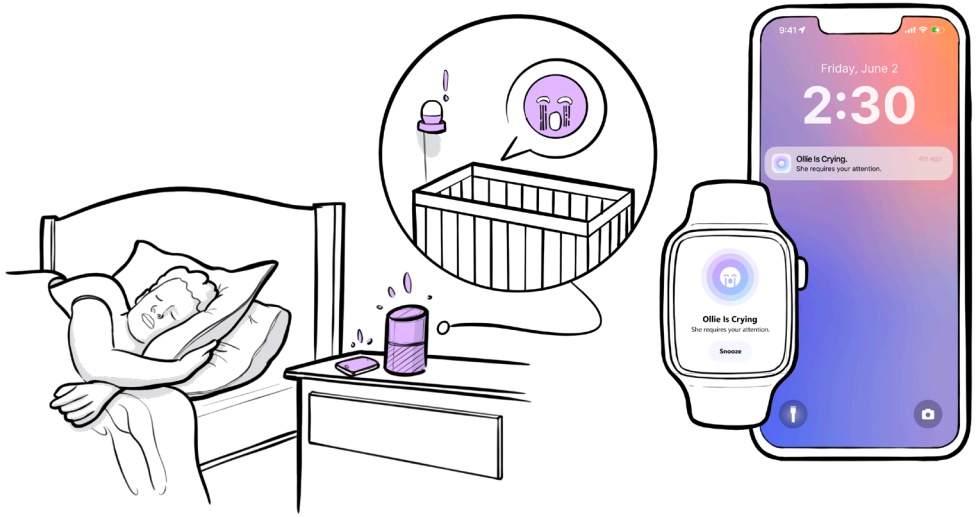
3.
The webpage explains that also a preloved has warranty, it is functionally and aesthetically checked, it can be easily repaired, it has lower price and environmental impact.

A new proposition

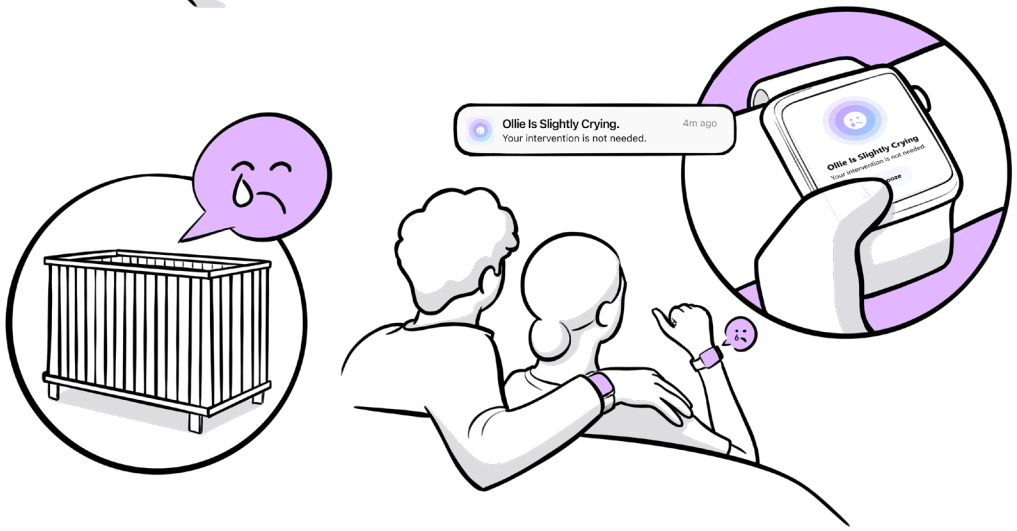
A new user experience, as desirable as sustainable



4.
The user receives the product. Since the product does not use a traditional camera, the app guides a correct positioning thanks to an intuitive UI.



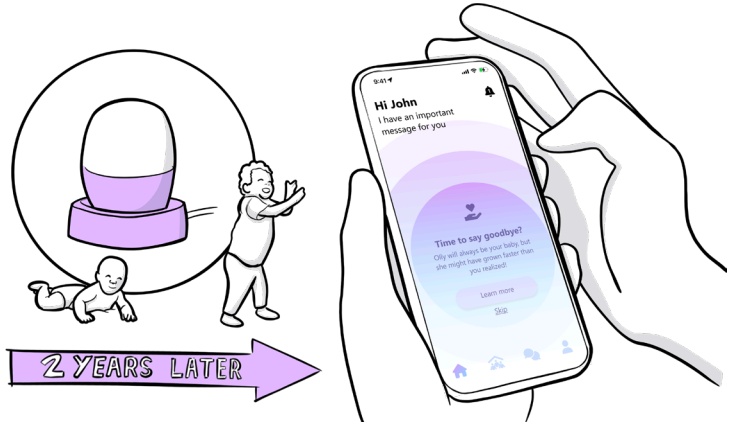
5.
Thanks to a smart monitoring system and a subtle notification experience, Bliss is able to suggest if parent's intervention is actually needed or not. This avoids unnecessary stress and overprotective behaviors.



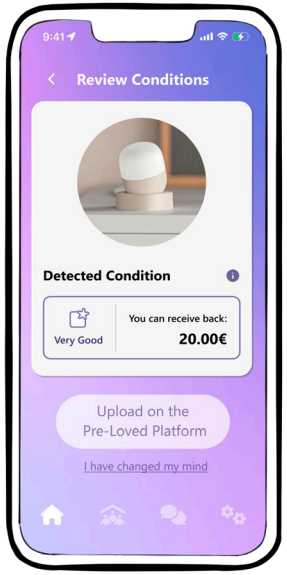
6.
When the baby is in need, Bliss promptly alerts the parent leveraging its compatibility with smart home devices, like speakers and lamps, smartphones and smart watches. This not only ensures that the parent will always hear alerts, but it also allows to avoid a parent unit.

A new proposition

A new user experience, as desirable as sustainable

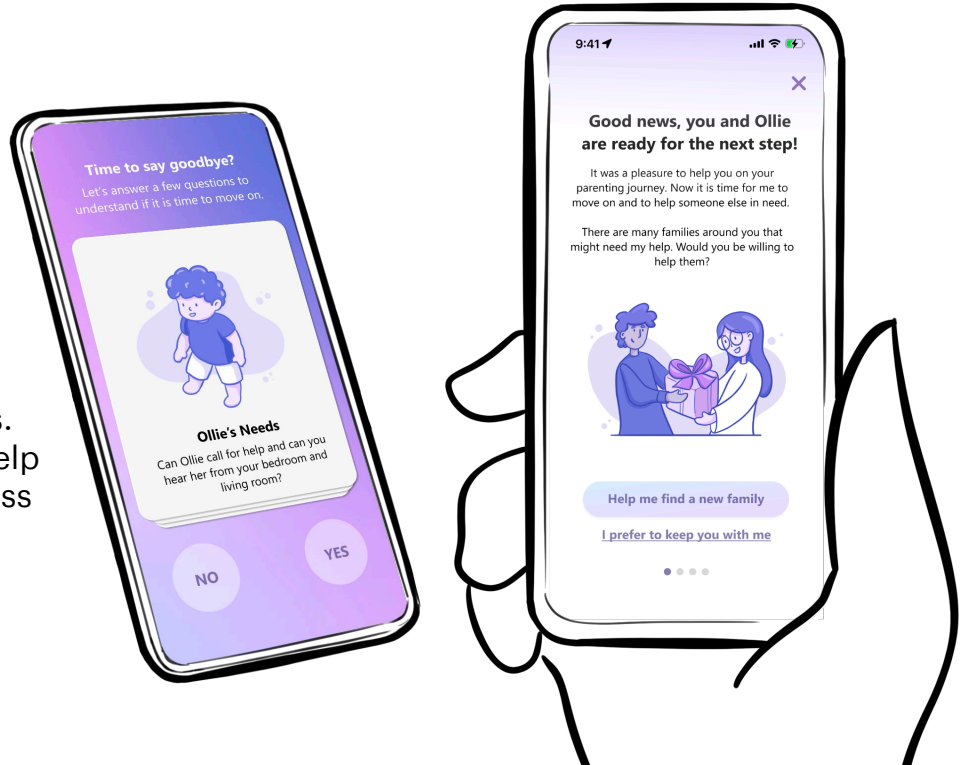


7.
When Bliss recognizes, thanks to the smart image recognition, that it has been used for a while and the baby seems not to need monitoring anymore, the app explain to the user that it might be time to move on.



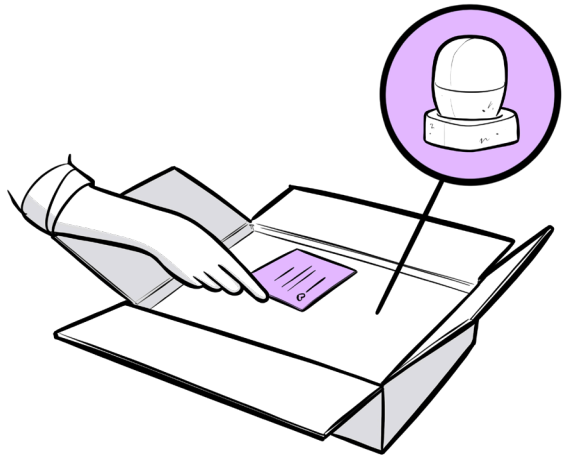
9.
The app asks the user to take a few pictures of the product to automatically check if the product is aesthetically in good condition. At the same time, the system is running self diagnostics in the background to check functional integrity.

8.
By answering a few questions, the user can understand if it is indeed time to stop using the product, avoiding overprotective behaviors. The app proposes to the user to help another parent by passing over Bliss on the “Preloved platform”.

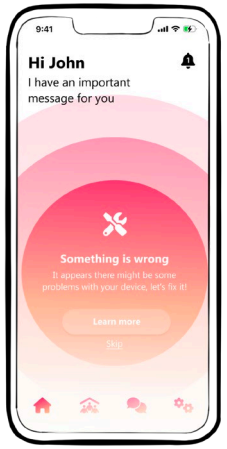


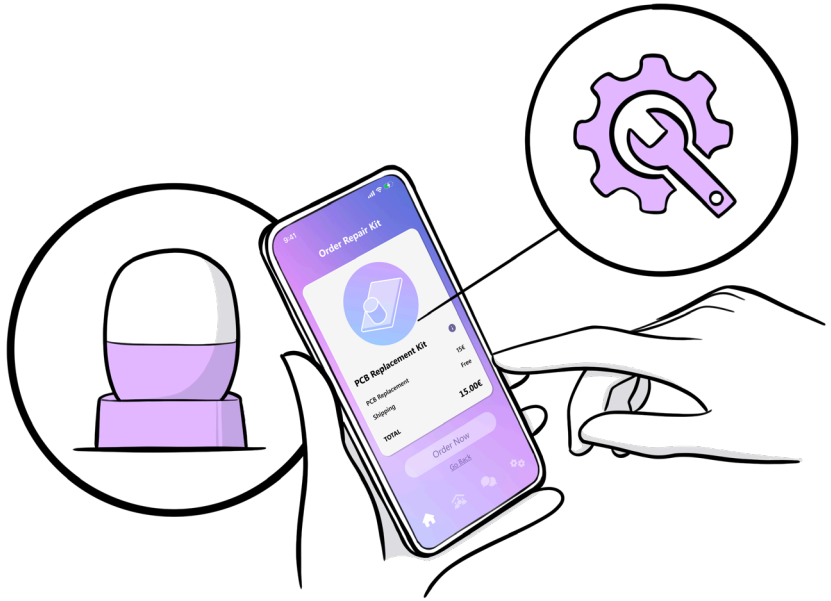
A new proposition

A new user experience, as desirable as sustainable



10.
The user receives a shipping box and label directly at home. They just have to ship it with a personalized message to the next parent!



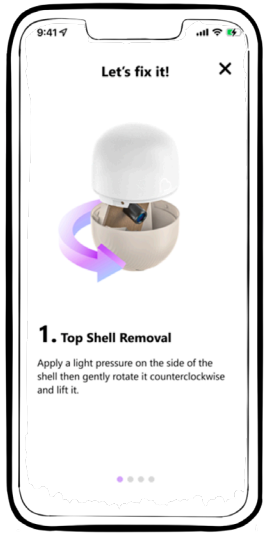


11.
The next user receives the preloved Bliss, including the message left by the previous user, who congratulates them on their new baby. Not only the product is in good state, but it also has warranty.

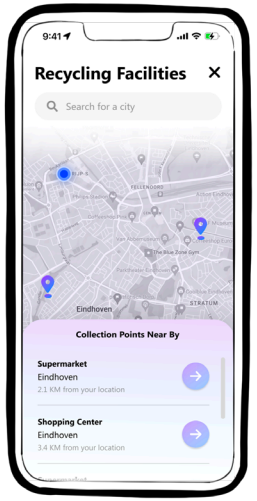
12.
After some use cycles, the product breaks. The app recognizes something is wrong and notifies the user that they can repair the product. The part is very inexpensive, and they would receive it at home the day after. The app shows a preview of how simple the replacement operation is.

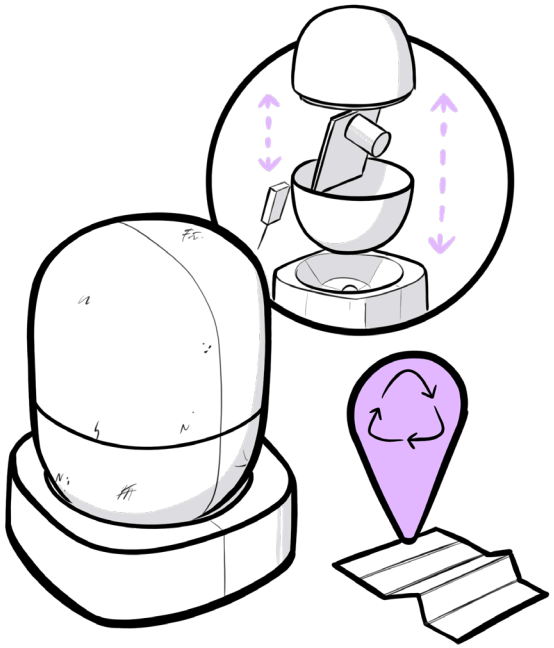
A new proposition

A new user experience, as desirable as sustainable



13.
The user orders the part directly from the app. The app guides the user through the procedure, which is extremely easy. In fact, the product can be opened without requiring any additional tools, just hands.





14.
After having gone through many use cycles, the product is aesthetically and functionally in bad shape. The user does not feel comfortable to give it to someone else. The app suggests to recycle the product, by showing how to separate different parts (to facilitate recycling) and a drop off point.

15.
There is an e-waste collection point at the supermarket that the user usually goes to, where the user can comfortably dispose the product.

The system

A re-circulation strategy that simply makes sense

The solution proposed has been designed by re-imaging an engaging user experience, intrinsically sustainable. This has resulted in an entirely new value proposition that is as desirable as it is sustainable.

