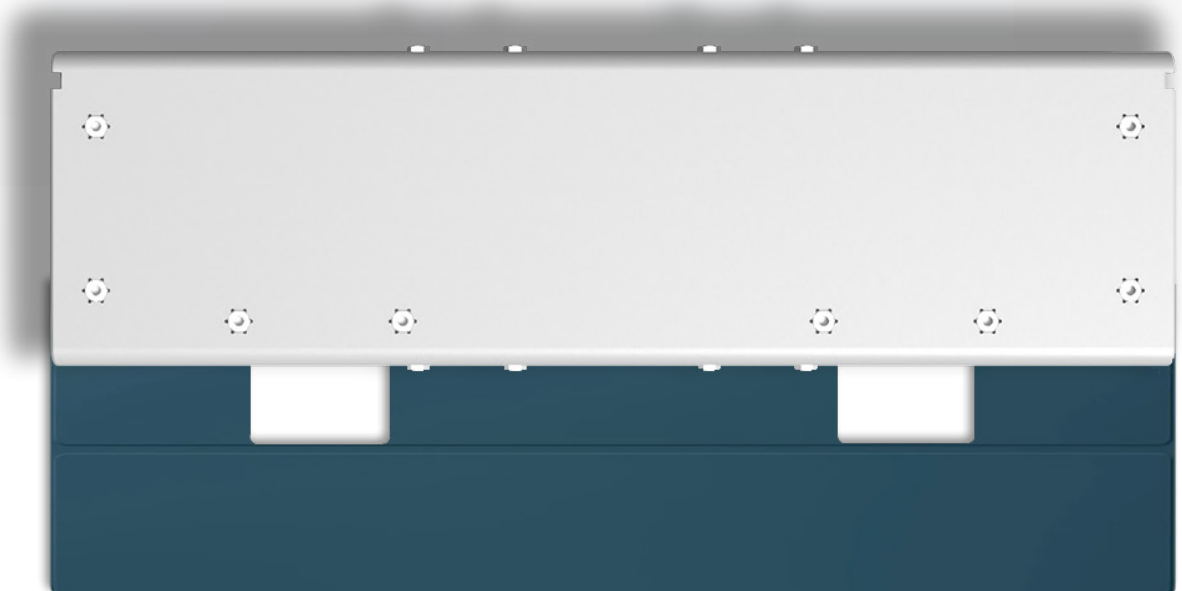
Improving computer peripherals: exploring modular design

Graduation report Msc. Integrated Product Design & Strategic Product Design

Stan Zwanenburg



Delft University of Technology

Faculty of Industrial Design Engineering

December 2025

Master Thesis
MSc. Strategic Product Design
MSc. Integrated Product Design

Improving computer peripherals
Exploring modular design

Graduate
Stan Zwanenburg - 4883098

Supervisory Team
Chair: Prof. dr. ir. R. (Ruth) Mugge, Department of Design, Organisation and Strategy (DOS)
Mentor: Dr. K.W. (Katherine) Song, Department of Sustainable Design Engineering (SDE)
Company mentor 1: B. (Balazs) Kovacs
Company mentor 2: Dr. Y.H. (Yi-Hsieh) Wang

Project Partner
Logitech

Preface

By handing in this report, my journey at the faculty of Industrial Design Engineering of just over seven years comes to an end. The opportunities I have had and the people I have met during my studies have had an incredible impact on who I have become and will continue to do so for the rest of my life. I am grateful for the fact that I was surrounded by people who believed in me, both academically and as a person, and I am incredibly excited to see where my professional career will take me.

This has been the longest and most challenging project I have done, combining all aspects of design together with time and stakeholder management. I have met many new people in industry who enthusiastically helped me with my quest to figure out what modularity means and how it could be used to help both companies and society. The target group of Digital Nomads also provided me with new perspectives on work–life balance, making me appreciate the time I have with friends and family even more.

I never identified with the sustainability-first mindset some of my fellow students had; I was always concerned with the bigger picture. *Perfectly sustainable products are not sustainable if nobody uses them*... This project allowed me to combine my user-centric focus with an angle of sustainable design that I could identify with, one that nestles itself deeply in the product, providing a better experience for company, consumer and planet. It has changed my view and deepened my understanding of sustainable design.

Acknowledgements

Throughout the ten months I have been working on this project, I have been supported by many people, some of whom I would like to specifically thank for their efforts, as I could not have achieved this result without them.

First, I would like to thank Balazs, Yi-Hsieh and everyone at Logitech who made this project possible. It was a dream to collaborate with people who are so passionate about their work and willing to spend the time to teach me the ropes. I have not only learned from the project itself; working with such a large international company was a new experience, and I really appreciate the patience you had with me.

Next, I would like to thank my IDE supervisors Ruth and Katherine, who helped me through a somewhat chaotic start and guided me to focus on the things that really mattered. You helped me find my client and formulate a project brief that kept me enthusiastic throughout the entire ride. You were always prepared to provide direct and constructive feedback, which was exactly what I needed.

Thank you to all the Digital Nomads who helped me with my never-ending series of interviews, especially those who put in the effort to reach out to their other Digital Nomad friends so I could hear their stories as well. From the countless calls, there was not one that felt pressured, even though you live all around the world and are plenty busy. Your representation of the Digital Nomad target group allowed me to create a concept that matters.

Finally, I would like to thank my friends, family and girlfriend for providing me with feedback when needed and laughter when I needed that even more. You showed me that graduation is a time to celebrate, and that there is more to life than deadlines.

Please enjoy reading!

Executive Summary

This project investigated the question: "*What role can modularity fulfil in computer peripherals, and how can it be used to improve consumer adoption of sustainable products?*" It did so in the context of short life cycles, tightening right-to-repair legislation and the reference brand of Logitech with its ambition to combine sustainability with a great user experience in PC peripherals.

Following Buijs' product innovation process, the work combined an exploration of modular architectures with an internal analysis of Logitech's capabilities and initiatives, and an external analysis of modular leaders Framework and Fairphone. Literature on consumer behaviour and sustainable choices was integrated with a requirements framework to connect modularity to repairability, upgradability and user experience.

Digital Nomads were selected as target group through DEPEST and SWOT analyses, then studied via semi-structured interviews and thematic analysis to understand their needs, tensions and attitudes to modularity. This led to a case study: a modular laptop hub for Digital Nomads, developed through iterative ideation, weighed-criteria concept selection, prototyping and validation sessions, and embedded in a business model and roadmap including a supporting community platform.

To answer the research question: The findings show that modularity is most effective when it forms a platform that enables repair, refurbishment, upgrade and configuration over time, while addressing concrete user benefits such as flexibility, reliability and compactness. For Digital Nomads, the modular hub demonstrates that such an architecture can support more sustainable behaviour through extended product lifetimes and improved end-of-life handling, provided it is framed around freedom and self-sufficiency, supported by accessible repair information, spare parts and credible modules while being distributed via fitting touchpoints. In this way, modularity can meaningfully improve consumer adoption of sustainable peripherals.

Table of Contents

1. Introduction

Today's personal computer (PC) peripherals undergo rapid life cycles, leaving users to juggle adapters, contend with changing standards, and replace devices that become obsolete before they wear out. This project begins with that friction: how might we design peripherals that evolve with users while enhancing the experience and reducing waste? By exploring modular strategies in this context, the report investigates concrete design moves that align sustainability with day-to-day usability.

Modular design aims to develop product architecture consisting of physically detachable units for rapid product development, ease of assembly, servicing, reuse, recycling and other product life cycle objectives (Gu et al., 1997). More recently it has become a major topic in the Right to Repair movement, where modularity is seen as one of the key factors for consumer empowerment (Preethish. Kumar et al., 2024)

Design for modularity is often perceived as the opposite of design for integration. Where integration focuses on having parts be multifunctional to improve performance and efficiency, modularity focuses on the parts' autonomy to improve scalability and upgradability (Mikkola, 2001). Modularity can also enable new product variations, more rapid assembly and simple disassembly to improve the product lifecycle (Machado & Morioka, 2021).

Modularity does not have to be physical; software can be programmed in specialised modules to increase efficiency and upgradability. Organisations are often structured in modules (departments) to promote specialisation and efficiency (Langlois, 2002) and biologists refer to modularity as one of the key factors in an organism's capability to evolve (Zelditch & Goswami, 2021). This project focuses on physical modularity, where a physical product is composed of modules that provide it with specific functionality.

Some examples of conventional goals of physical modularity in products, as coined by Eppinger and Ulrich (1995), are to:

- Upgrade (i.e. upgradable graphics in a PC).
- Replace worn-out parts of (i.e. car tyre or blown LED light).
- Adapt to (i.e. charger with interchangeable outlet standards).
- Allow for flexibility in use (i.e. different camera lenses for different use cases).
- Add onto (i.e. expandable storage in a phone).
- Add/top-up a consumable (i.e. lead in a mechanical pencil or ink cartridge in a printer).
- Allow for reuse of parts without having to change the rest of the product (i.e. incremental changes to a car or coffee machine).

Taken together, these goals of modularity suggest a powerful response to wider societal pressures: the need to reduce material waste, comply with evolving right-to-repair expectations and cope with rapidly changing digital tools in everyday life. These subjects are amongst the ones discussed in this report, used as a lens to examine how modularity could play a meaningful role within the contemporary landscape of computer peripherals.

2. Context

This project will specifically focus on the market of consumer PC peripherals. This market is characterised by short product life cycles, intense competition, frequent new product introductions, rapidly changing technology, dynamic consumer demand and evolving industry standards (Logitech, 2024a). This makes it an interesting and challenging market for meaningful, long-lived implementations of modularity.

2.1. Reference brand for study

This graduation project uses Logitech as the primary brand of reference. Logitech is a large corporation with four main segments, each with its own design and engineering teams: Logitech Personal Workspace Solutions (Logitech PWS), Logitech G (Gaming), Logitech for Business (L4B), and China for China (C4C).

This project will mainly focus on Logitech PWS, seeing that this is the department producing the most consumer PC peripherals. Logitech PWS contains most products one might associate with the main brand of Logitech:

- Headsets
- Webcams
- All non-gaming pointing devices and keyboards
- Microphones
- Lighting
- Control pads
- Tablet keyboards

A more extensive Brand analysis, argumentation for the initial scoping of Logitech PWS and elaboration on the PWS segment can be found in Appendix A.

2.2. Problem definition

Modular designed electronics are often presented as an environmentally superior approach to integrated alternatives, slowing down consumption and thus reducing associated environmental externalities (Agrawal et al., 2016). Consumer electronics that have modularity as one of their main drivers have however not yet been proven to be successful compared to their integrated counterparts. One reason for this might be that implementing modularity often requires redesigning products from scratch while balancing costs, sustainability, user experience (UX), feasibility and scalability. Another reason might be that, even though modularity is often used to improve product repairability and future-proofing, it in itself does not always necessarily instigate a lower carbon impact (Agrawal et al., 2016; Ebert et al., 2024).

The implementation of modularity is, however, becoming more urgent. New legislation in the European Union strengthens right to repair expectations by requiring consumer electronics manufacturers to consider design for repair and to make so-called priority parts accessible for easy replacement by consumers (Parliament, 2025). For a company with a broad portfolio, the absence of a clear modularity strategy can lead to inconsistent decisions, missed opportunities to reuse parts across product families, and limited progress on sustainability goals.

This project explores what forms of modularity exist and uses the brand of Logitech as the main point of reference to develop product concepts that apply modularity effectively through improved user experience and sustainability. The question that arises is:

What role can modularity fulfil in computer peripherals, and how can it be used to improve consumer adoption of sustainable products?

Answering this question could provide insights for a company like Logitech to develop products that benefit consumers in a way that is sustainable and effective.

2.3. Assignment

With increasingly strict sustainability requirements and an eye towards continued market growth, an assignment was formulated to explore the question mentioned above:

Investigate how a PC peripheral manufacturer could implement modular product design to improve both the sustainability and user experience of computer peripherals through the development of an innovative prototype.

The research questions that arise from this assignment are:

RQ1: Which forms of modular architecture should be considered/ruled out when designing a modular PC peripheral?

RQ2: How can the capabilities of an established PC peripheral manufacturer be leveraged to create modular PC peripherals?

RQ3: How is modular product design currently being used to improve a product's sustainability?

RQ4: How is modular product design currently being used to improve a product's user experience?

RQ5: What users would benefit most from modular product design in PC peripherals?

RQ6: How do you convince *[Chosen user]* to choose modular product design?

RQ7: What modular product concept fits the needs of *[Chosen user]?*

RQ8: How does the product system of the chosen concept and its modules come together into a coherent package?

RQ9: Would a PC peripheral manufacturer like Logitech be able to effectively manufacture the chosen concept?

RQ10: How do users interact with the concept prototype?

RQ11: Does the chosen concept provide the value it aims to deliver for *[Chosen user]*?

RQ12: What is the role of a manufacturer like Logitech in distributing a modular product designed for self-repair and open sourcing?

2.4. Project approach

The project will follow the product innovation process by Buijs (2012) for the fact that it looks to internal and external factors to develop innovative new concepts while incorporating valuable segments for both masters of Strategic Product Design (SPD) & Integrated Product Design (IPD). An overview of the process is shown in Figure 1.

Figure 1. An overview of the Product innovation process by Buijs (2012).

Following de product innovation process, the following steps will be taken:

1. A detailed analysis of the types of modularity and their presence in the market of PC peripherals will be conducted, resulting in two "modularity maps".
2. Through an internal analysis (courtesy of Logitech), the current state of modular product design and other sustainability initiatives is sampled and assessed.
3. Through an external analysis, the market for sustainable and user-friendly modularity is investigated.
4. Using the newfound knowledge combined with a trend analysis, a target group is chosen as a case study for modular PC peripheral design.
5. Product ideas for modular PC peripherals are generated based on the needs and challenges the target group experiences.
6. One idea is selected and developed into a design brief, based on the requirements formulated in the analysis.
7. A prototype is developed based on the design brief, and evaluated on its desirability, feasibility and viability.
8. A market introduction plan is formulated in the form of a roadmap.

3. Exploring modular architecture

Seeing that the project is focused on modular design, it is critical to understand what forms of modular architecture exist and how to distinguish them from each other. Through this overview, it will be possible to see what the current use of modularity is in PC peripherals and what value it provides to the user. This chapter focuses on creating a common language which can be used to map out modular products, followed by the creation of “modularity maps”. These maps should guide the following steps of the project, showing what forms of modularity have and have not yet been applied in the market of PC peripherals. Secondly, the maps will be a tool designers and companies could use in future endeavours to orient and explore new directions for modularity. This chapter answers the following questions:

RQ1: Which forms of modular architecture should be considered/ruled out when designing a modular PC peripheral?

RQ1.1: How can you objectively distinguish between forms of modular architecture?

RQ1.2: Which forms of modular architecture are currently being applied in the market for computer peripherals?

RQ1.3: Which benefits are existing forms of modular architecture in computer peripherals providing to the user?

3.1. Types of modular architecture

There has already been work on mapping and categorising forms of modularity, Eppinger and Ulrich (1995) distinguish between three different segments in a modular system: chunks, architecture and the interface that is used between the two. The mechanical parts of a product are typically organised into several major physical building blocks, called *chunks* (Eppinger & Ulrich, 1995). Each chunk is made up of a collection of components that implement a certain function into the product. The *architecture* of a product is the scheme by which the functional elements of the product are arranged (Eppinger & Ulrich, 1995). The interface of a chunk makes sure it physically fits into the architecture and arranges other functionalities, like data transfer and power to the chunk. Eppinger and Ulrich visualise these modular systems by using simplified schematics, as seen in Figure 2. Although the system can be used for both electronic and non-electronic architectures alike, it focuses on solely on the physical arrangement of the architecture and not on the electrical layout.

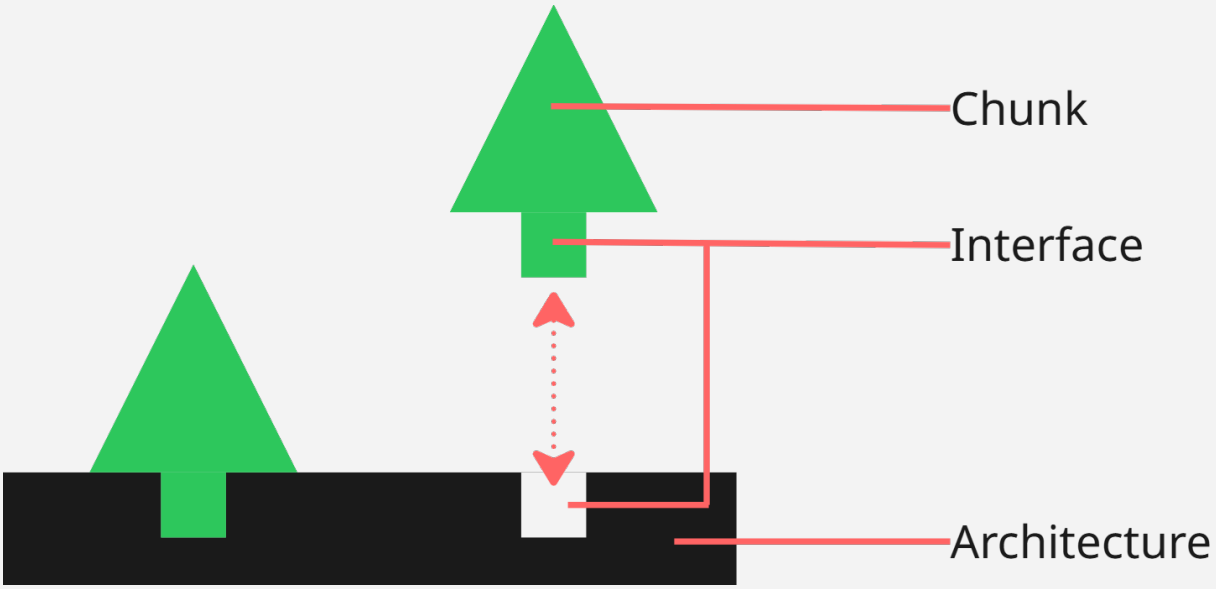


Figure 2. Segments in a modular system.

In their book *Product design and development*, Eppinger and Ulrich (1995) present three types of modular architecture: Slot-modular, bus-modular and sectional-modular. Mascitelli (2004) later added the three types of modularity called component sharing, component swapping and cut-to-fit modularity. These forms of modularity and their schematic interpretation formed the base of all modular forms used in this project.

In total, 9 forms of modularity were found; during analysis two extra forms were created for this project: Semi-sectional modular and hub-sectional modular. These two forms were added seeing that they provided such a significant difference in architecture that they were split off their related form of sectional modularity. shows the schematic representations of all 9 forms of modularity alongside that of integrated and proprietary architecture. For a more detailed explanation of each form of modularity, see Appendix A.

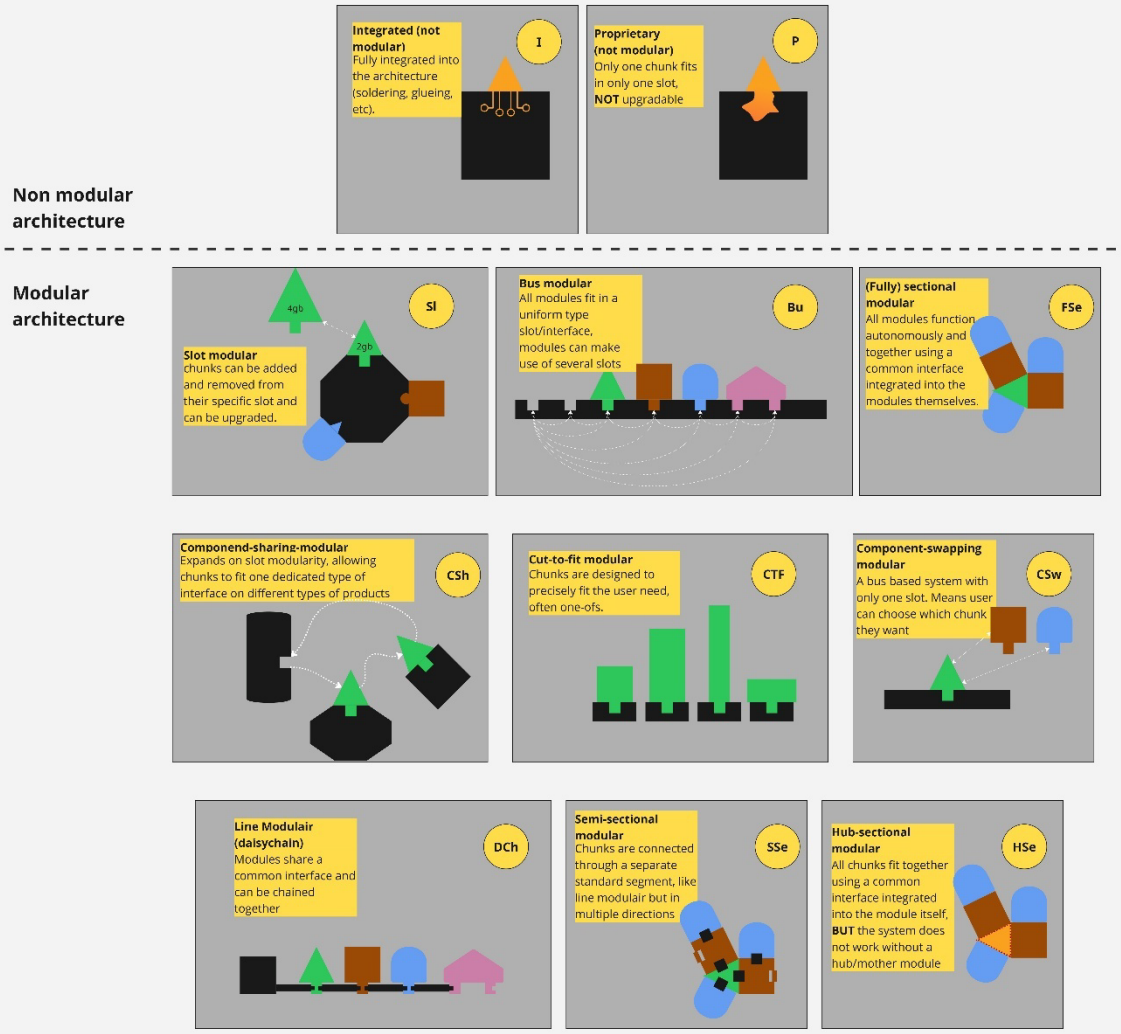


Figure 3: Overview of all modular and non-modular schematics, including a description and their abbreviation.

3.2. Modularity database

Alongside discovering the forms of modularity, a database was created. The database aimed to establish a complete overview of the use of modularity within the market of PC peripherals, which could then be used for creating the modularity map. In addition, different forms and applications for modularity were analysed in a wide range of products and added, with the aim of finding a saturation point for types of modularity and their desired aims.

The final database contains 101 products that use some form of modularity; 95 of the entries concern the use of modularity in PC peripherals. The complete database can be requested by contacting the report author.

3.3. Modularity mapping

Using the products collected in the database, several modularity maps were developed. Within the process of creating *the* modularity map, it became clear that creating one single map to visualise the landscape of modularity in computer peripherals was impossible, the main reason being that there are near infinite definitions of the word modularity, let alone ways to interpret and score products. Below are the two modular maps that provided the most valuable information are shown and explained.

3.3.1. MAP A – MAPPING INTRINSIC MODULARITY

The first type of modular map, called Modularity map A, is shown in Figure 4, aimed to create an overview of how intrinsically modular certain forms of modularity are and which forms of modularity are being used in PC peripherals. All forms of modularity mentioned earlier in this chapter were mapped on an axis from *non-modular architecture* to *intrinsically modular architecture.* To decide what forms of modularity should be placed on which position of the axis, a novel, somewhat arbitrary form of calculation was used; an explanation of said calculation can be found in Appendix B. The map can be used by designers to experiment with moving a concept or product's architecture along the axis, trying different forms of architecture to discover new ways of using modularity to benefit the products design.

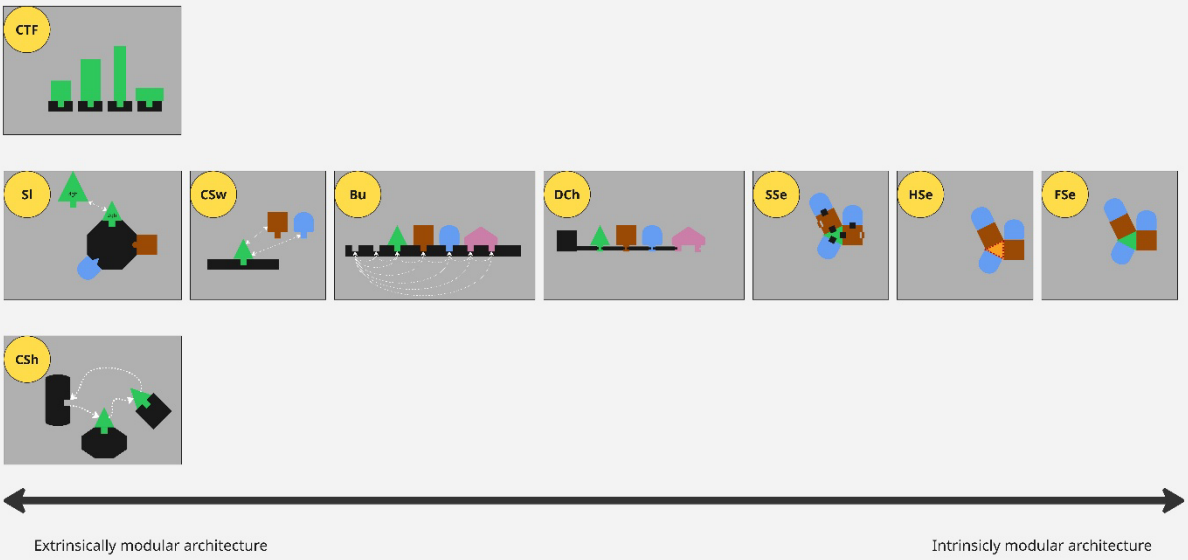


Figure 4. Modularity map A, showing all discovered forms of modularity on a scale from extrinsically modular architecture to intrinsically modular architecture.

The map was then simplified by only using the abbreviations of the modularity types (Figure 5).

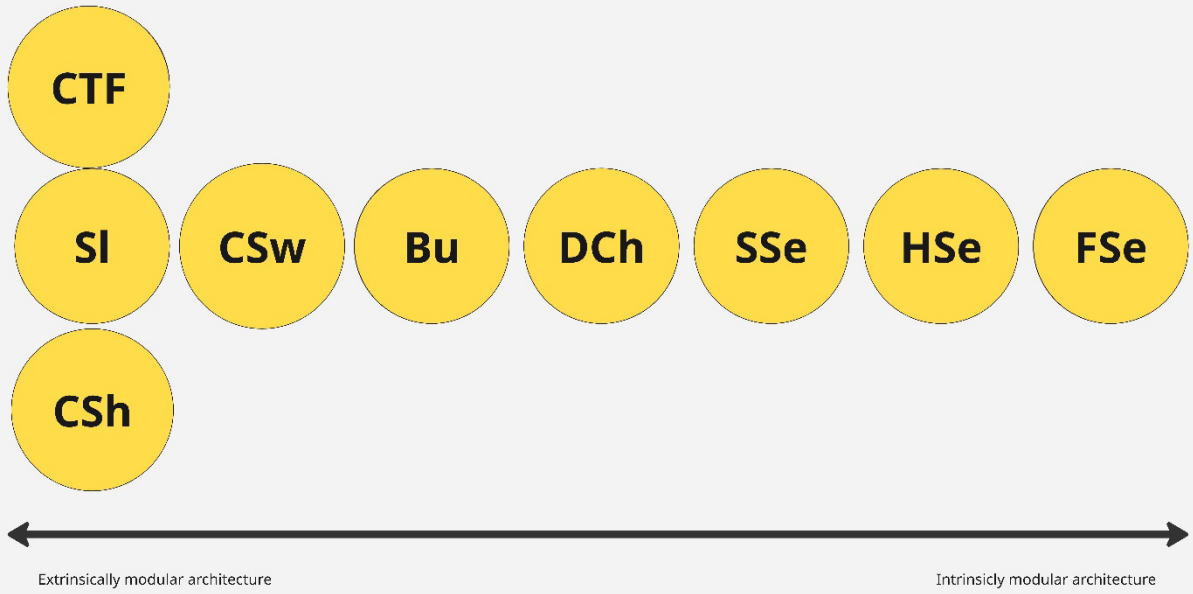


Figure 5. Simplified version of Map A using only the abbreviations of the modularity types.

Mapping the modular PC peripherals from the database onto the map gives the map shown in Figure 6. The total count is higher than the amount of PC peripherals in the database, seeing that some PC peripherals make use of several forms of modularity.

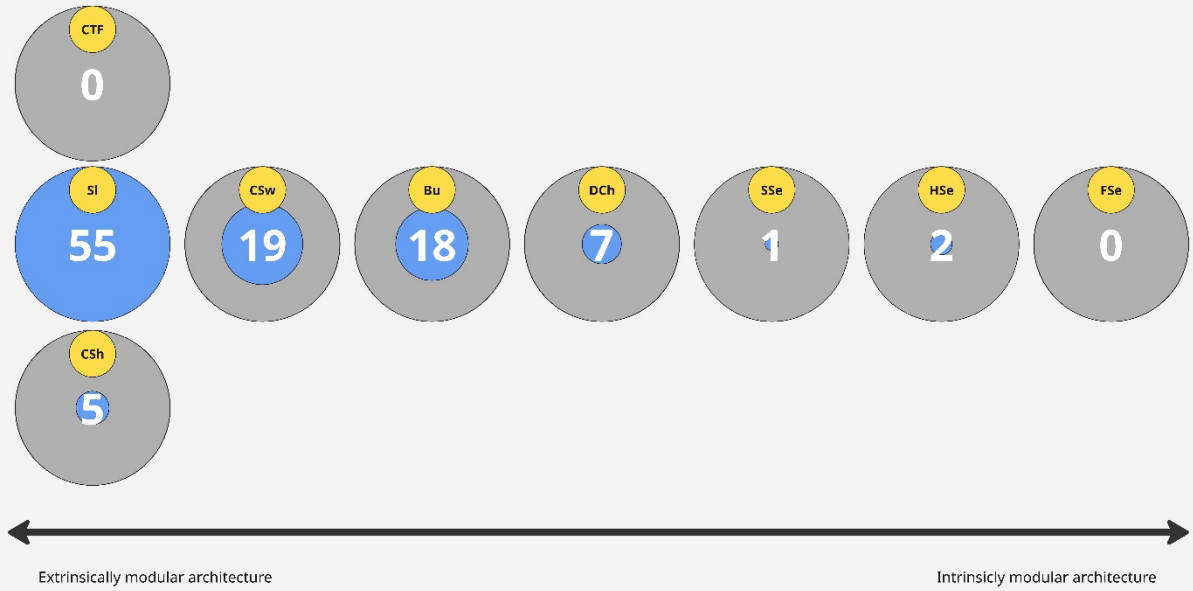


Figure 6. Modularity map A with all modular PC peripherals from the database.

To answer **RQ1.2:** *Which forms of modular architecture are currently being applied in the market for computer peripherals?* The map shows that most modular PC peripherals are slot modular (55) or component-swappable modular (19), with the second being a derivative of the first. There are also 18 modular PC peripherals making use of bus modularity; this form is mostly applied to keyboards and control panels, for example, in interchangeable keyboard keys.

The reason these kinds of modularity seem to be most present is most likely because their implementation is the simplest and is also the most achievable through iterative design steps, while the more intrinsically modular forms of architecture require more radical change in a products design.

Less represented forms of modularity are component-swapping, daisy chain, semi-sectional (only one entry) and hub-sectional. Daisy-chained products are solely focused on adapting or expanding products, whether it is as an amplifier or splitter; these products never work as a standalone. A big benefit of Daisy-chained products is that their linear interchangeable design allows for easy replacement of modules.

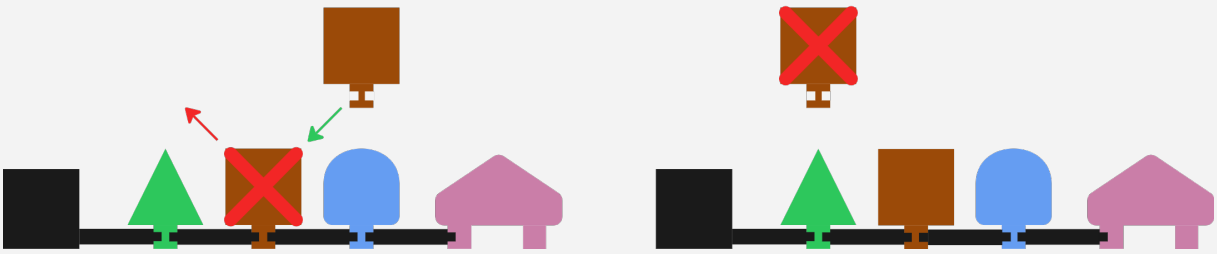


Figure 7. Daisy chain (line) modular architecture allows for easy replacement of modules along a linear track without affecting surrounding modules.

Cut-to-fit and fully sectional modularity are not used in any PC peripherals on the market, which creates an interesting gap that could be used to design a novel modular product. One example of cut-to-fit modularity in PC-peripherals would be 3D-scanning a consumer's hand palm and making a custom fit to their mouse. An example of fully sectional design would be a LEGO-like design which allows the user to place any part of a PC peripheral on any of the other pieces.

Consideration 1: To investigate novel and potentially innovating appliances of modularity, the product could consider making use of one of the less represented forms of modularity: Component-swapping, Line, hub-sectional (only one entry), hub-sectional, Cut-to-fit, semi-sectional and/or fully sectional.

RQ1.1: How can you objectively distinguish between forms of modular architecture?
Map A shows that it is possible to distinguish between forms of modularity and scale them to an extent. It is, however, not possible to objectively score products and their architecture on their modularity due to the wideness of the term.

RQ1.2: Which forms of modular architecture are currently being applied in the market for computer peripherals?
Existing modular PC peripherals mostly make use of more basic forms of modularity like slot, component sharing or bus. There are some examples of more intrinsic forms of modularity being used in PC peripherals, and they show how modularity can be used to provide novel functionality that was not possible before.

3.3.2. MAP B – MAPPING BENEFITS OF MODULARITY

The second map, Modularity map B, shows what functional benefits the modular architecture of each PC peripheral in the database provides to the user. The products are divided by using the seven types of functional benefits for modularity coined by Eppinger and Ulrich (1995) as were also explained with examples in the introduction of this report:

1. Upgrade
2. Wear
3. Adaptation
4. Flexibility in use
5. Add-ons
6. Consumption
7. Reuse
8. Accommodate

Looking at the right to repair angle, Wear and Reuse are the most valuable benefits seeing that they allow for replacing parts in a PC peripheral without having to replace other parts that are still functional. An eighth functional benefit was added to this list is named “accommodate”, this functional benefit was created for this project and describes modularity that aids the user in storing the product or provides a housing for the product with benefits during or outside of its use. The only example of the accommodate benefit found in the current market of PC peripherals is displayed in Figure 8.

Figure 8. An example of the modularity benefit "accommodate"; The ESR magmouse allows the user to store and charge the mouse on their laptop

Figure 9 displays Map B. The map shows that most modular PC peripherals fall under the benefit of Flexibility in use. This benefit describes the ability to alter a module to cater to the use case of the consumer.