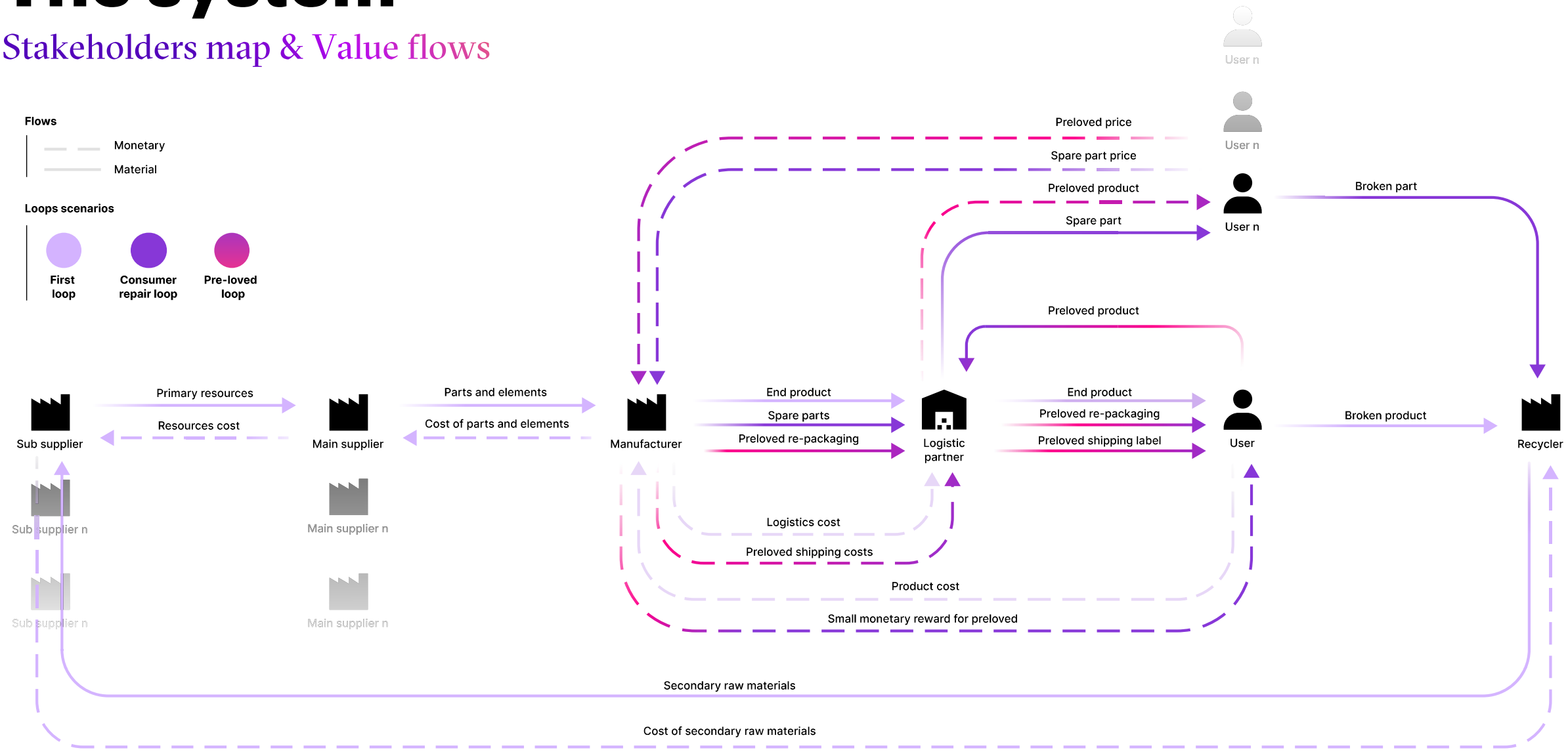
From the research phase we identified important First Principles:

- Baby monitors are usually still functioning at end of use
- Using the monitor for too long can determine negative psychological effects on the sense of security of both parent and child. Despite this, some parents struggle with understanding when it is time to stop using the baby monitor.
- Parents interviewed explained that they enjoyed donating their baby monitor to others once it is no longer needed
- Current baby monitors can create anxiety and overprotection, because of data overload and excessive monitoring features

The main system solution we propose focuses on creating an engaging EoL divestment experience, which allows to circulate the product when not used. Through the app, Bliss guides users to understand when it is time to “move on”, proposing different EoL options. One of these options is to pass the product to another parent in need, leveraging the predisposition of parents to donate the product to someone else. Shipping label and box are provided to the user and, after functional and aesthetics integrity is automatically and remotely assessed, the product is sent directly to the next user. Avoiding in-between industrial refurbishment operations allows to decrease costs for the manufacturer. While the selling user receive a small monetary contribution, the biggest margin is made by the manufacturer. The second user receives a limited warranty. If anything is wrong with the product, replacement parts are promptly and directly sent to the user. When a new customer visit the Bliss website, they will be lured in buying a preloved unit, thanks to the lower price and carbon footprint indication.

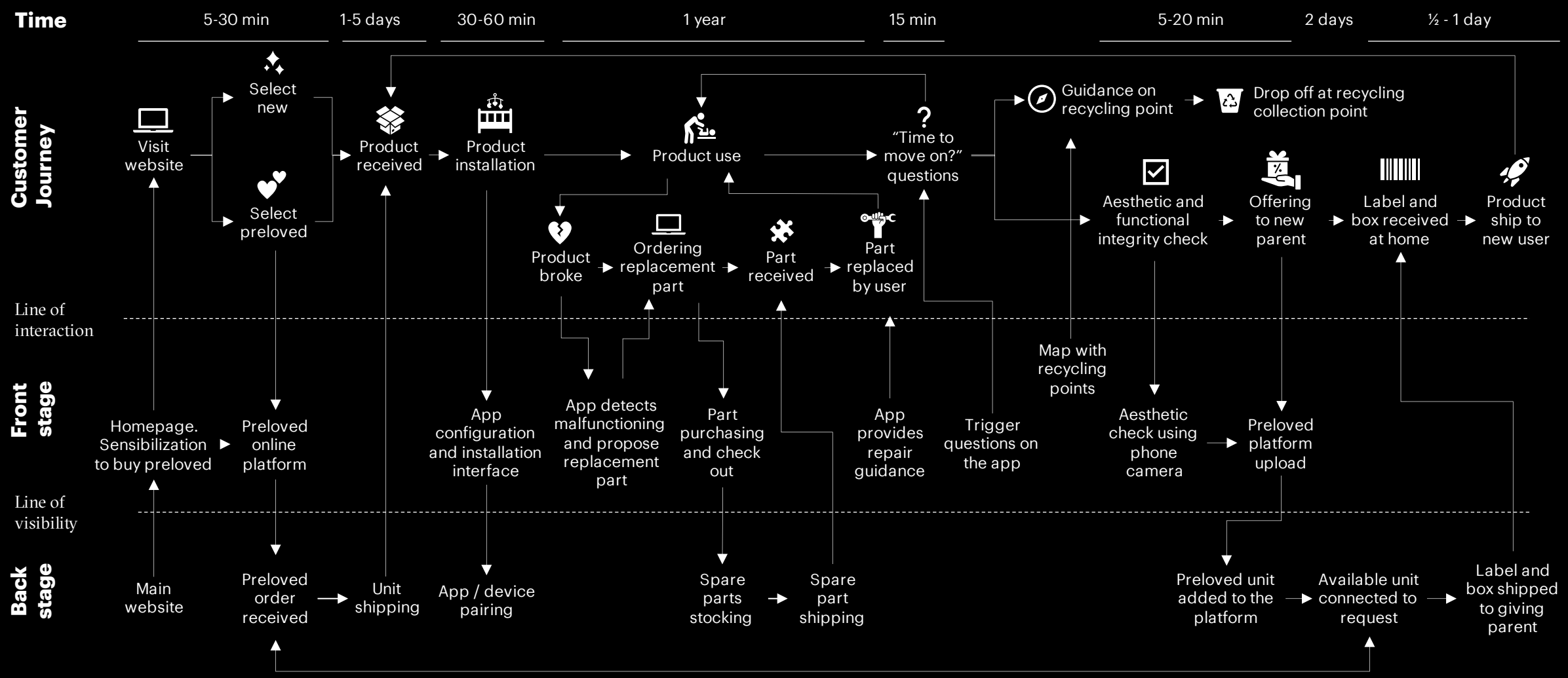
The system

Stakeholders map & Value flows



The system

The service blueprint



The physical solution

Overall physical architecture

A key objective that guided the new design was creating a solution that would be perceived less as a spy camera and more as a smart, trusted, and discrete companion. An object whose main purpose is to support and guide the user throughout the first steps of their parenting journey.

Smart monitoring without video feed

Traditional baby monitors work in a rudimental way: the user is notified when sound or movement is detected; by looking at a video feed the user decides if their intervention is needed. This solution not only leads to many “false alarms”, but it is also not reliable: from the video feed it might seems that the baby is ok while it is not the case. Thanks to advanced thermal imaging recognition, Bliss will alert parents only when needed. This avoids false alarms while identifying emergency situations that could not be identified just by looking at a video feed. The thermal sensor if fully hidden beneath an IR transparent polycarbonate dome. The camera is hidden because no video feed is provided to the user.

The main reasons for this choice are:

- Video feed transmission is one of the functions with the highest energy consumption. In Bliss, video-based recognition happens completely on-device, without the need of being broadcasted.
- It provides a false feeling of security to the parent
- It can trigger un-healthy controlling and dependency behaviors (continuous check of video feed)
- Video quality is one of the main features that can determine perceived obsolescence. Baby monitors can hardly keep up with the quality of media devices we use every day (i.e., smartphones).
- Moving away from aesthetics that resembles a spying device

The physical solution

Overall physical architecture

A design optimized to provide an enjoyable user experience, from installation to end of life.

Adaptable and intuitive installation
Bliss can be both placed on a flat surface or hanged on a vertical one. The internal camera is slightly tilted to facilitate a correct viewing angle. The installation and positioning is guided by an intuitive app experience and an LED light.

Aesthetics optimized for functionality and emotional durability
The aesthetics of the product has been designed to be timeless, to communicate a feeling of trust, and to fit in most interior environments. The pattern at the bottom of the product has been designed in order to lessen the visibility of potential scratches that could occur during the use of the product.

The physical solution

Overall physical architecture

Intuitive tilting mechanism for optimal positioning
Bliss uses an intuitive mechanical tilting mechanism, which allows to easily tilt the product in all directions. This facilitates a correct product installation, which offers the best monitoring POV.

Smart cable management for a tidy design, surface grip and higher recyclability
A recess is present at the base of the product, where the power cable can be easily routed through. This design feature not only allows for a great aesthetic, but it also provides surface grip without using glue rubber feet, which would hinder recyclability of the main hard plastic part.

Optimized for consumer repair and recycling
Thanks to a bayonet system, the top PC dome can be disassembled by hand, without the need of any tool. This allows easy access to the internal PCB, for repair or recycling purposes. The PCB design is optimized to minimize the number of components, size and layers. A soluble FR-4 alternative material is used as a carrier. The cable routing at the bottom of the product allows for grip while avoiding non-recyclable rubber feet.

The physical solution

Product Design

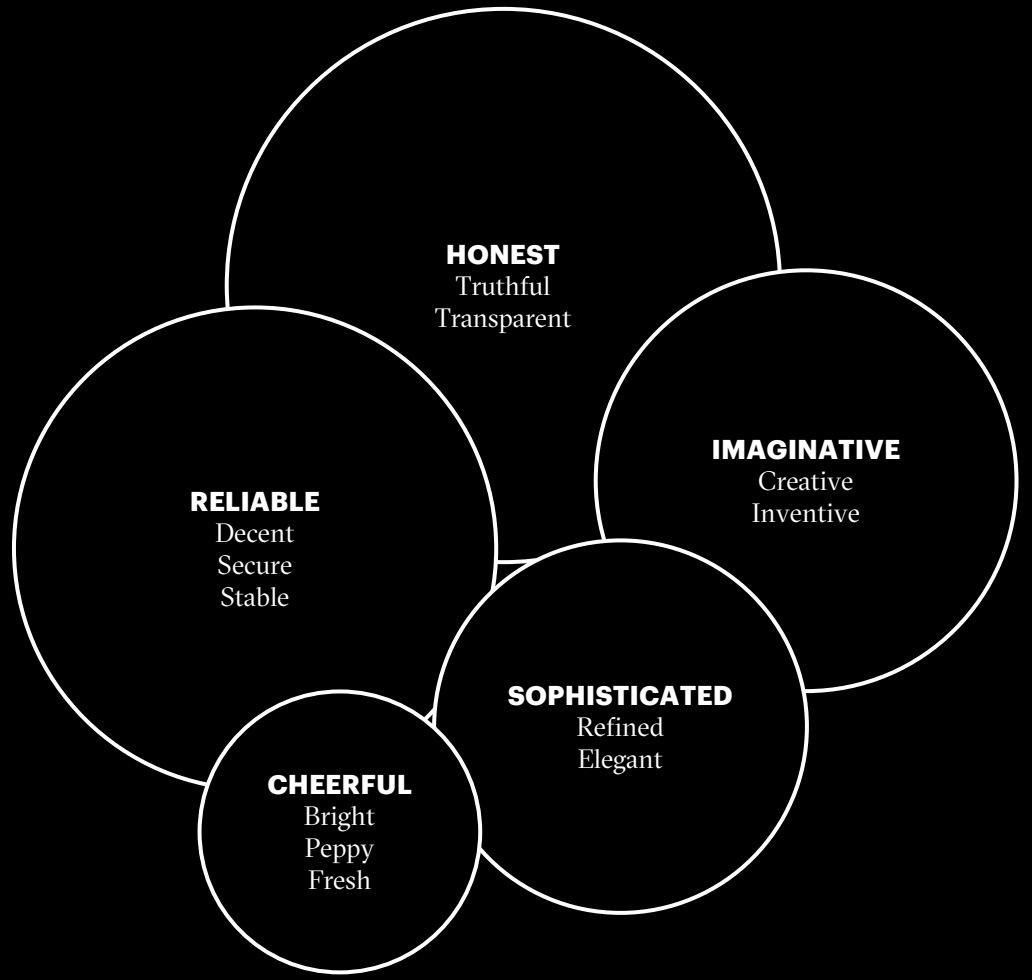
Just like a person, a brand is something you can love and even build a relationship with. Imaging your brand as a person walking into a room. What personality traits should show directly?

Brand Personality Model from Jennifer Aaker research

The Brand Personality Model is a framework that describes how brands can possess human-like personality traits. Jennifer Aaker identified five core dimensions of brand personality (sincerity, excitement, competence, sophistication, ruggedness) which are then broken down further into more specific facets or traits.

We developed the Jennifer Aaker Brand Personality Bulls-Eye. It's a canvas tool where the bullseye represents the core values of the brand. We are using it to trigger and facilitate a discussion in the client team, where they are going to place the different personality traits cards more or less close to the center according to its relevancy and importance. The outcome of this method is a hierarchy of 3 to 5 personality traits that will be illustrated into design DNA moodboards of shape, details, materials, colour and branding. The design DNA then helps us to make those personality traits tangible.

We use the brand personality model to shape and differentiate the perception of a brand in the minds of users. By assigning specific personality traits to a brand, we can establish a distinct identity and build emotional connections with their target audience. A well-defined brand personality helps consumers relate to the brand, fosters brand loyalty, and influences purchase decisions. Those traits can be translated into a design DNA.



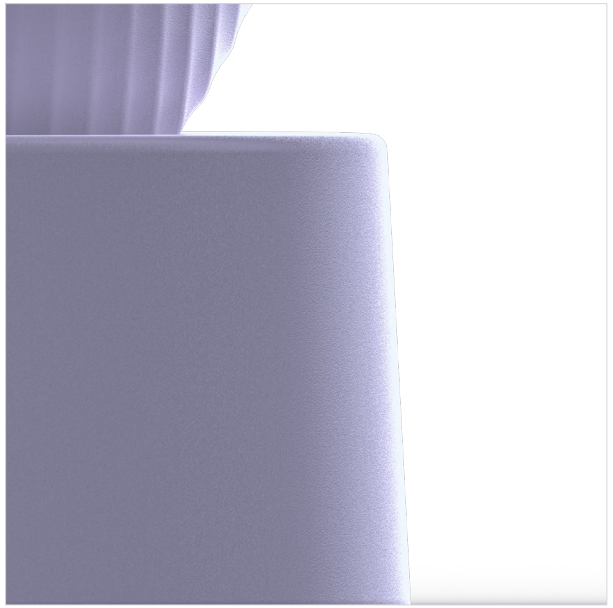
The physical solution

Product Design

Design DNA - Shape

Honest mono-shape

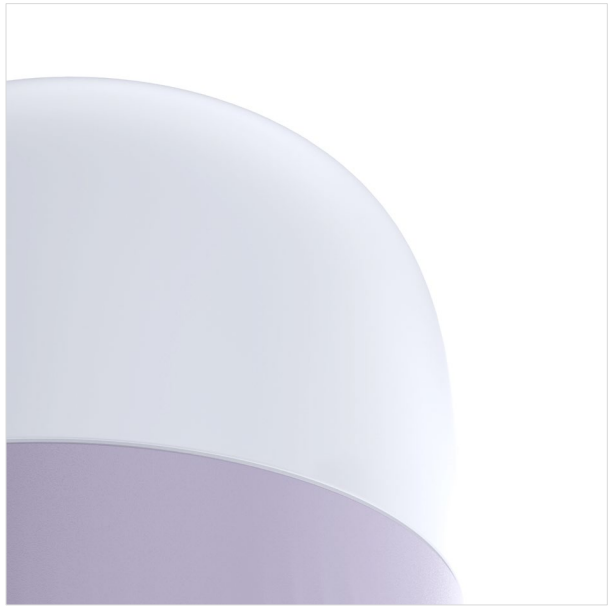
A geometrical mono-shape is perceived as minimal and non-decorative. By a single shape, it creates a sense of cohesive stability and robustness.



Reliable tapered

A tapered shape conveys balance and reliability by having its weight grounded to the bottom.

It communicates trust and reliability.



Friendly softness

The softness of the shape and edges make the product more approachable and reassuring. They convey security and comfort and are perceived as non-harmful.

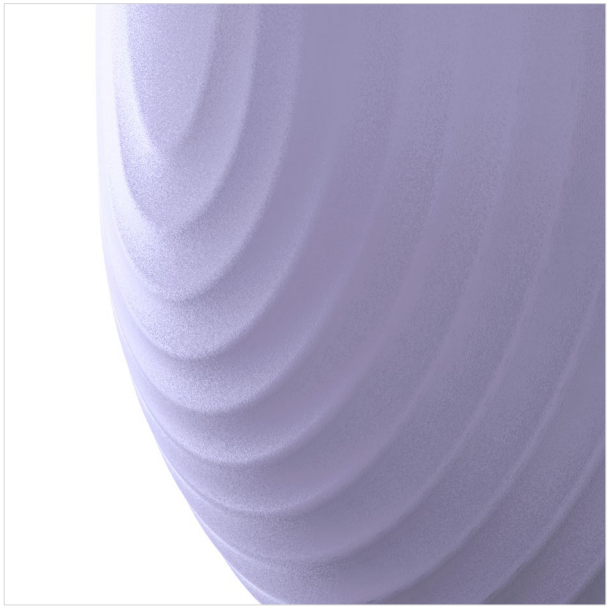
The physical solution

Product Design

Design DNA - Details

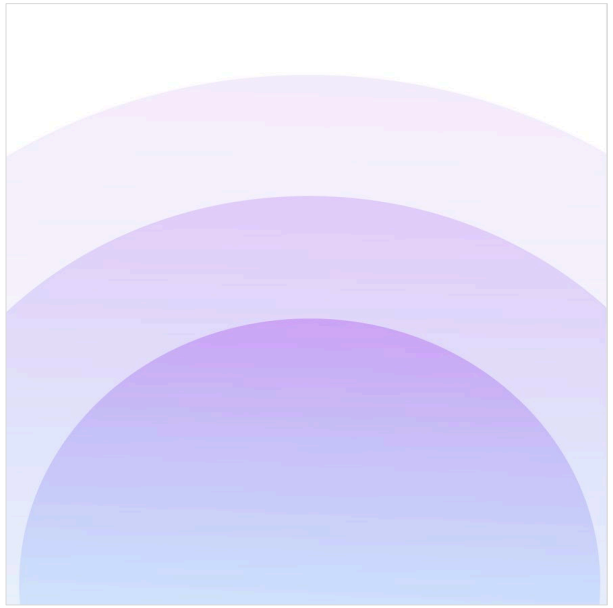
Intuitiveness

The interactions with the product are visually and physically self-explanatory. The user can’t be wrong because it shows clearly what to do.



Delicate durability

A minimalist geometrical pattern adds refinement and robustness to the product in a subtle way. It’s not visible at a first glance, but reveals itself during interactions.



Cheerful functionality

The main interactions and visual feedback are highlighted by a color accent which communicates the peppy and bright aspect of the product.

The physical solution

Product Design

Design DNA - Branding

Debossed stamp

The stamp is perceived as an approved check mark. It communicates quality and reliability. Being debossed keeps the surface flush and assures to not hurt.

Assumed boldness

A bold branding conveys a sense of reliability and confidence.

Glossy refined touch

Having a glossy logotype on a mat surface creates contrast and brings sophistication.

The physical solution

Product Design

Designed to fit in any home interior
The minimalistic and universal geometrical silhouette of the product, in combination with its delicate and subtle CMF, aims to be discreet and allows to easily blend in a variety of home interiors.

Unisex and light colors
By choosing a limited selection of soft color tones, the product is gender neutral. Furthermore, using light colors facilitate masterbatch recoloring of recyclates derived from the recycling of the plastic parts.

Textured logo
A subtle texture difference in the top dome is used to integrate branding in the product without introducing separate parts, production techniques and ensuring full recyclability of the part.

Aesthetic durability: a design expected to withstand trends
Considering the “Preloved platform”, the product aesthetics must be designed to remain relevant over a 10-year timeframe. A minimalist design approach helps in achieving this longevity.

Grooved bottom for higher usability and scratch resistance
The product’s patterned base enhances its aesthetics appeal while providing a sense of direction during interaction. Furthermore, this subtle pattern provides higher scratch resistance to the surface most exposed to wear.

Avoiding coatings and finishes that hinder material sortability and recyclability
Many plastic coatings and finishing commonly used hinder plastic sortability and recyclability, since they modify material density and pollute the end recyclates quality. By using pure plastic, lightly colored with small masterbatch percentage, sortability and recyclability is ensured.

Plastic: a durable and light-weight solution
The inherent durability of plastics aligns seamlessly with the intended lifespan of the product, ensuring long-lasting performance. Furthermore, using plastic allows for a lower production and shipping environmental impact compared to other options, like metals.

The physical solution

Technology directions

Different technological solutions were created using the First Principles approach, and the most suitable solution was identified to meet the core user need of “making the parent aware of when their intervention is needed, feeling secure and in control”.

Questioning assumptions and identification of essential vitals to be monitored
We started by questioning two of the core building blocks of current baby monitors proposition:

- Parents need a continuous video feed to feel comfortable
- A RGB camera provides the best understanding into the child’s wellbeing

Through literature we composed a list of vitals important for monitoring the health and well-being of babies. From this list, we selected three essential vitals, one to cover each of the following categories: short-term health, long-term health and emotional connection. Respectively these vitals are:

Body temperature: The temperature of the baby’s skin, which can reflect if the baby is too hot, cold, or has a fever or hypothermia. (relates to e.g. glycaemic disorders).

Respiratory pattern: The rate and rhythm of the baby’s breathing, which can indicate if the baby is sleeping peacefully or having any respiratory problems.

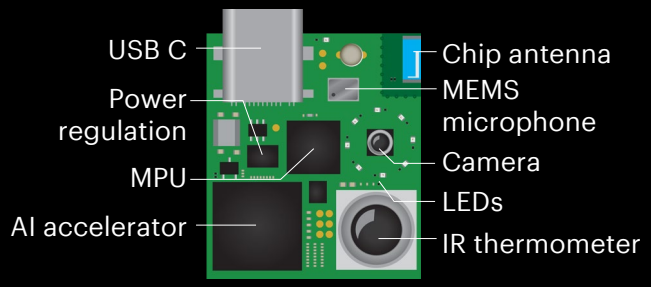
Sound feed: The audio signal from the baby’s room, which can let the parents hear their baby’s cries, coos, or other noises.

Other secondary functions, like room temperature, speaker, lullabies, night light are being offloaded to smart home devices.

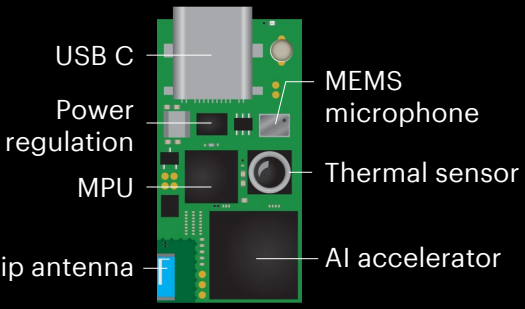
Investigating different technology options to monitor the essential vitals
Based on three main essential vitals to be monitored, we identified four different technology directions:

- RGB Camera with microphone and IR thermometer
- Thermal sensor with microphone
- Radar sensor with microphone and IR thermometer
- Wearable solution with with IMU, microphone, thermometer

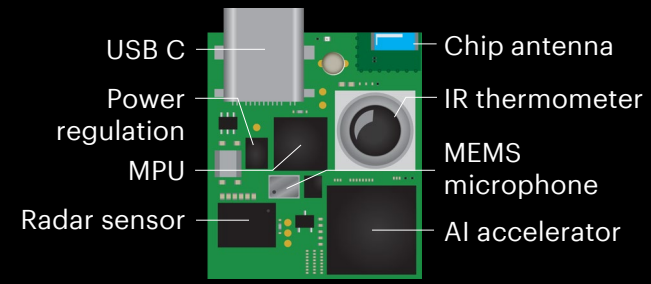
RGB camera concept



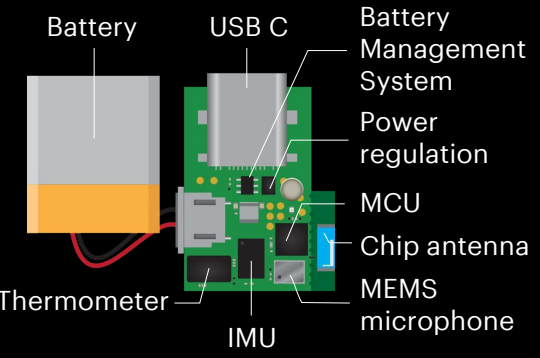
Thermal Sensor concept



Radar concept



Wearable concept



The physical solution

Technology selection

Different technology directions have been assessed based on their ability of monitoring essential vitals, ease of use, environmental impact, circularity potential. The thermal sensing technology was selected as it allows to minimize the number of electronic components required, while being able to monitor all the essential vitals parameters and being suitable for circular strategies that involves a change of ownership and user.

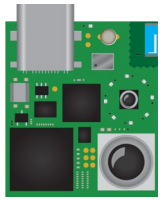
Comparing different concepts monitoring capabilities
Even though thermal sensors have a lower absolute accuracy than infrared thermometers, they provide consistent readings that enable relative comparisons, allowing to monitor change in body temperature. They also have a larger field of view than infrared thermometers, which improves both reliability and user experience.

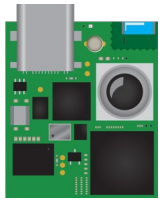
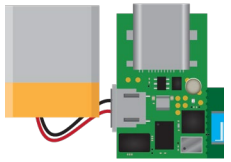
Different options measure respiratory pattern differently. Wearable device and radar sensor use frequency separation, but movement can distort the signal.

Camera and thermal sensor use motion magnification and optical flow, which are more robust to movement. The thermal sensor can also see through blankets.

Sound is similar across different solutions, but the wearable device is closer to the baby and might capture more of its sound. However, it also picks up more noise as the baby moves, which cancels out the benefit of being closer.