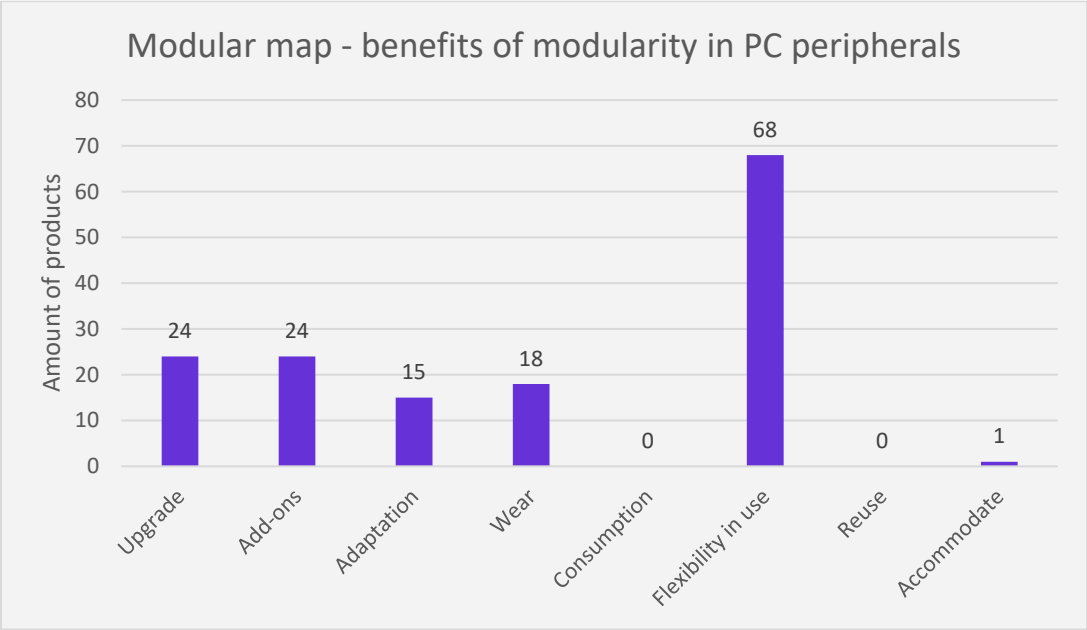


Figure 9. Map B, showing how the modular PC peripherals from the database are dispersed per type of benefit. Some products are placed in several sections because they provide several benefits to the user.

The reason there are so many products in this category is that modules that enable the user to express themselves through colour and patterns also fit this category. Using modularity for expression is the most explored direction in the current market for PC peripherals.

Consideration 2: Although flexibility in use is a successful benefit of modularity, its overwhelming presence in the current market and lack of direct benefit to sustainable design makes it a less interesting direction to take.

The four benefits of Upgrade, Add-ons, Adaptation and Wear are relatively evenly distributed. (Almost) No products from the database used the benefits of Consumption, Reuse or Accommodate. The biggest reason for no products using consumption is most likely to be because adding any form of consumable to a PC peripheral would make it significantly more complicated, please note that the most obvious form of consumption, standardised batteries (AA, AAA, etc.), are not taken into account in this analysis, otherwise this pillar would have been the biggest by a large sum.

The benefits of accommodate and reuse are not (well) represented in the PC peripheral market with a reasonable guess being that they are either too complicated to implement or obstruct the use case of the product too much. For accommodate a reason could be that solely adding an interface to a product to store it is often unnecessary seeing that PC peripherals are often thrown in a bag or just laying on a desk.

RQ1.3: Which benefits are existing forms of modular architecture in computer peripherals providing to the user?

The benefit that is represented most in Map B is flexibility in use/personalisation, showing that modularity is used most to allow users to express themselves through their PC peripherals.

Benefits like consumption, reuse or accommodate that are either represented little or not at all and seem to be challenging or even undesirable to implement into a PC peripheral, this is most likely because these "benefits" are either not perceived as beneficial in PC peripherals or because they are complicated to implement into these types of products. The lack of their presence in the market however also provides an opportunity for new ideas that could challenge our perception on what PC peripherals should look like.

PC peripherals providing proven forms of functional benefits can be used as a base for modular product design, while the underrepresented forms should be used to inspire for new opportunities during ideation.

3.4. Conclusion

This chapter was focused on getting a better understanding of what the term modularity means and how it relates to the scope of computer peripherals. Building on existing theory, nine different forms of modularity were distinguished. These forms of modularity were used to create the first modularity map (Map A), which displays existing applications of modularity on an axis of being non-modular to being inherently modular. Through this map, it became clear that there is a difference in the amount of representation per form of modularity. There are very few PC peripherals that come close to being inherently modular, which hints towards an interesting solution space.

A second modularity map (Map B) was created to better understand the needs that existing modular PC peripherals were providing to users. The need that was clearly most represented was flexibility in use/personalisation, showing that modularity in PC peripherals is most often used to alter the product to the user's liking in terms of either feel or aesthetics.

RQ1: Which forms of modular architecture should be considered/ruled out when designing a modular PC peripheral?

A total of 9 different forms of modular architecture were identified, two of which were new. Although these 9 different forms of modular architecture are distinguishable from each other, they can have overlap, resulting in products fitting several different forms of modular architecture.
The two modular maps show the distribution of existing products and therefore allow us to spot novel combinations and opportunities for PC peripherals that have never been sold. However, the form of modular architecture used for the product should not only be based on its novelty. The main reason most modular architectures in PC peripherals remain basic is that creating truly modular product designs is very difficult to implement. There might also be other benefits to more simple implementations of modularity like ease of use and comfort. Therefore, all forms of modularity will still be considered in the ideation stage of the project.

4. Internal analysis

This chapter analyses organisational structure and operational capabilities to understand how a company's current state aids modular design (using Logitech as case study). The chapter aims to answer the following question:

RQ2: How can the capabilities of an established PC peripheral manufacturer be leveraged to create modular PC peripherals?

4.1. Current state of modular product design within reference brand

Logitech was founded in 1981 and the way products are designed inside Logitech has organically grown together with the size of the company. Through this organic growth, most design work is iterative, focused on improving an existing product with short design iterations from 4 months to 2 years per product. This is one reason why modular product design has not yet made a large impact in Logitech PC peripherals, seeing that modular product design requires an entirely new way of approaching a product, from manufacturing and sale to repair and recycling. Interviews with industry experts and those familiar with the company of Logitech have, however, suggested a growing interest in, and experimentation with, different aspects of modular design, and see opportunities for it to have a positive impact on the user and company. This project, therefore, not only examines how modularity can be used in the Logitech of today but moreover how modularity might be integrated and used in the Logitech of the future.

Requirement 1: Products design should be inspiring and advocate for the future of modular design.

Most Logitech products are currently designed with the longevity of parts being prioritised above their accessibility, movements like design for repair have had an impact, but the effect is only slowly being seen in the designs of products. There are arguments to be made for Logitech's more integrated approach; For one, Ebert et al. (2024) mention three examples in which products can be more sustainable by being integrated compared to modular:

- Using adhesives to improve the liquid ingress protection on a device can significantly reduce the need of repairs from liquid damage.
- Integrated solutions can be more energy efficient, producing less carbon through power consumption.
- Integrated solutions require fewer parts, therefore having a lower initial carbon footprint.

Lastly, products in lower price ranges, or in lower production quantities, do not always have a modular option that is financially attractive.

What this proposes is that modularity in itself is not inherently better and or more sustainable than integration. Ebert et al. (2024) therefore, advocate for the fact that the best way to determine whether a part should be integrated or modular is by conducting a Lifecycle assessment (LCA) and considering the failure rate of parts throughout the product's lifetime.

Requirement 2: The application of modular parts in the product should have a positive effect on the products carbon footprint over the use-phase period of the product compared to an integrated alternative.

When Logitech does use modularity, it is often in more subtle ways, targeted towards replacing specific parts that are more prone to failure/need of replacement, two examples are the:

- Replaceable earcups on the G335, G535, G733 and G935 headphones (Figure 10).
- Replaceable keycaps on the POP keys keyboard (Figure 11).

Figure 10. Replaceable earcups on the Logitech G935 headphones.

Figure 11. Replaceable keycaps on the Logitech POP keys keyboard allow for customisation and prevent the loss of functionality when a keycap gets lost.

These examples provide the user with a functional benefit of *flexibility in use* in the sense that the replacement of the parts also allows for customisation (colour or pattern), which can, in its turn, also stimulate emotional attachment to the product (White et al., 2019). The current way Logitech implements modularity fits in the perspective of an ever-changing market like that of PC peripherals; not knowing what the market will look like in even 5 years means long-term commitments to modular design are hard to argue for (Logitech, 2024a). It is also important to note that Logitech is planning for its next generation of products to be more repairable to adhere to new regulations for repairability (Parliament, 2025).

Another way Logitech uses modularity is through software. Logitech devices are well known for being hyper-configurable through their accompanied software tools, allowing users to customise the functionality of their products to their needs through:

- Changing the functionality and sensitivity of buttons and sensors.
- Allowing the user to create their own custom shortcuts.
- Fluently switching between computers using the Logi Flow software tool.

This shows that software is a very effective way to add functionality to a PC peripheral without adding any extra material. Therefore, it is important to consider that the use of physical modularity should be well argued for and should only be used if a software-enabled alternative is not possible or significantly less practical.

Requirement 3: The application of modular parts should provide a benefit that cannot be attained using software functionality alone.

4.2. Sustainability initiatives

Logitech prides itself on being a market leader in terms of both company growth and sustainable initiatives. The company aims to reduce carbon emissions by half by 2031, compared to 2021 levels, while also doubling revenue (Logitech, 2024b). This chapter aims to answer the question of what systems for sustainable design which are already in place can be leveraged for modular design.

4.2.1. SELF-REPAIR INITIATIVES

Logitech provides information for self-repair through the *Logitech Repair Hub*, a partnership with iFixIt on the iFixIt Website (Logitech, 2025d). The Logitech repair Hub was explored, and an expert familiar with the iFixIt partnership was interviewed. The Logitech repair hub contains repair guides for 100+ Logitech products from current and older generations. It also provides the user with the opportunity to buy genuine Logitech spare parts, and the tools required to perform the repairs/replacements (Figure 12). It is also possible to order the replacement parts without the tools.

Figure 12. A package of genuine mouse feet for the MX master 2S mouse, together with iFixIt tools that can be used to replace the feet, sold in the Logitech repair hub (iFixIt, 2025).

Diving deeper into the Logitech repair hub shows that it is still being developed; not all Logitech products are shown on the website, with some product pages containing incomplete information. Being able to repair products also does not necessarily mean that repairing is easy; many repairs require soldering and glue.

The collaboration with iFixIt was set up due to several reasons:

- Logitech does not have the logistical capabilities to manage spare part inventory.
- iFixIt has the expertise needed when it comes to regulations for importing different types of parts (mechanical, electrical, metal, chemical) into countries all over the world.
- iFixIt has the network needed to reach users and the logistical knowledge to deliver to them.
- iFixIt has the knowledge needed to keep initiatives like a repair hub cost-effective.

Logitech has explained that its goal is to grow its internal capabilities for repair alongside its iFixIt collaboration.

Thinking about how the Logitech Repair Hub could be used in designing a modular PC peripheral, it becomes clear that providing non-standardised product-specific parts to the end user for repair is currently only possible using iFixIt's network. Two ways to circumvent this would be to:

- Work with internationally standardised parts available through other vendors.
- Make parts open source, meaning to give users and external parties open access to the designs of parts so they can produce them themselves.

Concerning the latter, Mevo, a subsidiary of Logitech, is already experimenting with open sourcing and principles that lean towards it. For one, Mevo has a page on their website where various creators can share their 3D printing files for creating custom accessories specific to the Mevo cameras (Mevo, 2022). The platform is curated by Mevo, but the Logitech subsidiary does not create these parts. The quality is not guaranteed, and Mevo does not take any responsibility for permanent alterations to the product. Secondly, Mevo has decided to make the cloud software that the cameras require to stream open-source, allowing users to host the software on their own servers (Mevo, 2025).

Allowing users to 3D print their own replacement parts through Original Equipment Manufacturer (OEM) designed models is still very new. One company that is introducing such a program is Philips, through its program Fixables (Philips, 2025). There is some scepticism about programs like that of Philips, mainly since these platforms are not always managed correctly. Philips's platform was released with one part and now, after 5+ months, it contains only two. The issue that arises is that creating an open-source platform can be a long-lasting and resource-intensive commitment, while not maintaining or cancelling such a platform can be perceived as a lack of commitment by consumers. This leads to a crossroads where it is either best to dedicate everything to the platform or to not start at all.

Making parts open source could complement the existing collaboration with iFixIt. The hubs out of which iFixit ships parts are mostly focused on Western countries and do not support deliveries to China or any countries in Africa and South America because delivery would not be financially attractive. Providing parts through open source would allow consumers in these areas to repair their devices without requiring access to original equipment manufacturer (OEM) parts.

Requirement 4: Modular parts and tools needed to repair the product need to be accessible to the user (widespread availability, low cost, etc.), exceeding the services already provided by iFixIt.

4.2.2. REFURBISH AND RECYCLE CENTRES

Logitech products that get returned by the consumer mainly end up in refurbish/recycle centres (RRCs). At these centres, the product is assessed and is then either refurbished, partly reused or recycled. The partnership between Logitech and the RRCs is not only important for making sure products are handled correctly and accordingly, but also because RRCs provide Logitech with a large amount of recycled plastic that can be reused in Logitech products. As of now, 73% of Logitech products use recycled plastics (Logitech, 2024b). This subchapter discusses how modularity could aid RRCs.

4.2.2.1. Refurbish

If a returned product can be repaired to a “like-new” status by replacing the battery or cosmetic parts, it can be refurbished for resale or donation through either Logitech’s own Certified Logitech Refurbished program or through third parties. A visit by industry experts to an independent RRC in Texas provided several points of feedback to improve the ability to repair products. Among the points of feedback, it was advised to make high-value parts, from either a cost or sustainability perspective, more accessible. This is because RRCs assess the accessibility of a product's parts by timing how long it takes to get to parts, and from there, it is calculated which parts are financially attractive to remove. Removal of valuable parts is often by hand; this is mostly because of the large variety of ever-changing products. Standardisation would be beneficial to the disassembly speed and, therefore, the number of parts that are financially attractive to take out before shredding the product.

Requirement 5: Repairs and replacements to the products' most resource-intensive parts should be performable by the user.

Requirement 6: Repairs and replacements to the product's parts with the highest failure rate should be performable by the user.

An interview with an expert on refurbishing and recycling informed on the fact that a license is required to open up their products for internal component repair and refurbishment, Seeing that Logitech does not hold such a license, the company is not allowed to repair electronics itself; a modular architecture could allow Logitech to refurbish non-damaged modules without the need for a manufacturing license.

Consideration 3: Modular architecture in electronics can be designed so that companies like Logitech can refurbish non-affected modules without needing a manufacturing license.

Parts that cannot be reused or refurbished are recycled. An issue that is often experienced in electronics is that batteries are difficult to remove from the product, slowing down the dismantling process. Difficult removal of batteries is seen as the number one reason for products not being recycled. Making the battery easy to remove would benefit both RRCs and the end user of the product in repairs.

Requirement 7: The batteries of the product should be safe yet easy to remove by RRCs and the end-user.

4.3. Conclusion

The current state of modular product design within the company of Logitech was analysed through assessing the past and present product portfolio, as well as talks with experts familiar with Logitech products and their existing network. Through this assessment, it became clear that most products that are currently in the product portfolio of Logitech are designed with an integrated approach, but that there are an increased interest and movement towards modular design.

This chapter aimed to answer the following research question:

RQ2: How can the capabilities of Logitech as a company be leveraged to create modular computer peripherals?

Logitech currently has a critical view on using modularity in their products; their focus lies on increasing the longevity of their products rather than the accessibility of their parts. The company allows the user to extensively customise their product using software but has limited implementations of physical modularity.

In terms of relevant sustainability initiatives, Logitech's partnership with iFixIt seems to be of most interest. Through this partnership, instructions for repair and maintenance, together with genuine Logitech spare parts are offered. Seeing that Logitech does not have internal capabilities to provide the user with any of the services named above iFixIt is required to enable at-home repair of Logitech PC peripherals. A way to circumvent the use of the iFixit network would be to use standardised parts and tools or to make parts open source.

RRCs can benefit from modular product design seeing that it can simplify and speed up disassembly, increasing the number of parts that are financially attractive to remove. Making parts modular would circumvent the issue of requiring a manufacturing license for the disassembly of electronics, further benefitting Logitech, RRCs and the user.

5. External analysis

To get a picture of how modularity is being used to improve sustainability and user experience of consumer electronics an external analysis was conducted. This chapter aims to answer the following questions:

RQ3: How is modular product design currently being used to improve a product's sustainability?

RQ4: How is modular product design currently being used to improve a product's user experience?

The sections that follow present the findings most pertinent to this project and its design choices.

5.1. Market of sustainable and user-friendly modularity

To get a better idea of how modularity is being used in consumer electronics to improve both sustainability and user experience, two industry leaders were analysed: Framework and Fairphone. These two companies were chosen since they are perceived as being at the forefront of modular design in consumer electronics, meaning they use modularity as one of the key features/selling points in their products.

5.1.1. FRAMEWORK

The company Framework focuses on making consumer electronics (laptops & desktops currently) that offer great performance, have a beautiful design and are easy to repair. Framework devices implement modularity in several ways; the two most interesting ways are explained below.

All framework devices are designed with the aim of making them as repairable as possible. This takes shape through multiple efforts:

- Making parts easily accessible by making disassembly steps toolless or use standardised tools.
- Labelling and highlighting parts so they are more easily identifiable.
- Providing the consumer with replacement parts and instructions on repair through their own website and placing the QR codes to said pages on the parts themselves (Figure 13).

Figure 13. Scanning the QR code on an internal part of a framework laptop.

Framework has used the modularity in their products to not only make their products more repairable, but several design choices also combine repairability with user experience:

- Making parts like graphics cards, CPUs and memory modular also provides the user with the ability to upgrade their device, providing the opportunity to extend the lifecycle.
- Expansion cards (Figure 14) on the Framework laptops allow the user to customise the ports on the laptop, these cards allow for a variety of options like Ethernet, (micro) SD, audio jack and many more. There is also an option to put in a 1TB storage card.
- External panels like the screen bezel are connected using magnets, allowing for easy removal, Framework allows users to customise the colour of the screen bezel to fit their aesthetic requirements.
- The *Laptop 16* product that Framework sells also allows users to move the keyboard and add other modules like a numpad, macro pad or LED strips to the sides.

Figure 14. The expansion card mechanism on a Framework laptop

5.1.1.1. Open sourcing

Lastly, it is valuable to mention Framework's efforts to make parts in their products open source, meaning external parties, companies and consumers alike, are allowed to design and manufacture their own parts to fit the Framework product architecture. The 3D files for the expansion cards are freely available online (Framework, 2025). The *Laptop 16* goes a step further, it contains an *Expansion Bay* that allows the laptop to be upgraded with larger form-factor parts like graphics cards and SSD storage with a more direct connection to the motherboard from either framework itself or external parties. Some relevant benefits of open-source design, as explained by (Maxwell, 2006), are:

- It provides the user with trust, transparency and more choices over how their device should work and what it should look like.
- It stimulates the creation of communities that develop and share designs for new modules, especially modules for more niche needs that would not be financially attractive for Framework to produce themselves.
- Looking at activity in the communities gives framework information on what users might like to see in new devices and could even reduce R&D costs for new functionalities.
- It gives the users more tools to come up with their own solutions to problems and improves legacy support.

The company provides the user with a base product which can then be altered to fit their exact needs, whether Framework sought out to provide a feature or not.

5.1.2. FAIRPHONE

Another company that clearly positions itself as a more sustainable and ethical alternative in a market focused on performance is Fairphone. Fairphone's mission is to create fairer products across the board; from material sourcing to use, repair and recycling (Fairphone, 2025). Ways Fairphone has improved the repairability of their *Gen 6* phone are:

- All electronics are removable using one standardised screw head or through connectors detachable by hand.
- Almost no use of glue.
- All spare parts are ready to order on their website, including instructions in collaboration with iFixIt.

What strikes as most important, is that Fairphone sought to find the right balance between repairability, simplicity and user experience:

In simple words, the narrative should change from ''Sustainability, sustainability, sustainability and oh yes we have a phone.'' To ''We have a really good phone, which is also sustainable.''

- (Passchier, 2025) (Translated)

This quote shows how Fairphone is adapting their strategy of modular and sustainable product design is moving, understanding that performance still needs to be a key feature.

One way Fairphone is finding this balance is in repair. Modules like the cameras and print boards can easily be replaced if broken, but users are not expected to pry open a camera module to analyse the exact broken connector. This approach allows users with very little experience in repair to easily fix their phone.

Next to making their phones more accessible, Fairphone wants you to use your phone for as long as possible. The Fraunhofer Institute found that keeping a Fairphone for 5 years instead of the average 3 years cuts the carbon footprint of the device by one third (Sánchez et al., 2022). The longevity of the device is mostly thanks to its use of modularity, alongside the 8 years of guaranteed software and parts support. This extend in the device's lifecycle shows that modularity in consumer electronics can in fact be used to improve a device's carbon footprint, countering the earlier discussed findings of Ebert et al. (2024).

Fairphone also uses the repairability of its products to improve the user experience:

- An easy-to-remove battery was a feature until smartphones and headphones got more integrated, Fairphone argues it's a selling point, allowing the user to easily swap the battery when needed.
- Making parts easy to remove provides the opportunity for customisation, Fairphone allows for customisation across all their products, an example being the back panel of the *Gen 6*, providing alternative back panels with loops and other features.
- Although it is not confirmed that Fairphone itself will provide the support, the device is designed so that parts can be upgraded in terms of performance, making it more future proof.

5.2. Conclusion

This Chapter analysed how the companies Framework and Fairphone use modularity to improve sustainability and user experience.

RQ3: How is modular product design currently being used to improve a product's sustainability?

The design of Framework and Fairphone devices shows that there are many steps a company can take to design their product for repair. Information, accessibility and availability of parts play a major role in the success of modular design. It is also clear that companies like Fairphone and Framework have changed strategy to better fit user needs; making a product that is more repairable/accessible/carbon friendly is not an excuse to deliver a lesser user product experience. Companies that wish to implement sustainable initiatives need to be able to compete or come close to competitors to be successful, and modularity can be leveraged to provide this boost in sustainability while also improving the user experience.

RQ4: How is modular product design currently being used to improve a product's user experience?

The use of standardised modular interfaces increases opportunities for customisation and open sourcing. Design for repair in itself can be seen as an improvement for the user experience, but it can be leveraged to provide more value by allowing for more customisation by the user. The way both companies provide opportunities to change (open-source) parts shows that there has been careful consideration of what freedom the user should have when customising the product by balancing repairability, simplicity and aesthetics.

6. Finding a relevant target group for modular design – Digital nomads

Previous chapters have focused on creating a strong base for the project; the questions that arise now are about who a sustainable modular PC peripheral should be designed for. This chapter therefore answers the following questions:

RQ5: What users would benefit most from modular product design in PC peripherals?

RQ5.1: What type of PC peripherals does this user already use?

RQ5.2: What interesting tensions lie in the product use of said user?

To find a relevant target group to use as a case study for modular product design, a DEPEST and SWOT analysis were conducted, leading to relevant *search areas (Buijs, 2012)*. These analyses made use of a varied set of sources like trend reports from big consultancies, financial reports of Logitech, news articles and social media. The process led to 12 target groups, of which eventually one was selected based on its potential and relevance: Digital Nomads (DNs). Figure 15 shows the selection process for the 12 target groups. The DEPEST analysis, SWOT analysis and selection progress can be found in Appendix D.

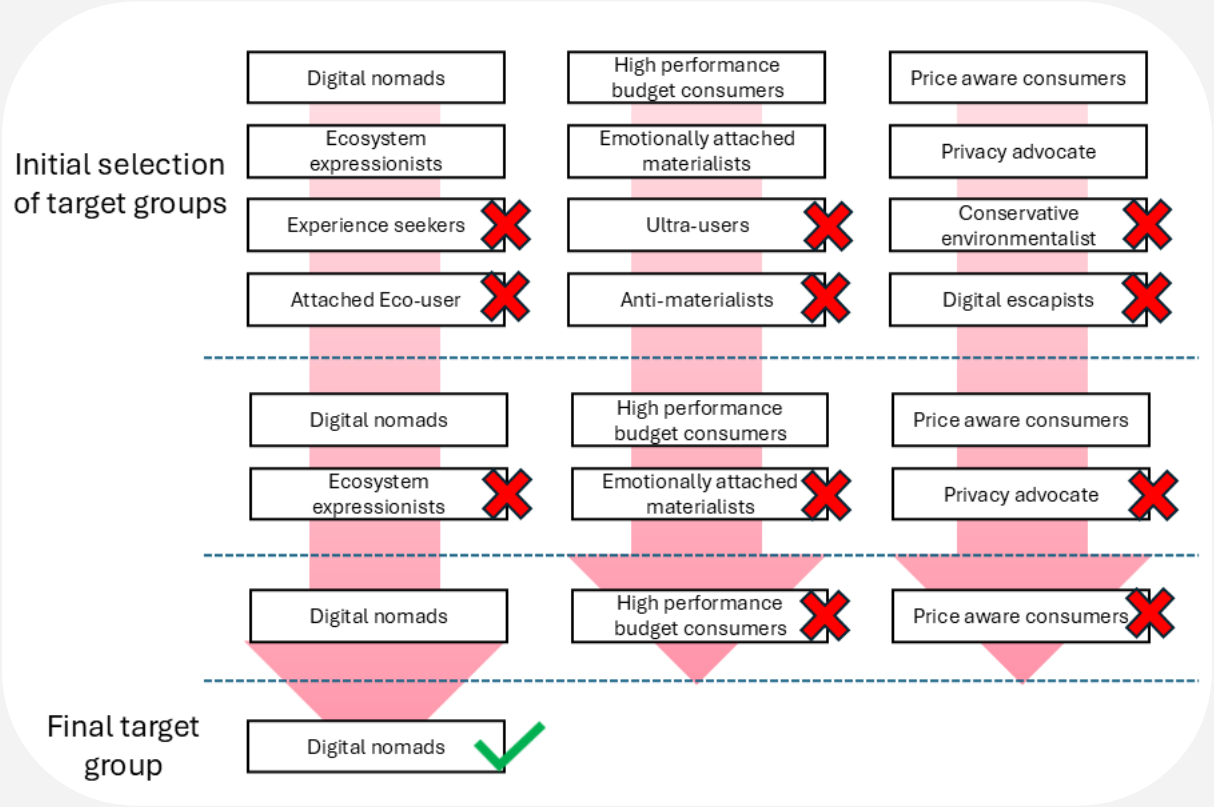


Figure 15. Selection flow from the initial 12 target groups to the one selected target group of Digital Nomads.

The term Digital Nomad is contested (Ekaterina Chevtaeva, 2021), therefore, it is important to provide a clear description of what is meant by the term in the context of this project. Digital Nomads are perceived as people who are not bound to one country or location for work and make use of that freedom by travelling across the world to discover new cultures, enjoy good weather and make use of a locations lower cost of living. It is estimated that there are over 41 million Digital Nomads throughout the world, 44% of them being US citizens (Myskiv, 2025).

The target group of digital nomads fits into the group of the on-the-go user Logitech is aiming to target with current and future products using innovative and market-leading solutions (Figure 16).

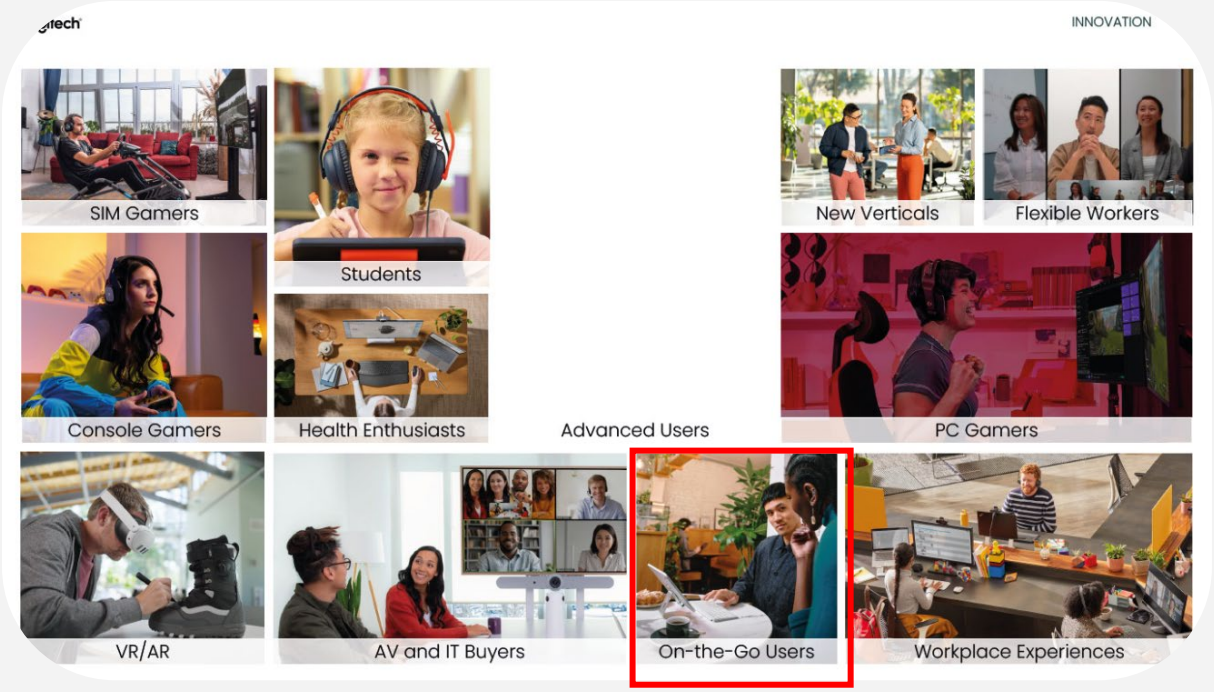


Figure 16. Target groups Logitech is targeting according to Logitech AID 2025 (Logitech, 2025a).

The target group of DNs was chosen for four key reasons that resonate with modular product design:

- DNs have interesting challenges when it comes to travel and accessibility to tools and repair facilities.
- Their frequent travelling leads to challenging requirements for compact travel and multifunctionality.
- The group was assessed to be relatively niche compared to others, allowing for a more concrete case study.
- Most DNs are completely dependent on digital productivity for their work, making them an ideal candidate for PC peripherals.

Further details on the process that led to finding the target group of digital nomads are explained in detail in Appendix D.

6.1. Needs of the target group

A small overview of associations with digital nomads is shown in Figure 17.

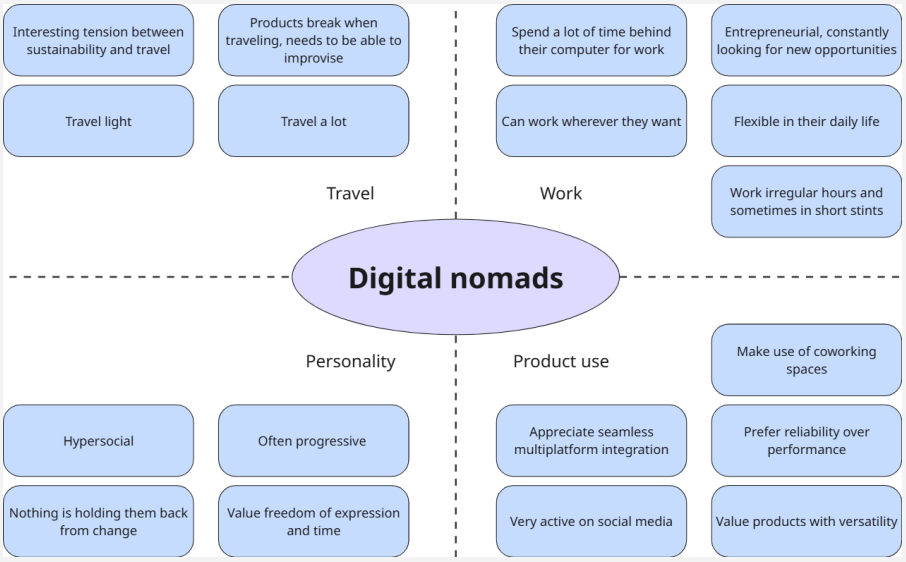


Figure 17. Mindmap of associations with the target group of digital nomads.

Although these associations are based on the conducted DEPEST & SWOT analysis, there are still many assumptions that need to be confirmed before starting ideation. The associations shown above were translated into functional and emotional needs that could be tested through interviews. The list of needs used in the interviews and their relevance to different functional benefits of modularity is displayed in Table 1. A detailed explanation of the developed needs and their relevance to the project can be found in Appendix E.

Table 1. Developed needs and their connection to types of modularity (pink/X means relevant connection).

		Relevance to modularity types							
		Upgrade	Add-ons	Adaptation	Wear	Consumption	Flexibility in use	Reuse	Accommodate
Emotional needs	**Trust in reliability –** DNs rely emotionally on tools that won't fail them on the move.							X	
	Ease in transition – DNs Value smooth shifts between locations, schedules, and work contexts.			X					X
	Security in versatility – DNs are emotionally grounded when one product or system can serve multiple roles.	X	X	X			X		
Functional needs	**Multi-functionality –** Products DNs use must serve several purposes to reduce the need for excess items.	X	X	X			X		
	Cloud-based or sync able tools – DNs appreciate seamless access to data and work from any device or location.						X		
	Durability and weather resistance – DN gear must handle travel wear-and-tear, different climates, and daily use.	X			X				X
	Versatile clothing and accessories – DN fashion and gear should fit both work and social settings.		X				X		
	Compact workstations – DNs use foldable keyboards, mobile monitors, ergonomic travel gear, etc.	X	X				X		X

6.2. Interviews - Confirming assumptions and exploring digital nomad life

To test the assumptions made on the target group of DNs, 10 interviews were conducted, foregone by one pilot interview with a DN. All interviewees were required to sign an informed consent form before taking part in the interview. The interviews took 30 to 60 minutes and were transcribed using Microsoft Teams. Interviews were held in either Dutch or English. The questions that were asked to the interviewees were semi-structured and questions were based on:

- Needs formulated through assumptions (as mentioned earlier in the chapter).
- Their product use and work habits.
- Their general values and views.

Questions were structured from broad to stricter to make sure interviewees did not know the topic of the study until the end of the interview. All questions asked during the interview can be found in Appendix F. The interviews were analysed using thematic analysis and inductive coding. The thematic analysis contained a total of 5 iterations in which codes were categorised to the point where clear (sub-) categories emerged. An overview of all iterations can be found in Appendix G. Every code used in the final iteration was backed up by at least two separate interviewees. The job description of all DNs interviewed can be seen in Table 2.

Table 2. Job description per DN interviewee.

Participant #	Job description
1	Videographer
2	Sales
3	Sales
4	Information technology
5	Online Trainer/Marketing
6	Recruitment
7	Online Trainer
8	Quality control
9	Marketing
10	Virtual assistant

6.2.1. RESULTS

Based on the conducted interviews, the view on DN professions was somewhat shifted. Where the literature showed DNs are often employed in the sectors of marketing, IT, Creative and Software development (ÅVIK & TURIKBAYEV, 2023; López, 2025), the DNs found through the interviews were mostly employed in the sectors of Coaching, Recruitment, social media influencing and sales. This shift in employment resulted in different use of PC peripherals compared to what was assumed based on the literature. For one, only 4 out of 10 DNs used a keyboard and/or mouse; most interviewed DNs mentioned that these products were not necessary for their job because their work was not that intense from a PC interaction perspective. Seeing that the sample size for the interviews was only 10, there is a good chance that the difference in professions was a result of the sampling method (mostly convenience and snowball sampling). The difference in professions suggests that it is important to keep in mind that the target group is not fully represented in the findings presented below, following steps in the design process should also keep this in mind. Table 3 shows which PC peripherals were being used by the interviewed DNs.