Comparison on vitals monitoring capabilities



		RGB camera concept	Thermal sensor concept	Radar sensor concept	Wearable concept
Essential	Respiratory pattern	✓	✓	✓	✓
	Body temperature	✓	✓	✓	✓
	Sound feed	✓	✓	✓	✓
Nice to have	Heart rate	✗	✗	✓	-
	Sleeping position	✓	✓	-	✓
	Sleeping stage	-	-	✓	✓
	Video feed	✓	-	✗	✗
	Haptic feed	✗	✗	-	✓

✓ Accurate monitoring - Sub-optimal Monitoring ✗ Monitoring not possible

The physical solution

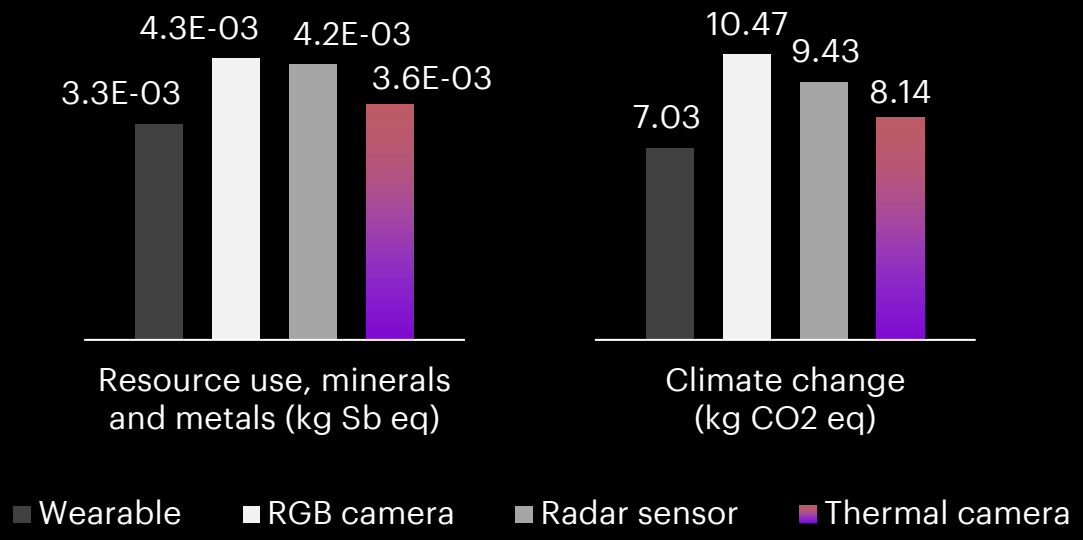
Technology selection

Ease of use and environmental impact were also considered in the selection of the thermal sensing technology.

Ease of use
While both RGB camera and thermal sensor can be integrated in a stationary product, positioned on furniture close to the crib, the Radar concept would need to be positioned on a wall, in a location which would provide sufficient aerial view. The thermal sensor would also need special guidance for correct positioning. The wearable concept can present many ergonomics challenges: the baby might find it uncomfortable and take it off. This becomes even more of an issue when the child grows up (e.g. at the age of 2-4, when the child can walk and take the wearable off). Additionally, from literature research it was found that many parents fear health issues that could be generated by applying an electronic device directly in contact with the skin of the baby for a prolonged period. Finally, a wearable requires to be charged every time before use.

Environmental impact (1 use cycle)
The environmental impact of the four concept was assessed. We focused the electronics only and on the two most impactful life phases, identified during the first, more extensive, LCA on the original design. These are electronics production and energy consumption during use phase. While the radar and the RGB camera concepts show higher energy consumption compared to the other concepts, the wearable concept shows the lowest. However, its impact in production is close to the thermal sensor, since it requires a battery and a docking station/HUB. What is not considered in the LCA is that different wearable bands might be needed to adapt to the growth of the baby. An important consideration is that, based on the Future Scanning, we expect the energy grid to become greener in the coming 10 years, making energy consumption during use less relevant than impact in production. Furthermore, this LCA did not consider considerations around suitability for reuse/reprocessing and the fact that the wearable would probably require upgrades to adapt to the growth of the child (e.g. mounting system, like wrist band size).

Environmental impact comparison of the electronics production (1 life-cycle)



Energy consumption comparison

	RGB camera concept	Thermal sensor concept	Radar sensor concept	Wearable concept
Lower estimate	530mW	685mW	600mW	90mW
Upper estimate	830mW	745mW	815mW	175mW

The physical solution

Technology selection

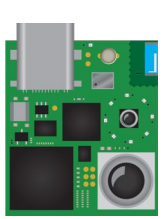
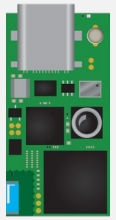
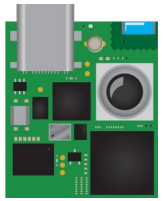
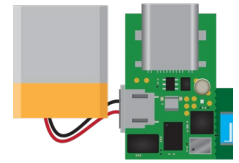
Although the environmental impact of one use-cycle of the wearable could be lower than any other concepts, issues with durability over multiple cycles, reuse/reprocessing and recycling are expected. The thermal sensor concept is suitable for multiple reuse cycles, it requires the least amount of electronics, while still being able to monitor essential vitals to fulfill the core user needs.

Durability
While RGB camera, Thermal sensor and Radar concept would all be stationary solutions, the Wearable would be more heavily exposed to wear and tear during use (e.g., impacts during baby moments, possible contact with liquids). Furthermore, the presence of a battery brings extra failure risks.

Suitability for circularity
Higher exposure to wear and tear of the wearable make it less fit to reuse models compared to the other concepts. The product would be in direct contact with the baby skin, and it could get in contact with body liquids. This would require industrial refurbishment and replacement of all skin contact parts to avoid any health safety risks. The battery and wrist band in the wearable would probably need to be replaced after each use cycles. On the other hand, all other 3 concepts would require limited reprocessing, due to their stationary use case.

Recycling
The battery in the wearable could create issues during recycling and it would need to be sorted in a selective way. The wrist band would probably have to be made in flexible thermosets or thermoplastic elastomer, which is not commonly recycled by e-waster recyclers. All other concepts could be optimized for sorting and separation, since they could be made of thermoplastics and the PCB could be centralized in one single piece.

Comparison on user experience, environmental impact and potential to enable circular strategies

	RGB camera concept	Thermal sensor concept	Radar sensor concept	Wearable concept
Ease of use	+	0	0	-
Environmental impact (1 life cycle)	-	0	-	+
Durability	+	+	+	-
Ease of repair	+	+	+	+
Ease of refurbishment	+	+	+	-
Ease of recycling	+	+	+	-

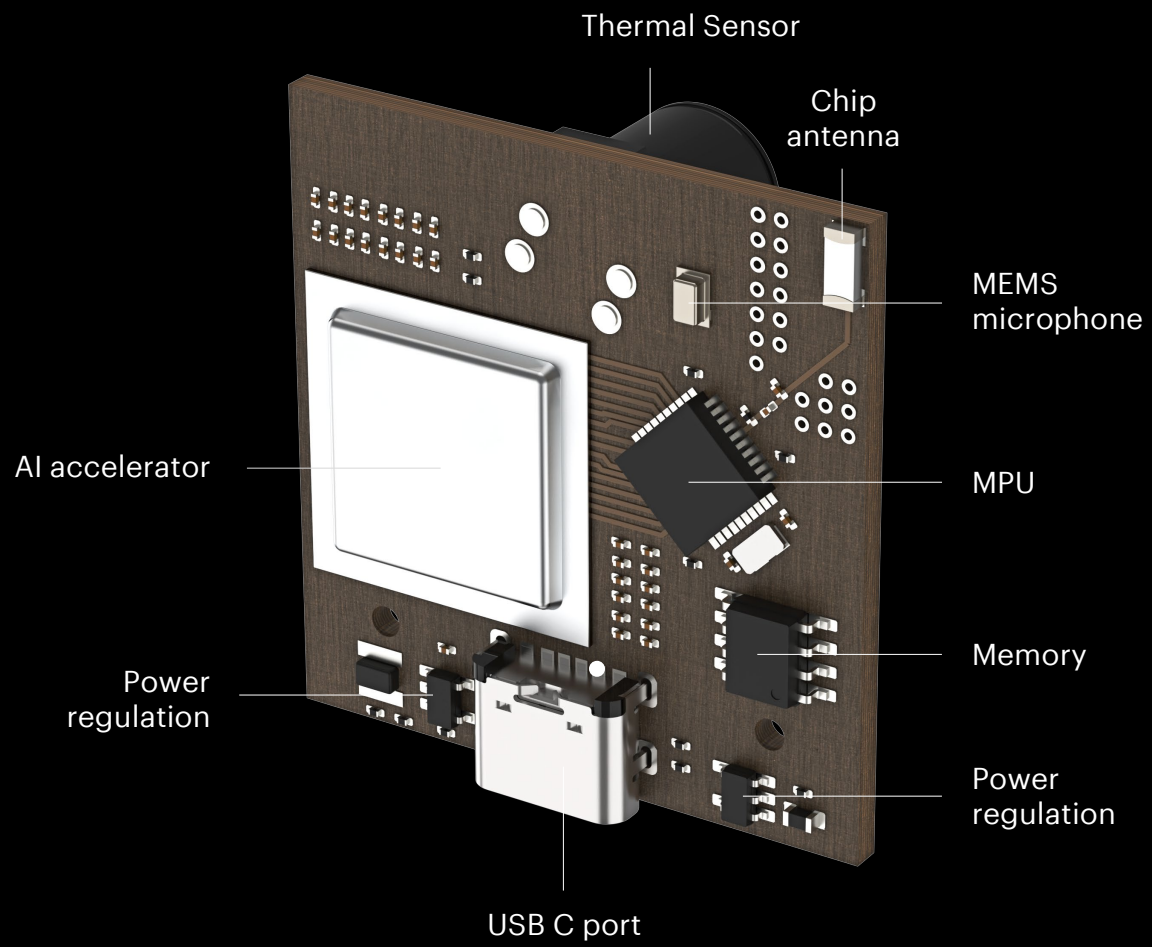
The physical solution

Electronics design

Components minimization through thermal sensing technology
By implementing a thermal sensor, there is no need for extra IR LEDs to monitor in dark environment. Additionally, it can replace a discrete thermometer whilst boasting a wider FOV enhancing both reliability and UX.

On-device AI processor
The on-device processor runs real-time computer vision models to monitor essential vitals and predict potential health fluctuations. This also allows to decrease the amount off-device data transfer, determining lower energy consumption and higherr data safety.

Centralizing all electronics in one PCB to facilitate disassembly and dismantling
Integrating all electronics in one single main unit facilitates disassembly and dismantling activities.



Smart power management logic for energy use optimization
To optimize energy usage, the thermal sensor's frame rate and inferences adjust dynamically until a baby is detected. Once detected, the device enters a steady state, ensuring proper functioning and connection through fixed reporting intervals.

Smart home devices compatibility to offload secondary functions
Additional electronics that would be required for secondary functions is avoided by offloading to smart home devices (e.g., temperature monitoring through smart thermostats, two-way talks and lullabies through smart speakers, night lights through smart lighting).

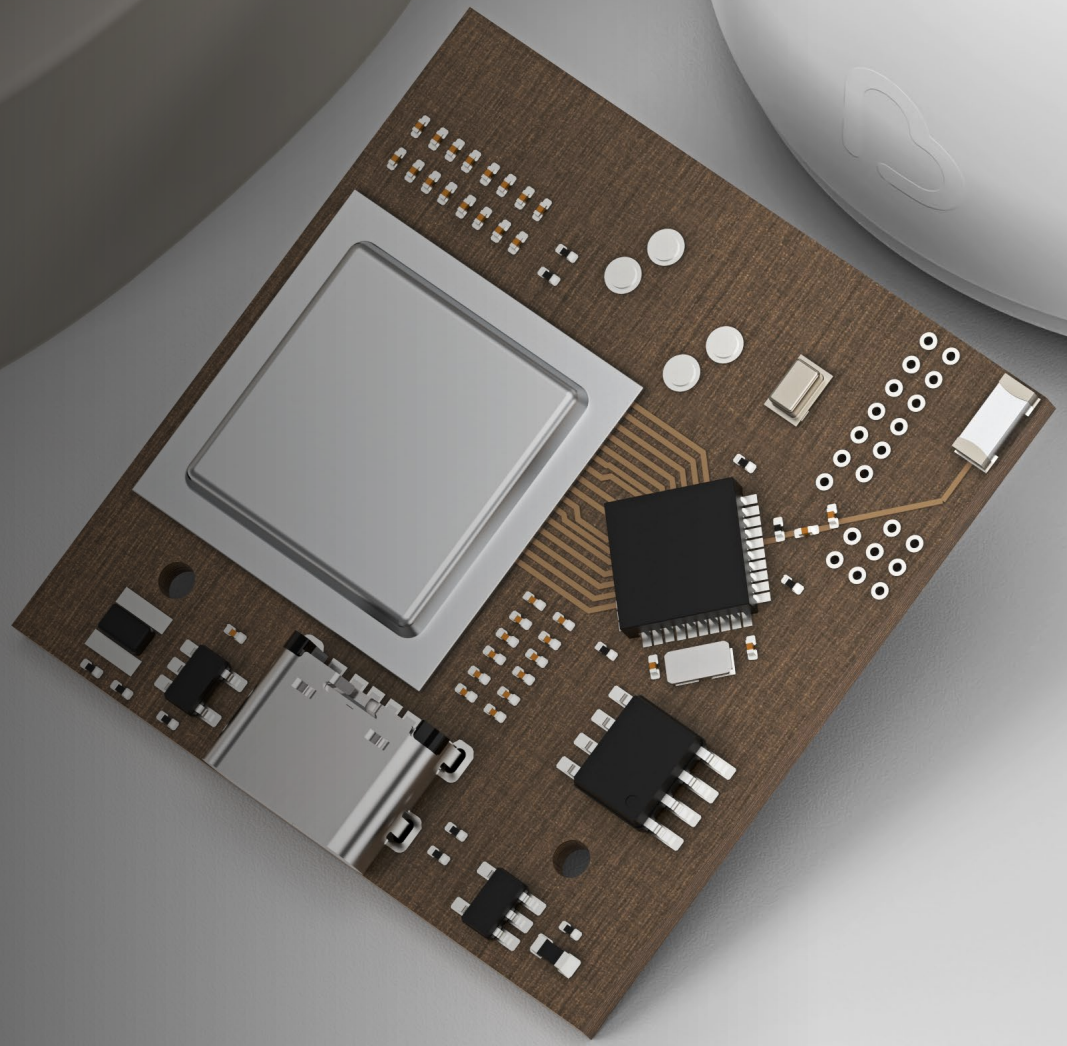
Less carbon intensive and soluble carrier material
An alternative carrier material to FR-4, like the one developed by JIVA®, offers a lower embedded carbon footprint and higher recyclability rates at end of life.

The physical solution

Electronics design

PCB size and layering optimization
The PCB boasts a compact 30x33mm form factor achieved through careful layer management, without compromising on signal integrity, EMI/EMC, heat dissipation, and cross-talk. The small form factor minimizes material usage and shipping costs. Additionally, because of the rectangular profile, process waste from carrier cutting is avoided.

Low voltage architecture and embedded self diagnostics, safe for consumer repair
The low voltage architecture ensures user safety during repairs, while embedded self diagnostics simplify troubleshooting without requiring specialized tools.



Copper optimization and OSP finishing
OSP finishing optimizes the lifespan of the device by protecting the copper and optimizing routing for signal integrity. Furthermore, using OSP and avoiding other forms of plating like Au, Tn, Sn/Pb, allows to avoid additional processing, to reduce resources used, and to reduce process waste.

Use of integrated circuits to minimize components use
The use of integrated circuits and multi chip modules (SOM's) is beneficial as every chip has a package and lead frame that adds weight and impacts the LCA significantly. Using less components helps to simplifying the PCB and reducing the size and layer count. Furthermore, it helps to minimize the PCB size.

Avoidance of additional masking and printing process on the PCB
Avoiding additional processes, like additional silkscreen, screen printing, inks and solvents allow to avoid additional production materials, fixtures, equipment and related materials.

The physical solution

Mechanical Design

The entire architecture can be disassembled by hand, without the need of any tool
In order to make consumer repair as convenient and as accessible as possible, it is essential to eliminate the need for tools and minimizing the number of steps and time needed to access internal parts. A smart bayonet system with friction lock prevents accidental opening while simultaneously providing an intuitive way to access the PCB when it's up for replacement. All the other parts, including the base, can also be easily detached from each other by hand: not one single screw is used.

Tool-free PCB fixation
The PCB, heart of the device, is the part with the highest likelihood of needing replacement during multiple use cycles. For this reason, it is secured using integrated snap fixtures that can be unfastened by hand. This design not only obviates the need for tools during assembly and repair, but it also facilitates user separation before disposal. Furthermore, this design facilitates liberation during the automated shredding process commonly used by many recyclers.

USB C connection
A standard USB C connector is used, to ensure future proofing and compliance with coming EU standardization regulations. This also enables the user to use another USB C charger if needed. The positioning of the USB port is optimized for PCB connection and product stability.

IR Translucent top dome
To the human eye, it presents a soft, cloudy appearance, yet it remains entirely transparent to a thermal sensor peering through. This unique effect is realized by incorporating Epolight® additive into the primary material, PC.

Mistake proof disassembly and reassembly
All parts are designed in such a way that assembly and disassembly can only be done in one way: the right one. This is achieved by either asymmetry and blocking geometries integrated the dome bayonet system and PCB internal support.

Mono-material tilting mechanism
A robust integrated snapper between the shell and base allows for rotation of the top unit. No screws or glues are needed. Stable positioning of the unit is achieved by applying the right textures and tight tolerances between the 2 parts. Furthermore, the simplicity of the system decreases likelihood of failure and ease of repair compared to a motorized or metal bearing solutions.

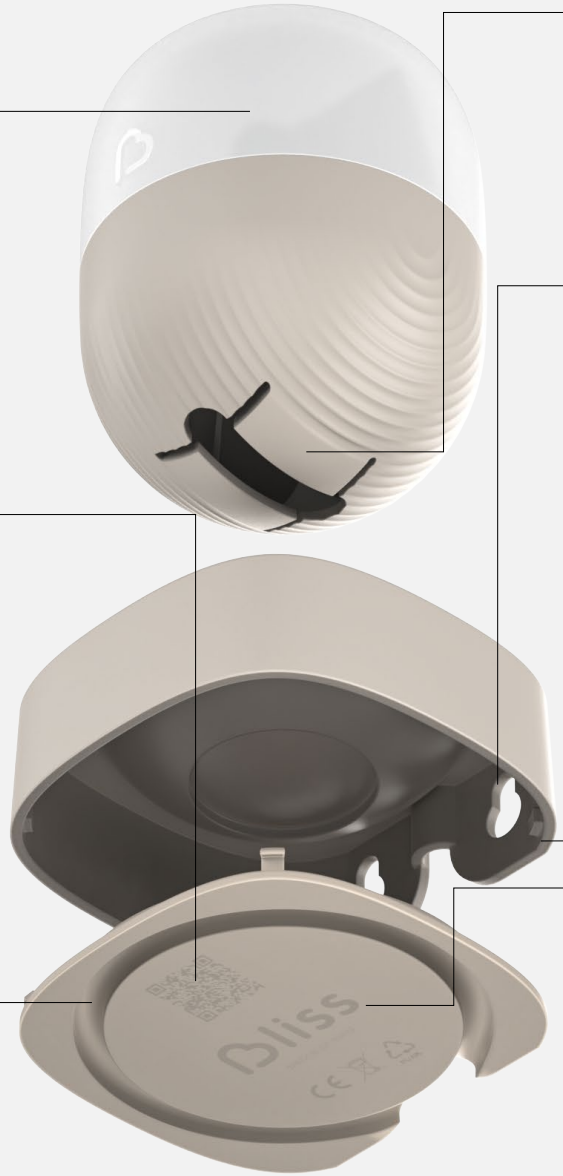
The physical solution

Mechanical Design

Small form factor
The product is designed to occupy minimal space while ensuring ease of handling. Minimal size and weight are essential to ensure low environmental impact in the multiple back and forth logistics required by the multiple use cycles (enabled by the “Preloved platform”).

Bottom QR code for traceability
The bottom QR allows for deployment of tracking-based systems like future Digital Product Passport.

Avoiding rubber feet by leveraging the charging cable routing
Rubber feet are typically made of thermosets or thermoplastic elastomers which are either not recyclable, or not common to be recycled by e-waste facilities. Routing the cable through a recess in the base obviates the need for such materials and further simplifies assembly. By using a circular shape, the cable can exit the product at any convenient angle.



Sliding contact area
Durability is in the details: a small curved area interrupting the pattern increases contact surface for the hinge, reducing peak wear on the grooved pattern. In assembled state this is not visible to the user.

Integrated wall mounting system
To avoid any extra adapters for a wall mount setup, mounting holes and a straight back surface are organically integrated in the overall base profile. The cable can be easily routed to ensure wall alignment.

Use of commonly recycled materials
The product housing is made out of PC/ABS, a polymeric blend which provides the optimal balance between durability and ease of manufacturing. Furthermore, this thermoplastic blend is frequently recycled at e-waste centers, streamlining the process and facilitating effortless differentiation from other materials during recycling.

Laser engraved markings to facilitate plastic sortability and recyclability
Industrial markings are indicated at the bottom of the product by using laser engraving. This guarantees that the critical information will endure throughout multiple use cycles, without compromising the recyclability of the part.

The digital solution

The design language

With the smartphone taking over the role of the parent unit, the app becomes the key interface connecting the user and the product. The importance of this digital experience is emphasised by the absence of any video feed shared with the user.
The design of the digital experience has been shaped by two key elements of Bliss proposition: “A real support in stressful moments” and “It simply works: reliable and effective”.

The digital solution

The design language

A calming design language
Colors, animations and quantity of information shown have been designed to provide a calming and reassuring experience. Soft animations are present throughout the app; they mimic the breathing of the baby and they are used to communicate different levels of urgency: soft animation and colors when no urgent intervention is needed; more fast paced and stronger colors when urgent intervention is required.

Optimized pairing and installation
The main concern identified during user interviews, concerning the replacement of the parent unit with an app, was about complex pairing procedures and reliability. For this reason, particular attention was given to this initial stage of the app experience. Based on several parameters, such as the available networks, the device can predict when a pairing cycle is required and initiate the procedure for a smooth experience. Creating a user profile is recommended, but optional. Bliss installation is a particularly sensitive step, since the user cannot see the video feed. The correct positioning of Bliss is guided through an intuitive interface, that guides a correct alignment of baby and product.

A humanized experience with no data overload
From the user interviews we found out that features and data overload create user anxiety. Bliss app communicates with the user in a human way:

- It uses your and your baby's name and it communicates with a kind, reassuring and familiar tone
- It does not provide technical information that the average user does not understand (e.g., respiratory rate). On the contrary, it communicates with straightforward wording what is happening. From "Your baby's heart rate is 65 BPM" to "Ollie is breathing irregularly, please check out if she is doing ok!"
- It communicates information through intuitive animations and visualizations rather than numbers and hard metrics. If numbers are needed, they are spelled out as words.

The digital solution

Subtle notification experience

We combined the need of the parent to always be able to hear an alert (identified during user interviews) and the fact that future homes are expected to become smarter (identified through Future Scanning) in what we called “Subtle notification experience”: a reliable, but un-stressful, notification system which leverages smart home devices as additional notification systems and offloads to them some secondary functions to minimize electronics used in Bliss.

Bliss is not only connected to a smartphone, but it is also compatible with smartwatches and smart home devices. These devices can be leveraged as extra alert systems: if something very serious is happening to the baby, the parent is not only notified through the app, but also through smart lighting and smart speakers positioned around the house. Secondary features, which are not essential to monitor the baby’s condition, but are still “nice to have” for the user, are offloaded to smart home devices. This allows to minimize as much as possible the amount of electronics used in Bliss, decreasing its environmental impact:

- Room temperature can be monitored through smart thermostats
- Lullabies and two-way talk can be enabled through smart home speakers
- Night lights can be provided through smart light bulbs

The digital solution

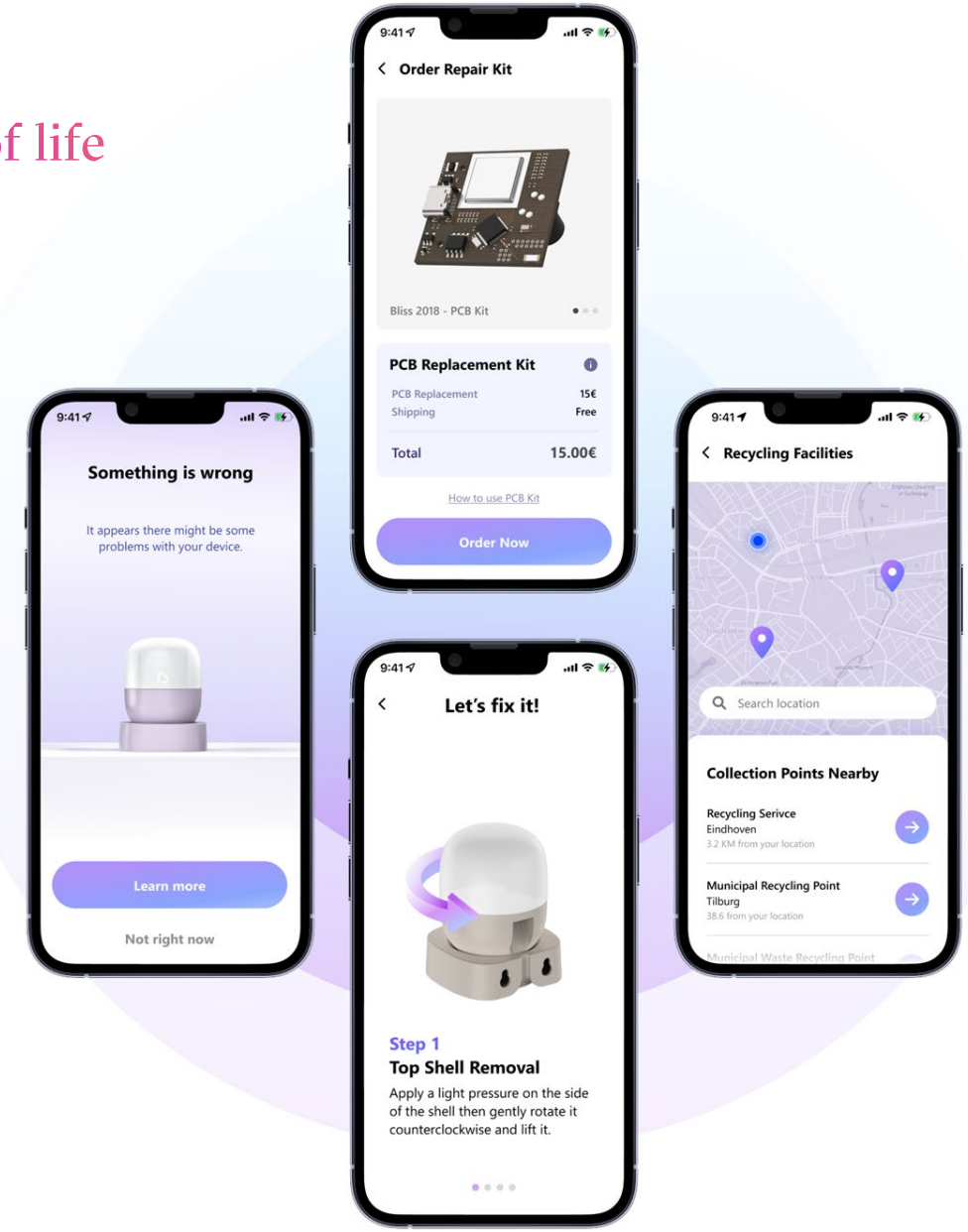
Guiding sustainable user behavior and divestment at end of life

Through User Journey and Value Chain Mapping we found out that user decision plays a key role in determining the end of life of the product. Users are often not aware about options to extend product life or how to properly dispose the product. Through the app, Bliss triggers and guides the user towards repair, resale and recycling.

Luring consumers towards repair
Thanks to self-diagnostics functions embedded in Bliss, the app is able to automatically recognize if the product has malfunctions. If that is the case, the user will be promptly notified. The product is optimized for safe and intuitive consumer repair. The app suggests to the user which part to order, and it shows a preview of the repair operation. The part is cheap, it is shipped for free and in a short period of time. The repair operation is very simple.

Guiding divestment at end of use
Whether it is time to “move on”, or the app recognizes the product is no longer used, the user will be notified and guided through different end of life options:

- The main option is passing the product to someone else. The suggested way of doing so is through the “Preloved platform”. Alternatively, the user is sensibilize to just pass it to someone they know.
- If the user is neither interested in passing the product to someone else, nor to keep the baby monitor and use it again in the future, the app will guide the user towards an e-waste collection point. Furthermore, the app will show how to dismantle the product in a very intuitive way. By partially dismantling the product before disposal, the user is facilitating sorting and recycling at the industrial processor.