Table 3. Distribution of use of PC peripherals per participant

		Use of PC peripherals as a DN											
Participant #	Job description	Mouse	Keyboard	2nd screen	Webcam	Laptop stand	Wireless earphones	Headset	Microphone	USB dock	External drive	Light	Total per DN
1	Videographer	X					X			X	X		4
2	Sales						X						1
3	Sales						X						1
4	Information technology						X						1
5	Online Trainer/Marketing	X	X	X	X	X		X	X				7
6	Recruitment						X						1
7	Online Trainer							X		X		X	3
8	Quality control						X						1
9	Marketing	X	X			X	X						4
10	Virtual assistant	X	X	X		X	X						5
	Total per PC peripheral	4	3	2	1	3	8	2	1	2	1	1	

The table shows that the most used PC peripheral was wireless earphones, with eight out of ten DNs making use of them. Only two DNs did not make use of wireless earphones; these two DNs did, however, make use of high-quality headphones. When asked about their use of these products, DNs often explained that the most important part of the product was the noise-cancelling, which was necessary so they could communicate with their clients from any location necessary.

Taking out the 5 DNs that only use wireless earphones changes the average amount of PC peripherals per DN from 2,8 to 4,6 (1,8 difference), leading to the idea that DNs decide to either take multiple PC peripherals with them, or none. When designing for DNs it will be important to decide to either design an earphone-like product for all DNs, or another kind of product that only targets the group of DNs that is willing to bring it with them.

Consideration 4: DNs seem to either only pack wireless earphones or take multiple kinds of PC peripherals with them.

Table 4 shows the overview of the thematic analysis created from the ten interviews, containing values and challenges they experience in their lifestyle. An enlarged version of the table can be found in Appendix G. This subchapter will elaborate on the categories found through thematic analysis and their impact on the project.

Table 4. Thematic analysis of the ten interviews with DNs

Theme	THE CHALLENGES OF THE DIGITAL NOMAD LIFESTYLE					THE CHALLENGES OF THE DIGITAL NOMAD LIFESTYLE				DIGITAL NOMADS TAKING PRIDE IN SELF SUFFICIACY	
Category	HARD TO FIND COMFORT IN CHANGING ENVIRONMENTS		SUSTAINABLE NOMADS TAKING PLANES			NO ONE SINGLE HOME			MINIMALIST TRAVEL VS WORK RELATED PC PERIPHERALS	SELF SUFFICIENT NOMADS	
Sub-Category	**Outside sound makes it hard to commuicate and portrays you unproffessionally**	**Bad internet makes DN life impossible**	**Wanting to compensate for traveling emissions**	**Freedom**	**Not wanting to waste anything**	**Having a "home base" from home**	**Need for social contact but far from home and moving all the time**	**Travelling at high frequencies is stressful when you need to take a lot of things with you**	**Many PC Peripherals are not needed in many professions, when you are only**	**Living remotely makes you creative and solution oriented**	**Striving for self sufficiacy**
Codes	*Outside sound makes videocalls challenging	*Uses Starlink *Cannot work with bad Internet connection	*DN is sustainably minded *Sustainability is Reducing consumption *Sustainable behaviour hypocricy *Broken does not mean worthless *DN lifestyle getting in the way	*Freedom is the biggest benefit *Limited in freedom of travel due to boat *Seeing the world is the reason for becoming DN *Sees no downsides to being a DN	*Buys electronics refurbished *Selling for rest value/refurbishment	*Having a homebase far from home	*Ultra high travel frequency *Local travel *Getting to know new/likeminded people *Far from "home"	*Job type and frequency based packing *Working hybrid *Ultra high travel frequency *Take PC peripherals everywhere you go *Train is annoying *Minimalist packing	*Do not need PC peripherals for amount of work performed *Do not use PC peripherals, do not miss it	*Everything takes more effort *modular boat parts *Everything breaks *Boating makes you more repair minded	*Striving for self sufficiency *Everything takes more effort

6.2.1.1. Category 1: Hard to find comfort in changing environments

One of the main characteristics of the DN lifestyle is the ability to go wherever you want. Many DNs make great use of this possibility by travelling plenty. Several DNs pointed out that frequent travelling also had downsides; for one, they never exactly knew what their next place of stay would look like, leading to the problem that some places are not suitable to work from. This could be because of noise pollution, limited space, bad internet connection, bad lighting or even power outages. Seeing that many of the interviewees had several important video calls each day, it was vital for them to represent themselves online professionally.

Interviewees tried to combat the inconsistencies by buying equipment (lights, noise-cancelling headphones, Starlink arrays) or by visiting coworking spaces that provided a more hospitable working environment. Research shows many DNs make use of coworking spaces for their practical facilities (high-speed internet, ergonomic desk setups), a sense of belonging (the DN community gathers in coworking spaces) and finding likely minded people (Ekaterina Chevtaeva, 2021). Still, equipment was only able to partially solve the problems, and not all places had coworking spaces. This meant that DNs had to either plan their trips around confining restrictions or accept the fact that their quality of work was uncertain.

> *"If I have good internet at home, then I choose to work from home. That wasn't the case in Sri Lanka at the time. There were a lot of power cuts, so I had no choice but to go to the coworking space to work... If I really need to train (customers) for three hours, then yes, I talk continuously and I don't want to sit in an open café where other people are also working. Then I go to a coworking space where I would rent a separate room."*
>
> *– Participant 5 (translated from Dutch)*

Consideration 5: Providing Digital Nomads with a product that improves the quality and consistency of their work environment and online representability not only improves quality of work, but quality of life in general.

6.2.1.2. Category 2: Sustainable digital nomads being conflicted in their frequent plane travel

What feels like the biggest contradiction resulting from the interviews is that of how sustainably oriented many DNs are, while their carbon emissions from travelling are excessively high. Eight out of ten interviewed DNs travelled four or more times by plane every year, with the average being eleven trips (one-way). All DNs knew a large part of their carbon footprint came from their travels but also acknowledged the fact that their lifestyle was not possible without it.

The travelling seemed like an outlier when it came to their view on actions towards sustainable behaviour. Many of the interviewees mentioned the fact that they tried to live a sustainable lifestyle by for example:

- Reducing the number of products, they use and consume, which fits their minimalistic lifestyle.
- Buying second-hand and refurbished as much as possible, this was mentioned for clothes as well as electronics.
- Repairing products that are still "good enough".
- Actively taking part in community programs that contribute to their local environment.

"Yes, we try to repair everything ourselves first, sometimes up to ten times. At some point, when we really don't know what to do anymore, we call in help. If it's really not possible anymore, we buy something new. But even then, my phone is refurbished, refurbished laptops, that kind of thing."
– Participant 2 (translated from Dutch)

"And shoes. I repair shoes. I don't throw them away. If something breaks, I just take them to the shoemaker. They fix my heels. They fix my like soles besides that."
- Participant 6

This contradiction could be a good way to target Digital Nomads, playing into their feeling of responsibility by providing them with a product that can in some way offset their emissions.

6.2.1.3. Category 3: Having no single home

4 Interviewees mentioned they struggled with the fact that they were no longer living in a trusted environment close to friends and family. This issue was amplified by the fact that it is harder for DNs to make friends during their trips, mostly because they and the like-minded people around them keep moving around. This, however, did not stop the DNs from finding friends, through social media, coworking spaces and co-living houses.

These issues led to several interviewees mentioning that they tried to bring their home with them on travel. This was done by creating a so-called "home base", most often this was the place where the DN was sleeping. This home base could be made to feel more like home by decorating it with personal objects. Another way to create comfort and familiarity is by revisiting places of stay where the DN has stayed before.

"On the one hand, I was jumping into his life, but I did have a kind of base. That makes it different, of course, because I had that ... life just went on, so to speak."
- Participant 1 *(translated from Dutch)*

Consideration 6: Product can be of extra value if it makes the Digital Nomad feel more at home in their place of stay.

6.2.1.4. Category 4: Minimalist travel VS work-related PC peripherals

As mentioned before, the interviewees held jobs that differed from those typically found in general research on DNs, which led to different use of PC peripherals. When DNs were asked about why they used certain PC peripherals and whether they missed certain products, the explanation was often that PC peripherals improved productivity and comfort, but that they were not worth the space they consumed in the DNs' baggage Figure 18, especially for the amount of work the DNs were performing (which was often less than what is normal in western countries). The DNs were often used to having PC peripherals like a second screen or mouse, and keyboard at their office job before they became a DN, but these products were often not worth keeping around due to their size and clutter.

Figure 18. An ergonomic setup of a Digital Nomad takes up a lot of space, which is not worth it for many.

> *That (PC peripherals) makes it messy; it's just a lot, I just want one device that can do everything well.*
> *– Participant 4 (translated from Dutch)*

This was especially true for DNs doing sales and recruitment. They explained that most of their work consisted of making calls and that the little work they spent typing was not worth taking a mouse or keyboard.

> *It might be better for my posture if I used a screen, keyboard and mouse, but we work so infrequently and sporadically that it doesn't bother me. And there's simply no room to set up a second screen here.*
> *– Participant 2 (translated from Dutch)*

This shows DNs make decisions on what PC peripherals they bring based on their profession, the size of the peripheral and the amount of time they are planning to work. There is a tension where DNs want to be as productive as possible but are limited to the size and weight of their luggage.

Requirement 8: Product should be worthwhile to bring for Digital Nomads (by for example playing into the factors of professional relevance, size and amount of use).

Consideration 7: If multiple relevant functions are combined into one product, it will most likely reduce the total size and increase the total use of the one product.

6.2.1.5. Category 5: Self-sufficient nomads

The last category that emerged from the thematic analysis concerned the DNs' urge for self-sufficiency. DNs often come from Western countries and are used to a high quality of life. The places DNs stay at often do not provide the same services as those they are used to from home. This leads DNs to become more self-sufficient. This mindset is also backed up by the fact that DNs want to have as little of an impact on their environment as possible.

> *Sometimes we order it in the Netherlands because it's in stock there. Then we have someone send it to us by post to where we are. That's sometimes faster than getting something locally here.*
>
> *– Participant 3 (translated from Dutch)*

The desire for self-sufficiency also translates into the products DNs use; examples of such products are:

- Repair kits
- (Salt) water filters
- Solar panels
- Starlink arrays

The three interviewed DNs who lived aboard a boat were especially self-sufficient. They all mentioned that living on a boat meant everything in life costs more effort, and that you are often on your own when it comes to solving problems.

> *Yes, if you live on salt water, it's bound to break, isn't it? We found that out too.*
>
> *– Participant 8 (translated from Dutch)*

A PC peripheral that would fulfil this urge for self-sufficiency would resonate strongly with Digital Nomads, examples of these could be devices that can work independent of external power sources, ones that can be repaired without the need of any proprietary tools or ones that can be repaired using widely available items.

6.3. Interesting tensions in needs

The lifestyle of digital nomads presents interesting challenges in terms of the tensions created by their diverse needs. Some of their needs seem to contrast with each other. This subchapter elaborates on the tensions found and aims to answer the following question:

RQ5.2: What interesting tensions lie in the product use of said user?

6.3.1. COMPACT YET ERGONOMIC

Products made to be more compact often must give up some of their ergonomics for the sake of their size. This is for example clearly visible in computer mice, where smaller mice can no longer provide the user with an ergonomic palm shape due to their size (Figure 19).
Making products this compact leads to designers challenging the idea of what a product should look like, Figure 20 shows a premium compact mouse where the mouse design has changed into something barely recognisable as a mouse.

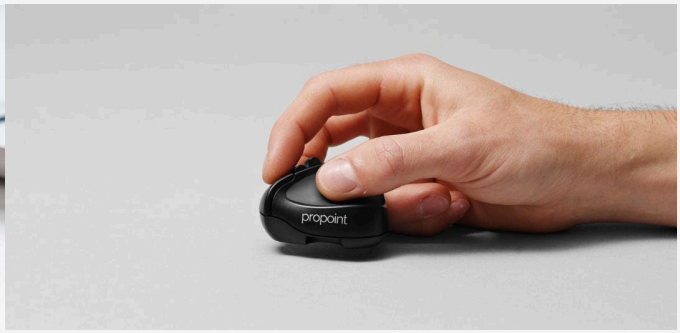


Figure 19. Ultra compact mouse that is no longer ergonomic (Torres, 2025).

Figure 20. An ultra compact mouse that challenges the concept of what a mouse is in terms of shape and use (Swiftpoint ProPoint).

Consideration 8: When designing for travel/compactness, it is valuable to drop assumptions on what shape a product should have. This way it is possible to come up with new designs that provide the same functionality in a form factor that is smaller that was deemed possible.

6.3.2. COMPACT YET EXPRESSIVE

Making a product more compact often leads to simplifications in design, less of a product also means there is less to the customise in the first place. An example of compact simplification is key finders (Figure 21), the size requirements and use case of these products change them into pebble-shaped devices that lack much expression. Ways to go around such an issue are by using colour patterns (Figure 22) and accessories (
Figure 23).

Figure 21. Key finders that look alike due to their simplistic, pebble-like design.
Figure 22. The brand Tile produces key finders in expressive colours, allowing the user to express themselves and to easily spot the device.
Figure 23. An Apple AirTag with a cover made from genuine leather, showing that key finders can also be used to express oneself.

Consideration 9: Compact products can still be expressive using colours and accessories.

6.3.3. COMPACT YET REPAIRABLE

One-way products can get more compact is by integrating parts into each other, which starkly contrasts the aim of modular design and design for repair. An example of this phenomenon is the design of Nespresso machines, of which repair is unrealistic for most users due to their complex mechanisms confined to a small space (Figure 24). Often, such a machine breaking leads to the consumer buying a new one instead of repairing it. Designer Mair (2022) has taken to it to improve the design of small-scale coffee machines, proving that modularity, recyclability and compact sleek design can coexist (
Figure 25).

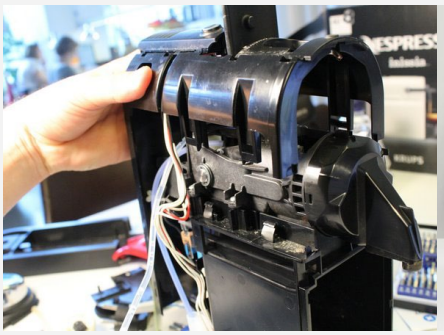


Figure 24. The inside of a Nespresso machine, constructed to be compact but hard to access
Figure 25. New vision on modular coffee machine design by Mair (2022).

Consideration 10: Design for compactness should not be taken as an excuse for making internals inaccessible, it is possible to combine the two. Product should not only keep in mind the user experience of the product when it works, but also when it breaks and needs to be repaired.

6.3.4. MULTIFUNCTIONAL YET COMPACT

Making a multifunctional product more compact often leads to making concessions. An example of this is multitools, at a certain point it is no longer possible to fit certain tooling into a certain amount of space (Figure 26 &
Figure 27). One solution to this issue is using negative space to add functionality instead of trying to add material (
Figure 28).

Figure 26. Large Swiss Army knife with a large variety of functionalities.
Figure 27. A compact Swiss army knife needs to trade in functionality for size.
Figure 28. A multitool showing that negative space can be used to fit more functionality into a small space.

Consideration 11: There is a finite amount of material that can be fitted into a volume, if more functionality needs to be added the product can make use of negative space.

6.3.5. MULTIFUNCTIONAL YET DURABLE

Adding more features to a product inherently means that more parts can fail, especially with automated electronics. With “bean to cup” coffee machines (Figure 29) using an integrated coffee grinder, one machine is responsible for the entire workflow from grinding coffee to getting it into your cup. If the grinder fails, this leads to the fact that the entire machine is now useless.
This also brings in the concept of upgradability, seeing that, with espresso especially, the quality of the coffee is often held back by either the grinder or the extraction, which means that there will always be one of the two that is holding back the potential of the other. Another example is the centralised control panel in newer cars (Figure 30), if said panel malfunctions you can no longer adjust music, air-conditioning, heating and navigation.

Figure 29. A bean-to-cup espresso machine.

Figure 30. A centralised control panel in a car that controls many different functions.

There is however an argument to be made for the multifunctionality, Bean-to-cup machines combine a simple automated brewing experience with fresh ground coffee, something that, measuring the success of these devices, many consumers are interested in. When it comes to this tension between multifunctionality and durability there seems to be no direct solution to get both, it is more about providing the user with the decision on how much responsibility they want to take in the use of the product.

Consideration 12: The user should be able to decide how much freedom they want to give up for multifunctionality and automation of the device.

6.3.6. MULTIFUNCTIONAL YET LONG-LIVED

Like durability, adding more functionalities to a product will also increase the chances of at least one part of the device becoming obsolete before other parts are, it is therefore best to keep functionalities in separate devices or allow upgradability using modularity.
With digital devices, this phenomenon can also be linked to planned obsolescence, where a manufacturer purposefully bottlenecks the capabilities of a device through parts or software, nudging the consumer to replace the product while a large part of the product still functions well.

Consideration 13: Modularity can be a key factor in providing the user with a product that is both multifunctional and long-lived, by providing the opportunity to upgrade or replace obsolete parts.

6.3.7. CONCLUSION

This chapter aimed to find a relevant target group that ought to gain from modular product design in PC peripherals. Through SWOT and DEPEST analyses, the target group of Digital Nomads (DNs) was chosen to be central for further development of ideas and concepts in this project. Through interviews and thematic analysis, themes and categories were identified that are interesting to play into when designing for DNs. Finally, interesting tensions in the lifestyle of DNs were identified that would aid in solving issues the target group is currently experiencing.

RQ5: What users would benefit most from modular product design in PC peripherals?

Digital Nomads (DNs) stand to benefit significantly from more modularity in their PC peripherals for the fact that they work in challenging environments that constantly change, while they have a direct need for digital productivity and online representability.

RQ5.1: What type of PC peripherals does this user already use?

The PC peripherals DNs use vary greatly depending on their profession and personal preferences. Wireless earphones are the most used device with eight out of ten DNs using them. The second and third most used peripherals are the mouse (4) and keyboard (3). The low amount of PC peripheral use mostly has to do with the profession the interviewed DNs had, namely Coaching, Recruitment, social media influencing and sales. The needs of DNs interviewed differed from the assumptions made beforehand that were based on the idea that DNs mostly worked in sectors where PC peripherals were more critical for productivity.

RQ5.2: What interesting tensions lie in the product use of said user?

There are plenty of tensions to be found in the product use of DNs, these mostly revolve around the idea that products need to be compact enough for travel while also being multifunctional, ergonomic, expressive, repairable, durable and long-lived. The tensions presented in this chapter provide a clear view of what DNs require from the products they use, and which challenges lie ahead.

7. Understanding modularity in consumer behaviour

Implementing modularity in products is a significant challenge, let alone the fact that it alters products to the extent where consumers need to make considerable changes to how they handle, service and dispose of said product. To create impactful and long-lasting habitual changes in the life of Digital Nomads, it is vital to consider how the product's design could stimulate the adoption of modularity and enforce the desired behaviour that goes along with modular product care. This chapter will answer the following questions:

RQ6: How do you convince Digital Nomads to choose modular product design?
RQ6.1: How do you frame modular product design towards Digital Nomads?
RQ6.2: How do you increase Digital Nomad's adaptation of a modular product?
RQ6.3: How do you stimulate the desired behaviour once a Digital Nomad has bought the product?

7.1. How do you frame modular product design towards Digital Nomads?

Previous chapters have shown that there is a significant leap from non-modular to modular designed consumer electronics, companies that spearhead the modular design philosophy see it as one of their key pillars, which makes sense when considering that modular design needs to be implemented through the entirety of the products production and lifecycle. Because of this leap, it is important to consider how the modular PC peripherals will be perceived by consumers. Shaping the consumer's view of a product can aid in its adoption. Epstein and Seymour (2003) discuss that humans make use of both a preconscious *experiential (emotional) system* and a conscious *rational (cognitive) system*. The two systems are interactive, with each influencing the other, and the interaction occurs both sequentially and simultaneously. Both systems can be targeted to improve the consumer's perception of the product.

7.1.1. TARGETING THE EXPERIENTIAL SYSTEM

Targeting users through the experiential system requires a more holistic approach and is more emotionally oriented. Figuring out what consumers will relate to the message of your product can be somewhat generalised by looking at behaviour that is closely associated with the one you are trying to enforce; Like if a consumer identifies as a "typical recycler", it not only predicts their recycling intentions, but also other factors such as attitudes, subjective norms, and perceived behavioural control (Mannetti et al., 2004). This is mostly because consumers tend to select sustainable options to make a positive impression on others and to improve their social status (White et al., 2019). The interviews of Chapter 6.2 showed that Digital Nomads prefer to be self-sufficient, which not only says something about what is required in their lifestyle, but also what they believe a DN should be able to do to be part of the group. A second example from the interviews is about the most mentioned benefit of the DN lifestyle: freedom (mentioned in 10 out of 10 interviews). One interviewee went as far as stating that you would not be able to be a *real* DN while being employed by a company because it would limit your freedom. This shared perception can be leveraged by promoting the product as providing the user with more freedom, increasing their social status in the DN community.

A consumer's attitude towards modular or sustainable design can also be negative if said consumer perceives the accompanied traits as something they do not want to be identified with. One way to combat this is to make the behaviours more socially desirable by creating new, more compelling associations (White et al., 2019).

Consideration 14: The DN should be able to identify with the product, feeling that it fits with their needs, values and way of life.

Another way to influence the consumer through emotions is by comparing the consumers' in-group (the social group(s) they feel part of) to other out-groups (the social group(s) they do not feel part of) that perform better in terms of certain benchmarks (White et al., 2019). It should be highlighted that these types of “competitions” only work effectively in public settings, and when challenges are friendly. Like the use of intense guilt, fierce competition can lead to a negative impact on consumer adoption (Kollmuss & Agyeman, 2002). Seeing that implementing competition is risky and requires a lot of control this project should focus on the in-group, where the DN community internally aids each other to together strive towards the goal of being a more sustainable DN.

Consideration 15: The product's design should stimulate in-group collaboration and improvement.

Lastly, another factor to consider when targeting the experiential system of consumers is that they are mostly present-focused (Wade-Benzoni et al., 1997), while a modular sustainable product design is mostly future-focused. The intention of course, is to provide a product that is as good or better than non-modular, less sustainable alternatives, but this will, in most situations, lead to some form of downside for the user (Bayraktaroğlu & İdemen, 2024). Many of the societal benefits that a more sustainable product may provide will not be visible or directly beneficial to the consumer, it is therefore important to emphasise the direct benefits of the product at the point of sale. We also see this in the companies analysed in chapter 5.1, where benefits like customizability and repair are communicated in front of arguments on how much CO2 is saved compared to non-modular alternatives.

Requirement 9: Product should clearly communicate its benefits to the Digital Nomad’s lifestyle through its design.

7.1.2. TARGETING THE RATIONAL SYSTEM

The rational system requires justification via logic and evidence (Epstein & Seymour, 2003). It is therefore important to provide all the knowledge required for the consumer to make their buying decision, especially for novel new products that stand out from the norm (White et al., 2019). It is important to mention that interventions providing information only are often not enough to spur long-term sustainable changes (Abrahamse et al., 2005). The information should contain the product's capabilities and its contribution to a more sustainable society, but also its short- and long-term benefits to the user. The latter should be made as concrete as possible by framing the relevance to something the consumer can relate to through vivid imagery, analogies, and narratives (Marx et al., 2007; Myers et al., 2012). For example, Many DNs live on Bali, which has a massive plastic pollution problem, highlighting the positive impact on this relatable issue would help make the issue at hand as relatable as possible.

The modular products design and presentation should also emphasise how much value consumers would receive out of a product that is repairable and customizable, seeing that it would be a personal benefit while also providing them with more social status for only a small premium. Asking a premium for modular product design in trade for DIY repair has also been proven to work in other products (Bayraktaroğlu & İdemen, 2024).

Consideration 16: Products design and presentation should consider how the sustainable impact of the product could be made as clear as possible.

7.1.3. IMPLICATIONS

RQ6.1: How do you frame modular product design towards Digital Nomads?
Effective framing for DNs should deliberately engage both the experiential (emotional) and rational (cognitive) routes in ways that align with the group's identity markers of freedom and self-sufficiency together with how decisions are made at the point of choice.

On the experiential route, lead with immediate, self-relevant gains: portability, uptime, "fix-anywhere" resilience, and the freedom to reconfigure on the road. Make these benefits legible at a glance so users do not need technical explanations to grasp value. Frame the product as a badge of DN competence and autonomy, reinforcing in-group norms and collaborative problem-solving rather than competitive or guilt-based appeals, which risk backlash. Position modularity to belong more fully to the DN community "I can keep working and travelling because I can adapt and repair on my own."

On the rational route, provide concise, concrete evidence that substantiates the promise: total cost of ownership, repair and upgrade scenarios, payback on any premium, durability metrics, and clear comparisons to non-modular alternatives. Use relatable, place-anchored examples and vivid scenarios to translate long-term and societal benefits into personal, near-term relevance.

7.2. How do promote desired behaviour in Digital Nomads using modular products?

Understanding the issue at hand is one thing; acting is another. That is why this subchapter looks at how DNs can be supported in their use of modular products. Chapter 6 showed many reasons for DNs to use modular PC peripherals, and the literature shows that for self-sufficient, remotely located target groups like DNs, self-repair might be the generally preferred option (Bayraktaroğlu & İdemen, 2024). Still, this does not mean DNs will choose to use modular PC peripherals if given the choice. This is because making such a decision requires a change of behaviour that significantly impacts the user's life. To better understand the challenges at hand, the Fogg Behaviour Model (FBM) will be used as a guide to analyse what is required to get DNs to the desired behaviour of modular product adaptation. In short, the FBM combines a mass of psychological theories into an organised and systematic model that provides a clear overview of the factors at play in behavioural change (Fogg, 2009). Figure 31 shows the FBM. Here, we see the three factors that are key to behavioural change: Motivation, ability (or simplicity) and triggers.

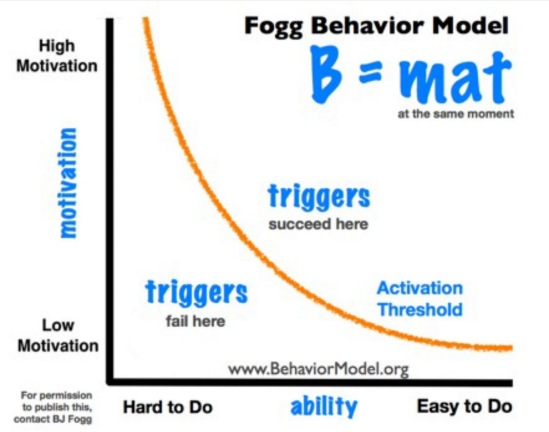


Figure 31. The Fogg Behavioural Model (Fogg, 2009), showing the interaction between the three factors of motivation (y-axis), ability (x-axis) and triggers (in plane).

The most important point to note about the model is that it shows how the desired behaviour is easier to trigger if motivation and or ability are high. Also important to note is that due to the asymptotic behaviour of the curve, even a behaviour that has extremely high motivation will never succeed if the behaviour is incredibly difficult to do. Fogg (2009) mentions the best way to create behavioural change is through *baby steps*, that way consumers do not feel overburdened by the change and will even gain momentum to the point where they can handle much bigger changes (coined the *springboard moment*). This, for one, means that radical changes in behaviour have a small chance of success and incremental implementation of new forms of product design is required to make a large-scale impact on the target group. Luckily, modularity can be used as a facilitator to implement such incremental steps in behavioural change by starting off with a product that is recognisable to the consumer (starter pack) and slowly building said product towards what the designer wants to achieve.

Consideration 17: Modularity could be used to facilitate incremental change in a product, with the aim of consumers changing their behaviour toward repair and modular customisation more easily.

Below, each of the three factors from the FBM is analysed to ensure DNs will be empowered in the desired behaviour required in the use of modular PC peripherals.

7.2.1. MOTIVATION

Fogg (2009) mentions three *core motivators* that contribute to the motivation of a certain behaviour. These motivators each contain two sides which can both be used to influence the behaviour of the consumer. Below, the relevant aspects of each core motivator are linked to the target group of DNs. Figure 32 shows how each motivator influences the ability of a DN towards behavioural change. The motivators with the best fit to the DN target group based on previously discussed literature and the thematic analysis are discussed below.

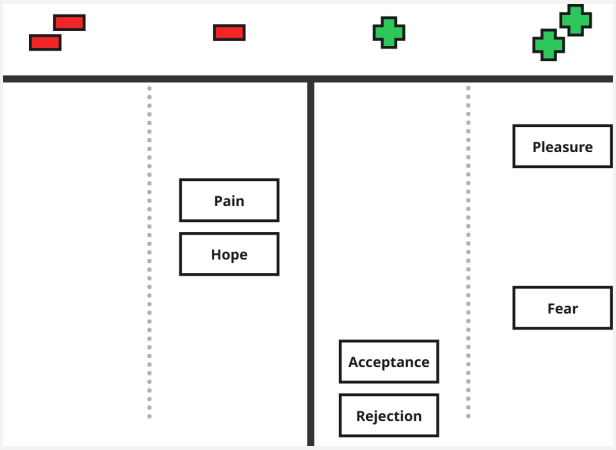


Figure 32. Effect of modular product motivators on DNs' ability to change behaviour.

Pleasure. For DNs, the pleasure and pride associated with self-sufficiency are key factors for motivating them towards behavioural change. Next to that, it could be argued that, seeing that eight of the ten DNs from the interview acknowledged the fact that they struggled with their carbon footprint (especially from plane travel), providing more sustainable alternatives could allow them to feel more pleasure from their lifestyle without feeling guilty.

Fear. The most straightforward factor in this core motivator is the fear of climate change. DNs are often very aware of their impact on the environment and will therefore resonate with the message of "act now". Another fear could be the idea of not being able to work effectively if an integrated product breaks when the DN is in a secluded area. Bayraktaroğlu and İdemen (2024) showed that consumers saw companies providing Facilitated DIY Repair (FDR) as more reliable, and FDR also increased brand loyalty.

Acceptance & rejection. When accounting for any social aspects that might motivate a DN towards changing their behaviour, there are a couple of things that come to mind.
For one, modular design and standardisation can aid freedom and a feeling of self-sufficiency, which are both important factors for feeling part of the DN community. To the outsider, these factors might not seem like factors a DN would be judged on by other DNs, but the interviews showed DNs often did feel their freedom and self-sufficiency were crucial parts of their DN identity.
Secondly, modularity allows for more self-expression, which can accommodate the DN in expressing themselves towards what they perceive as socially acceptable behaviour. The fact that personalisation of products is a more generally acknowledged way to instigate behaviour change and attachment does not mean it should not be used with this very niche target group. As a matter of fact, DNs might benefit more from personalised products than the average consumer seeing that many of them are highly active on social media (Miguel et al., 2025) and many of them are freelancers, requiring them to diversify themselves from others in the same job sector (Delavani & Linando, 2025).

Consideration 18: DNs can be motivated to use modular design by framing it as more sustainable, reliable and expressive.

7.2.2. FACTORS OF SIMPLICITY (ABILITY)

Fogg (2009) mentions six *factors* that contribute to the ability of a certain behaviour. Figure 33 shows these factors and positions them based on how much they influence the ability of a DN towards behavioural change, the ranking was done based on the findings of the interviews of chapter 6. The most influential factors are then linked to the target group of DNs.

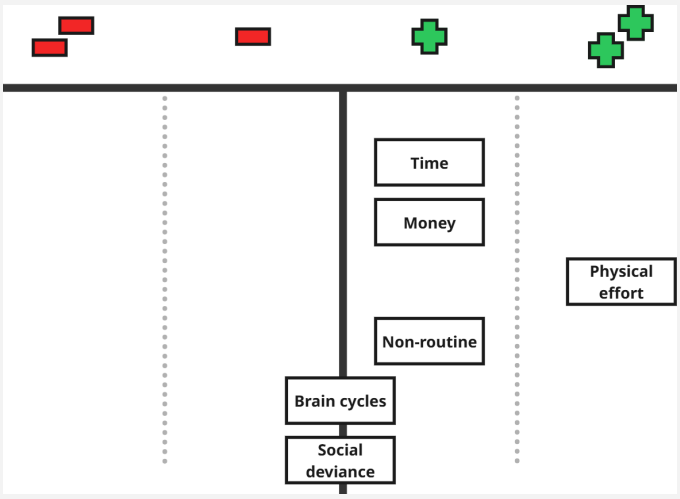


Figure 33. Effect of modular product factors on DNs' ability to change behaviour (Fogg, 2009).

Time. The ten interviews have shown that DNs do not necessarily have more “free” time to spend on behavioural change. The time they save on not having to commute to work is often spent on sports, social and cultural activities. Often, their remote lifestyle also means things simply take longer than in Western civilisation. This means that time is still a valuable factor in the DN's life. From a repair standpoint, Facilitated DIY Repair (FDR) is, when done right, experienced as reducing time compared to specialised repair services (Bayraktaroğlu & İdemen, 2024).

Consideration 19: A modular PC peripheral that could save DNs time through FDR would increase the ability for behavioural change. One that however takes away time through assembly can also have a negative effect.

Money. Most DNs from the interviews mentioned that the money they earned from work went directly into their travels. Four out of ten DNs mentioned that the sole purpose of their work was to finance their travels. This shows that, although becoming financially rich might not be a goal for DNs, it is a facilitator for their lifestyle. Many DNs also mentioned they lived a sober life so they could prolong their travels and reduce the weekly hours of work needed to stay financially healthy. This means that if a product breaks, a DN might choose not to replace a broken product at all rather than to spend money on repair or replacement.

Consideration 20: Costs of repair can have a significant effect on the readiness to repair amongst DNs.

Physical effort. Being able to easily service and repair the PC peripheral yourself instead of having to go to a specialist can reduce physical effort, especially as a DN when a visit to such a specialist involves travelling large distances and/or long waiting times (Bayraktaroğlu & İdemen, 2024).

Repairability is more important than part availability: spare parts are not worth anything if you cannot access the broken part in the device. This however does not mean part availability should be neglected, parts can be made more accessible by for example licensing part production to external parties or by making parts open source.

Consideration 21: Modularity can have a positive effect on physical effort due to improvements in ease of repair, with part availability playing a significant role in said ease.

Non-routine. Introducing modularity into PC peripherals would most likely change routines in the consumer's life, especially when it comes to maintaining the product. This could be seen as a negative, seeing that it differs from what the consumer is used to. However, it is also proven that the ritualistic aspect of modular product maintenance can have a significant positive impact on the emotional attachment a consumer feels towards a product (i.e. a clumsy barista coffee machine or an old-timer car). Another reason the effect might be more positive is due to the naturally non-routine lifestyle DNs live by, where no day is the same. Having one more factor of change should not make a significant impact on their choice for adaptation.
Weighing the pros and cons, the effect of non-routine on ability is partly dependent on the exact use of modularity, still, its overall effect is more positive than negative.

7.2.3. CURRENT PLACEMENT ON FBM

Now that both axes of Motivation and ability have been analysed, we can make a rough estimation of where the target group of DNs is positioned, and whether any extra actions need to be taken to move them towards behavioural change. The position of DNs on the FBM will also show us which trigger(s) will be most effective in getting them to buy modular products. Figure 34 shows that DNs are positioned close to the required threshold for behavioural change, meaning that using well-placed triggers should make them move towards modular product design.

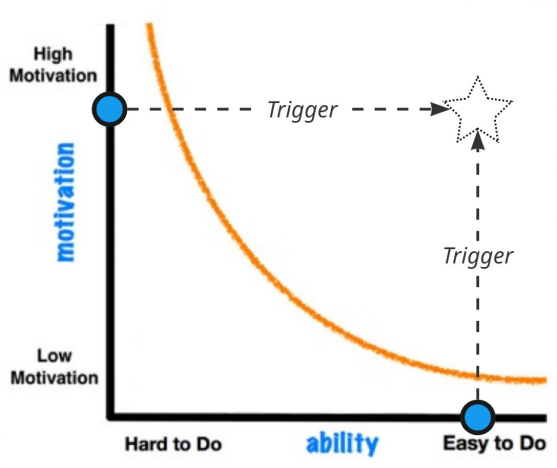


Figure 34. Estimated position (blue circles) of the DN target group based on ability and motivation towards modular product adaptation.

7.2.4. TRIGGERS

Fogg (2009) describes triggers as something that tells people to act *now*. Once a consumer has gathered sufficient motivation and ability, only a trigger is required to change towards the desired behaviour. Fogg (2009) describes three types of triggers: Spark, Facilitator and Signal. Seeing that DNs seem to have sufficient motivation and ability to change their behaviour to modular product design, Fogg (2009) suggests the best way to get them to change is by using signals. This subchapter explores what signals could be used to get DNs to make the jump towards modular products.

Using signals is not as straightforward as bombarding the user with information until they change their behaviour. For one, too much information can lead to overload (Neumann et al., 2012) and confusion (Chen & Chang, 2013). Secondly, sources suggest that providing consumers with too much detailed information can backfire and result in lower adaptation (White et al., 2019).

Signals should be timed effectively at moments where the DN can act on the behaviour (Fogg, 2009).

When it comes to selling the modular product, this would mean a location where DNs would be able to buy the product or make a buying decision. With DNs, contact points can vary based on where and how the DN lives (say, living in an Airbnb, boat or campervan). Still, some contact points are universal; airports and coworking spaces would be suitable locations to signal DNs and to sell modular products. Signals can also be provided through online advertisements and stores, if the DN stays at a location where they can have the product delivered to them.

When it comes to signalling the DN to stimulate the desired behaviour in use, the timing of the signal is mostly dependent on the functional benefits (that were explained in chapter 3.3.2) the modularity provides; When it comes to signalling for potential upgrades or add-ons any moment seems like the right moment while signalling to replace worn-out modules would be something to only do later on in the product's lifecycle (Figure 35)

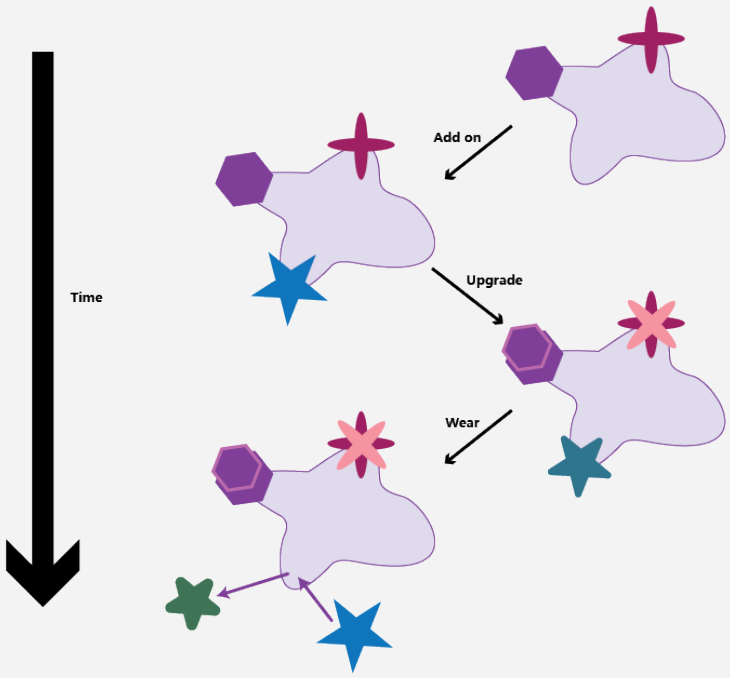


Figure 35. Change in functional benefits required through the lifecycle of a product.

7.2.5. IMPLICATIONS

RQ6.2: How do you increase Digital Nomad's adaptation of a modular product?

The FBM was used to analyse the current position of DNs in terms of their readiness for behavioural change to modular products. DNs seem to be ready for the adaptation of modular product design in terms of both motivation and ability. The biggest challenge lies in providing them with the right amount of information and effective signals.

Practically, adoption increases when the offer is introduced in incremental, "baby steps" (starter kits, easy swaps, guided upgrades) that avoid overwhelming users with detail. Signals should be situated at action points (airports, coworking spaces, and targeted online touchpoints).

7.3. How do you stimulate the desired behaviour once a Digital Nomad has bought the product?

Once a DN has bought the modular PC peripheral, it is critical to guide them in how the product should be used seeing that the benefits of its design might not be self-evident from the start. This subchapter uses the stages of product use by Shi et al. (2022) to identify where modularity can impact product use. The two phases that were identified to be most relevant were:

1. **Early use** – initial testing and getting familiar with the product
2. **Middle use** – everyday usage, deriving functional or emotional benefit

7.3.1. EARLY USE

Users must understand their responsibilities when buying and using a product. Modular products could allow for easier repair, but in addition to that the consumers might also become responsible for part of the maintenance to the product. Conducting preventive maintenance and care improves the product's lifespan and user-product relationship and also reduces the risk of physical and emotional obsolescence (Bayraktaroğlu & İdemen, 2024). Modularity should therefore not only be leveraged when a product is broken, but also for ensuring it is cared for and its lifecycle is extended as far as possible.

Research has shown that consumers are more likely to execute on habitual change when the actions they need to take to improve their current situation are clearly mapped out (White et al., 2019)Therefore, information on desired product use and care should be provided clearly. It is also important to provide this information through different mediums so that the information can reach as many users as possible (i.e. quick-start card, short video, in-product walkthrough). The user should for example have a clear understanding of what to do if the product fails. There have been examples of consumers being uncertain about what to do because it was unclear whether repairing a modular product would lead to affecting warranty (Bayraktaroğlu & İdemen, 2024), this is especially relevant in non-Western countries where consumer protection laws might be less strict. Countering this issue once again comes down to clear and accessible information.

7.3.2. MIDDLE USE

During the middle use phase, the product is worn but functions well. During this phase, the direct benefits of modularity to the user should shine, whether those are through increased productivity, comfort, expression or something else. Using the product will lead to attachment which in its turn increases the amount of care.

During these phases there is also a chance the user develops dissatisfaction with the performance of the product, this dissatisfaction is one of the key reasons consumers buy new products, above that of a product breaking (Bayraktaroğlu & İdemen, 2024; van den Berge et al., 2021). Therefore, modular products should facilitate the modular benefit of upgradability so users can act on their dissatisfaction without having to buy a completely new product.

Dissatisfaction can also come from aesthetic issues with the product; therefore, modularity should be used to allow the user to refresh the aesthetics of the product with ease. Changing parts of a product for pure aesthetic reasons does affect the carbon footprint of the product negatively if the barrier is too low and the user gets too much freedom. It can also lead to consumers demanding the replacement of certain parts with insignificant defects. Therefore, it is important to consider how and when to provide spare parts to consumers for aesthetic reasons. Ways to prevent such negative effects are through minimum wear thresholds, bundled refresh kits and transparent footprint disclosures.

Consideration 22: Modules should be replaceable even if they are not completely broken in order to prevent total product replacement, it should however also not be too easy so overconsumption is prevented.

7.3.3. IMPLICATIONS

RQ6.3: How do you stimulate the desired behaviour once a Digital Nomad has bought the product? Using the product use stages an overview of the most important behavioural aspects was created. To make modularity “pay off” in practice, DNs need structured guidance immediately after purchase and low-friction support during everyday use. In early use, pair a concise, multi-format onboarding with a clear care/maintenance plan that spells out user responsibilities, intervals, and simple checks. Reinforce these with timed signals and unambiguous policies on warranty-safe DIY so users know exactly what they may open, swap, and service.

In middle use, let the everyday benefits of modularity be visible and felt. Users should feel attached to the product by making upgrades and repairs the obvious alternative to replacement. Provide clear performance roadmaps (“if X bothers you, swap Y”), easy access to parts, and guided upgrade flows. Enable aesthetic refresh options to curb dissatisfaction but add sustainability guardrails to discourage unnecessary cosmetic replacements.

Requirement 10: The product's modular design should prevent premature replacement.

Consideration 23: The product's design can help in giving the user confidence for care by making use of clear use-cues.

Consideration 24: Giving the consumer more responsibility for product care means facilitating the behaviour through physical or digital touchpoints.

7.4. Conclusion

This chapter aimed to better understand how to create impactful and long-lasting habitual changes in the lives of Digital Nomads through modular product design. Based on several papers and methodologies from consumer behaviour research, a complete view was created on all relevant aspects for modular product design for Digital nomads. The answer to the main research question of this chapter is discussed below.

RQ6: How do you convince Digital Nomads to choose modular product design?
Although DNs seem to be a very fitting target group for making the switch towards modular PC peripherals, there is a base that needs to be firmly set before that move can take place. Their personal motivation to be more sustainable and the pressure they experience from their community should be leveraged to get them to change their behaviour. Modularity can play a major role in gradual habitual change and in creating emotional attachment with PC peripherals, which in its turn results in a reduced need for product replacement. For all these changes to work it is vital to understand that DNs need to be well informed before they are willing to make any radical choice, and that reducing the radicality of said choice will also improve adaptation.

Modularity should be framed by engaging both the experiential system and the rational system. Experientially, lead with communication that signals freedom and self-sufficiency, and support in-group collaboration. Rationally, provide concise evidence so DNs can make an informed decision.

Adaptation can be increased by combining motivation, ability and timely signals. Introduce modularity through baby steps and place signals at action points such as airports, coworking spaces, and targeted online touchpoints while avoiding information overload. Modular product design fits well with incremental change, lowering the effort and helping consumers change their behaviour more easily.

Desired post-purchase behaviour can be stimulated by providing concise, multi-format onboarding , clear care and maintenance plans, timed signals, and unambiguous warranty safe DIY policies. In middle use, repair and upgrade should be the default over replacement, and aesthetic refreshes should be possible with sustainability guardrails.

8. Ideation

The following two chapters aim to answer the following question:

RQ7: What modular product concept fits the needs of Digital Nomads?

All findings from chapters 1 to 6 come together in the ideation phase of the project. Varying methods were used to approach the ideation from different angles, The methods used were:

- HowTo (Van Boeijen et al., 2014)
- Morphological chart (Van Boeijen et al., 2014)
- Scamper (Van Boeijen et al., 2014)
- C-box (Van Boeijen et al., 2014)
- Free sketching

The most important source of inspiration for ideation is the list of requirements that has been constructed through the project, all requirements are listed in Table 5.

Table 5. Overview of the 10 requirements formulated through the project.

Nr.	Requirement
R1	Products design should be inspiring and advocate for the future of modular design.
R2	The application of modular parts in the product should have a positive effect on the products carbon footprint over the use-phase period of the product compared to an integrated alternative.
R3	The application of modular parts should provide a benefit that cannot be attained using software functionality alone.
R4	Modular parts and tools needed to repair the product need to be accessible to the user (widespread availability, low cost, etc.), exceeding the services already provided by iFixIt.
R5	Repairs and replacements to the products' most resource-intensive parts should be performable by the user.
R6	Repairs and replacements to the product's parts with the highest failure rate should be performable by the user.
R7	The batteries of the product should be safe yet easy to remove by RRCs and the end-user.
R8	Product should be worthwhile to bring for Digital Nomads (by for example playing into the factors of professional relevance, size and amount of use).
R9	Product should clearly communicate its benefits to the Digital Nomad’s lifestyle through its design.
R10	The product's modular design should prevent premature replacement.

A list of considerations was also created, containing all kinds of factors that were gathered throughout the project to aid in sustainable modular design for DNs, all considerations are listed in Table 6.

Table 6. List of considerations formulated throughout the project

Nr.	Consideration
C1	To investigate novel and potentially innovating appliances of modularity, the product could consider making use of one of the less represented forms of modularity: Component-swapping, Line, hub-sectional (only one entry), hub-sectional, Cut-to-fit, semi-sectional and/or fully sectional.
C2	Although flexibility in use is a successful benefit of modularity, its overwhelming presence in the current market and lack of direct benefit to sustainable design makes it a less interesting direction to take.
C3	Modular architecture in electronics can be designed so that companies like Logitech can refurbish non-affected modules without needing a manufacturing license.
C4	DNs seem to either only pack wireless earphones or take multiple kinds of PC peripherals with them.
C5	Providing Digital Nomads with a product that improves the quality and consistency of their work environment and online representability not only improves quality of work, but quality of life in general.
C6	Product can be of extra value if it makes the Digital Nomad feel more at home in their place of stay.
C7	If multiple relevant functions are combined into one product, it will most likely reduce the total size and increase the total use of the one product.
C8	When designing for travel/compactness, it is valuable to drop assumptions on what shape a product should have. This way it is possible to come up with new designs that provide the same functionality in a form factor that is smaller that was deemed possible.
C9	Compact products can still be expressive using colours and accessories.
C10	Design for compactness should not be taken as an excuse for making internals inaccessible, it is possible to combine the two. Product should not only keep in mind the user experience of the product when it works, but also when it breaks and needs to be repaired.
C11	There is a finite amount of material that can be fitted into a volume, if more functionality needs to be added the product can make use of negative space.
C12	The user should be able to decide how much freedom they want to give up for multifunctionality and automation of the device.
C13	Modularity can be a key factor in providing the user with a product that is both multifunctional and long-lived, by providing the opportunity to upgrade or replace obsolete parts.
C14	The DN should be able to identify with the product, feeling that it fits with their needs, values and way of life.
C15	The product's design should stimulate in-group collaboration and improvement.
C16	Products design and presentation should consider how the sustainable impact of the product could be made as clear as possible.
C17	Modularity could be used to facilitate incremental change in a product, with the aim of consumers changing their behaviour toward repair and modular customisation more easily.
C18	DNs can be motivated to use modular design by framing it as more sustainable, reliable and expressive.
C19	A modular PC peripheral that could save DNs time through FDR would increase the ability for behavioural change. One that however takes away time through assembly can also have a negative effect.
C20	Costs of repair can have a significant effect on the readiness to repair amongst DNs.
C21	Modularity can have a positive effect on physical effort due to improvements in ease of repair, with part availability playing a significant role in said ease.
C22	Modules should be replaceable even if they are not completely broken in order to prevent total product replacement, it should however also not be too easy so overconsumption is prevented.
C23	The product's design can help in giving the user confidence for care by making use of clear use-cues.
C24	Giving the consumer more responsibility for product care means facilitating the behaviour through physical or digital touchpoints.

The list of considerations alongside an overview of all requirements (including page numbers) is shown in Appendix K.

To feed the individual ideation sessions, a stakeholder map and 10 different mood and inspiration boards were created. Three focused on the target group of DNs, looking at products and brands the target group uses and why. Seven focused on mechanisms and products that in some way solved DN issues at hand like self-sufficiency, compact travel, minimalism and multifunctionality (Figure 36).

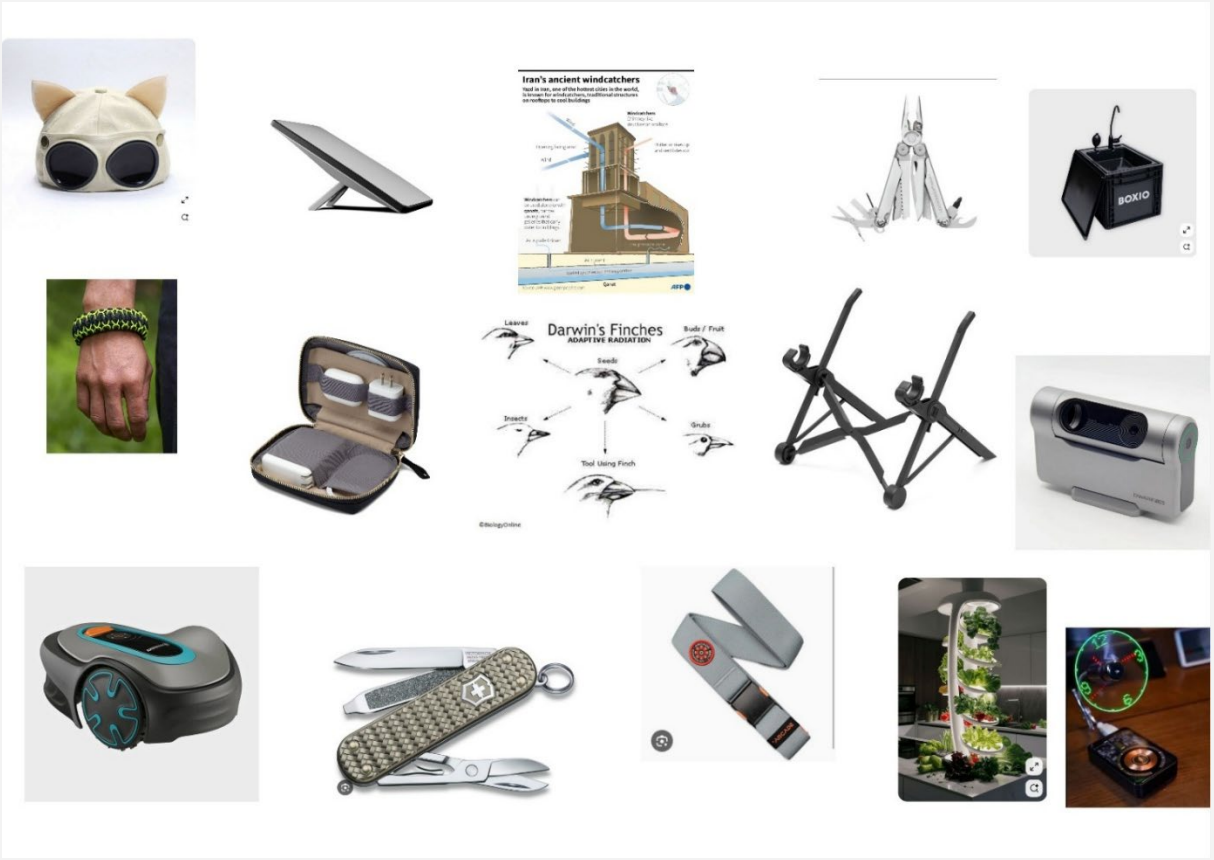


Figure 36. Mood board used for inspiration in ideation, containing DN products, solutions and other inspirational images.

This chapter will go into what design directions were explored, what directions were chosen to develop further and why. These directions were inspired by findings from the thematic analysis and/or emerged through the ideation process.

8.1. Explored design directions and resulting ideas

A total of 5 different directions were explored during the first stage of ideation, these directions focused on exploring how to:

1. Use modular architecture to create value for DNs (based on 3.3 - modularity maps)
2. Improve online representability through modularity (based on 6.2 - thematic analysis)
3. Make products both compact, minimalist and multifunctional (based on 6.2 - thematic analysis)
4. Make DNs feel more at home, creating community (based on 6.2 - thematic analysis)
5. Use novel materials to create value for DNs (added to stimulate broader thinking)

Information on all directions and ideas explored in this first stage can be found in Appendix I.

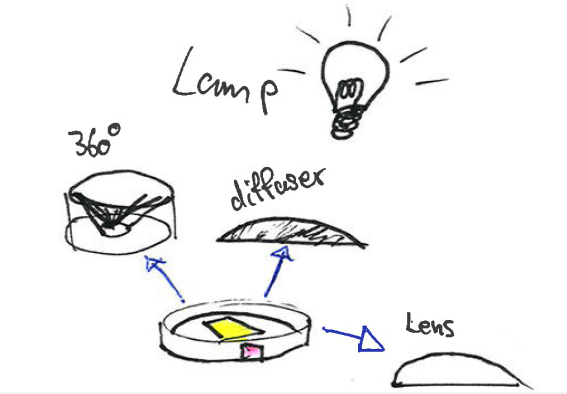
To get from initial ideas to more concrete products that could be developed into concepts, the PMI method was used, it takes the Plus, Minus and Interesting aspects of ideas so they become easier to assess. Using the PMI method has several benefits:

- If an idea is hard to assess on its PMI's, it is likely the idea is not concrete or coherent enough.
- After assessment ideas with the most positives can be improved with interesting and positive aspects of the ideas that score worse.
- PMI's make it easier to see whether combining certain ideas can negate negatives and create synergy.

The PMI method helped in getting from ±130 ideas and mechanisms to 25 PMIs into seven concrete ideas. The seven ideas that were eventually chosen to develop further using PMI, along with their PMI evaluation, are explained below.

8.1.1. LED LIGHT

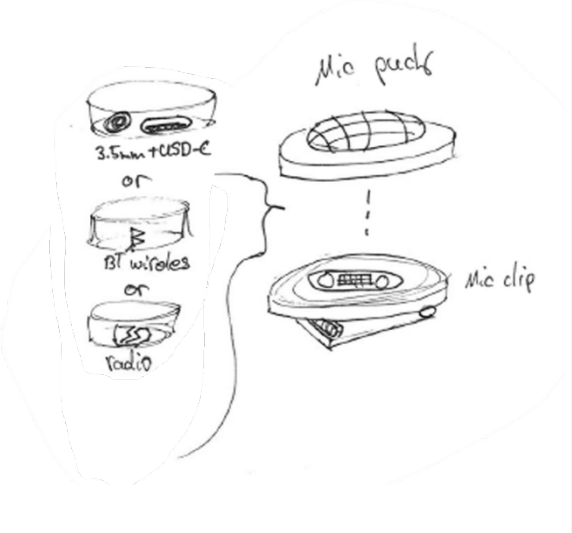
The modular LED light aimed to solve the issue with online representation by providing the DN with a multifunctional LED light that could be used as a soft-box light, flashlight or lantern. The idea behind the concept was to provide DNs with a tool to improve their video quality while requiring them to add little to no extra volume to their baggage, seeing that the product would also serve other purposes. The option for an inflatable soft box module was also explored.



Plus: Base product is very barebones, improves digital representation. Modules are "dumb" and can be very compact.
Minus: Not very innovative in the sense that it is "just a light".
Interesting: The simplicity can elevate the use of the product.

8.1.2. LAVALIER MICROPHONE PUCK

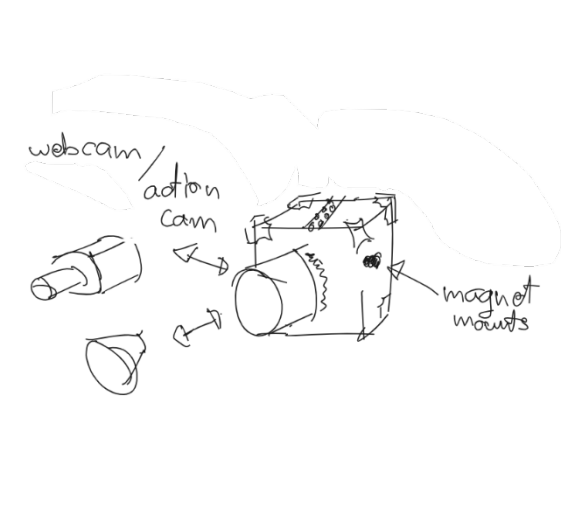
The Modular Lavalier microphone tried to solve the issue of online representation most directly and effectively by providing DNs with a high quality Lavalier microphone using radio waves to transmit audio from the recorder (attached to the user's shirt) to the receiver (attached to the device used for (video-)calling). The core functionalities would be housed in modules, allowing the DN to decide how to power the microphone, how to transmit the signal and how to record audio. For power the user would be able to use either a detachable Lithium-ion battery, a cable to an external battery or an adapter for an alkaline battery. For recording devices, the standard microphone could be detached, allowing the user to change the type of sensor to their specific needs.



Plus: Base product is very barebones, improves digital representation. User would be able to customise the product to their exact need and leave all other optional parts out.
Minus: Stacking system would mean all pucks need to be able to connect with all others. could create a lot of clutter. Wireless pucks should probably come standard in the main puck.
Interesting: Design is strong it its simplicity and is solution focussed.

8.1.3. WEBCAM X ACTIONCAM

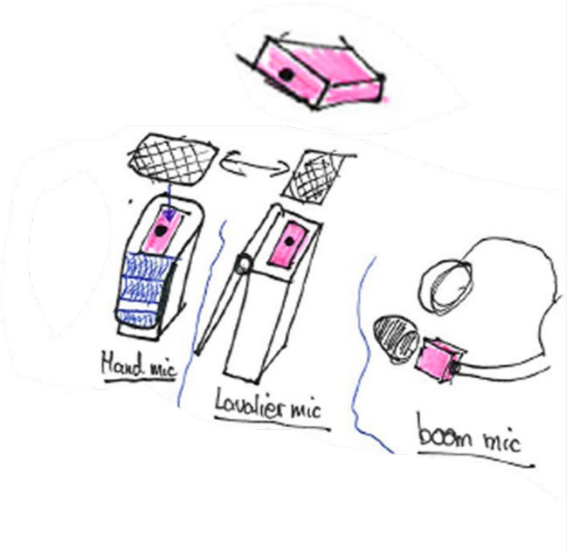
The Idea was inspired by the fact that actioncams like GoPro's are used by consumers as a webcam. The reason being that action cams often provide decent image quality in a varied number of situations, and that consumers do not have to take a separate webcam with them for representing themselves online.
The approach for this idea was to turn the script around, and to look at whether a webcam could be changed into a more versatile camera, also usable outside and perhaps also in more active environments. The product would be a barebones webcam at its core, with modules allowing the user to build it up to their needs with features, durability and waterproofing.



Plus: Multifunctional and smart use of products that overlap in terms of function.
Minus: Products are far from each other in terms of design and durability requirements, in danger of creating a product that tries to be the best of both worlds and therefore delivers on neither use cases.
Interesting: Creative view on multifunctionality and product positioning.

8.1.4. FULLY MODULAR MICROPHONE

With the fully modular microphone, a microphone was stripped down to its core to then build it back up into different types of microphones for different use cases. The core of the product would contain a sensor, Analog to digital converter (ADC) and an output. The idea being that all use cases, from a handheld microphone to a boom microphone attached to a headset, could use this exact mechanism. From here, the modules would expand the product and its architecture to what is required in each specific use case. Stripping down the microphone to its core allows the DN to be more versatile and adapt the microphone to what is needed in one specific situation.



Plus: User would be able to customise the product to their exact need. Base product is very barebones, improves digital representation.

Minus: Most likely only one configuration will be used for most cases, making the ability to change into other configurations less appealing. Small parts.

Interesting: Using one microphone for every use case could reduce packing space.

8.1.5. MOUSE X CLICKER X MICROPHONE

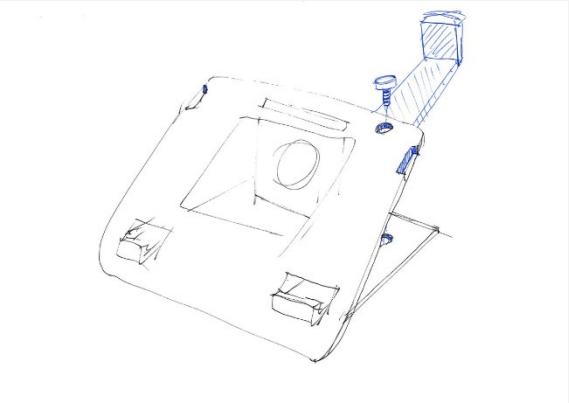
Inspired by the versatility compactness of the Logitech cube mouse & clicker (Red-dot, 2012), an idea was developed that expanded the product by also adding other functionalities like a microphone, light and laser pointer. The idea aimed to provide the DN with a product that provided multifunctionality in different scenarios (videocalls, physical meetings, productivity work) while being compact and easy to use.

Plus: Seems like a product DNs would use, multifunctional and modular through standardization seems well attainable.

Minus: Derivative, improvement on product of which production has long seized. Design incorporates standardisation but no novel appliance of modularity.

Interesting: Using a small formfactor "hub" to deliver multiple functionalities can also be applied to other products, shapeshifting them to fit certain use cases.

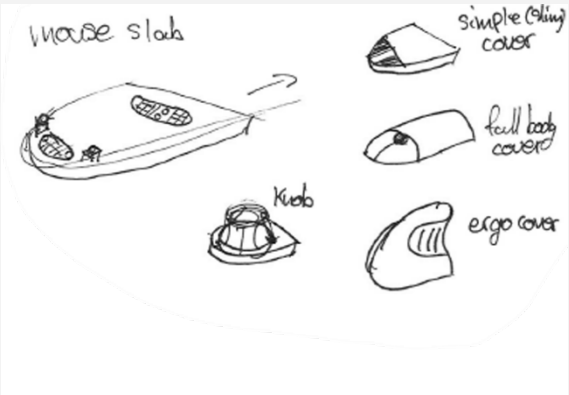
8.1.6. MODULAR LAPTOP STAND



The modular laptop stand brought the idea of improving the quality of life of DNs by allowing them to bring a customised “3D home office” wherever they go, with the freedom to customise the stand with personally designed modules. Prefabricated modules would also be available through Logitech and other parties. The idea was to make it so that DNs would now have a “home office” they could use anywhere, instead of always having to rely on the resources available in a specific location of stay. The laptop stand could also be used as a form of expression and start a module sharing culture to promote DN communities.

Plus: Could facilitate the DN in making a custom workplace to take on the go, giving them the consistency between locations they desire. Would improve productivity and therefore provide the DN with more freedom.
Minus: Little fit to the brand of Logitech in terms of technology.
Interesting: Good example of a product that can facilitate hacking quite easily.

8.1.7. FULLY MODULAR MOUSE



The versatile modular mouse consists of a core, barebones mouse product that serves as the bare minimum for a wireless mouse (switches, battery, sensor, motherboard, casing). The idea for the design being that DNs would only have to bring the core product during travels and could upgrade their mouse to whatever they need by renting modules at contact points like airports, coworking spaces and harbours. This way, DNs are still able to enjoy the benefits of a full-size mouse without it taking up space in their baggage.

Plus: Base product is very barebones, allows the DN to choose for higher productivity without having to add too much to their baggage. Product fits well with the Logitech reference brand.
Minus: A rental system is quite complex for the touchpoints of DNs.
Interesting: Using a rental model is not only useful for DNs in terms of space reduction, it might also improve the lifecycle of the product when implemented right.

9. Concept development

The concept development process is displayed in Figure 37. The seven ideas that resulted from the ideation analysis were developed further based in the PMI assessment to get a better understanding of how the products would work in terms of mechanics, material, user interaction and business model.

Once the seven ideas were developed further, they were assessed based on the list of requirements that was constructed through the project (Chapter 8). First a rough selection was made in collaboration with industry experts familiar with Logitech products, three of the seven ideas were dropped in this stage. The three discontinued ideas are shown in Appendix K.

The four ideas that remained were presented to six digital nomads in interview sessions lasting between 30 and 60 minutes. Based on the feedback of both industry experts and the interviewed DNs, the four ideas had another iteration of improvement, leading to four concepts.

Finally, the weighed criteria method was applied to select one concept to develop further for the rest of the project.

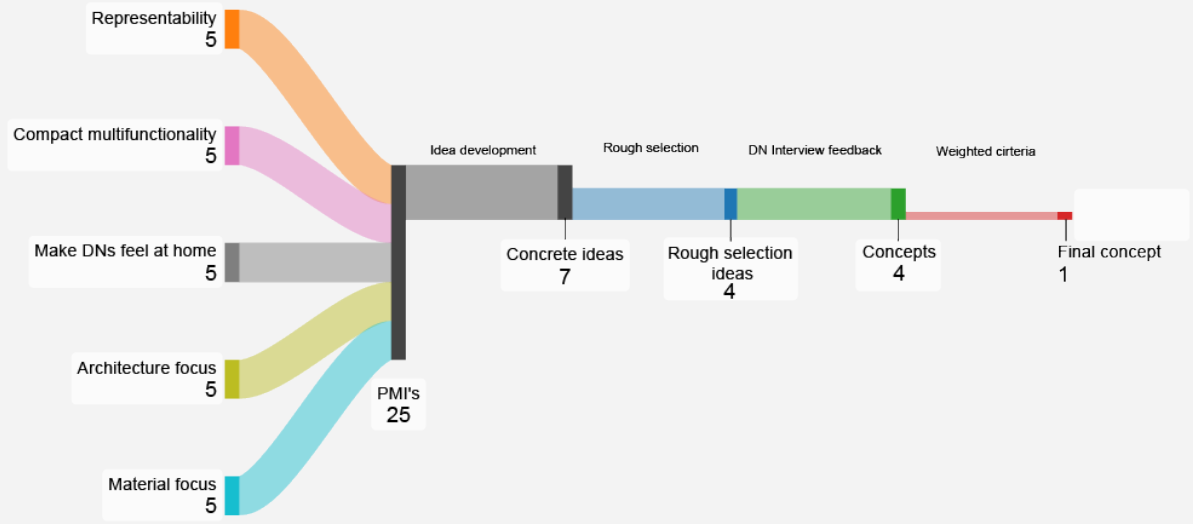


Figure 37. Development process from ideation directions to final concept.

Below, the four concepts that were developed and tested in the weighted criteria method are explained and their assessment based on the requirements is discussed.

9.1. Concept A: Modular LED light

A concept based on the LED light idea from the initial ideation phase. Figure 38 displays the modules and different functionalities of the concept. The light modules would make use of component swapping modularity, allowing different functionalities to be interchanged. The product would also contain a hub-sectional, stackable battery interface that could be expanded to provide the light with extra battery life or power.

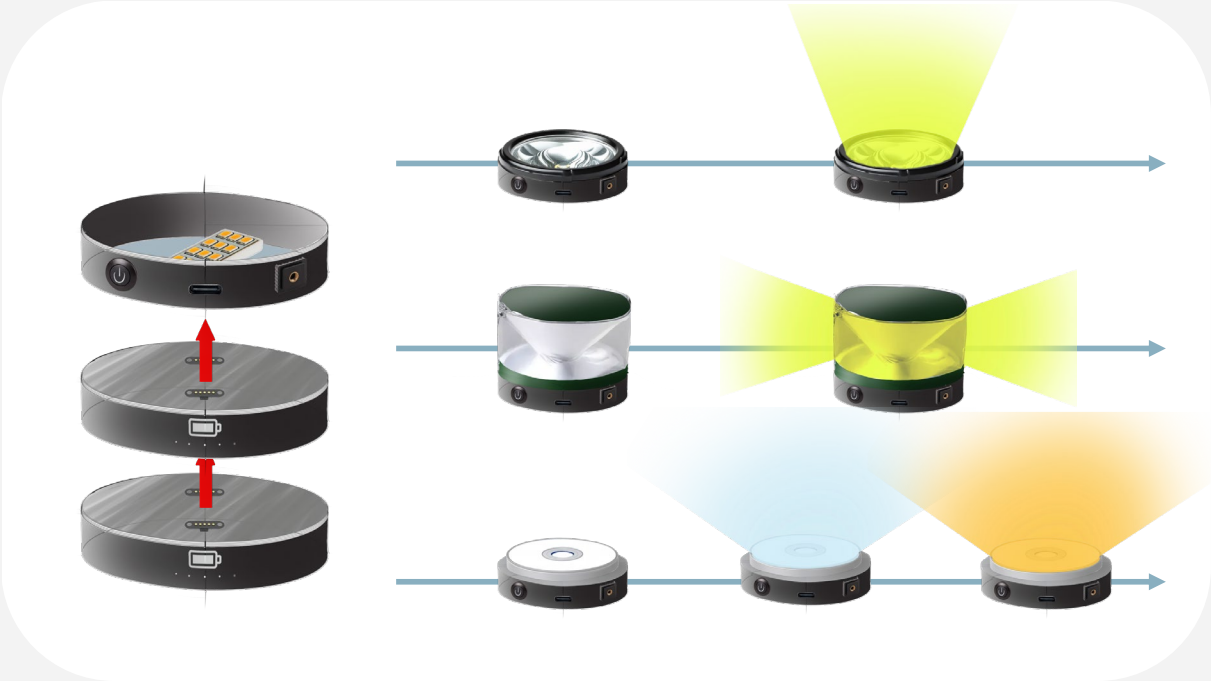


Figure 38. Display of the different functionalities and use cases of the modular LED light concept.