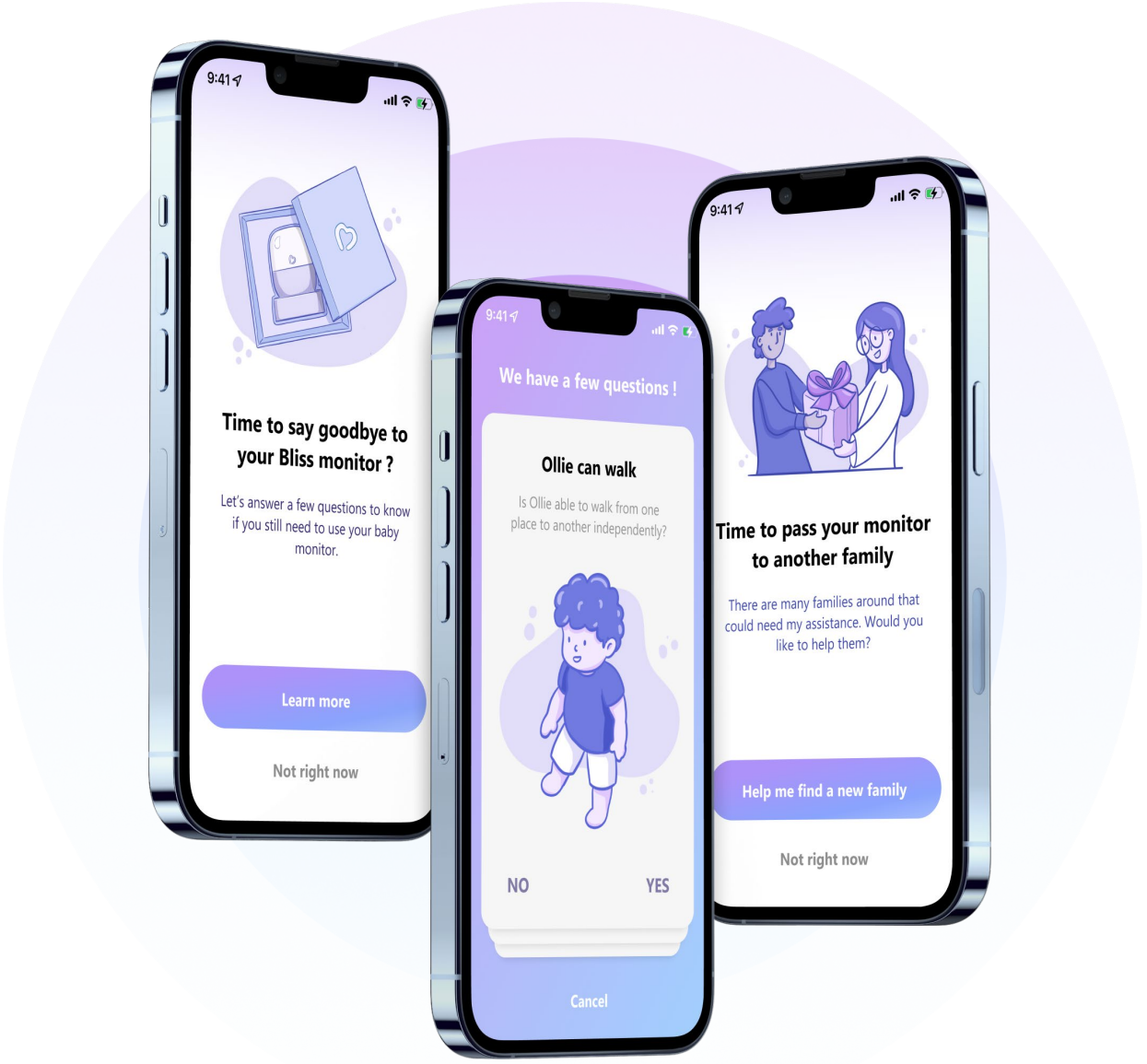
The digital solution

The “Preloved platform”

A key element of Bliss’ proposition is to enable a healthy relation between parent and child, based on independence and trust. An important part of it is to stop using the baby monitor when no longer needed, before risking overprotective behaviors. The “Preloved platform” is a divestment experience which combines healthy relations benefits with environmental ones, by triggering reuse of the product and circular business.

Leveraging intrinsic motivation to help others as a trigger for divestment

Based on the use period and the data processed, Bliss can automatically identify when smart monitoring is no longer needed. The app notifies the user when it might be time to “move on”. The app will ask the parent to fill out simple questions that are meant to understand if it is indeed time to stop monitoring the child. If this is the case, Bliss leverages the intrinsic motivation, identified during user interviews, of users to help other parents, to lure the user to move on. It sensibilizes the user to the fact that, while they might not need the product anymore, many other parents do.



The digital solution

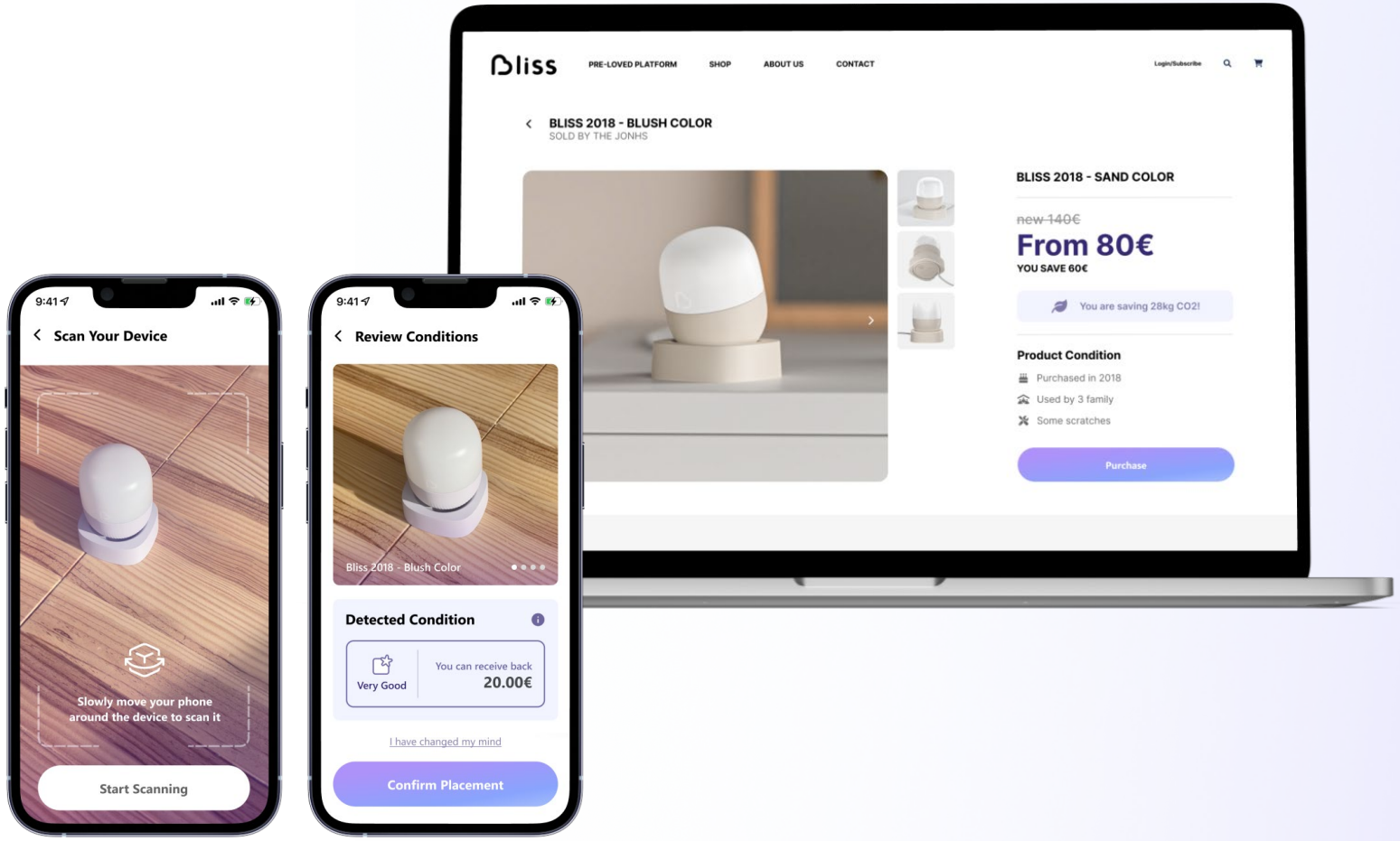
The “Preloved platform”

The user will be advised to pass the product to another user through the Preloved platform. This is a platform that automatically links demand and offer of preloved Bliss.

The user can of course decide to keep the product for themselves (e.g., for a future child). By following an intuitive procedure, Bliss runs an automatic product functionalities diagnostics. By using the smartphone camera, the app guides the user in scanning the product to check aesthetics integrity. Based on this diagnostic, the app indicates how much monetary value the user can receive. The user can always decide to decline or stop the procedure.

On the other side, there is a new user who is interested in buying Bliss. They will be sensibilized to the fact that they can buy preloved rather than new, for a lower price and lower environmental impact. They can pick among different units, with different quality state and colors: a product in neat condition for a higher price or a product with some imperfections for a lower cost.

When the system matches a new demand, the first user is notified. They receive a shipping box and label directly at home. If they want, they can leave a nice note to the future owner.



This new design delivers a staggering environmental impact reduction, even just considering **one use cycle** and no reuse.

75%

Carbon footprint reduction

(kg CO2 ep)

57%

Resource Use reduction

(kg Sb eq)

The North Star value

Value for the User

Healthier and balanced relationship with your child and with yourself

- An app that guides the parent to find a healthy balance between monitoring the state of the baby, without becoming overprotective and anxious.
- The user experience is not based on using a camera anymore, but on a subtle notification system meant to alert the parent only when it is really needed. This to avoid anxiety and overprotective behavior
- The app UI is designed to provide only the necessary level of information, in a human and comprehensible way, to avoid data overload which leads to anxiety
- The app helps the parent to understand when it is “time to move on” and stop monitoring the child, avoiding prolonged used psychological effects on parent and child.

Precise and reliable monitoring
A thermal sensor is used instead of a traditional camera, for a more reliable monitoring compared to traditional baby monitors

The “Preloved platform”: a way for parents to help each other and to access used products for a fraction of the price
Thanks to the “Preloved platform”, where baby monitors that are not needed anymore are offered to other parents, new parents can access the same proposition for a fraction of the price of a new unit. Previous owners find a sense of purpose, by passing the product, which is not needed anymore, to someone in need.

The North Star value

Value for the Planet

A "Preloved platform" to circulate used products
Once it is time to move on, Bliss will guide the user to offer the product to other parents in need. This avoids that fully functioning units are stored in a drawer or thrown away.

Sufficient technology: materials use optimization
The amount of hardware, in particular electronics, is minimized by implementing smart sensing technologies which monitors only the strictly necessary parameters to achieve the core user need.

- No parent unit is needed, since the experience is not based anymore on a video feed
- All electronics is centralized in one PCB, which size and design is optimized for minimal material use
- Using a thermal sensor allows to minimize the number of components required to monitor key vital signs
- Unnecessary functions have been completely removed. Functions like sound and visual notifications are offloaded to smart home devices (e.g., smart speakers and lightbulbs)

Energy consumption optimization
A smart power management logic allows to minimize power consumption in stand-by mode and activate the product only when needed for monitoring

Ease of disassembly

- Parts have been minimized to reduce failure likelihood
- All parts can be accessed and replaced entirely by hand, without the need of any tools. This thanks to a bayonet system and an overall architecture which is not only intuitive, but also safe and mistake proof

Aesthetic durability

- The design of the product is meant to be timeless and withstand trends over time
- Textures are used to avoid scratches on the parts exposed to highest wear and tear

Ease of recycling

- Materials diversity has been minimized to two materials (PC/ABS, PC), both commonly recycled
- Apart the PCB, there are no parts requiring selective treatment
- No coatings are used on plastics

The North Star value

Value for the Business

Reduced production costs
Production cost benefits are expected from the drastic reduction of parts, materials and simplification of design of PCB and material finishings. The “Sufficient tech” approach drives efficiency on both environmental impact and economics.

New value proposition and competitive differentiation
Bliss is a completely new proposition, which opens a new product segment. There are no other products on the market with a similar proposition. It will require time for others to launch products in direct competition. This provides competitive advantage to conquer market share before others can propose similar solutions.

New post sales revenue streams

- A “Preloved platform” that mostly rely on peer-to-peer exchange of used products, allows for low maintenance costs and high revenue margins on units that are sold multiple times.
- The sale of consumer replacement parts also brings post sales revenues

The physical proof of concept

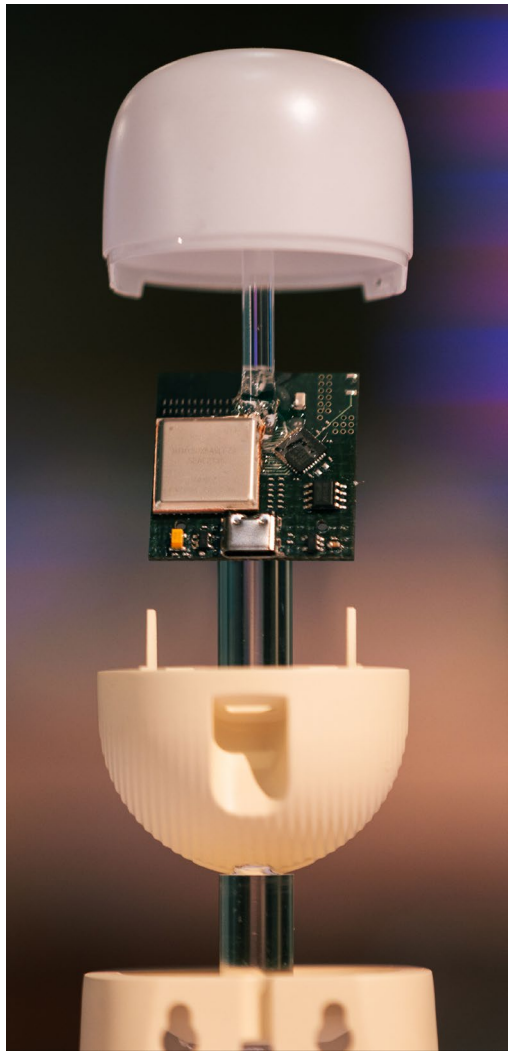
The power of making things tangible

To be a real Sustainable North Star, a concept might integrate technologies and solutions which are not available yet, or not ready for mass scale production. However, it is important to start at least testing and validating parts of it. There is huge power in translating a vision from visuals to an actual physical proof of concept.

We developed a physical proof of concept of Bliss; something tangible, which a change maker in a company could use to push this ambitious North Star forward. In this physical prototype we show cased:

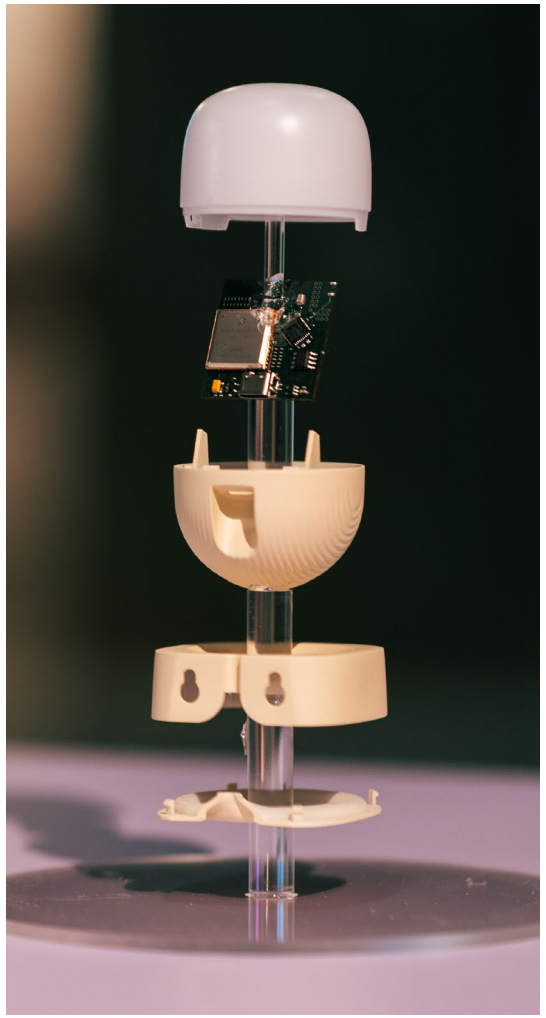
- A looks like real model, to show case the aesthetics and finishing
- A mechanical proof of concept assembly, to test mechanisms and assembly interfaces
- An app, connected to a smart speaker and smart light bulb, to validate the digital experience
- A first-generation thermal novel sensor, which run an edge AI powered image recognition, at low energy consumption, produced by Calumino®
- We built the main PCB using Soluboard®, the world's first fully biodegradable and recyclable PCB laminate from Jiva. With this prototype board, we were able to test this new material and showcase the PCB layout which is technically achievable using Soluboard. Although not functioning, this allowed us to test this new material and to showcase the PCB layout and size which we expect to be achievable in a 10 years timeframe. Furthermore, the dissolving of the substrate was also tested.