The last relevant aspect of the concept was that the core module and the battery modules would contain a threaded fitting that would fit standardised PVC piping, this way, it would be possible to create custom mounts and light boxes (Figure 39 & Figure 40).

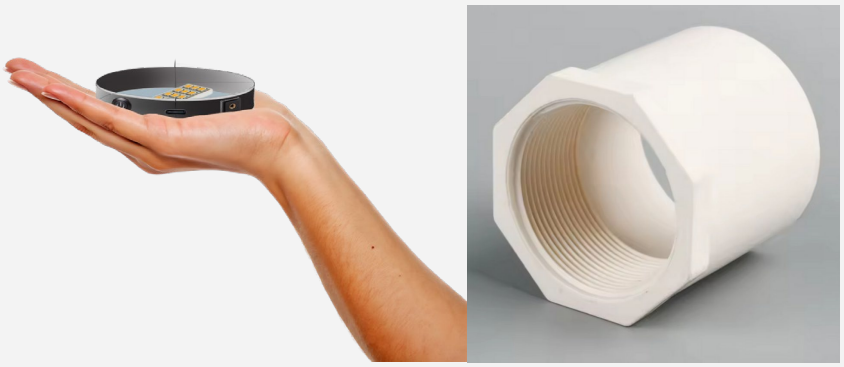


Figure 39. Estimated size of modular LED, showing the threading on the top on which PVC piping can be attached.

Figure 40. Example of a part of PVC pipe that could be attached to the LED light.

9.1.1. ASSESMENT BASED ON REQUIREMENTS

The positives of the product were that it seemed to solve one of the key issues of online representability found in the thematic analysis and the multifunctionality and compactness of the concept seemed to catch on very well with DNs **(R9)**. The product also allowed for easy access to critical parts **(R6)**.

The biggest issues that came with the concept were that there was no significant jump in innovation when looking at existing lights aimed at for example camping and survival **(R1)**. Also, the addition of the PVC threading did not feel integrated into the product as a key feature. Lastly, it is important to mention that interviewed DNs saw little to no value in the product for improving their online representation, instead, they praised the product for its multifunctionality and use outside of video calling **(R8)**.

9.2. Concept B: Versatile modular mouse

A concept that builds on the Fully modular mouse idea, Figure 41 displays the core product along with ideas for modules. The mouse would use component swapping modularity to allow for different attachments for different use cases.

Figure 41. The barebones mouse (bottom left, blue) together with all types of modules that can be attached to the base mouse.

Alongside the rental module, the concept also incorporated the idea of users making their own modules, the top right module was designed to allow for custom *cut-to-fit* modules, which would aid in making specialistic pointer devices as well as improve the product use for less abled. The interface also had potential for open sourcing. The product also gave a glimpse of an opportunity where in the future the contact points like airports and coworking spaces would have Logitech hubs where users could rent modules, interact with each other, talk about the hacks they applied to their personal mouse and more.

There was an idea to make all modules “dumb”, so that they did not contain any electronics resulting in less critical components. This idea was shelved seeing that there seemed to be too difficult to make a high quality clicking device without integrated switches and electronics while having a smaller carbon footprint than its integrated counterparts, which is relevant due to **Requirement 2***: The application of modular parts in the product should have a positive effect on the products carbon footprint over the use-phase period of the product compared to an integrated alternative*..

9.2.1. ASSESMENT BASED ON REQUIREMENTS

This widespread fit to DN needs made it a solid candidate, the relevance and potential for inspiration through the physical application of modularity was also assessed to be high **(R1 & R3)**. The fact that DNs would no longer be limited in their productivity by their packing space seemed to provide a lot of value, also the fact that the core mouse could be used as a standalone was useful since all functionalities were not necessary all the time **(R9)**. Lastly, the core concept of the mouse makes improves the accessibility of critical and high value parts **(R5, R6 & R7)**.

There were also some drawbacks from the concept. Firstly, the wide variety of modules and all the different parts required to provide all different options in all different hubs would require a large logistic network and a lot of standardization to improve the situation as it is now **(R4)**. There were also serious questions about whether users would use different modules, this issue was confirmed when interviewing DNs, all six of which confirmed that they would rather just pack one mouse that integrated the functionalities they needed and did not want to be dependent on contact points **(R8)**. Lastly, there was uncertainty when it comes to the impact of this form of modularity on the carbon footprint and lifecycle of the product **(R2)**.

9.3. Concept C: Customizable laptop-stand - 3D home office

A concept that builds on the modular laptop stand idea. The development of the concept focused mostly on understanding which modules would provide the most value to the user, how the modules would be made and how the device and its modules would be made travel friendly. As Figure 42 shows, the modules would be attached to the stand using some form of bus modularity, allowing the user to place any kind of module anywhere on the product, this would allow the user to customise and orient modules to their exact needs.

Figure 42. The concept reder of the hackable laptopstand containing a wireless charger (right), light (top) and LEGO (left) module.

Adding to the travel aspect of the DNs life, the laptop stands and its modules could be deconstructed/folded into a compact package for travel purposes (Figure 43).

Figure 43. The modular laptop stand packed flat with the modules gathered in a pouch and strapped on the top.

When looking at the creation of new modules by DNs, the most straightforward production technique would be 3D-printing. This method has proven itself when it comes to its accessibility and

its ability to adapt products to new use cases, it would also provide DNs with the most freedom when designing modules making *cut-to-fit* solutions to their own needs. Building modules by hand was not taken out of the question, it was however not considered to be a key part of the design seeing that it was assumed that DNs did not have access to woodworking shops or tooling required for making said modules.

Making the interface used for the modules open source would allow online communities to design their own modules easily and would allow them to share ideas and models so users around the world would be able to benefit. Members of the community would be able to recognise other members at touchpoints through their custom laptop stands. Moreover, open sourcing would fit the idea of expanding the network of Logitech to outside that of what its partner iFixIt is capable of, assuring that DNs are able to expand and repair their product wherever they are in the world (Figure 44).
The idea of the laptop stand itself also being open source through for example laser cutting wooden panels was also explored.

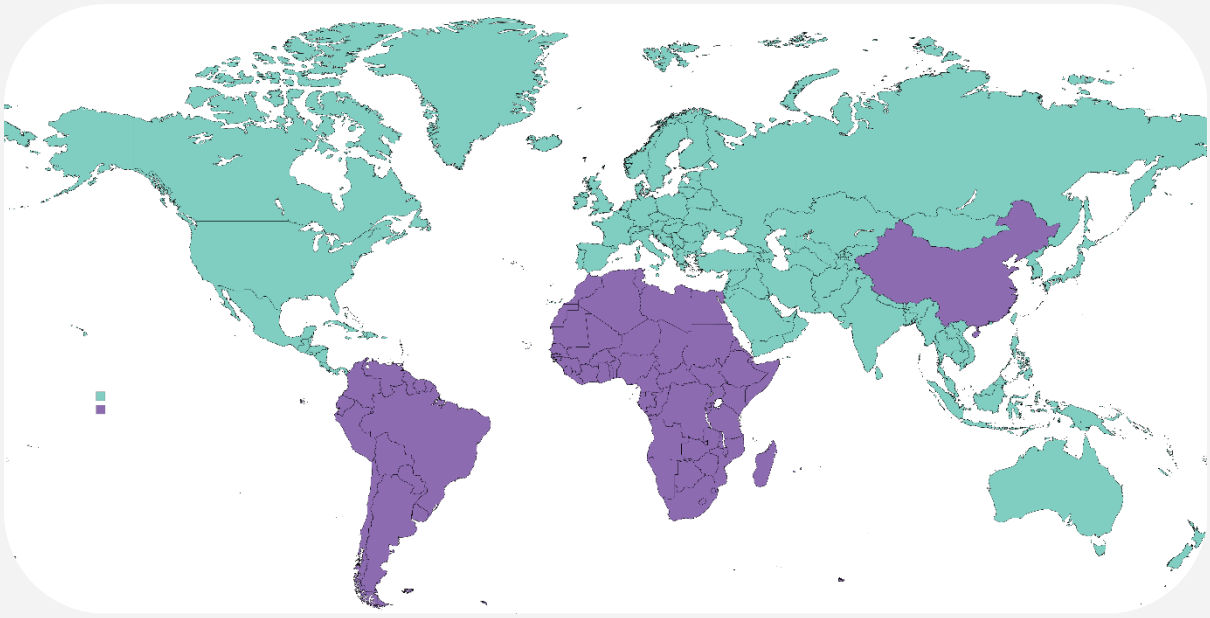


Figure 44. World map displaying the countries iFixit is (Cyan) and it is not (purple) able to deliver parts.

9.3.1. ASSESMENT BASED ON REQUIREMENTS

The concept played into the freedom and self-sufficient mindset of DNs, allowing them to work how they want wherever they want, idea being that hacking the product would allow them to alter the design, so it fitted their specific needs: from working on a plane to boat, from working as an influencer to a data analyst **(R3 & R8)**.

The concept had a lot of positives from the perspective of both a company like Logitech and consumers, seeing that it explored opportunities for introducing open-source architecture and infrastructure to its products **(R1)**. The freedom that open sourcing would provide to users would also aid in the large variety of users and use cases for the product, as well as aid in the devices repairability and lifecycle **(R5, R6 & R7)**. The ergonomic benefits and customizability were received positively by the six interviewed DNs, there however was reasonable doubt whether they would be open to hacking the product themselves **(R9)**.

The biggest challenge with the concept was understanding the mechanics and potential of the interface seeing this aspect was not yet developed when the concepts were being discussed, this

also made the impact of modularity on the total carbon footprint of the product hard to assess **(R2)**. Lastly, there were questions about whether core concept was required to be a laptop stand seeing that this is not a core part of the Logitech PWS product portfolio used for reference, and whether the interface would incorporate electronics to expand the concept to more of a laptop hub **(R1)**.

9.4. Concept D: Modular Lavalier microphone

Taking inspiration from the lavalier microphone puck, the developed concept simplified the application of modularity by focussing on two key components: power delivery and audio sensor (Figure 45).

In terms of power delivery, slot modularity was applied for the different modules, and a cabled module was added next to the two battery types. For the audio sensor a standardised 3.5mm audio jack was implemented (component sharing modularity), allowing users to attach any kind of microphone/headset they want, also improving the repairability of the concept.

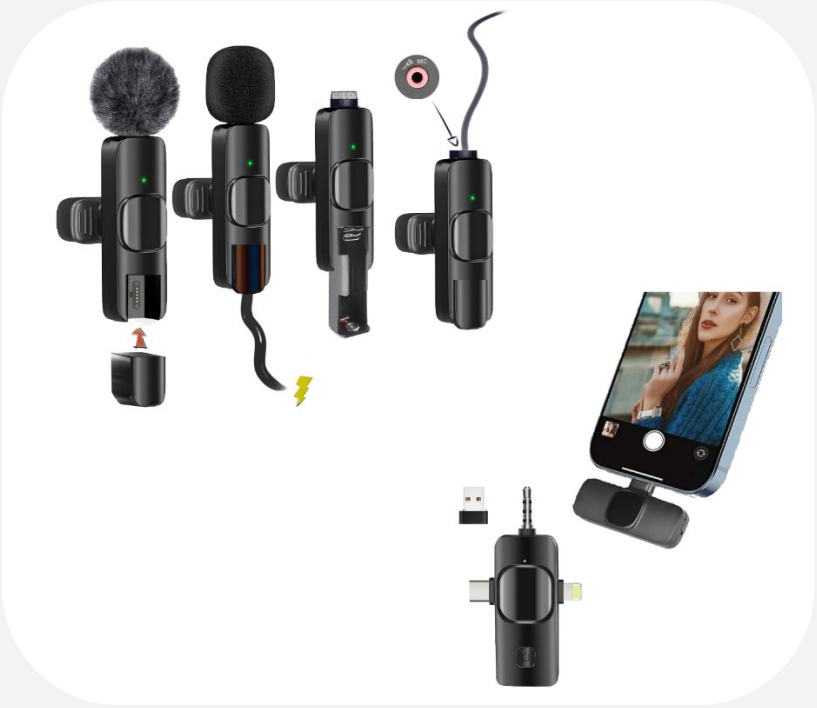


Figure 45. Rendering of the modular lavalier microphone concept, displaying the recording device and its configurations (top left) and the receiver (bottom right).

9.4.1. ASSESMENT BASED ON REQUIREMENTS

Although the concept solved a direct issue of online representability, which was discovered in the thematic analysis, the feedback that was received from DNs showed that this issue did not seem to be as dramatic as was assessed earlier. DNs mentioned they knew they could improve their online representation if they wanted to and knew there were other steps to take before resorting to a product as presented in the concept **(R3 & R7)**.

Next to that, the concept assessed to lack innovation, not implementing modularity in any novel or exciting way and focussing more on standardization rather than full on modularity **(R1)**. Lastly the concept scored lower when it came to repairability seeing that critical electronics inside the device were neither made modular or accessible **(R4 & R5)**.

9.5. Results second round interviews Digital Nomads

To get a better understanding for the relevance of PC peripherals and the concepts, interviewed DNs were asked about which PC peripheral they would take with them if it did not take up any space. The "no space" aspect seems to be quite contradictory for this target group, but it purposefully was added to remove the interviewees bias on a PC peripherals size so they would focus on value of use instead. All six DNs were presented the same options shown in Figure 46.

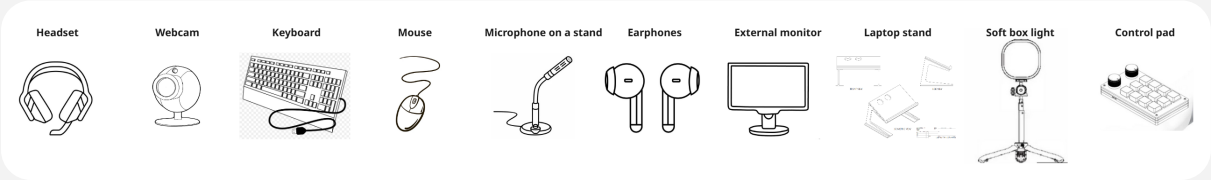


Figure 46. The different PC peripherals shown to DNs before allowing them to pick which one they would take with them if it did not take up any space.

The last question of the interview was formulated the same, but now concerned the concepts, results for the questions can be seen in Table 7.

Table 7. Results to the question which PC peripheral or concept DNs would want to take with them if they did not take up any space.

		If you could choose any form of PC peripheral to take with you without it taking up any space, what would you choose *(before presenting concepts)*		**Do you recognize the problem this product is trying to solve as a problem that Digital Nomads can have?**			
Participant #	**Job description**	Type	Why?	Light	Mouse	Laptop stand	Mic
2.1	Sales	External monitor or Laptopstand	Larger screen, better ergonomics	No	No	Yes	No
2.2	Sales	External monitor	Larger screen	No	No	Yes	Yes
2.3	Marketing	Laptopstand	Better ergonomics	Yes	No	Yes	No
2.4	Real estate	Laptopstand	Better ergonomics	Maybe	No	Yes	No
2.5	Real estate	Laptopstand	Better ergonomics	Maybe	No	Yes	No
2.6	Personal coach/traine	Light or headset	Needs to record a lot of content	Yes	No	Yes	Yes

Although design should never only consider the users opinion, especially in this small sample size, there were some clear points that presented themselves worth considering when picking a concept. Three out of six DNs considered the laptop stand to be the most valuable PC peripheral to take with them if it did not take up any space, note that the question concerned PC peripherals that they did not *yet* bring with them, all DNs already made use of for example earphones.
When asked the same question but concerning the concepts the clearest winner was the laptop stand, all DNs mentioned they experienced issues with their ergonomics. The modular mouse was considered least useful, mostly because users did not see the value in multiple kinds of mice and preferred just one kind.

9.6. Choosing concept – weighed criteria

After this last iteration of concepts, the weighed criteria method was used to select one concept for final development. The weighed criteria method (Van Boeijen et al., 2014) assessed the four concepts based on the requirements of the project (as shown in chapter 8). The weight and assessment of requirements was discussed with multiple students from the studies MSC Integrated Product Design and MSC Strategic Product Design at Delft University of Technology and was made as objective as possible using clear set values for the 0-, 5- and 10-point score per requirement. The complete assessment, scores and values can be found in Appendix L. The table containing the argumentation of each single score can be requested by contacting the author of the report. All requirements were categorized into the themes of innovation, sustainability and user experience to assess how much weight was being put on each theme, weight used for the assessment per theme is shown in Table 8. A summary of the assessment is shown in
Table 9.

Table 8. Distribution of weight between themes.

Theme	Total Weight
Innovation	25
Sustainability	55
User experience	20

Table 9. Summary of Weighed criteria assessment.

Nr.	Theme	Weight	Modular LED light	Modular Lavalier microphone	Hackable laptop stand	Versatile modular mouse
R1	Innovation	20	5	2	8	10
R2	Sustainability	15	7	6	4	6
R3	Innovation	5	8	4	10	9
R4	Sustainability	15	7	5	8	5
R5	Sustainability	5	8	5	10	8
R6	Sustainability	10	9	8	10	9
R7	Sustainability	5	8	7	10	9
R8	User experience	15	6	7	9	6
R9	User experience	5	10	8	7	8
R10	Sustainability	5	10	9	9	7
	Total score excluding weight:		78	61	85	77
	Total score including weight:		710	555	805	750

Table 9 shows that the Hackable laptop stands concept wins the assessment with the next best scoring concept being the Versatile modular mouse.

The hackable laptop stand only has one score below 5 (**R2**), that requirement being the positive impact of modularity on the carbon footprint of the product. It could positively affect the concept when considering ability to repair and replace parts but could also have a negative effect seeing that parts production is getting decentralised and the effect of all modules is dependent on their quality and use. The product scores a 4 on this requirement because the potential open-source aspect makes it difficult to assess. It is important to mention that the concepts were not developed far enough for a LCA calculation at the point of assessment, the scoring of this **R2** was therefore based in an estimation comparing the concept to existing products in its product category. (Modular LED Light with monitor lights, Versatile modular mouse with high quality productivity mouse, etc.)

The concept that scored second best is the Versatile modular mouse. Some of the concerns with the concept are the same as that of the laptop stand, the distribution needed for getting the modules in remote locations will be a challenge of which is uncertain what the impact will be on the lifecycle and carbon footprint of the product. Also, DN interviews showed that the application of modules in the concept would likely not provide a lot of benefit, seeing that users would not need multiple modules for their use cases.

9.7. Formulating design brief

As per the Delft Innovation Method (Buijs, 2012), a design brief is formulated so prototyping could be done effectively. Formulating the design brief is meant to make the concept as concrete and relevant as possible for the brand of reference, user and designer to assure that everyone is on the same page in one of the final stages of the project that will be the most visible at the end of the project: prototyping.

9.7.1. RELEVANCE FOR BRAND

There were some concerns on the relevance of the laptop stand for the Logitech product portfolio. Although Logitech sells a laptop stand in the form of the “Casa” product (Figure 47), and has sold multiple types of laptop stands in the past (Figure 48), the concept (as was shown in 9.3) does not show anything the division of Logitech PWS is currently focussing on as one of their key product categories. The biggest divide seemed to be the fact that the stand did not include any form of electrical interface and had no clear set out use cases. Adding an electronic interface would allow for significantly more options for module customization and would also fit better into the Logitech ecosystem and software customization tools.

Figure 47. The Logitech Casa product: a laptop stand which also contains storage for an included keyboard and trackpad.

Figure 48. Logitech has sold multiple sorts of laptop stands in the past, some of them also contained an integrated hub with ports.

The concept was developed into a more relevant direction where the core of the concept would be changed into a hub rather than a laptop stand, with the idea being that the focus of the concept should be on enabling use of electronically powered modules rather than on the ergonomics of the laptop stand. The hub would contain multiple ports on the sides and back to allow the user to expand on the hub with modules in 3-dimensional (3D) space. Based on the new direction, concept sketches were made (Figure 49).

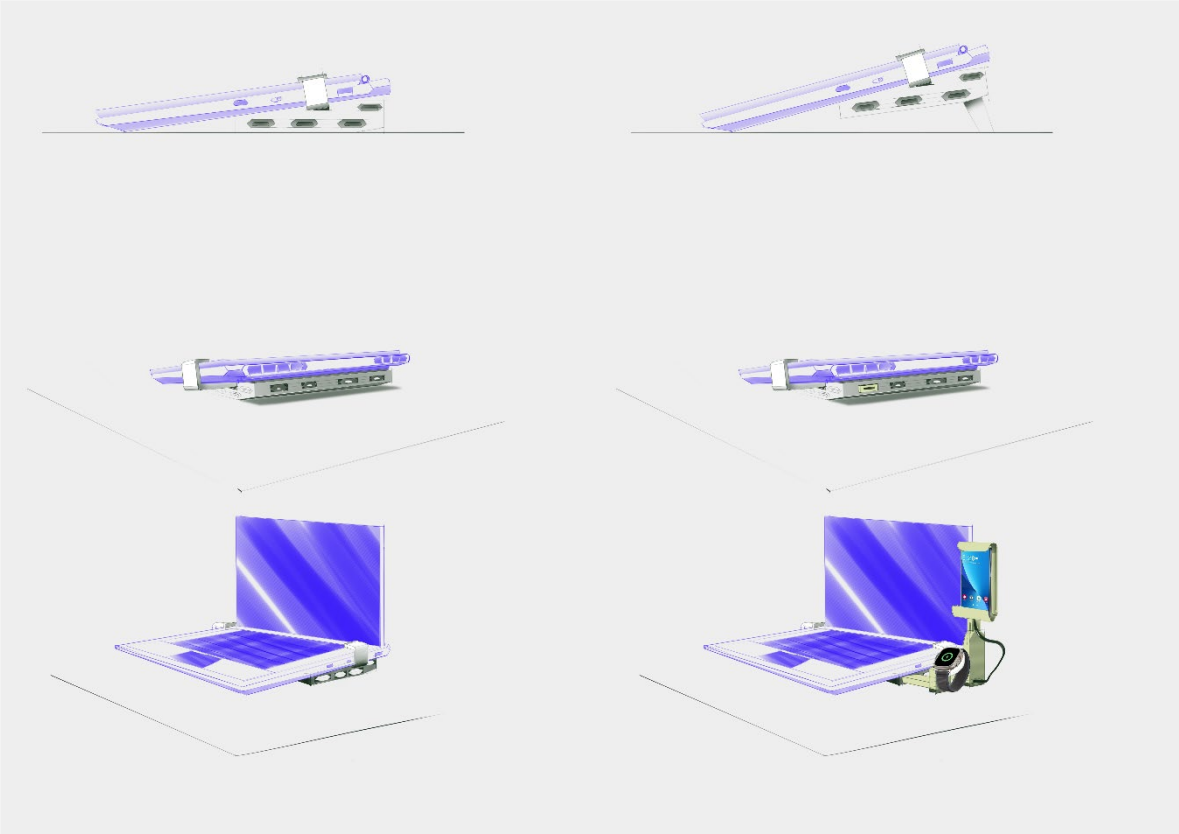


Figure 49. Sketches created to visualise the new improved direction from laptop stand to laptop hub.

The reenvisioned concept envisions three different use cases for the ports:

- Modules that provide accommodation and power for other devices (i.e. phones, watches, screens, etc.).
- Adapters that provide ports (video, audio, data, etc.).
- Modules that accommodate external storage.

9.7.1.1. Fit to brand product categories and style

Finding the right look and feel for the product is largely dependent on the needs of the DN target group and the design identity of Logitech PWS. Through combining these, the product should fit practical and aesthetic needs of the DN while also clearly communicating that it is part of the Logitech PWS product family. There are different design styles within Logitech PWS that cater to different users, the first step is to understand which of these styles fits their use best.

Logitech PWS current product portfolio still contains legacy products; some have been on the market for decades (btarunr, 2011). These legacy products vary widely in terms of design style and have stuck around due to their continuing success. The newer Logitech PWS products mostly fall into one of the design categories it has created, Figure 50 displays three key design categories within Logitech PWS, from left to right:

- **MX**, designed for power users. Devices use premium materials, ergonomic shapes and contain many buttons to optimize productivity.
- **Lifestyle,** budget friendly products that value the ability to express through colour and playful design.
- **Ergo,** as the name suggests, aimed at optimizing ergonomics when using the computer.

All three lines have a variety of products including mice, keyboards, webcams and more.

Figure 50. The three main design categories of Logitech PWS (from left ro right): MX, Lifestyle and Ergo

For this project the style of the MX category was chosen for developing a concept, this is for a couple of reasons:

- Analysis and interviews showed that the DNs that use PC peripherals use high quality PC peripherals aimed at performance. This is mostly because they spend all their hours working behind their laptop and therefore need proper equipment to optimize productivity. The MX line fits this need best.
- DNs are from western countries and have the financial freedom to acquire premium solutions for their workspace. An MX product is seen as an investment that pays itself back in productivity, leading to more freedom.
- The premium build quality of the MX products appeals to the DNs need for reliable productivity on-the-go.

Figure 51 displays an analysis on the MX design style. Key features that can be used in the design of a concept fitting of the MX category are:

1. Repetitive use of stadium shaped features on parts like a product's housing, buttons, lights and holes.
2. Use of sculpted shapes and micro textures on surfaces the user interacts with when using the product. The textures are created by applying a rubber like layer containing the texture on top of the hard-shell casing, or by directly integrating the texture in the injection mould of the hard shell.
3. Minimalistic green LED indicators that inform the user on power and other information.
4. Machined metal rings for the user to interact with.
5. The brand name used on the newer MX products is always "Logi", never "Logitech".
6. A limited colour palette, mostly keeping to Greys, whites and metallic surfaces. A rare few MX products come in more expressive colours, but their use is still uniform and calm.

Figure 51. Key design features of the MX line highlighted.


1
3
6
Pr
Ae
Au
LrC
Ps
Ai
4
2
esc
tab
caps lock
shift
ctrl
fn
opt
cmd
alt
logi

9.7.2. DESIGN BRIEF

Based on the improved concept, the design brief displayed in Table 10 was created. Cost price, sales price & delivery date were not considered in this part of project brief seeing that they were not yet relevant for the state of the project.

Table 10. The design brief as formulated for the prototype

		Connected requirements	Connected considerations
Targeted clients	Digital Nomads		
Product functions	Provides a 3D home office experience while being compact and easy to (dis)assemble.	Requirement **8**	Consideration **5**
	Adapts to the users' needs by allowing the user to (incrementally) interchange modules and to build their own modules.	Requirement **8**	Consideration **12**, Consideration **17**
	Is easy to move from room to room.	Requirement **8**	Consideration **5**
	Is compact and functional when travelling.	Requirement **8**	
	Products design needs to clearly communicate its positive impact on its carbon footprint.	Requirement **2**, Requirement **9**	Consideration **16**, Consideration **18**
	Contains a rugged, reliable and easy to use interface.	Requirement **9**	
	Is easy to use, repair and upgrade through low-cost accessible architecture and clear use cues.	Requirement **4**, Requirement **5**, Requirement **6**, Requirement **7**, Requirement **9**	Consideration **10**, Consideration **13**, Consideration **19**, Consideration **20**, Consideration **21**, Consideration **22**, Consideration **23**
Needs to be fulfilled	Feeling more productive when travelling, leading to more freedom for DNs.	Requirement **8**	Consideration **5**
	DNs should be able to strongly identify with the product	Requirement **8**	Consideration **14**
	Making DNs feel more at home when working without the clutter of all kinds of separate products.	Requirement **8**	Consideration **5**, Consideration **6**
	Creating a feeling of community with other DNs.	Requirement **8**	Consideration **6**, Consideration **15**
Technology used	Bus modularity (Hub ports)	Requirement **10**	
	Line modularity (Hub internals)	Requirement **10**	Consideration **1**
	Semi-sectional modularity (Hub ports)	Requirement **1**	Consideration **1**, Consideration **2**
	Standardised interfaces	Requirement **10**	
Competitive offerings	Dongles, Hubs, Separate PC peripherals, Stands, Tripods		
Necessary features	Contains multiple versatile interfaces that allow for the use of both OEM modules as well as modules from external parties and open-source 3D-printable modules.	Requirement **4**, Requirement **10**	
	Procucts design fits the design style of the MX-lineup and makes use of inspiring modular architecture.	Requirement **1**, Requirement **3**	
	A logistical network that facilitates the user in their responsibility for self-repair, maintenance and customisation.	Requirement **3**, Requirement **4**, Requirement **5**, Requirement **6**, Requirement **10**	Consideration **24**
	Hub setup needs to be able to disassemble into a package without any separate parts.		Consideration **7**
	Hub should provide following features through its ports: Modules that provide accommodation and power for other devices (i.e. phones, watches, screens, etc.). Adapters that provide ports (video, audio, data, etc.). Modules that accommodate external storage.		

10. Prototyping

The next chapter uses iterative prototyping to make concept more concrete and feasible. The final prototype created from this chapter will also be used to validate the concept through calculating (manufacturing) costs and user testing. Th chapter aims to answer the following questions:

RQ8: How does the product system of the hub and its modules come together into a coherent package?

RQ8.1: What will be the best position, size and shape of the hub?

RQ8.2: What should the mechanical and electrical interface between hub & modules look like?

The design brief gives clear directions on the challenges and goals for the prototype. This chapter talks about the directions that were explored during prototyping of the hub as a product, the interface and the modules (Figure 52).

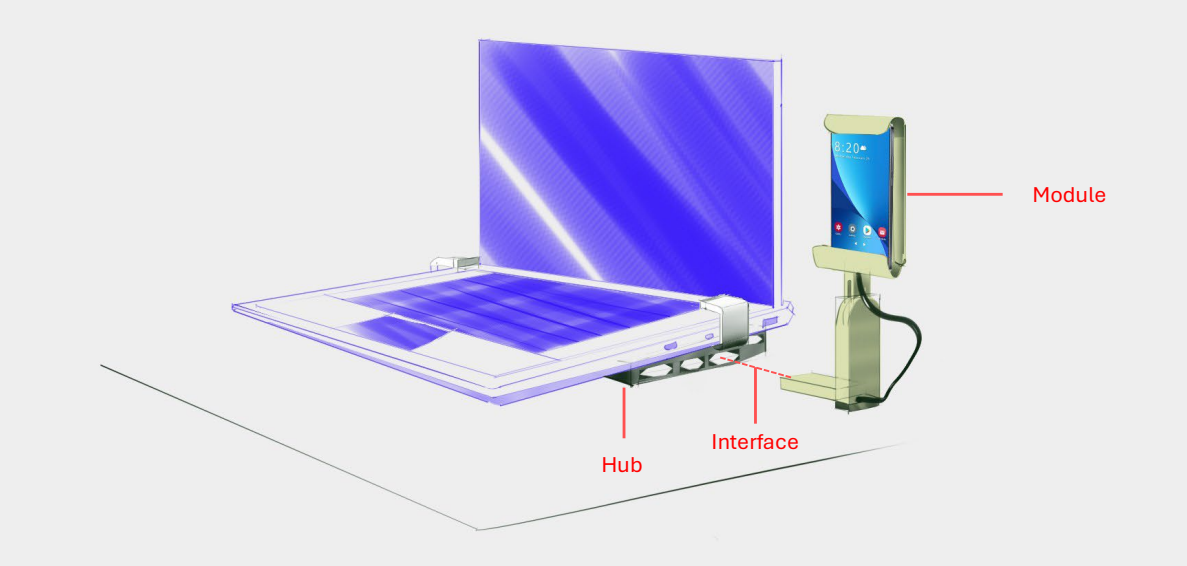


Figure 52. Annotated parts of the design to be developed in prototyping.

10.1. Hub

This subchapter will focus on answering the following question:

RQ8.1: What will be the best position, size and shape of the hub?

Knowing what the possibilities are in terms of size and shape provides us with an understanding of what is possible in terms of internal architecture and attachment of modules.

10.1.1. POSITION AND SIZE

The aim was to first understand the accessibility required to provide the user with the customization they need. To better understand this, several peripherals that were desired by DNs based on the analysis (Chapter 6.2.1 & 9.5) were drawn around a laptop to understand where ports needed to be placed (Figure 53). Mice and keyboard were not considered seeing that these are now mostly battery powered and wireless.

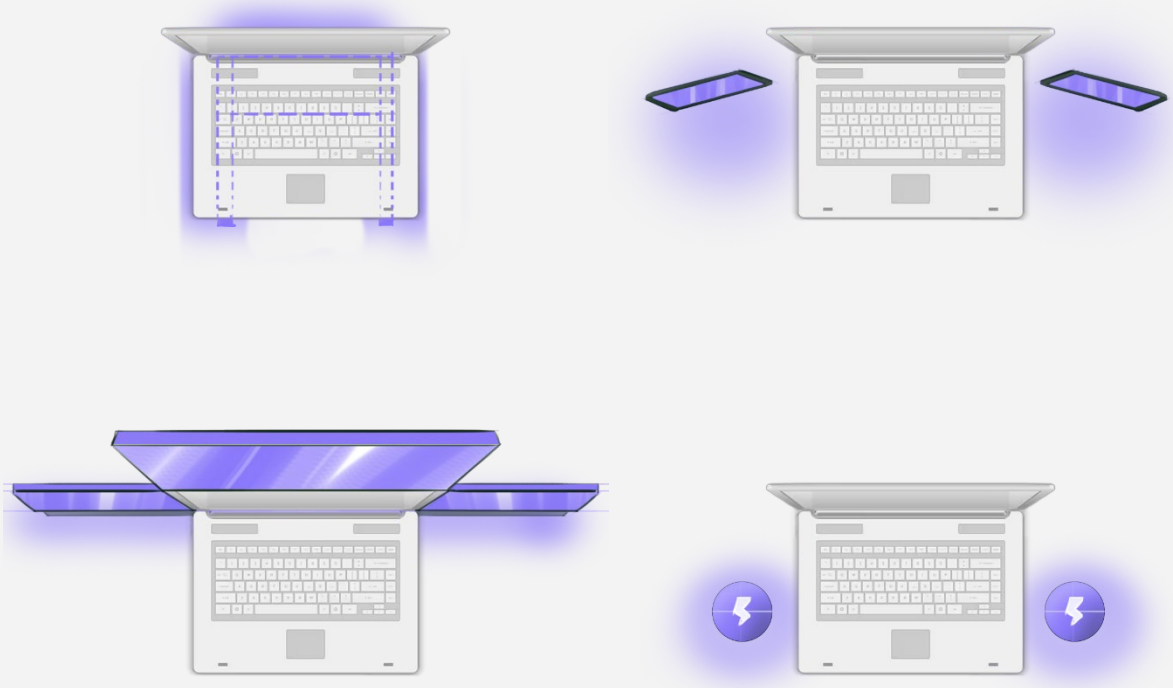


Figure 53. Top view of the preferred positioning of a laptop stand (top left), Tablets (top right), External monitors (bottom left) and wireless chargers (bottom right).

The placement of the peripherals led to a heatmap that showed the required positioning for the different PC peripherals shown in Figure 54.

Figure 54. Heat map of the PC peripherals, showing the most important places for acces.

The heatmap shows that to provide users with the most flexibility in terms of customizability and accessibility, the hub should be available from both sides of the laptop and preferably the back. To allow for a laptop stand feature, a module should be attachable to the bottom of the laptop.
In the placement of the hub, it should also be considered that certain modules should build in three dimensions (x,y,z), an example being the phone holder. For these kinds of modules, it is important to have a secure fit to the hub as well as a secure base, seeing that they have a long mechanical arm from their point of attachment as well as a heavy device at the longest point.

Two shape studies were conducted using Low-fidelity cardboard and foam prototypes to test what positions on the laptop would suit the hub best. The shape first study, of which some examples are shown in Figure 55, led to several findings:

- The shape of the hub itself can also be used to provide ergonomic benefits, shape B for example also functions as laptop stand. Positioning the hub underneath the laptop also has the benefit of not taking up any space in an often already cramped worksurface.
- Shape A provides the best access from any side of the laptop but is also significantly larger than other options making it unpractical.
- Positioning hubs higher up the back panel of the screen leads to balance issues, making the laptop easy to tip over and at risk of overextending.

Figure 55. The three most promising shapes and positions for the laptop stand.

The second shape study made use of a combination of cardboard and foam shapes combined in different configurations based on the three selected configurations from the first iteration. It tested:

- Whether the introduction of non-cuboid shapes could give new insights.
- Whether there was more room for multifunctionality in their shapes as was discovered in shape B in iteration 1.
- If the shapes were comfortable to work on ergonomically from different positions.

The Wedge shape (Figure 56) was eventually selected for the fact that it provides the most accessibility combined with the added functionality of a laptop stand and reduced footprint.

Figure 56. Wedge shape selected for the prototype.

The main dimensions of the chosen hub shape are displayed in Figure 57.

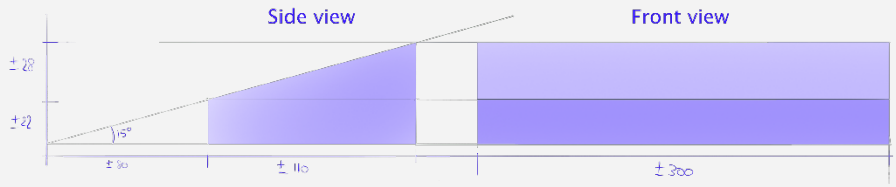


Figure 57. Rough dimensions in which the hub should fit to fit most laptops and provide a comfortable 15-degree angle.

The dimensions were designed so that the device would fit under most common sized laptops while still providing access for all necessary modules. The volume of the hub shape would provide plenty of space for the electronic architecture as well as providing a compartment where modules could be housed when traveling. The hub would be able to house six ports comfortably, which was assessed to be plenty for the number of modules DNs would use, the modules would be positioned as shown in Figure 58.

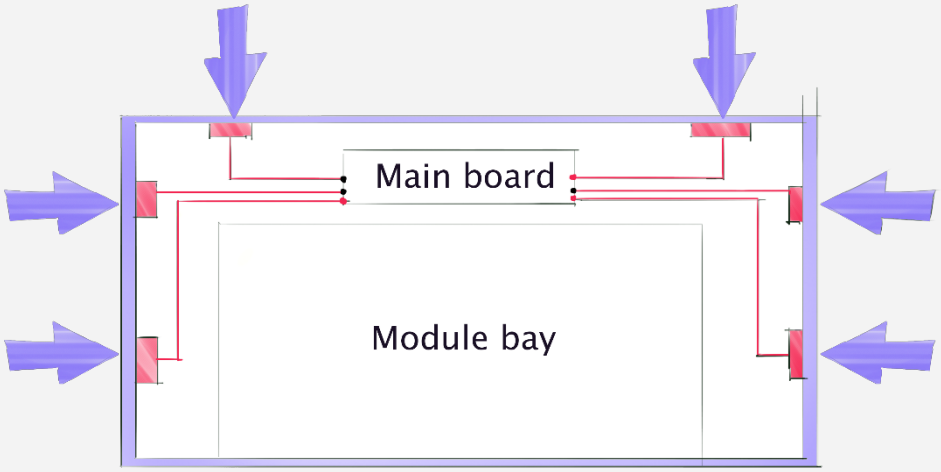


Figure 58. Position of the slots on the hub, based on shape of hub and preferred positioning of modules.

10.1.2. SHAPE

Now understanding the positioning and size constraints it is possible to start ideating on what the hub will look like. Figure 59 displays the Morphological chart used to explore a variety of possible configurations.

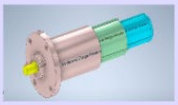
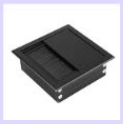
Adjustable width	 **Telescopic**	 **Rails**	 **Separate parts**	 **Foldable**	 **Non-adjustable**
Laptop stand	 **Solid**	 **Two arms**	 **Plate**	 **Foldable**	
Compartment	 **Latch**	 **Rolling shutter**	 **Fabric**	 **Hard case**	
Dust/Gunk prevention	 **Bristles**	 **VHS latch**	 **Rubbers**	 **Exposed ports**	

Figure 59. Morphological chart used to explore possible shapes and features for the hub.

The Morphological chart was used to come up with multiple configurations displaying different ways of deploying, storing and using the hub, four examples are shown in Figure 60.

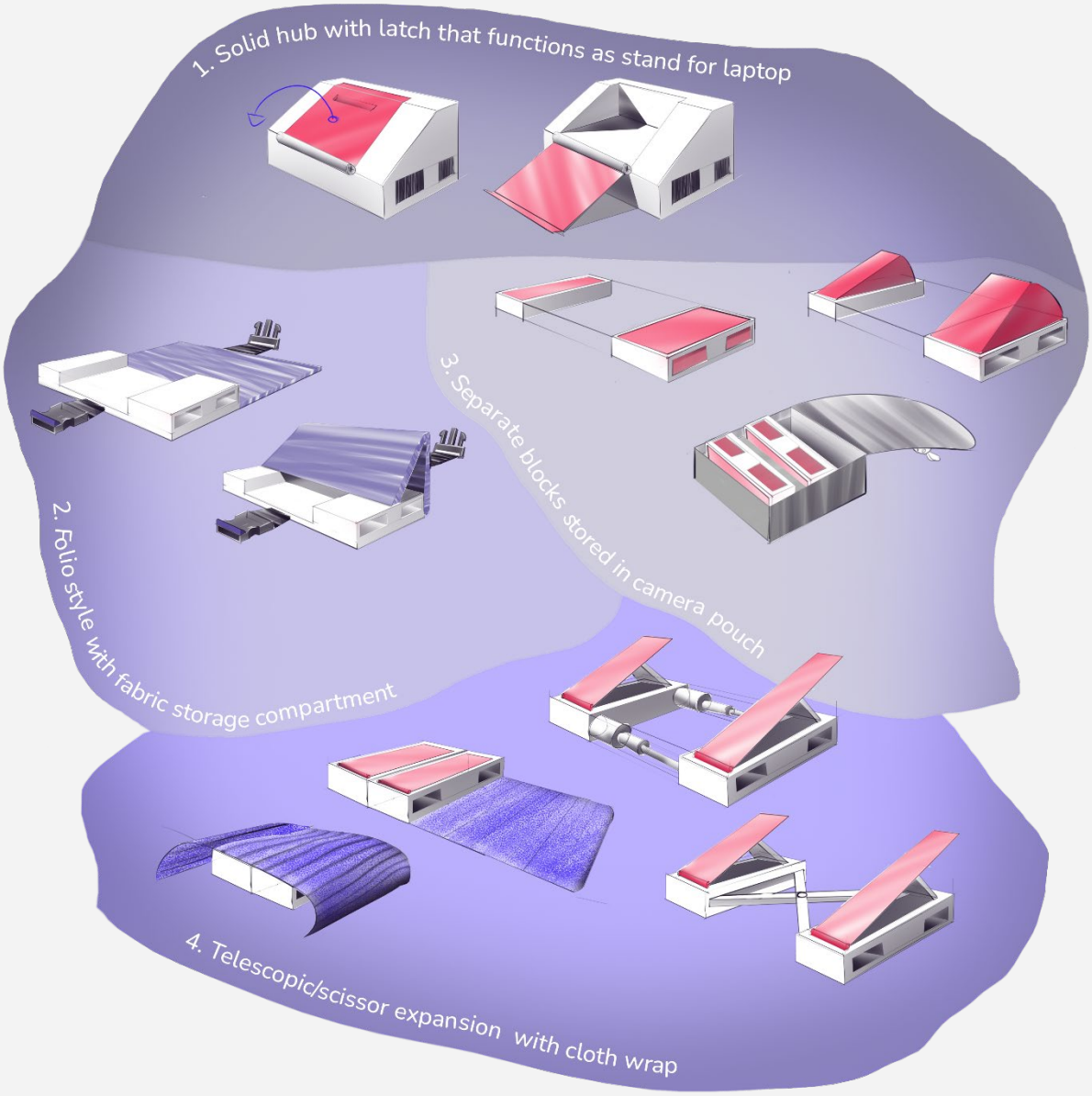


Figure 60. Designs for the hub that resulted from the morphological chart.

A Harris profile (Van Boeijen et al., 2014) was created to assess the different configurations (Figure 61). The requirements used for the assessment were based on the tensions in needs discovered in chapter 6.3. The assessment of the different configurations was discussed with several designers and DNs to better understand the benefits and shortcomings of each configuration.

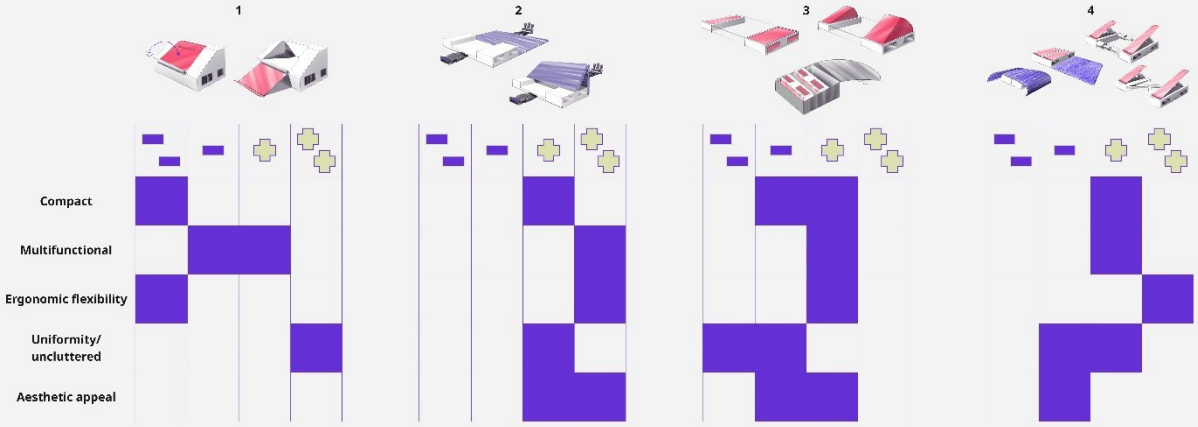


Figure 61. Harris profile used to assess the different design directions for the hub.

The decision fell on configuration seeing that it scored highest, particularly in its multifunctionality and ergonomic flexibility using a Folio case, comparable like the ones used in certain tablet cases like the existing Folio from Logitech (Figure 62).

Figure 62. The Logitech Folio case designed to combine flexibility, ruggedness and functionality

Figure 63 displays the folio mechanism developed on configuration 2. The folio style design allowed for a protective case to also function as a laptop stand, while taking up little to no extra space when the product is out of use. The sleeve could also be used as an enclosure for modules, and the belt could be used to attach the hub to a laptop or attach other peripherals to the hub when travelling (Figure 64).

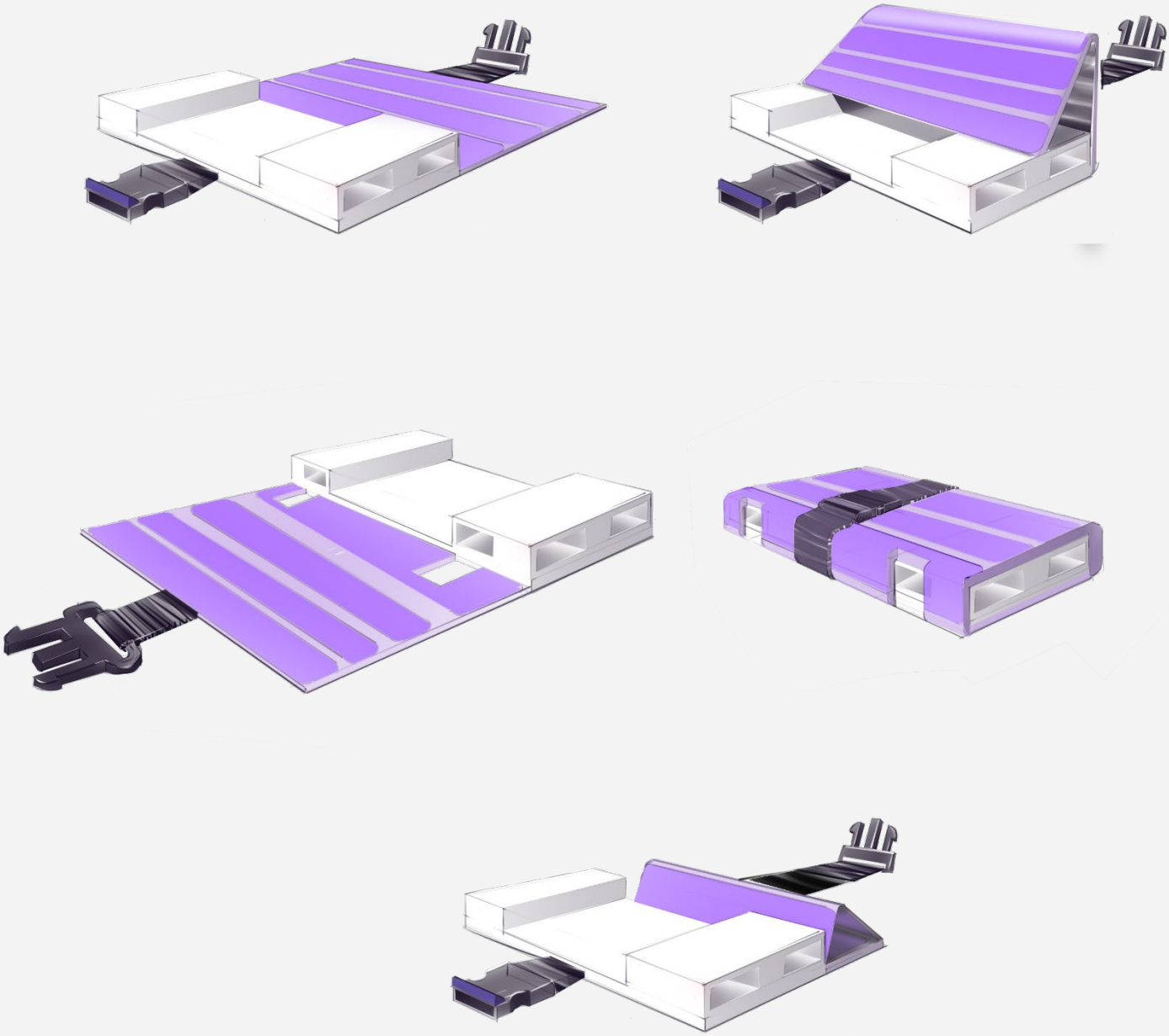


Figure 63. Applying the folio style design to the hub.

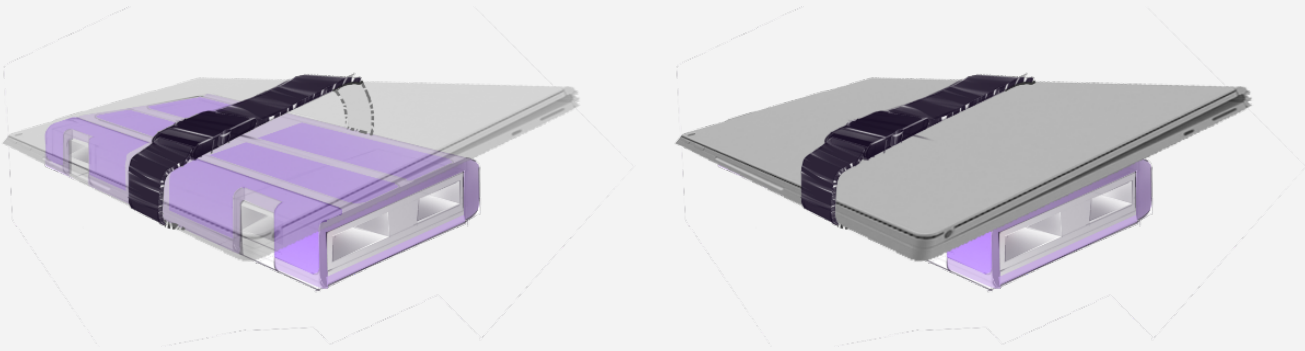
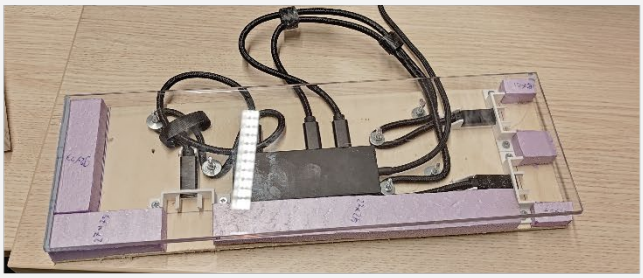


Figure 64. The belt can be used to attach the DNs laptop and other baggage.

10.1.3. EMBODIMENT

Below the design evolution of the hub is displayed.

Iteration 1

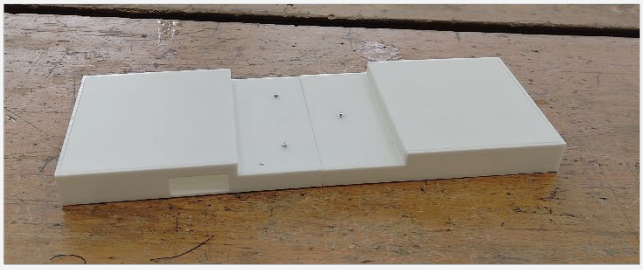


Mainly aimed at creating a proof of concept. Used an Ipad case as a stand in for the Folio case.
Prototype was too large and only contained two ports, but the system worked and showed that the folio design could support a laptop.

Points of improvement:

- Increase the amount of ports to 6
- Make hub into one uniform body
- Decrease the size by rearranging ports and improving cable management
- Create custom folio

Iteration 2



Designed to fit 6 modules and contain a module bay. due to the size of the internals the product remained about the same size as the first iteration with little improvement to be found in terms of space management.

First folio was designed with the aim of understanding the amount of material needed to create the stand, once again the size of the hub created worries on the portability of the product, especially since the hub is designed for DNs.

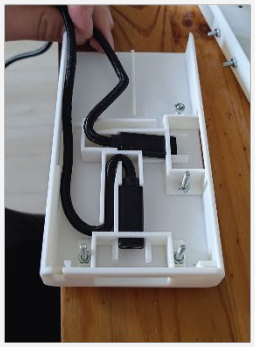
The module bay was smaller than expected, internals restricted the bay from being larger. Decision was made to remove the bay and pack modules separately.

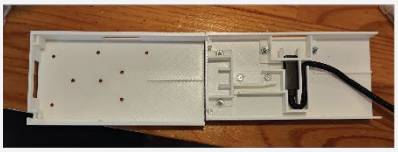
The decision was made to remove one port from both sides of the hub to slim down the product, leading to both a smaller hub and folio.

Points of improvement:

- Reduce the amount of ports from six to four.
- integrate electronics and improve cable management even further.
- Project brand identity of MX line on the shape of the hub.
- Add an exit hole for the link cable.

Iteration 3.1-3.3



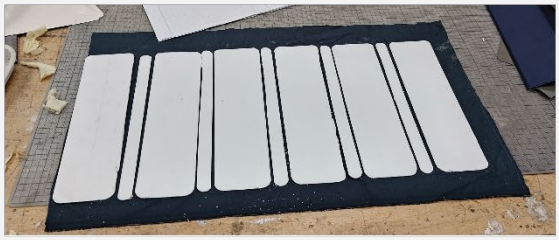


Several half hubs were printed to find the right fit for cables and the main board. screw holes were added tactically to reduce the total amount of bolts required to dissasemble the product.

Points of improvement:

- Make a full scale version of the hub that fits all cables.
- Make a more sophisticated version of the folio with buckle

Iteration 4



Full hub was made functional, one rmaining issue being that internal cables were too long, resulting in too little space. Limited space meant only two ports could be made functional.

Folio is made from PVC panels that fit tightly around the hub and is secured to the bottom of the hub. holes are made through the folio so the ports on the backside of the hub can still be used if the folio is wrapped around the hub. New finding is that the slots on the back of the hub can no longer be used effectively when the folio is folded into a stand.

Belt and buckle are attached to the folio to secure the hub tightly, also allow the hub to be attached to a laptop or bag. Separate pouch is added to house modules that are not installed in the hub.

Points of improvement:

- Reduce length of cables to make all 4 ports active
- Ensure that slots on the back of the hub can still be used when folio is converted into a stand.

Figure 65 displays renders of the hub's internals with annotated design decisions.

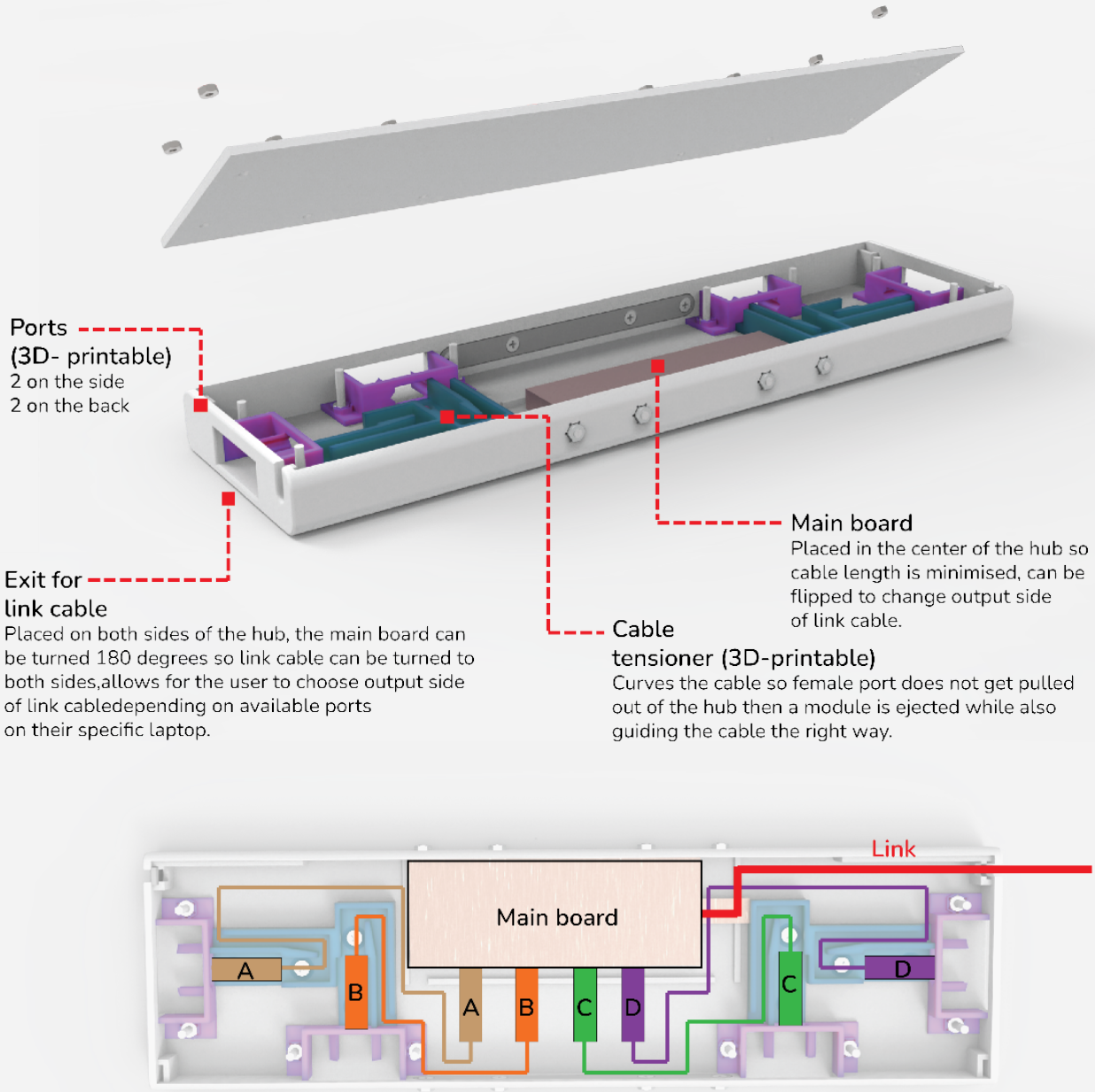


Figure 65. Angled view and top view render of final prototype with annotated design decisions.

10.2. Interface

This subchapter will focus on answering the following question:

RQ8.2: What should the mechanical and electrical interface between PC, hub & modules look like?

10.2.1. LINK BETWEEN PC AND HUB

As with existing hubs and dongles, one cable will have to run between the PC and the hub for power and data transfer. This so called “Link” is displayed in Figure 66. It is important for the link to provide plenty of capacity when it comes to both power delivery and bandwidth seeing that it is responsible for all data and power transfer between PC and the connected modules. Having a connection with low capacity will result in a system that is bottlenecked.

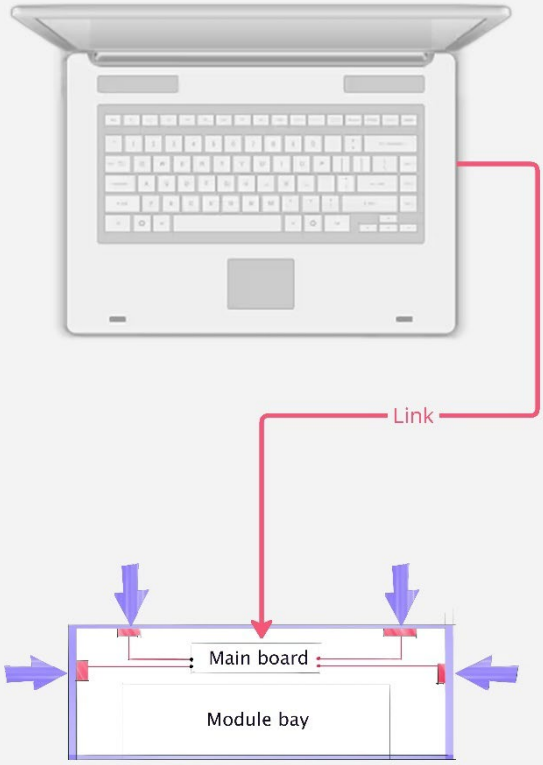


Figure 66. Schematic view of the "link" cable (red) connected between laptop and hub.

The electronic interface that was assessed to be the best fit for the link is USB type C (USB-C). USB is known as the most widely supported standard for data transfer between electronic devices, with USB-C being the newest and most capable version. The most capable versions of USB-C are USB4 v2.0 (using the USB protocol) and Thunderbolt 4 (using the PCIe protocol). Although Thunderbolt can provide higher data transfer speeds, USB4 v2.0 was chosen for the reasons listed below:

- Thunderbolt is developed by Intel, although the core technology is free to use, some features require licensing (Intel, 2025). USB4 v2.0 is completely free to use and implement outside of compliance tests.
- Thunderbolt is more expensive to implement and the performance of USB4 v2.0 is plenty for the use cases that are formulated in the design brief.

10.2.2. ELECTRICAL INTERFACE BETWEEN HUB AND MODULES

The interface between the hub and modules is an important part of the concept in the sense that it allows the user to connect the modules to the hub. The interface needs to be reliable and allow for a wide variety of modules to be attached. Like the link between PC and hub, the interfaces between hub and modules also makes use of USB-C. This is because USB-C is the most used interface for PC peripherals and other electronic devices one might want to connect to their PC.

For the interface design, a lot of inspiration came from the laptops of the brand Framework (Figure 67). What we learn from this design is that the expansion cards can be put in place by sliding them into a slot using a horizontal rail. Using a rail makes sure the USB-C male and female connector align correctly, and the tight fit makes sure no stress is put on the exposed USB-C port.

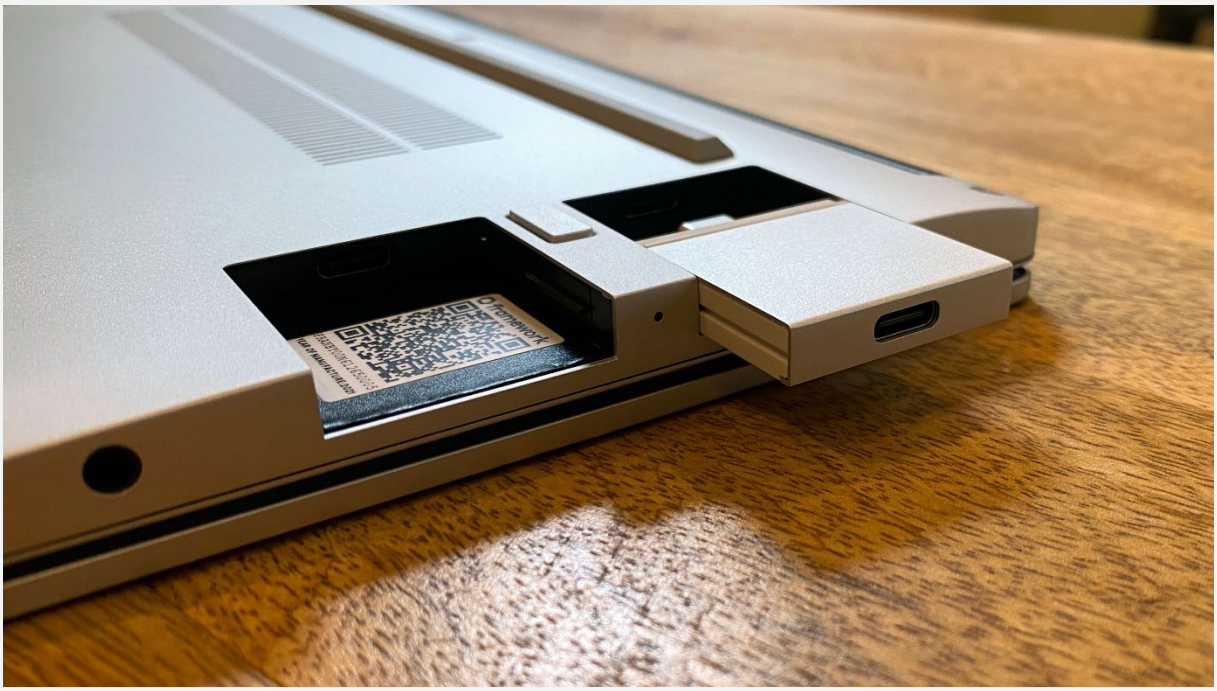


Figure 67. Mechanism of Framework expansion cards.

There are however aspects that need to be addressed in the use case of the concept:

- The cards are designed to expand on the laptop, but not for making an 3D-office.
- Framework allows users to make their own modules, but these modules require the user to design custom PCBs to fit into the slots (Elevated-systems, 2021). The interface is not designed for using USB-C cables. This does not fit well with **Requirement 6**.
- The slots are thin leading to the issue that many off the shelf-ports (like USB-A) do not fit, you need very specific parts or need to buy one from framework. This does not fit well with **Requirement 4Requirement 6**.
- The USB-C male port is exposed when the module is not clicked into the laptop, making it susceptible to damage (bending, water, etc.), for the use-case of DNs this would be a dealbreaker.

Also important to acknowledge is that the modular architecture of the framework laptop is directly attached to the motherboard of the laptop, allowing for many USB-C ports that, on paper, have little to no limitation on data and power delivery (Framework has not configured all USB-C ports for every purpose). With a hub, that has one “link” running from the laptop to the hub to make use of the ports on the hub (as displayed in Figure 66), the amount of power and data that can be provided through the hub is limited to the bandwidth of said link. Normally such an issue is tackled by powering a hub from an external power source and limiting the speed of certain ports to save on maximum bandwidth, this will also be the approach used in the concept. The hub will make use of different USB versions like USB3.2, USB4 v2.0 and USB-PD (PD stands for Power Delivery, a specific type of USB-C that supports higher wattage power delivery) to ensure that devices that can leverage such high performance are not bottlenecked by the interface, while devices that need less power and data speeds can be connected to the less powerful connections. An example configuration displaying the variety of ports is displayed in Figure 68.

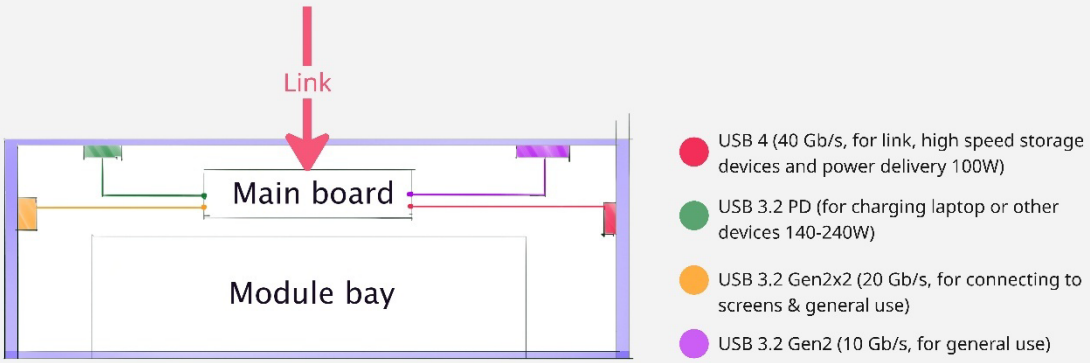


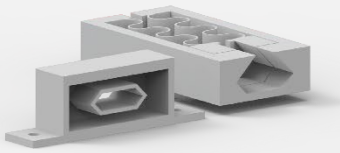
Figure 68. Example configuration showing how the hub can use USB-C cables that differ in performance.

Lastly, it should be mentioned that the different types of cables between main board and the ports in Figure 68 should be made modular as well, meaning that these cables should not be soldered to the main board, but rather also fit into each other using the USB-C interface. This is important seeing that the USB-C ports that are exposed on the outside of the hub are one of the most vulnerable parts of the hub, if these break, they should easily be replaceable to adhere to **Requirement 6**. This would mean the main board would use bus-modular architecture to allow interchangeable USB-C cables, while the USB-C cables going from the main board to the external modules would be daisy chained.

10.2.3. EMBODIMENT PHYSICAL INTERFACE

Below the design evolution of the physical interface is displayed.