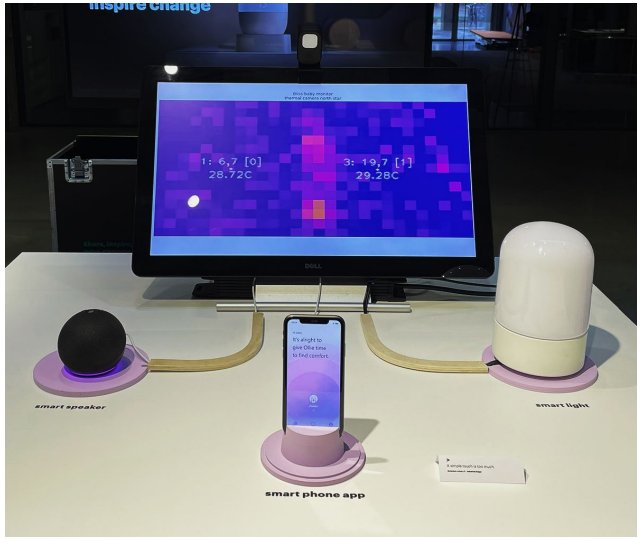
This work was exhibited during Dutch Design Week 2023, in Eindhoven at the **Accenture Industrial Design Center**. It was showcased to 9000 visitors.

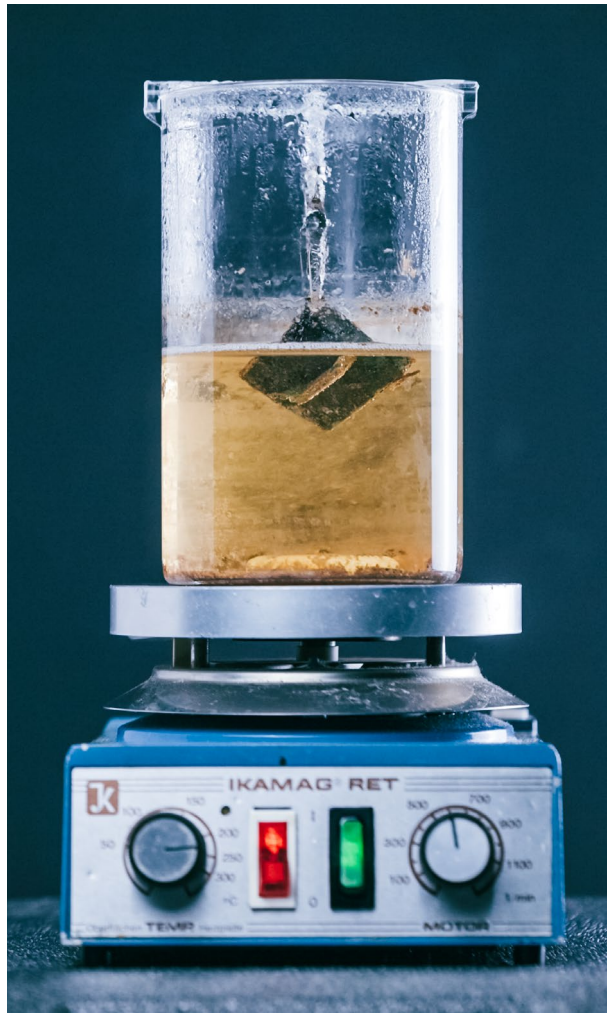


The physical proof of concept

The power of making things tangible







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The Roadmap

A detailed long-term plan

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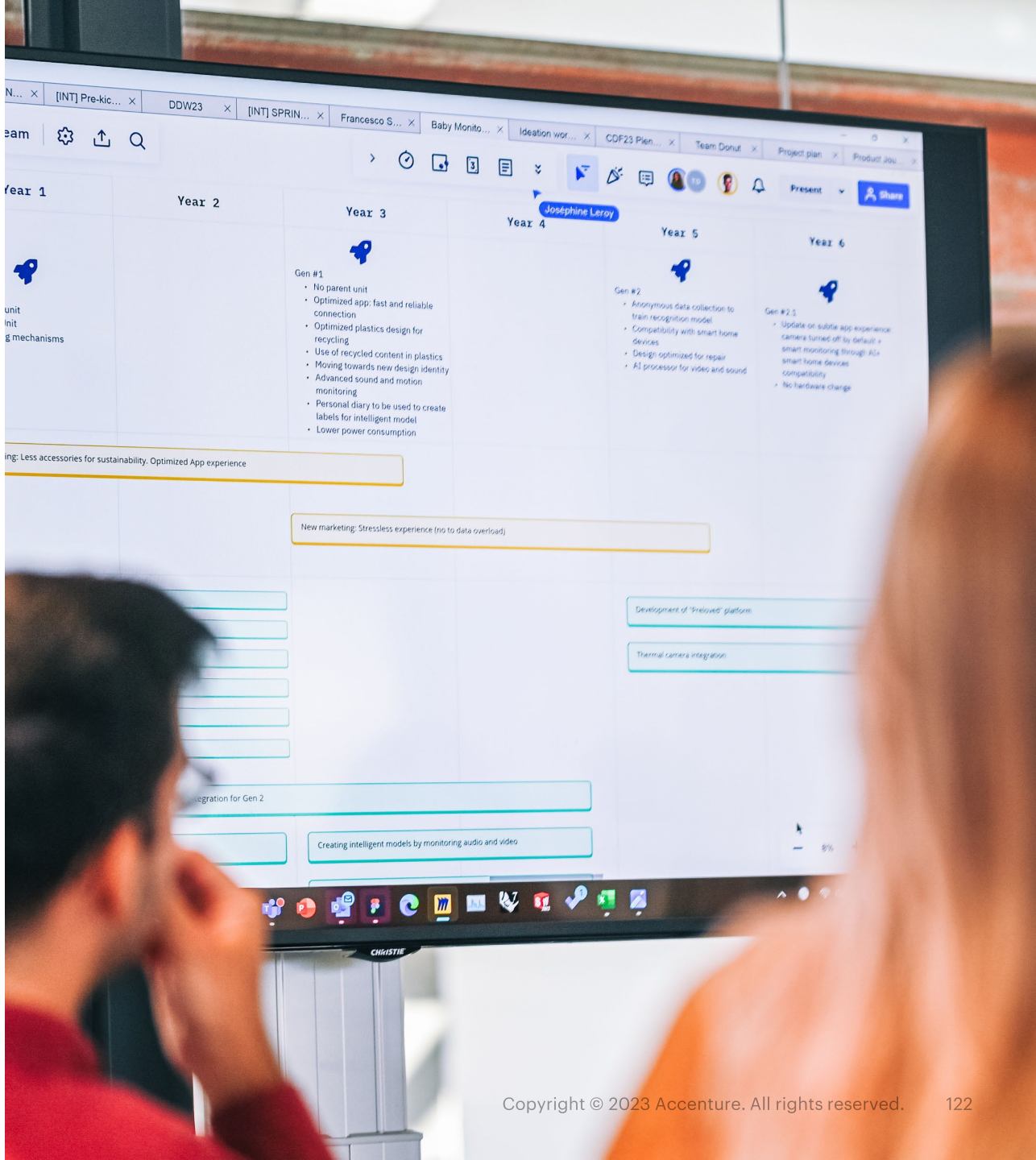


A shared and agreed plan forward

A transition thoroughly planned, but still flexible and evolving

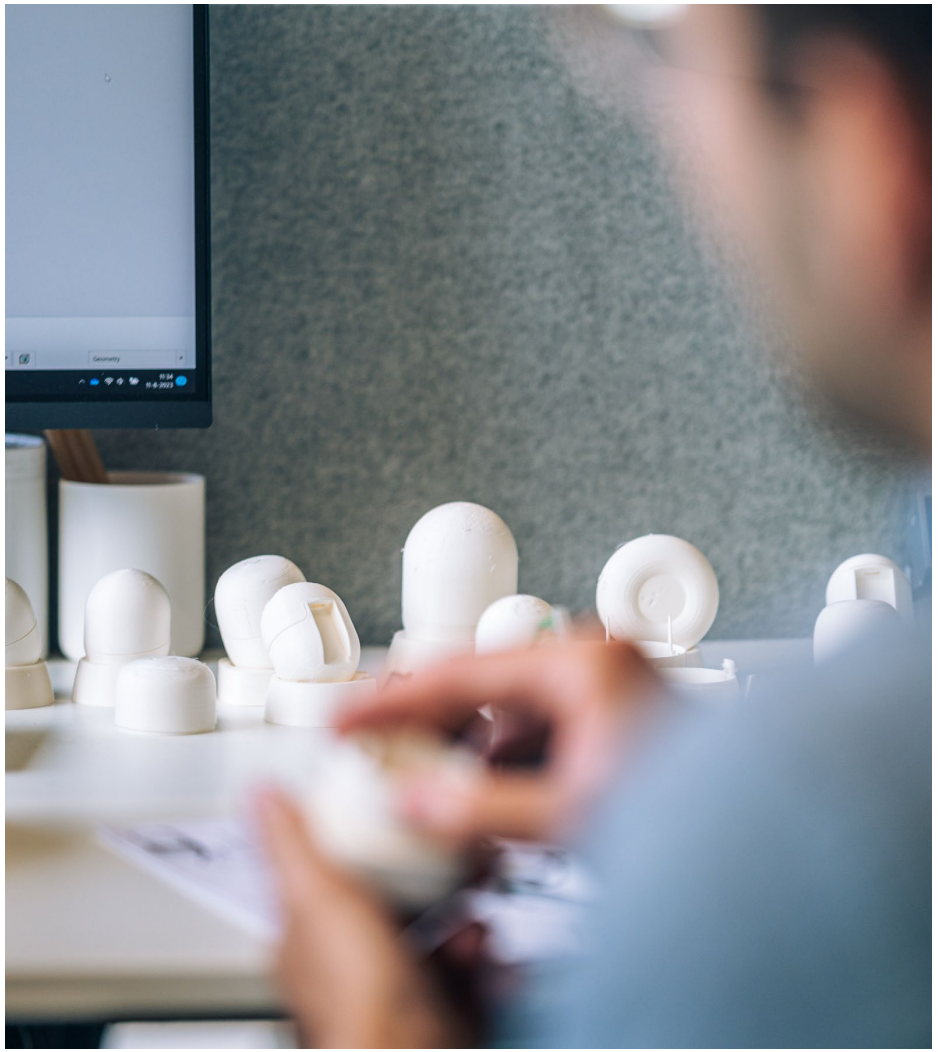
The Roadmap is perhaps the most important outcome of the entire approach. It is based on all insights and learnings collected through the entire process and the development of the North Star concept. It should be defined together with key SME's from different departments and signed off by business leaders with sufficient political power to push it forward and implement.

In this roadmap we focused on the most promising North Star direction: a thermal based monitoring solution, with an engaging EoL divestment experience, based on a peer-to-peer preloved resale platform. Based on learnings collected during the short- and mid-term exploration and pilot activities indicated on the roadmap, this North Star could evolve over time, and different choices might be taken. For instance, going for a subscription model instead (or next to) a "Preloved platform", or going for an industrial refurbishment process rather than a platform based on peer-to-peer direct exchange.
The roadmap spans over 10 years, a timeframe that was agreed to be sufficient to develop and implement the key features of the North Star.
Activities are grouped in 5 categories:

- Pilots and studies
- R&D
- Physical and Digital design
- Supply chain
- Marketing

Key Go / No-Go Gates are indicated clearly on the roadmap and mapped based on the activities required to make key decisions.

Specific new product introductions are defined to ensure a smooth transition from today's solution (Gen. 0) till the North Star (Gen. 4).



Transitioning generations

Year 1

Generation 0

This is the current design, consisting of a camera unit, parent unit, and mounting accessories.

Year 3

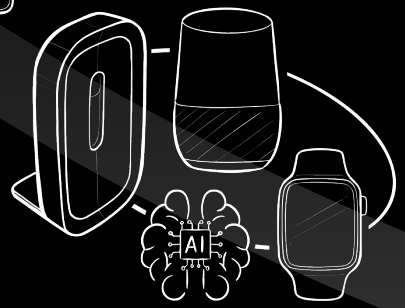
Generation 1

Mounting accessories will be minimized. The parent unit will be removed and fully replaced by the app. Event driven power management logic will be integrated to minimize power consumption during use. The architecture will be optimized for recycling and use of recycled plastic. Selective sound and image data will be collected through the cloud and labeled by the user through a “diary” function to train the future AI models.

Year 5

Generation 2

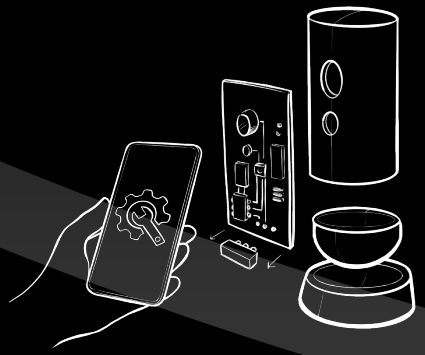
An AI processor will be embedded on device. Compatibility with smart home devices will be integrated; this will enable a first trial of full camera deactivation in Gen 2.1. The PCB will be optimized for size and layers reduction.



Year 6

Generation 2.1

Through an over the air update, in a controlled roll out, the video feed will be deactivated by default putting the subtle notification experience front and center. This will be used to test user acceptance of the experience and the trust in the AI processing.



Year 8

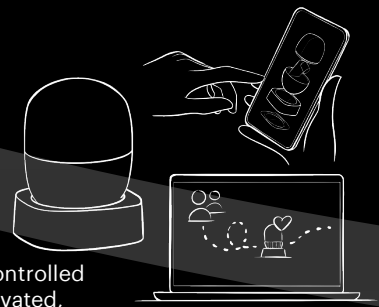
Generation 3

A thermal sensor will be integrated for the first time, next to the RGB one. Data collected by both will be used to gradually transfer the learnings from the RGB to the thermal imaging solution. A small-scale pilot of the “Preloved platform” will be launched. The architecture will be optimized for consumer repair, which will be fully enabled in Gen. 4. Sustainable carrier material alternative to FR-4 will be piloted for the first time.