Iteration 1

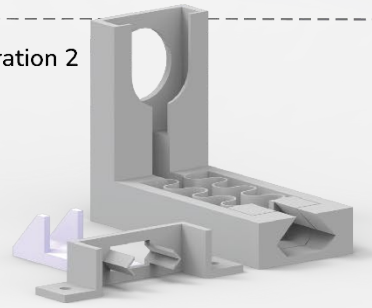


First try at creating a 3D-printable interface that could house a USB-C cable. First prototype did not contain any way to attach arms or extensions onto the interface. Female port was not flush with the bottom meaning the male module was hanging in the air more than necessary. design had no way of containing cable in female port.

Points of improvement:

- Create click-fit mechanism so user can build onto male interface.
- Improve female port by making it flush with bottom and adding a holder for the USB-C female port.

Iteration 2

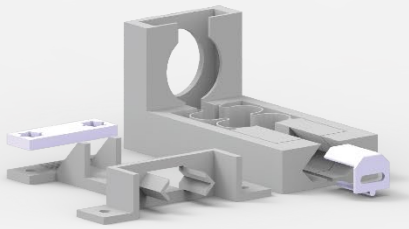


Male port now added a vertical click fit that allowed attachment of vertical modules, like a phone holder. Compliant mechanism is in the way of thicker USB-C cables Female port is now flush with the module and is reduced in size. cable holder is added so USB-C female port inside sits steady, issue now being that the cable can still be pulled out when a module is ejected. USB-C cable sits loose in the male connector, making it hard to consistently connect on the first try

Point of improvement:

- Make click-fit mechanism slim to make the shape less awkward.
- Make room for thicker cables in compliant mechanism.
- Improve female port to fixate the USB-C cable in all degrees of freedom.
- Create a cable guide in the male connector.

Iteration 3

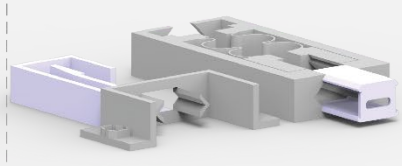


Click fit is made slimmer to improve portability, still feels a bit awkward to use. Compliant mechanism is widened so there is room for thicker cables. Cable guide is added to guide the male USB-C cable but is a very fragile piece.
A clamp is added to the female port to restrain the USB-C female port, issue with the clamp is that it does not secure well and damages the cable. Seeing that the female port only allows the male port to be inserted 10mm the connection is not sturdy.

Point of improvement:

- Completely remove L-shape from male connector so it is flush with the rest of the inferface.
- Improve clamp
- Improve guide to be stronger
- Make connection sturdier by making port longer and improve attachment points for fasteners.

Iteration 4



Male interface is completely flat at the top. Guide for male USB-C connector is made stronger and now has added rails so no stress gets applied to the part. Cable guide is improved and now shapes the cable so it naturally holds tension in both directions. Female port is extended and slots for hex nuts are added for a more secure connection.

10.2.3.1. Interface for open sourcing

For the modules the most important assessment is on whether it is feasible to have consumers and 3D-print manufacturers produce their own modules from scratch. The design of the modules should consider that not all 3D printers are the same in terms of capabilities, size and quality. The design of the module was optimized for Fused filament fabrication (FDM) printers seeing that these are the most common and cheapest type for consumer grade printers and are also widely used in industry. The hub contains several design decisions that make 3D-printing it more feasible, these design decisions are displayed in Figure 69.

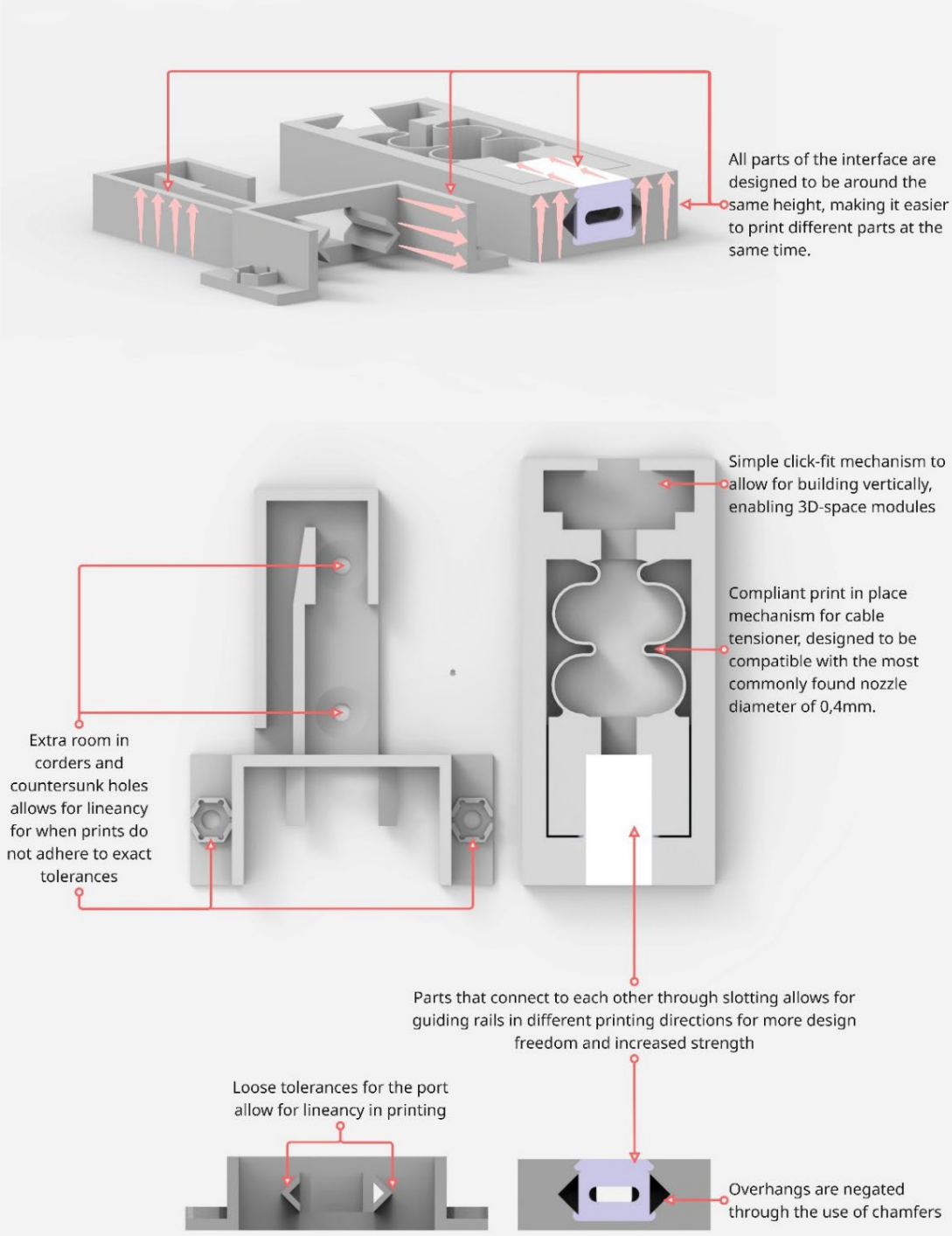


Figure 69. Design decisions in the external module interface that aid in open-source design.

10.3. Final design

The final design is shown below in Figure 70 to Figure 72.

Figure 70. Back view of the rolled-up hub, displaying the two ports that are still accessible in this configuration.

Figure 71. Three different modules displayed on the left side port of the hub, from left to right: LAN, HDMI, wireless charging.

Figure 72. Front and side view displaying the hubs capability to build up modules in 3D space, in this case a stand for a GoPro, to be used as a webcam.

10.4. Conclusion

This chapter has had its focus on improving key aspects of the concept through iterative prototyping. Below the concerned research questions are answered.

RQ8.1: What will be the best position, size and shape of the hub?

Positioning the hub underneath the laptop has several benefits; it reduces the required space needed to work, while allowing access to all the necessary sides of the laptop and hub, it is also multifunctional seeing that the hub can serve as a laptop stand.

RQ8.2: What should the mechanical and electrical interface between hub & modules look like?

Both the link cable and the interface for the external modules will make use of USB-C, seeing that this is the most common and capable interface for consumer electronics. The mechanical interface is designed so it fits a USB-C and does not put any stress on the fragile parts. The design of both sides of the external modules interface is made so it can be 3D printed easily.

RQ8: How does the product system of the hub and its modules come together into a coherent package?

The design of the hub and modules comes together in a compact and capable package, placed underneath the laptop where it not only obstructs the least, but can also provide the most functionality. Both internal and external parts can be 3D printed, allowing DNs to repair the hub when either side of this most vulnerable part breaks.
It is arguable that the final design is not a “coherent package” as is stated in **RQ8**, seeing that the modules are not housed inside the hub folio as was the plan, still, it provides a large amount of functionality in a small package.

11. Manufacturing & production costs

This chapter assesses the feasibility of manufacturing the hub as well as the ability to use innovative materials in the process, it also aims to estimate the production price. The following questions will be answered:

RQ9: Would a PC peripheral manufacturer like Logitech be able to effectively manufacture the hub?
RQ9.1: What (innovative) materials can be used to positively influence the final design of the hub?
RQ9.2: What would be the estimated cost of production of the hub?

A Bill of materials (BOM) of the prototype was created to get an overview of the materials that would be required for manufacturing. The summary of the BOM is displayed in Table 11, a more detailed version can be found in Appendix M. The technology and materials required for production are well known for a manufacturer like the reference company of Logitech and are not the interesting aspect to focus on. Instead, manufacturing experts were asked whether parts in the hub would be eligible for innovative internally developed materials, with the aim of further fitting the concept into **Requirement 1.**

Table 11. Summary of the prototypes BOM

Segment	Item no.	Part number	Material prototype ► Material final product	Manufacturing	QTY.	MASS final product (g)
Hub	1	Hub bottom plate	PLA►PCR ABS	Injection molded	1	118,60
	2	Hub top plate	PLA►PCR ABS	Injection molded	1	77,70
	3	Module dock	PLA►PCR ABS	Injection molded	4	9,43
	4	Cable tensioner R-handed	PLA►PCR ABS	Injection molded	2	9,32
	5	Cable tensioner L-handed	PLA►PCR ABS	Injection molded	2	9,32
	6	Link hole cover	PLA►PCR ABS	Injection molded	2	0,35
	7	Connector	PLA►PCR ABS	Injection molded	2	1,82
	8	Main board	Multiple►SustainaCircuits	Inkjet print	1	15,00
Cables	9	Link cable (USB4)	Multiple►PVC-free	Multiple	1	1,20
	10	USB-C male-female (USB4)	Multiple►PVC-free	Multiple	1	0,96
	11	USB-C male-female (USB3.2 PD)	Multiple►PVC-free	Multiple	1	0,96
	12	USB-C male-female (USB3.2 Gen2x2)	Multiple►PVC-free	Multiple	1	0,96
	13	USB-C male-female (USB3.2 Gen2)	Multiple►PVC-free	Multiple	1	0,96
Fasteners	14	B18.6.7M - M3 x 0.5 x 20	Stainless steel 304	Multiple	8	9,82
	15	B18.6.7M - M3 x 0.5 x 6	Stainless steel 304	Multiple	9	3,97
	16	B18.6.7M - M3 x 0.5 x 5	Stainless steel 304	Multiple	10	3,85
	17	B18.2.4.1M - Hex Nut M3 x 0.5	Stainless steel 304	Multiple	36	14,41
Folio	18	Folio panel L	PVC►TPU	Injection molded	6	468,18
	19	Folio panel S1	PVC►TPU	Injection molded	5	3,93
	20	Folio panel S2	PVC►TPU	Injection molded	10	6,55
	21	Folio vegan leather fabric	(el)PVC►PVC-free fabrics	Sheet extrusion	2	112,09
	22	Belt	Nylon	Multiple	1	49,26
	23	Buckle	POM	Injection molded	1	19,00
	Total				108	937,64

Because Logitech is used as a reference manufacturer for this project, it is possible to leverage their knowledge of Post Consumer Recycled (PCR) plastics to improve the carbon footprint of the device. Based on the FY25 Impact highlight report (Logitech, 2025b), we can assert that Logitech can manufacture an ABS-like plastic containing 80%+ PCR plastic.
The same report also mentions Logitech's partnership with Elephantech to produce *SustainaCircuits* PCBs that Use 3D inkjet printing and copper plating, reduce carbon emissions by 75%, water use by 95%, and boost reusability.
Lastly, the report mentions Logitech is capable of producing PVC-free cables and fabrics which can be used to improve the sustainability of the USB-C cables and Folio. This is an important aspect seeing that PVC is one of the most harmful consumer plastics when disposed of in nature (Lithner et al., 2012).

11.1. Production cost estimation

A rough cost estimation was made based on the formulated BOM, shown in Table 12. The mold cost per product part (+15% safety margin), production costs and packaging costs were estimated using an online tool. Purchase costs for circuit boards and cables was estimated based on current market prices. The estimation should be taken as a ballpark figure, seeing that costs of production in the market of PC-peripherals is highly confidential, especially for cutting edge materials and technology as would be used in this product. The full table can be found in Appendix M, calculations can be requested through the author.

Table 12. Estimated production cost per product.

Production quantity	10000	20000	30000
Mold cost (€)	12,68	6,34	4,23
Production cost (incl. material) (€)	37,48	37,48	37,48
Purchase costs (€)	34,70	34,70	34,70
Packaging costs (€)	4,32	4,32	4,32
Total cost per product (€)	**89,17**	**82,83**	**80,71**

The production quantities are kept relatively low for a PC peripheral, acknowledging that the hub is a first-generation product in a market that may not be new for a company like Logitech in terms of technology, but is relatively new in terms of consumer and logistics. Only the mold cost decrease over time seeing that it was uncertain how much economies of scale would apply in the manufacturing in the hub due to the specific materials and technologies being used.

11.2. Conclusion

This chapter investigated the manufacturing capabilities a manufacturer would need to create the hub, it looked into how innovative materials developed by Logitech can be used in the hub and calculated an estimated production cost. The following questions were discussed in this chapter:

RQ9: Would a PC peripheral manufacturer like Logitech be able to effectively manufacture the hub?

There seems to be no technology or material science required in the manufacturing of the hub that Logitech would not yet be known with. There is an argument to be made that Logitech is one of the most capable companies for creating a product like the hub.

RQ9.1: What (innovative) materials can be used to positively influence the final design of the hub?

Logitech presents itself online as a company at the forefront of PC peripheral design and innovation, part of that is in material science and manufacturing innovation. Several of their publicly known innovations, as PCR ABS and SustainaCiruits could be used in the creation of the hub.

RQ9.2: What would be the estimated cost of production of the hub?

The estimated cost of production would sit between €80,71 and €89,17 depending on the production quantity.

12. Validation

To assess the usability and desirability of the concept created through the DN case study, the concept was validated in two stages: physical user tests and online feedback sessions with DNs. This chapter aims to answer the following questions.

RQ10: How do users interact with the concept prototype?

RQ11: Does the concept provide the value it aims to deliver for digital nomads?

12.1. Physical user tests

The first stage of the validation consisted of four 30-minute physical user tests with students from the IDE faculty, in this study participants were observed while being instructed to interact with the hub. The users were able to configure the hub with a variety of modules; a complete overview of all modules can be found in Appendix N. The user test aimed to gather info on the following aspects:

- Whether users could successfully configure the hub to their liking and use it with their own personal laptop.
- Whether the folio-to-laptop stand mechanism was understandable and could consistently and successfully be used as a laptop stand in different seating positions (office desk, plane tray height, on lap, on couch).
- Whether users would find new and novel ways to interact with the hub that were not purposefully designed for.

The first finding was that participants experienced configuring the hub to their liking using the modules as interesting and novel. This was mainly because they themselves had a say in which modules to choose from. Something that got in the way of this freedom of configurability was that some modules did not fit in the back of the hub when the folio was folded into a laptop stand (Figure 73), which lead to the idea that a next iteration should consider adding more space or holes in the folio, so the freedom of customizability is not limited.

Figure 73. User removing a larger sized module from the back because it is obstructing folding the stand.

Several participants were surprised at the size of the folio and the amount of fabric that needed to be unwrapped before the hub was exposed. One participant stopped unrolling the folio because they thought it was taking too long and something must have been wrong (Figure 74). A redesign might be better of limiting the size of the folio, so the device becomes easier to handle.

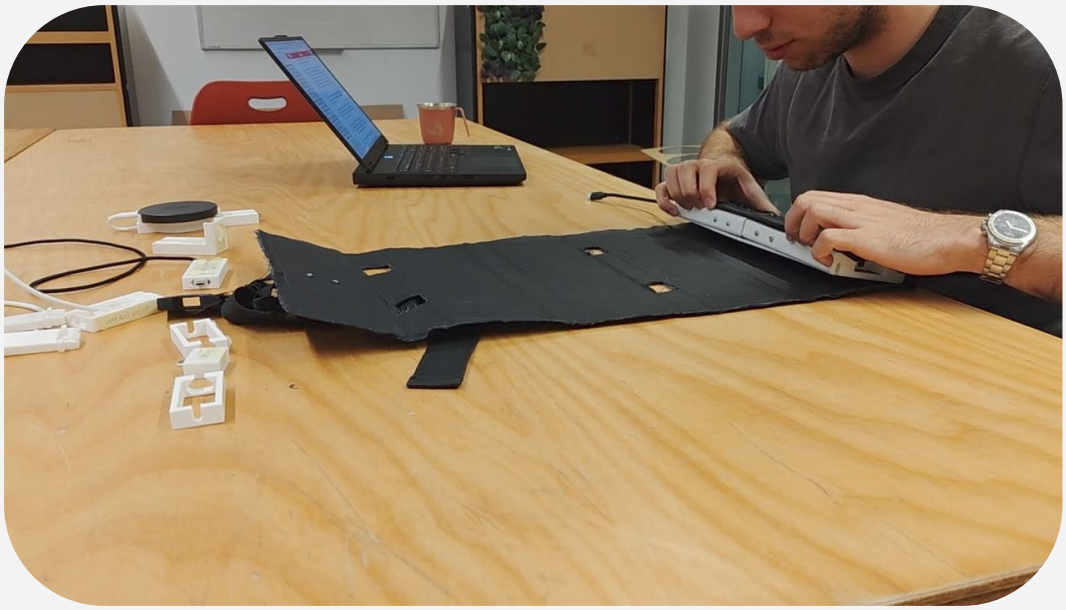


Figure 74. Participant is confused on the length of the folio sleeve, thinks about rolling it back in.

Folding the folio into a laptop stand without instructions was experienced as extremely complicated, this was a surprise seeing that all participants were well known with the Folio style iPad cases the design was inspired by. The most likely reason for this discrepancy is that the folio of the hub makes use of a longer folio with a pattern that alternates between different lengths of panels, resulting in more possible configurations, many of which were not stable enough to support a laptop. All users did indicate that folding the folio would not have been an issue if they had been given clear instructions beforehand, a new design should therefore provide the user with a manual and clearer use-cues (Dekker, 2016) on how to fold the folio. All three participants experienced the laptop stand as increasing comfort while working in both the office desk and plane tray seating position, taking the hub of a stable surface was considered uncomfortable seeing that the folio stand flexed and the laptop no longer stood sturdily.

Several observations were made on novel use of the hub that were not initially designed for.
The first case was a participant using the unrolled folio the other way around as a desk mat (Figure 75). This use case was not considered before but seemed to come quite natural to the participant. A future design might add the use of a mouse mat to further play into the DNs need for multifunctionality.

Figure 75. Participant explaining how they would use the folio a s a desk mat.

The second observation came when participants were asked to pack the hub in or on a partly stuffed backpack. Two out of the 4 participants decided to clip the hub on the outside of the backpack, on the top handle, side and arm straps (Figure 76). This displayed that the buckle on the folio would not only be useful to attach the hub to a laptop and to attach a bag with modules, but also to attach the hub to any location the user sees fit, playing into the need for multifunctionality and self-sufficiency.

Figure 76. Participants showing different ways of clipping the hub to the outside of the backpack.

RQ10: How do users interact with the concept prototype?

Part of the test showed that although participants were curious and liked the configurability, both the architecture and the multifunctional folio were difficult to interact with when not instructed on their use. Further iterations of the hub should consider making the design smaller, simpler and clearer through use cues.
Participants were able to find some novel ways of using the prototypes that were not initially thought of, like the use of the hub as a mouse mat. These kinds of use cases can be taken into account in a new design seeing that they seem easy to implement and further strengthen the concepts position as a multifunctional product.

12.2. Online feedback sessions

The second stage of the desirability validation concerned five 30 minute online one-on-one feedback sessions with DNs. DNs were shown two videos; one that displayed the use of the hub, including the opening, placing modules, folding the stand and packing up the hub and one that showed replacing internal cables (Figure 77), the instruction videos can be requested by contacting the author.

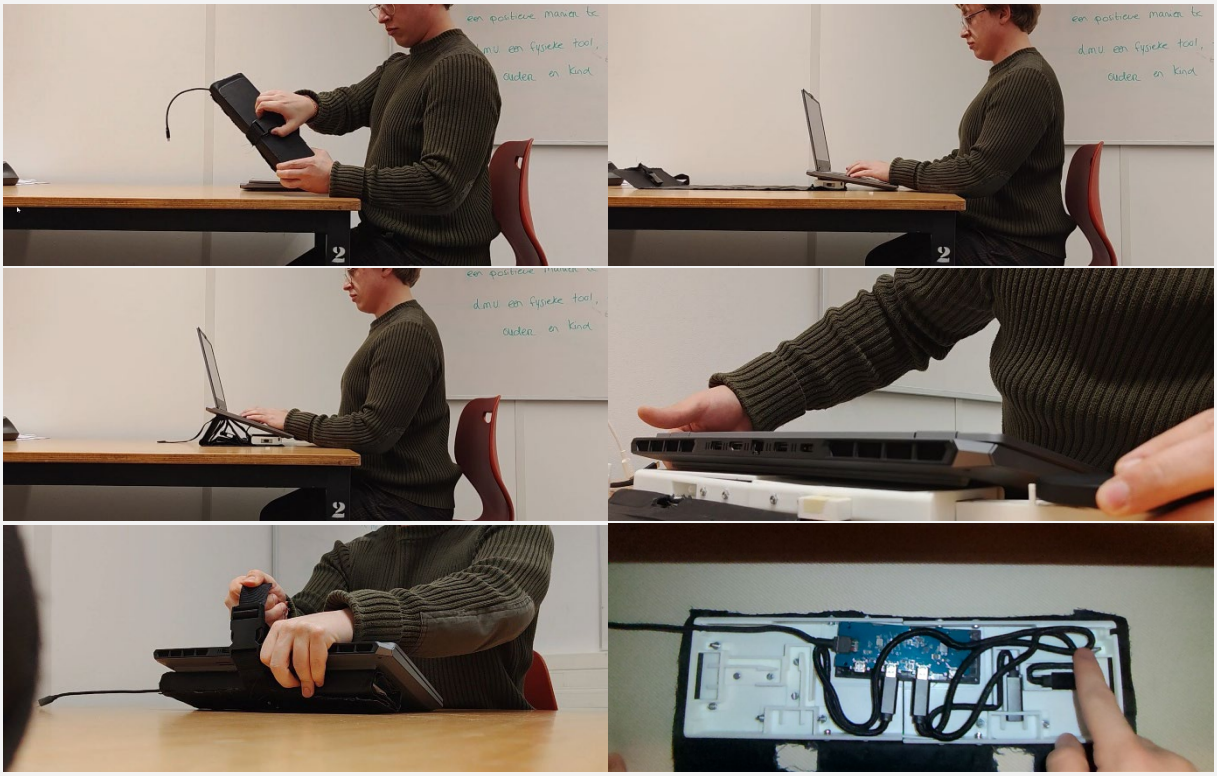


Figure 77. Screenshots from the instruction videos.

After watching the videos, the DNs were asked questions that aimed to evaluate whether the concept fulfilled needs and tensions that were found through thematic analysis as well as testing their interest in modular design and expectations for pricing. To direct the feedback into a specific use-case, the DNs were asked to place themselves into the shoes of a DN that was going to work while travelling for a minimum of three months, changing their residence at least twice a week. It should be acknowledged that the DNs were not all familiar with this situation, all were however familiar with DNs in their network who had such a lifestyle. The full list of questions can be found in Appendix O. The results of the feedback sessions are discussed below.

12.2.1. BENEFITS OF MULTIFUNCTIONALITY

All 5 interviewed DNs saw direct value from the multifunctionality of the hub to their lifestyle. DNs had many ideas on the ways they could customize the hub to be used in specific situations they had encountered (specific locations, tooling needs and compatibility issues).
The folio laptop stand was seen as a welcome addition to the product seeing that it provided a cover as well as a laptop stand in a package which is relatively small.

12.2.2. ADDED FREEDOM AND CONSISTENCY THROUGH PRODUCTIVITY

When asked whether the hub and its PSS would provide the DN with more freedom and consistency in their travel and work, two out of five said yes. The other three did not think freedom was the right word and preferred to describe it as comfort, which was still an important value to them. Three DNs that had experienced issues with the consistency and quality of their working environment mentioned that the hub would provide them with a platform they could use to create a more work-friendly environment in terms of both productivity and ergonomics.

12.2.3. WORTH PACKING?

When asked whether the DNs would pack the hub and its modules, weight was the most important factor being mentioned as a worry by three out of five DNs. Four out of five saw the hub as a device worth packing, acknowledging that the functionality outweighed the luggage space. One out of five DNs saw the size as too much of a restriction and advised to decrease the size because she did like the functionality the product provided.

"Yes, because I know from personal experience that having a stand or something you can click things onto is useful. I see a lot of people with strings and elastic bands, so I think it's an advantage that it's so compact and, as you showed in the video, you can also slide things underneath it, right? So, I think where most digital nomads go wrong is that they have six cables and things like that, and this is all in one package."

12.2.4. WHERE TO BUY THE HUB

When DNs were asked what their preferred place to buy the hub would be, the answer was unanimous that it differed based on whether they were already travelling or not. The Hub was seen as a product DNs would buy in preparation of their adventures, in which case an online store (Amazon, CoolBlue) would be the easiest.
If the DN was already travelling ordering online was no longer an option due to the frequent change of location and uncertain planning. In this case, there were two main options. The first, as explained by one of the DNs, being that the Hub would be bought in a large hardware store. DNs write down products they need on a list so they can go on a shopping haul the moment they visit a large city. The second option was in duty free stores in an airport, which was mostly because a DN mentioned that such a location would be the moment DNs realize they need a certain product (adapter, cable, etc.) and must wait anyways.

"Yes, for me that would be in an electronics shop in a large city. When I'm travelling, I would go there for repairs, shopping and things like that. And I'm thinking about electronics, so that would be the most logical place for me... Just in general, digital nomads always have something that breaks: their rucksack, their bicycle, all sorts of things."

These two different scenarios should both be considered when shaping the business model around the modular hub and its modules, seeing that both scenarios require different approaches.

12.2.5. REPAIRING THE HUB

Three out of five DNs stated they would be prepared to repair the internals of the hub themselves, one of them stating that it would be important that there were clear instructions available, and they would be informed on where to find them. The same DN also mentioned that the current design of the prototype used bolts and nuts which to her were somewhat intimidating.

A new design should have clearer use cues to indicate what parts of the hub are allowed to be repaired by the user and which are not, this aligns with the findings of Bayraktaroğlu and İdemen (2024), which showed that consumers are often reluctant when it comes to Facilitated Self Repair due to unclarity on warranty voids.

12.2.6. BUYING/MAKING MODULES

DNs were presented with 6 different options on buying or making new modules, as displayed in Figure 78. The aim of this question was to understand what their priorities would be when buying modules, comparing quality, reliability, cost and carbon footprint of the module.

DNs showed most interest in buying Main brand and 3rd party manufactured modules. There was no clear preference for buying online or in store, mostly because this was dependent on the situation, like it was with buying the hub.
DNs were not eager to 3D print modules, with only one DN having it in their top three of preferred options, the biggest reason was the fact that DNs preferred reliability at a higher price over lower carbon footprint with lower quality. As was expected based on chapter 7 on consumer behaviour, sustainability did not seem like a key decision factor, even for a target group like DNs who are more than averagely aware of their carbon footprint. The 3D-printed modules should be marketed more towards personalisation and availability rather than their impact.

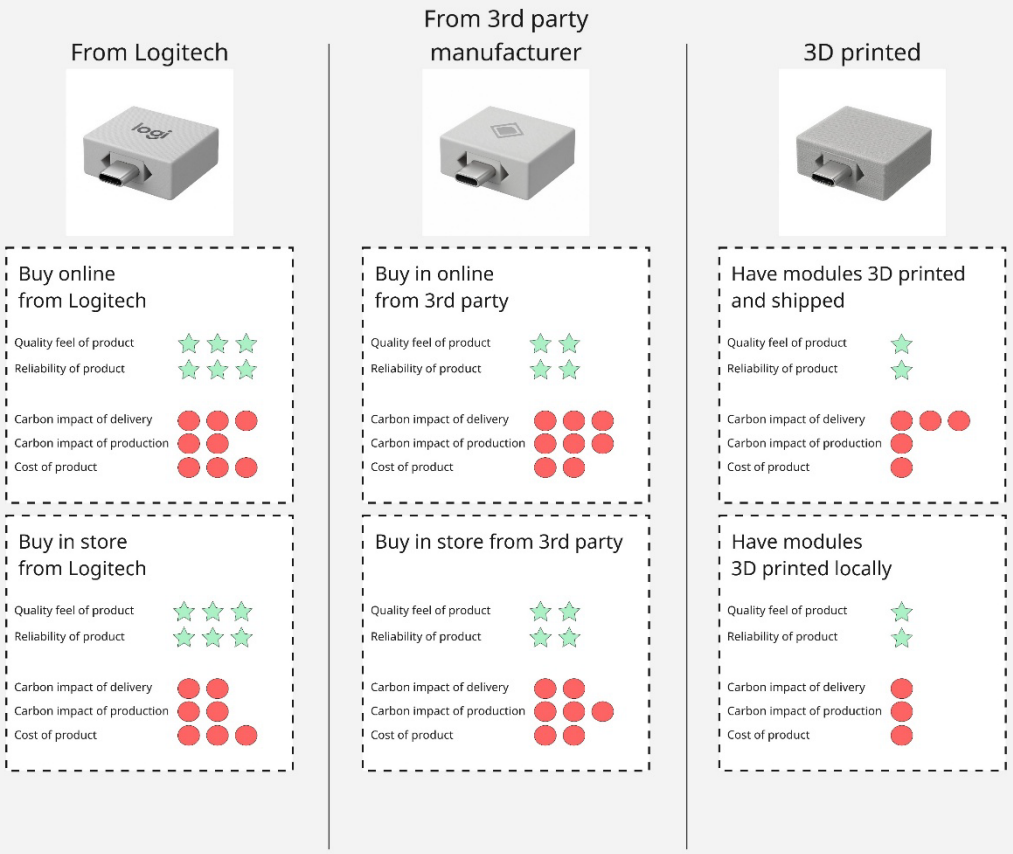


Figure 78. The different options presented to DNs for acquiring new modules, each differing in their price, quality, durability and carbon footprint.

12.2.7. PRICING

The last four questions concerned the questions used in the Van Westendorp method to get a price estimate for products (Ceylana et al., 2014). The Van Westendorp method uses the following questions to find a price range:

1. At what price would you consider the product/service to be priced so low that you feel that the quality can't be very good (too cheap)?
2. At what price would you consider this product/service to be a bargain—a great buy for the money (Cheap/good value)?
3. At what price would you say this product/service is starting to get expensive—it's not out of the question, but you'd have to give some thought to buying it (Expensive/high side)?
4. At what price would you consider the product/service to be so expensive that you would not consider buying it? (Too Expensive)

Participants knew they would have to buy the modules next to the hub, the aim was to better understand how much value was seen in the base system, while also making sure the complexity of the preferred modules did not influence the price assessment too much. It needs to be acknowledged that the validation only contained 5 participants and could therefore not provide statistically significant results, the aim was therefore more to get an estimate on the perceived monetary value of the base hub, as well as understanding the argumentation behind the different answers. Table 13 displays the result of the Westendorp questions.

Table 13. Results of the Van Westendorp test per participant.

Participant	Too cheap (€)	good value (€)	Expensive (€)	Too expensive (€)	Average
1	20	25	35	45	31,25
2	50	100	130	150	107,5
3	50	100	150	200	125
4	70	125	199	250	161
5	10	30	45	60	36,25

Looking at the average, there seems to be a divide when it comes to the value that is assigned to the hub product, while there is a chance that this difference could be proven through the low number of participants, there does seem to be a reason behind the difference. DN 1 and 5 priced the hub significantly lower than 2, 3 and 4, with the key difference between these two groups being that 1 and 5 were just starting their career as DNs and were not yet financially independent. 2, 3 and 4 were experienced DNs that were working (close to) full time. Although the difference cannot be perceived as fact, the big difference in financial independency within the DN target group it should be taken up into recommendations for future research.

RQ11: Does the concept provide the value it aims to deliver for digital nomads?

Not all DNs are willing to say the hub provides them with more freedom, but added comfort is a need they widely agree is fulfilled. Whether DNs would use and buy the hub depends on where it could be bought, its price, weight and the accessibility to information to repair. The last further signifies the responsibility of the manufacturer to enable the DN in repair.

13. Business model

The design of the hub not only puts responsibility with the user for use and repair, but also with the manufacturer for enabling the user to interact with the product as is intended. It is therefore important to consider the business model behind the hub that extends past the initial sale and ensures the consumer is empowered in their use. This chapter discusses the following questions:

RQ12: What is the role of a manufacturer like Logitech in distributing a modular product designed for self-repair and open sourcing?

RQ12.1: What services should an online platform for the hub provide?

RQ12.2: Would the hub be a viable product to bring to market in its currently developed product service system?

13.1. Customer journey and corporate responsibility

To answer question **RQ12** & **RQ12.1**, a customer journey is mapped, the corporate responsibilities of the hubs manufacturer are explained per step. Based on the interviews from chapter 5, 8 & 12 DNs would understand for a need of a product in one of two situations, the first being through preparing for travel, where DNs buys gear, they expect to need for productive work while travelling. The second way is through experiencing a lack of productivity while already travelling. Because these settings are significantly different in terms of location, setting and needs the customer journey starts in two separate tracks.

DN has unfulfilled needs

Preparing for DN adventure
Western country, permanent address

Partnerships with remote-work/DN communities and influencers can position the hub as part of the broader remote-work setup (Figure 81).

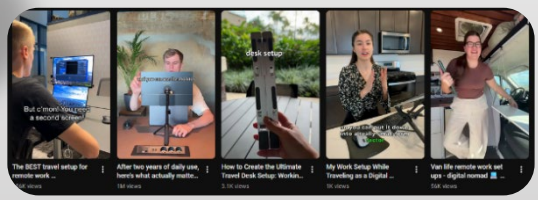


Figure 81. A quick search on any social media platform shows that work setup videos for Digital Nomads are popular.

On DN adventure
All over the world, secluded, moving frequently

DNs would find the hub through social media and word of mouth, the hub should also be a clear eye catcher in coworking spaces.

Buying product

DNs prefer ordering online through well-known vendors like Amazon. Selling through the Logitech website allows for a more detailed customisation, much like the Framework configurator (Figure 80).

Online sales also make it easier to communicate the more complex value proposition of modularity and repairability through visuals and links to repair guides than would be possible on a small product box in a physical store.