Year 9

Generation 3.1

Through an over the air update, in a controlled roll out, the RGB camera will be deactivated, and the reliability of fully thermal based imaging recognition will be tested.



Year 10

Generation 4

Only a thermal sensor will be integrated. The “Preloved platform” will be fully operational. Consumer repair and spare parts availability through the app will be fully enabled. Unzippable PCB technology will be piloted for the first time.

Generation 1

The first step towards a more sustainable solution

This generation is the first step towards a more sustainable solution. Lower hanging fruits, like accessories minimizations and parent unit removal will be tackled. First sustainability-driven innovation efforts will be made, such as power consumption optimization and design for/from recycling. A new function, the “diary” will lay the foundations for data collection and labeling to train a future AI based recognition model.

Goals
- Company mind shift, by launching the first sustainability-driven innovation activities and achieving the first small wins
- Tackling low hanging fruits to determine a first decrease in environmental impact at low cost/risk
- Laying down the foundations for future AI based recognition models
- Testing users’ acceptance of parent unit removal in exchange for faster and more reliable phone app
- Test accuracy and user willingness to keep a diary
- Starting to engage with new suppliers, exploring new innovative technologies (e.g. FR-4 carrier alternative) that can be implemented in Gen 3 and 4

Features
- Power consumption optimization
- No parent unit
- Faster and more reliable pairing experiences
- Accessories reduction
- Use of recycled plastic
- Architecture optimization for recycling
- Selective and anonymous audio and video collection through cloud
- Diary function for labelling
- New physical and digital design language

Tests and pilots
- Consumer study on acceptance of accessories minimization and parent unit removal
- First generation of data collection and labeling model

Gates
- Decision point: user driven data labeling in the diary is sufficient or should be extended with manual labeling

Generation 2 & 2.1

Introduction of first smart features

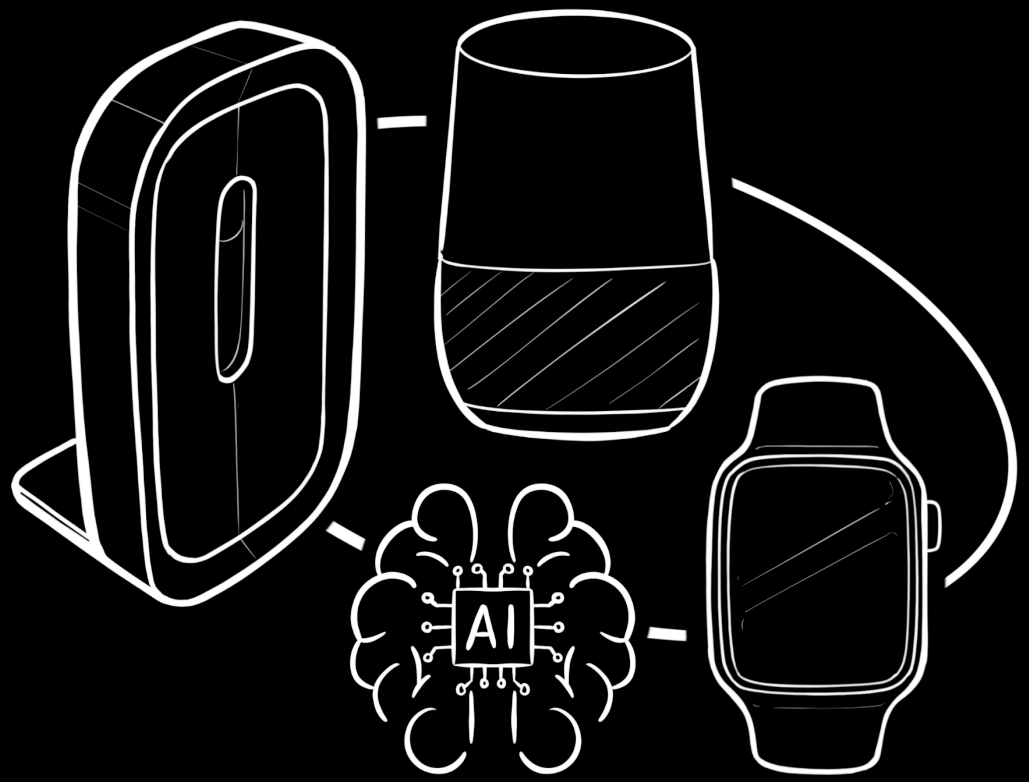
An AI processor will be embedded on device. Data collection will keep happening through the cloud and diary function will support labelling. Compatibility with smart home devices will be integrated to support a first trial of full camera deactivation in Gen 2.1 (which will happen through OTA).The PCB will be optimized for size and layers reduction.

Goals
- Embedding the first real smart features on device and testing embedded AI capabilities
- Preparing the design to become fully video feed free, thanks to smart home devices compatibility
- First big step in tackling PCB environmental impact, by redesigning it from the ground up and testing FR-4 carrier material alternative feasibility
- Consumer tests on acceptance of preloved, subscriptions, subtle notification experience (video feed off)

Features
- On device AI processor
- Smart home devices compatibility for subtle notification experience
- PCB design optimization: components, size and layers reduction and finishing optimization
- Video feed turned off by default in favor of the subtle notification experience through a controlled roll out (Gen 2.1)

Tests and pilots
- Consumer studies on acceptance of video feed deactivation, in exchange for subtle notification experience and smart monitoring. This by monitoring the number of users reactivating video feed after the OTA for Gen 2.1 in several A/B tests
- First pilots on implementation of FR-4 carrier material alternative, involving recyclers and suppliers
- Consumer study to investigate acceptance of preloved (used) products and subscription models.

Gates
- Go / No Go preloved products and subscription model
- Decision point: industrial refurbishment vs peer-to-peer preloved platform
- Go / No Go FR-4 carrier material alternative
- Go / No Go subtle notification experience (video feed off)



Generation 3 & 3.1

The introduction of thermal imaging technology

A thermal sensor will be integrated for the first time, next to the RGB one. Data collected by both will be used to gradually transfer the learnings from the RGB to the thermal imaging solution. Via OTA, the RGB camera will be deactivated and thermal only will be tested in Gen. 3.1. A small-scale pilot of the “Preloved platform” will be launched. Sustainable carrier material alternative to FR-4 will be piloted for the first time and the architecture will evolve to enable future consumer repair.

Goals
- Transferring learnings from RGB to thermal imaging solution and testing the reliability of thermal only.
- Setting up and testing for the first time the “Preloved platform”, including enabling app and device features like functional and aesthetics check.
- Testing FR-4 carrier material alternative
- Preparing the design to be ready for consumer repair in Gen. 4

Features
- Thermal sensor next to RGB
- FR-4 carrier material alternative
- Architecture optimized for consumer repair
- Preloved divestment experience in the app
- Embedded self diagnostics to enable testing in preloved exchange
- Aesthetics integrity check through app camera image recognition

Tests and pilots
- Deactivation of RGB camera and reliability test of thermal only, through a controlled roll out (Gen 3.1)
- First small-scale pilot of “Preloved platform”, to test supply chain and logistics set up
- Consumer study on willingness for consumer repair
- User tests to check safety risks and possible quality issues determined by new architecture optimized for consumer repair
- First tests on PCB unzippable technology integration

Gates
- Go/No-Go thermal sensing technology
- Go/No-Go “Preloved platform” and consumer repair
- Go/No-Go unzippable technology

Generation 4

The finish line

This represents the end goal of the roadmap. A solution fully based on thermal image recognition, completely on device and driven by an AI model. The “Preloved platform” will be fully running, and spare parts will be available through the app, enabling consumer repair. Either the sustainable FR-4 carrier material alternative or unzippable technology will be used to decrease the impact of the electronics and enable higher recovery rates at end of life.

Goals

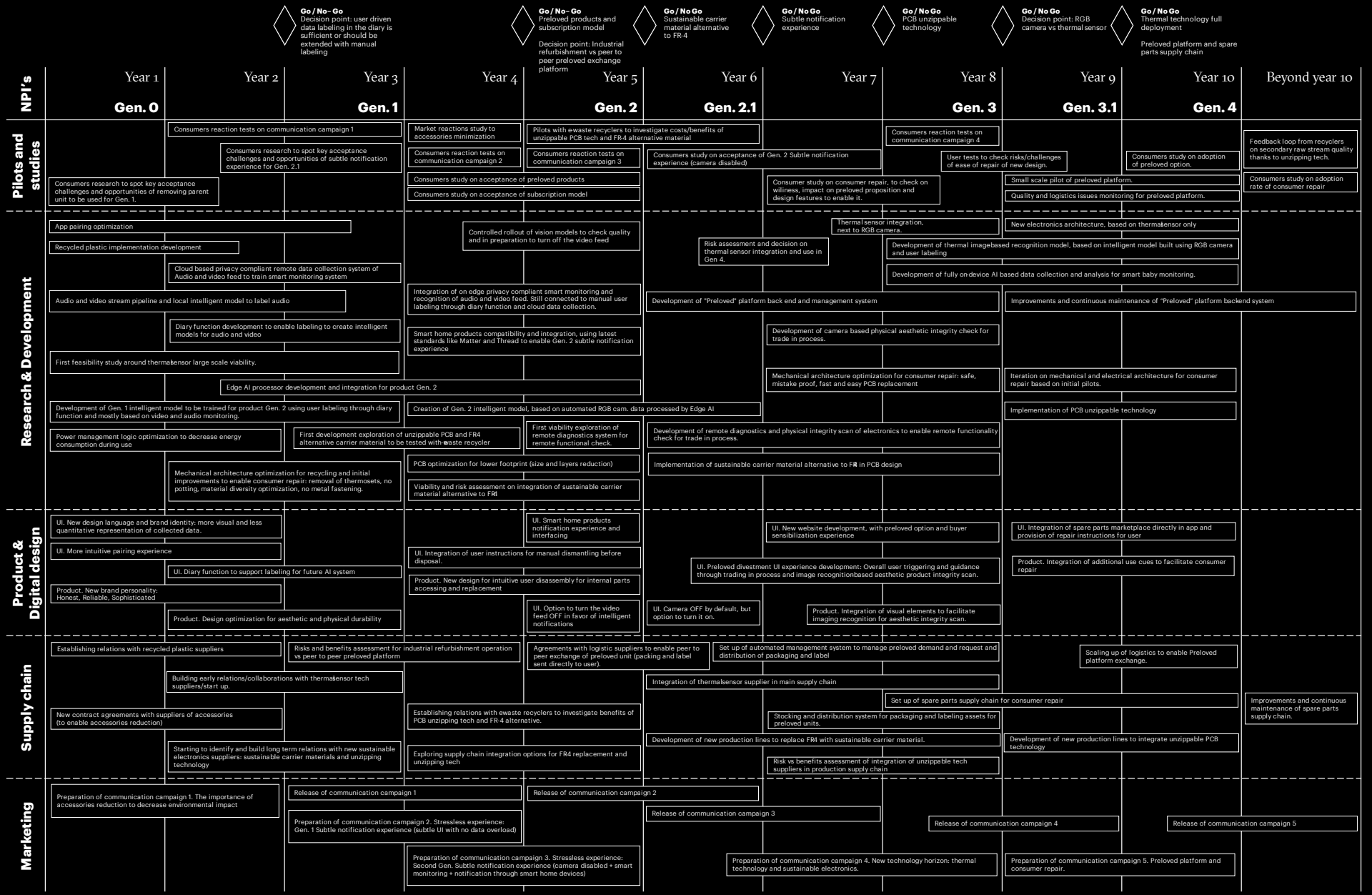
- Achieving the highest PCB optimization level, by combing size, layers and components minimization thanks to the thermal sensor
- Implementing at full scale technologies for PCB environmental impact reduction, like FR-4 material alternative or unzippable technology for higher recovery rate
- Enabling a convenient consumer repair service, to increase acceptance and trust in “Preloved platform” (if it breaks, you can easily repair it)

Features

- Thermal sensor only
- On-device, smart monitoring
- Consumer repair
- FR-4 alternative material or unzippable technology
- “Preloved platform” (and/or subscription)

The Roadmap

Zoom in to see in more detail



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Conclusion

The way forward

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A new chapter

Sustainability represents the next step for the design & innovation competence

Truly sustainable solutions require a much more holistic way of investigating and tackling design challenges: from product and user, to a system perspective. This is rapidly changing what being a designer and engineer entails, transforming forever roles which goal has often been producing as much as possible at the lowest cost.

A spark for radical innovation

Sustainability as a trigger to rediscover competitive advantage

With this work, we wanted to show how sustainability is not just important to avoid a climate disaster, because of regulations or marketing trends. It can be a powerful way to design new propositions and innovation to solve core user needs in a completely different way. When designing in a sustainable way, we are looking at the same core user needs with a completely new lens and perspective. This can lead to creating completely new value propositions; entirely new product segments. Sustainability can trigger new competitive advantage in sectors where innovative advantage is saturated.

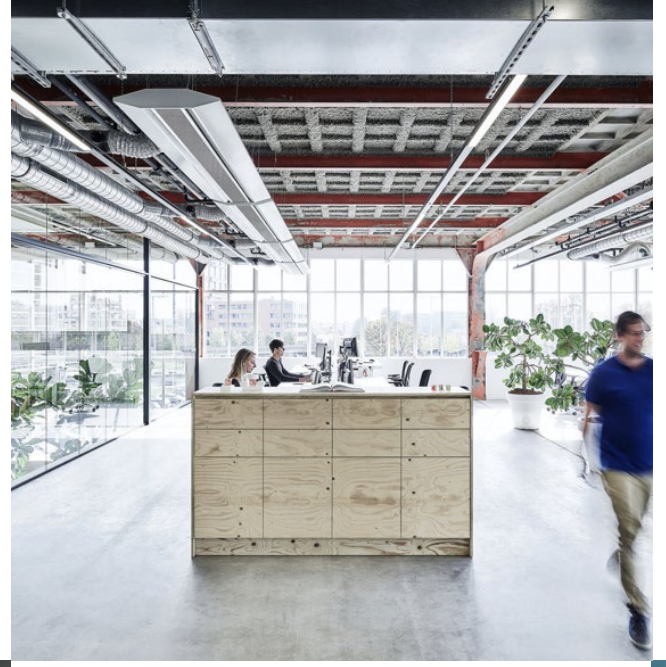
A holistic way of working

The importance of a cross competence team

To design truly sustainable solutions, we must tackle this wicked and systemic topic from different perspectives. It is too big to be tackled just by one competence in isolation. It must be broken down in smaller, more manageable pieces, which can be addressed in different ways. In this design guide we have shown how five different competences worked together in an organic way to develop a final Sustainable North Star. Insights and assets developed by each team were vital for the definition of the final design and roadmap.

Curiosity is a good habit

Get in touch



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