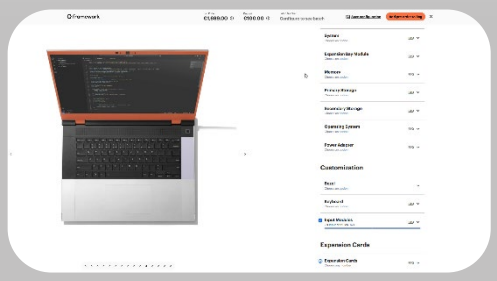


Figure 80. Screenshot of the online configurator on the website of Framework, allowing users to customize their own laptop.

Ordering online is often not possible because of DNs frequent and uncertain travel plans. DNs keep track of the products they need until they arrive in a place where they can buy everything in one single visit. In these cases, the hub should be sold through large local electronics retailers. Other valuable touchpoints would be airports (Figure 79) and large harbours. In these locations the hub can be sold in a starter pack with basic modules (i.e. port adapters), making the product more approachable. Other more specialized adapters can be sold separately so the user can take “baby-steps” to change their behaviour towards the use of a modular hub.

Figure 79. Illustration of what a hub touchpoint in a duty-free airport shop could look like.

From here, the two journeys come together. The user journey will focus on use during DN travel and work.

Start using the hub

Logitech is known for creating clear and sleek software for its products, including quick-start guides that swiftly take new users through the capabilities of a new device, it is important that the quick-start will include details on how the user can interact with the hub, and where they can find more detailed instructions on repair and open source design Figure 82.

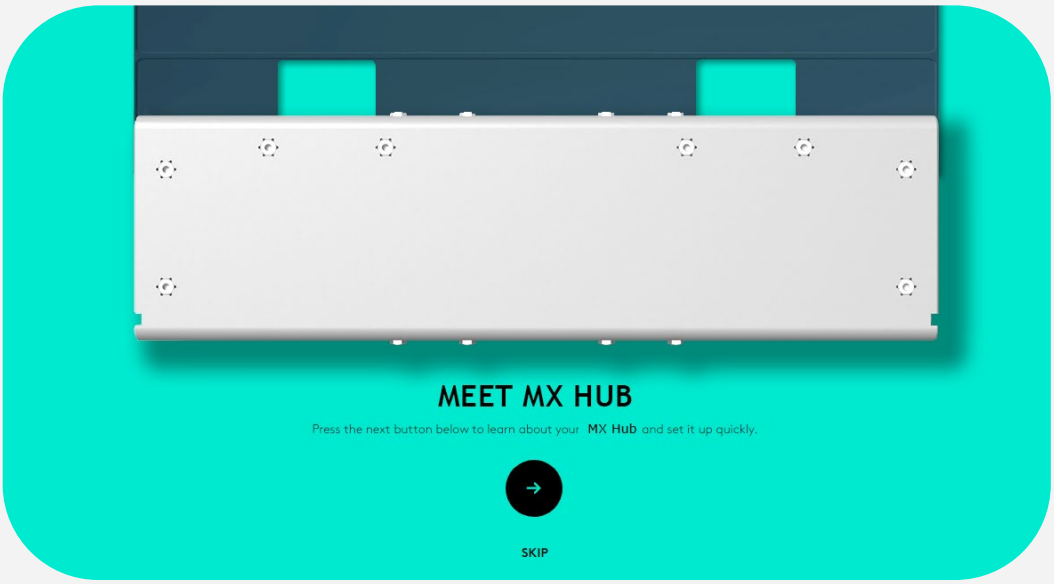


Figure 82. Illustration of the setup page for the MX hub when using the Logi options+ app.

Due to the everchanging (work)environment of DNs, the hub will be used in an incalculable number of ways and configurations. Here, it is important that Logitech takes responsibility for informing the consumer on everything from newly available modules to the communities that support the hub with open-source modules.

Wants new external modules

There are multiple reasons DNs might want to acquire new modules, the two main reasons are discussed below.

For one, DNs might want to change a module because an existing one has become obsolete or no longer provides the performance they seek. In this case, there is no real haste in replacing the module and modules can be bought in larger electronics stores and airports as the hub.

A second reason would be because an external module breaks and they want to replace it. In this case, there might be more of a hurry because the broken module could have a negative effect on their productivity. In this case, where there is no time to wait until the DN passes a store selling Logitech products, there are three options:

- The DN can try to find an external module from a 3rd party manufacturer.
- The DN can try to 3D print their own module, using the electronics that they can find.
- The DN can abandon the physical port aspect of the external module in its entirety and buy a device that can directly plug into the USB-C port without physically attaching using a cable (Figure 83).

Figure 83. The hub can also be used without external modules by plugging any USB-C cable into the port.

Logitech's main role in this stage is assuring that DNs can find information on where to buy or print new modules. This should already be primed through the setup, but it also important to keep the DN up to date on new features through online communities, social media and newsletters.

Acquiring new modules

The most straightforward way DNs would acquire new modules would be by buying Logitech or 3rd party manufacturer modules through physical stores and online web shops. The most important consideration here is that the product description needs to clearly communicate its compatibility with the hub and laptops. Seeing that not all ports will be the same due to bandwidth constrictions (Chapter 10.2), the modules should have a rating system explaining what type of USB-C connection is required for optimal use, this "level" system should also clearly be on packaging, modules and the hubs cables itself, colour coded if possible (Figure 84). To reduce the complexity of the system, newer designs of the hub concept should consider reducing the variety in cable types to make it easier for the user to find the modules that fit their need.

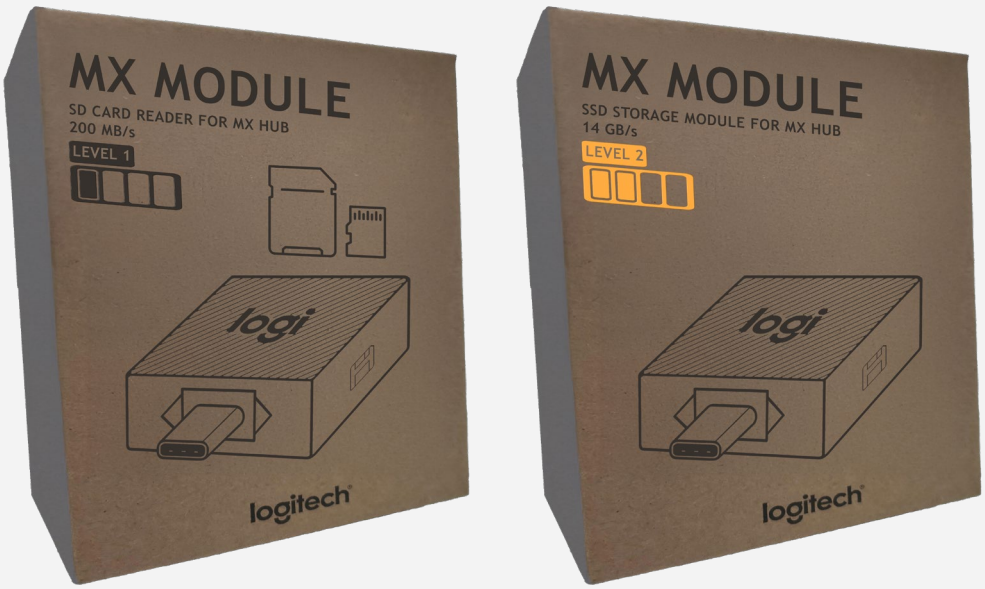


Figure 84. Illustration of the boxes external modules would be sold in, showing the different levels and colour coding that would be used to indicate the required speed.

The DN might decide to go the route of 3D-printing non-mass manufactured open-source modules. In this case, it is best to have a part of the online platform that is solely focussed on supporting modules for the hub, reason being that it will allow the creation of custom filters that provide the DN with the ability to search for the exact module they are looking for (i.e. a phone holder that fits a certain phone). To make 3D-printing more accessible, "certified" 3D-print farms should be linked on the website, these would be manufacturers that are aware of the Logitech hub ecosystem and can provide quality prints for a reasonable price.

The online platform should also contain instructions on how to make your own modules if the DN decides they want a custom module or a module that does not exist yet. Designing your own modules can be made easier if CAD files are shared with the exact dimensions of the open-source parts. This all improves further on requirements 4 to 6 by making repair and design for the hub more accessible.
Lastly, popular community made models should be certified by Logitech moderators, assuring that the use of the modules is safe and does not void warrantee.

Uses hub in preferred configuration

Once the DN has found a configuration they perceive as optimal for their workflow, it is important to keep them engaged, for DNs that use more than 4 modules this is inherent to the design, seeing that they will have to reconfigure their hub when they want to use modules that are not installed.
For DNs that only have four modules they regularly use the novelty of the hub dies down seeing that no alterations are being made.

A solution that would benefit both groups would be targeted updates based on a profile they provide during install. The most direct way to gather this information would be through a checklist during setup where DNs can check boxes on their interests and productivity needs.

DNs that have found their optimal setup could themselves become "hub veterans" that share their optimal setups through online communities and social media as displayed in Figure 81.

Hub/ Module breaks!

One of the key moments in the customer journey will be when a part of either the hub or a module breaks. As was found through interviews, electronics can and will break during a DNs journey and therefore it is important DNs know how to handle the repair and/or replacement of parts of the hub.

This segment is divided between the hub and its (modular) internals and the external modules that fit into the slots. The flowchart for a broken part within the hub is displayed in Figure 85.

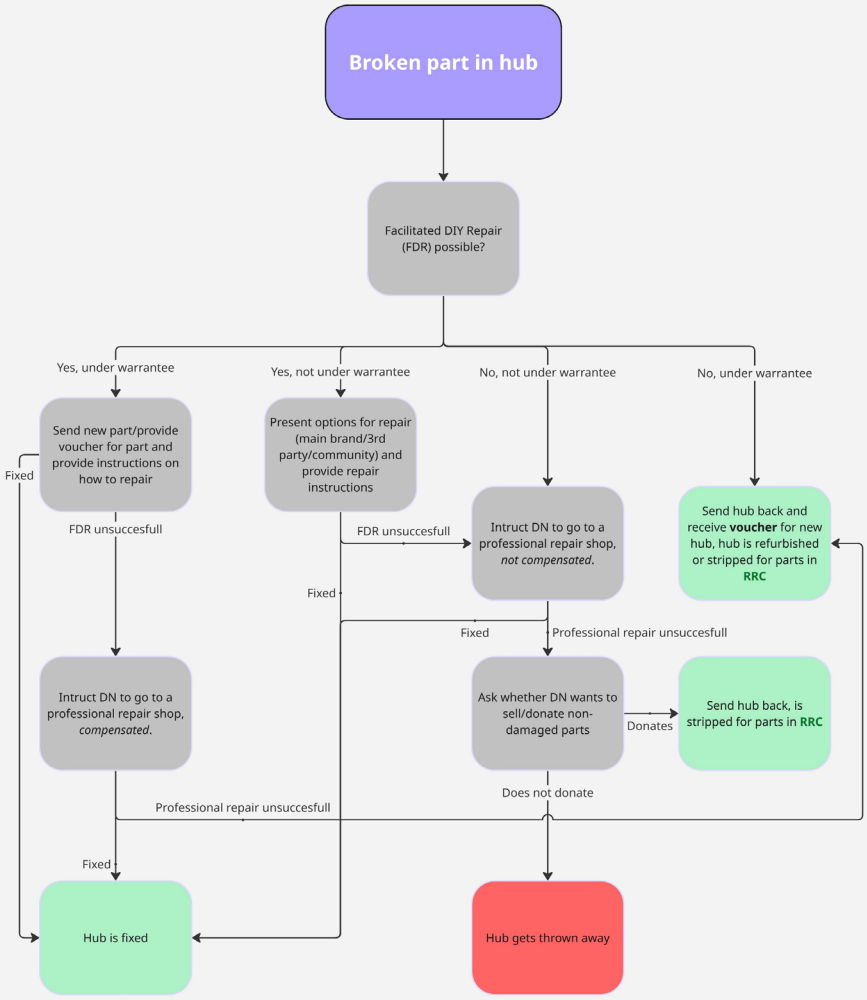


Figure 85. Flowchart for when a part breaks within the hub, showing the different possible outcomes.

The most important to note in the flowchart of broken parts within the hub is that the system is aimed at the consumer not throwing away the hub in any case. This is because even if FDR is not possible, there still is a likely chance that unaffected parts of the hub can be reused for refurbished hubs to be resold or donated. What the flowchart does not show, is the engagement that is required for the manufacturing company to ensure the DN follows the required path. Theoretically speaking, the DN could throw away the hub at any moment in any place, it should therefore always be made clear to the DN what the next step *would* be in the repair process if the initial attempt at repair fails. To increase reach, the online network of iFixIt should also be leveraged so that DNs can always find the information they need. DNs should have a clear understanding on what handlings will void the warrantee, this can be done through text but is more effective through design, by making warranty covered parts easy to access and labelled like in Fairphone and Framework products.

Another point to highlight is the vouchers. The system provides DNs with a voucher that gives them the choice to either order new parts online, or to receive money spend on a replacement part through cashback, this way DNs can acquire replacement parts without needing a fixed address. For this to work, replacement parts need to be available at key touchpoints, most effective being the places where the hub is sold.

The ever-changing location of DNs also provides a challenge when it comes to returns under warrantee, seeing that it might not be possible send a return box to the DN. One way this can be solved is by leveraging the AI enabled recycling bins Logitech has developed in collaboration with “Bin-e” (Logitech, 2025b), although these bins are only currently being piloted in Hong-Kong and focus on recycling at end of life instead of refurbishing, it shows Logitech is able to get these return points in places where it is easier for consumers to bring their products.
The flowchart for a broken external module is displayed in Figure 86.

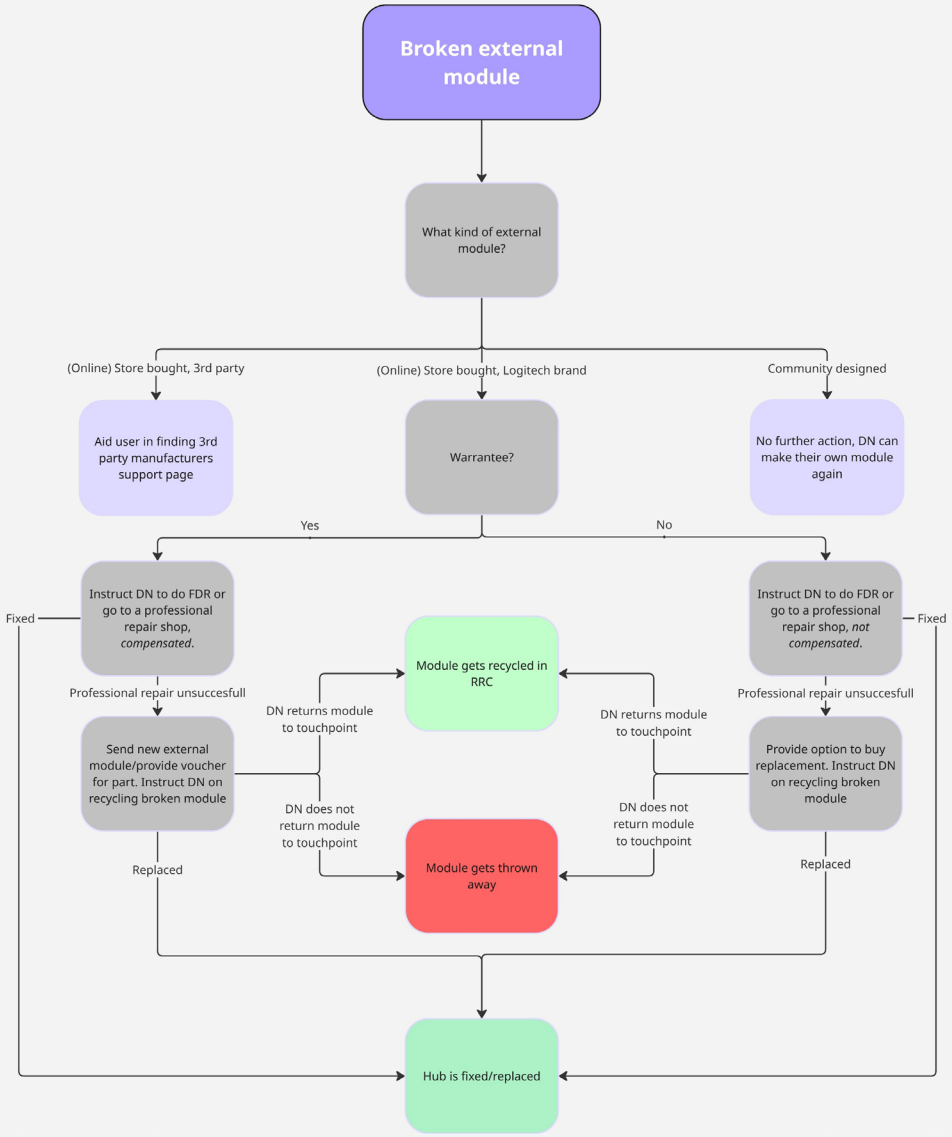


Figure 86. Flowchart for when an external module breaks, showing the different possible outcomes.

The most important to note in the flowchart of broken external modules is that open sourcing leads to reduced control when it comes to repair and end of life. Seeing that any manufacturer or consumer can design and produce their own modules, it is impossible to keep track of everything that is being released and produced. Even if it is not possible to support every type of module from every manufacturer, it is valuable to provide DNs with the information they need to come to the solution their problem requires. Online communities can play an important role, but Logitech should facilitate and moderate these communities to ensure DNs are being helped, especially in the early introduction of the product.
If a Logitech brand module cannot be repaired the DN should be instructed to hold on to the broken module until they can hand it in at one of the touchpoints, this is assessed not to be much of a problem seeing that the DN would most likely visit such a touchpoint to buy a replacement. If the DN was to order the replacement module online, the package could be returned with the faulty module in it, for this to work it is important that the viability of such returns is assessed before providing such a service. It might be that some modules are worth returning for the value of their materials while others are not.

End of (first) life

The business model should consider how the hub comes to the end of its life when it does not break. If possible the hubs should be reused and refurbished wherever possible, the hub's modular design leads to the benefit that users can do the refurbishing themselves, comparable to fixing up cars and other modular machinery.
For this to succeed, DNs need to be made aware of the retained value of their hub even if its housing, internals and/or external modules are broken or outdated. Selling/trading second-hand hubs and modules cannot be organized globally and should be approached at a local level. For one, touchpoints like coworking-spaces could store used modules for their visitors to use and buy, which can be compared to *Little free libraries*, where users can take modules and are expected to leave others they no longer use. This has a couple of benefits:

- It stimulates the perception of the coworking space being a community, enabling its visitors to experiment with modules, share experiences and show off their setups.
- It lowers the threshold for DNs with hubs to try new configurations and opens them up to new ways of working.
- It reduces the need for manufacturing new modules, lowering the carbon footprint of using the hub and increasing total use per module in its lifecycle.

This initiative can be taken one step further, by having partnerships with coworking spaces, providing them with hubs for visitors to try out (Figure 87).

Figure 87. Example of a little free library style stand for hub modules in a coworking space.

The DN interviews showed that DNs often have longer period visits to their home country, and when they decide to settle down return to their home country. When the DN stops being a DN, the hub still has plenty of value to provide through its customizability and ergonomic benefits. If the DN in this case decides they no longer need the hub, the business model should consider that it is better for the hubs to be reused rather than being shelved not to be used ever again. Interviews with DNs showed that even when travelling with little luggage, electronics that are no longer used are stowed away not to be looked at again, selling or donating a functioning hub would be beneficial to both the DN and the impact of the hub.

The hubs manufacturer can account for these situations by allowing (ex-)DNs to sell/donate their hubs to new DNs through the platform that is created for the community and sharing of module designs.

13.2. PSS Viability

RQ12.2: Would the hub be a viable product to bring to market in its currently developed product service system?

A rough assessment of the viability of the Product Service System (PSS) was made using the formulated cost of production, business model and Van Westendorp price assessment (Table 14).

Table 14. Estimated cost of product.

Manufacturing	Calculation			
Maufacturing quantity		**10.000**	**20.000**	**30.000**
Mold cost (€)	*See Manufacturing*	12,68	6,34	4,23
Production cost (incl. material) (€)	*See Manufacturing*	37,48	37,48	37,48
Purchase costs (€)	*See Manufacturing*	34,70	34,70	34,70
Packaging costs (€)	*See Manufacturing*	4,32	4,32	4,32
Total cost per product (€)		89,17	82,83	80,71
Platform development (€)	€100.000 divided by manufacturing quantity	10,00	5,00	3,33
Shipping & distribution (€)	25%	22,29	20,71	20,18
Marketing (€)	15%	13,38	12,42	12,11
Overhead (€)	25%	22,29	20,71	20,18
Margin (€)	25%	22,29	20,71	20,18
Retail margin (€)	30%	26,75	24,85	24,21
Total cost business	120%	117,00	104,39	100,19
Total estimated cost product		206,17	187,22	180,91
Low estimate (85%)		175,25	159,14	153,77
High estimate (115%)		237,10	215,31	208,04

Looking back at the Van Westendorp model, from the three DNs that were prepared to pay more for the hub two would consider the hub to be too expensive at the estimated cost from a manufacturing quantity of 10.000, with one being on the edge (Table 15). An increase in manufacturing quantity would reduce the price enough to get this DN to consider buying the hub.

Table 15. The three DNs what were prepared to pay a higher sum for the hub based on the Van Westendorp model.

Participant	Too cheap (€)	good value (€)	Expensive (€)	Too expensive (€)
2	50	100	130	150
3	50	100	150	200
4	70	125	199	250

Although these calculations are only rough estimates, they do show that the hub is priced in a higher bracket, which is not illogical for innovation and development that would be required.

One way to reduce the price further would be to take the strategy of modular design further, leveraging the touchpoints and platform for multiple products would reduce the total price per product. Selling the product directly would also make help reduce the price to a point where more DNs would be likely to consider buying the hub.

It should be acknowledged that such a step towards modularity is not easy and requires a lot of investment from a company like Logitech. Although having products be modular might make habitual change easier for the user through little steps, bringing such products to market and providing the required support is a deep investment that should be spread out amongst a larger portfolio of products.

13.3. Conclusion

This chapter aimed to discover what the business model of the hub should look like and used this to assert the responsibilities that come to the manufacturer through the lifetime of the product.

RQ12: What is the role of a manufacturer like Logitech in distributing a modular product designed for self-repair and open sourcing?

Given the complexity of the hub, Logitech should take clear responsibility for informing and guiding consumers throughout the product lifecycle. This includes lowering the initial threshold through starter packs with familiar functionality, clearly communicating (through both text and product design) which interventions are under warranty, and placing sales, repair and return touchpoints in locations Digital Nomads naturally visit. Logitech should also keep users engaged in a hub community so that “hub veterans” can support new users, and so that reconfiguration and second-hand modules become normalised ways of extending part lifetimes.

RQ12.1: What services should an online platform for the hub provide?

The business model benefits from a curated online platform that supports the hub across its lifecycle. It should explain the value proposition and use cases, help consumers select suitable modules for their configuration, and clearly communicate the user’s responsibilities in maintenance and repair, for example via repair instructions and collaborations with platforms like iFixIt. Even when modules are not manufactured by Logitech, offering basic support strengthens the overall ecosystem of the product.

RQ12.2: Would the hub be a viable product to bring to market in its currently developed product service system?

Current estimates suggest that only a limited share of Digital Nomads would purchase the hub at the calculated prices. Viability could improve by focusing on direct sales that avoid retail margins and target DNs before departure. Furthermore, costs would likely decrease if more Logitech products shared modular platforms, indicating that modularity is more promising as a long-term, portfolio-level strategy than as a one-off product.

14. Roadmap

The vision for the modular hub that is formulated in this report considers its fit to the DN target group, as well as its attainability in terms of viability, feasibility and desirability. Still, it is important to acknowledge that there are many steps to be taken before any such product can be put on the market by a company like Logitech. This chapter aims to create a rough overview of the steps towards realizing the concept vision while also looking further by seeking the applicability of findings in other product categories and services of Logitech. It does so by providing three horizons which Logitech can build towards.

Horizon 1

Setting up community and logistics for modularity.

0-5 years

Engage existing communities before launch

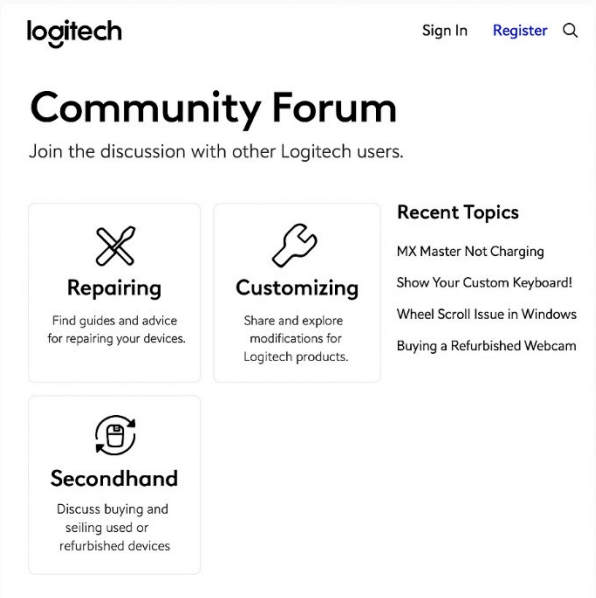
- Actively learn from current Logitech “hacking” and modding communities.
- Further research Digital Nomads’ needs and repair practices.
- Use these insights as input for the new platform.

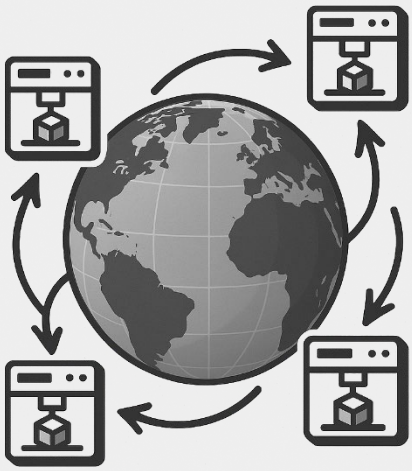
Develop the platform ahead of modular products

- Host the existing refurbishment programme and community on one central platform.
- Add forums personalising current products (e.g. MX line-up).
- Expand the collaboration with iFixit, shifting focus towards standardisation and open documentation rather than only OEM repairability.

Prepare the ecosystem of modules and production

- Proactively approach manufacturers to develop and supply third-party modules.
- Establish partnerships with 3D-print factories to enable local production of modules and replacement parts.





Horizon 2

Releasing first modular product

±5 years

1-2yrs

Launch offering

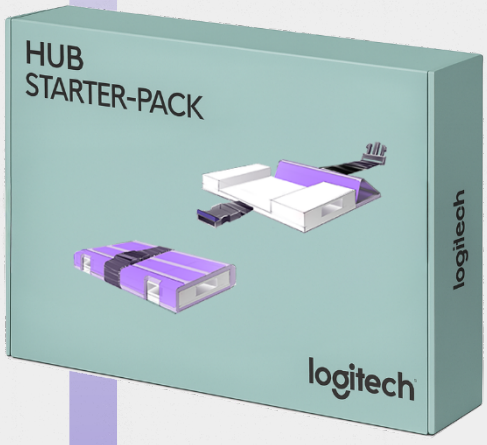
- Release the modular hub with a set of Logitech and 3rd-party modules covering the most requested functions (adapters, storage).
- Include a few more radical modules (e.g. power adapters, phone stands) to showcase the potential of the hub and trigger experimentation.

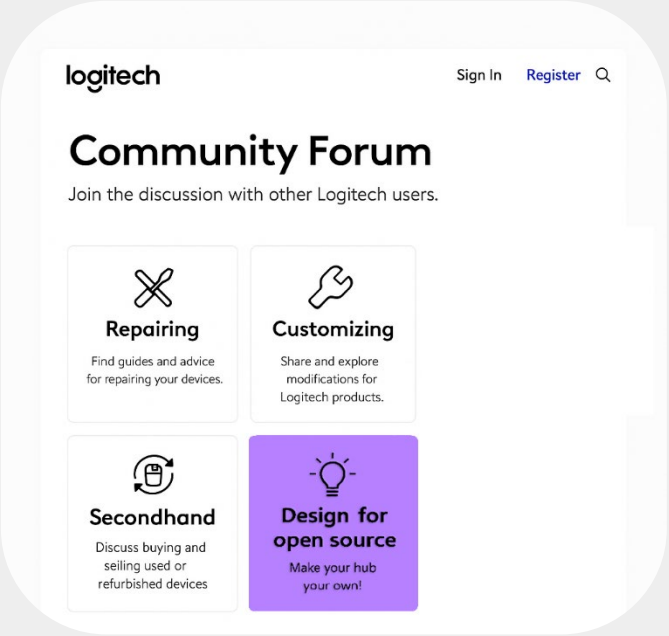
Incentivise coworking spaces

- Lend out hubs to engage DN community.
- Set up local “module shelves” where DNs can test and swap configurations.

Expand the community platform

- Provide technical drawings and specifications of interface.
- Host, showcase and support community-made module designs.





Horizon 3

Expanding modular design strategy

5+ years

As explained in chapter 13 – business model, the modular design strategy makes most sense if it is expanded to more products than the hub alone, this means the ideology of *modularity for sustainability and user experience* is applied to other PC peripherals that complement the hub, which serves as the centrepiece. One examples for the expansion would be a modular mouse, not unlike concept B (Chapter 9.2).

Consumers using the hub should be motivated to try new configurations through a combination of digital and physical touchpoints. Those who wish to sell or throw away their hubs should be reminded of the leftover value and should be supported in handing it in or finding a new user for the second-hand hub.

15. Discussion

Throughout this project many paths in the theme of modularity have been explored. This means there have also been plenty of paths that could have been explored more and others that might have been interesting but were left for the sake of constraints. This chapter looks at how the result of the project fits with the criteria it set out to fulfil, discusses the limitations of this project and presents recommendations for future research.

15.1. Reflection on final prototype based on criteria

Requirement 1: Products design should be inspiring and advocate for the future of modular design.
The final hub concept implements modularity in many ways, combining it to serve both manufacturer and consumer as was aimed. There is an argument to be made that the design could have used more intrinsic forms of modularity, leading to a more radical design, it is however not certain that such a design would have been feasible and especially desirable when looking at the DN target group.

Requirement 2: The application of modular parts in the product should have a positive effect on the products carbon footprint over the use-phase period of the product compared to an integrated alternative.
Due to the conceptuality of the design it was not possible to accurately asses the design on its carbon footprint, an attempt to validate during the final feedback sessions also led to nothing due to DNs not being able to provide a solid answer since the concept was lacking the required detail. A lot more work would have been necessary on the engineering side of the project to realize a satisfactory answer to this requirement.

Requirement 3: The application of modular parts should provide a benefit that cannot be attained using software functionality alone.
This requirement was fulfilled strongly, seeing that the hub provides a lot of physical benefits that would not be possible through software. It shows that in the current way of working there still is a need for a physical workspace that provides tooling, better ergonomics and improves productivity.

Requirement 4: Modular parts and tools needed to repair the product need to be accessible to the user (widespread availability, low cost, etc.), exceeding the services already provided by iFixIt.
The addition of making a part of the design open source has made the design of the hub more complementary to the network of iFixIt, allowing DNs to design and repair wherever they go. It is however hard to prove that the suggested business model could be provided at a low cost, as was written in the requirement.

Requirement 5: Repairs and replacements to the products' most resource-intensive parts should be performable by the user.
Seeing that almost every electronic part in the hub is replaceable, it fits the requirement, it should however be noted that no concrete research has been done on what the most resource intensive parts are exactly.

Requirement 6: Repairs and replacements to the product's parts with the highest failure rate should be performable by the user.
The aim was validate this requirement in the physical user test, and although the entire design of the hub is aimed at fulfilling this requirement, it was not validated whether the user was actually capable of performing the repair themselves.

Requirement 7: The batteries of the product should be safe yet easy to remove by RRCs and the end-user. The hub does not contain batteries and therefore passes requirement.

Requirement 8: Product should be worthwhile to bring for Digital Nomads (by for example playing into the factors of professional relevance, size and amount of use).
The feedback sessions showed DNs were enthusiastic about the prototype concept and its multifunctional design, there are clear hints to that this product fits their needs and that a segment of DNs would be willing to pack the hub on their travels.

Requirement 9: Product should clearly communicate its benefits to the Digital Nomad's lifestyle through its design.
The online feedback sessions showed that DNs understood the functionalities and benefits of the hub, it helped that the hub was solving an issue to a relatable problem with known technology. It is however not certain that the DNs could really identify with the product because it emanated DN values, or whether it provided more general benefits that appealed to all of them.

Requirement 10: The product's modular design should prevent premature replacement.
The hubs design aids the user in upgrading the hub whenever parts of it become obsolete, the business model also goes a step further by motivating DNs to pass on the hub if they no longer use it.

15.2. Limitations

The following paragraphs discuss the aspects of the project that upon reflection might have had a significant impact on the result. Each paragraph contains a suggestion on how further research might build upon the project, making the picture of modular product design in PC peripherals more accurate and complete.

15.2.1. MARKET OVERVIEW OF MODULAR DESIGN

During the exploration of modular architecture, a database was created to assess the different kinds of modularity and their frequency in the market of PC peripherals. One limitation was that it was not possible to map the entirety of the market due to the immense number of manufacturers and products. This limitation was felt further on in the project, it seemed like new kinds of modular PC peripherals kept popping up everywhere.
Another limitation of the database was that it did not contain much focus on the product category of hubs and laptop stands, even though this was eventually chosen as the direction to develop a concept in.
If the exploration on modular product design was to be continued, it would be worthwhile to expand on the current database with the insights that were found further on in the project.

15.2.2. A SCOPE LIMITED TO A BUSINESS SEGMENT

At the start of the project, the project was scoped down from the entirety of the Logitech company to Logitech PWS. It is important to acknowledge that although this segment operates independently in many factors, there are also a lot of aspects that are shared with other segments. Within the project, the capabilities of the entire company have often been used to assess the capabilities of the PWS segment, while it was not always certain that these capabilities aligned in their entirety.
Future studies should look to more clearly define the internal structures within Logitech to assess the corporates capabilities in terms of innovation, manufacturing and distribution. Creating the overview of this "bigger picture" would also provide a better idea of how modular product design can be used in other segments like Logitech G and Logitech B2B.

15.2.3. SAMPLE SIZE AND VARIETY OF INTERVIEWS AND USER TESTS

Contacting DNs for initial explorative interviews took significant effort. This was partly since the researcher had limited traction in this group from their own network, leading to a lot of unsuccessful cold calling.

It is debatable how varied the group of DNs that was eventually interviewed in the three rounds was. Initial literary research suggested most DNs have professions that do not fit the profile of the DNs that were interviewed (Coaches, recruiters), one reason this might be the case is because these DNs (data analysts, IT) are less (pro)active on social media and therefore harder to get in contact with. Lastly a part of the DNs of the initial round were also part of the second and third round, this helped in some aspects seeing that they knew the context and could provide more directed feedback. Still, it would have been better to have a larger and more varied set of DNs and to limit the amount of DNs used in multiple rounds. Future research should put in more effort to get a sample that better represents the entire group of DNs or should solely focus itself on the subgroup identified in this projects sample.

15.2.4. FIT OF THEMES ON THE TARGET GROUP OF DIGITAL NOMADS

During the second round of interviews (Chapter 9.5), questions arose on the relevance of one of the themes found in the thematic analysis of the first round. In the first round, multiple DNs mentioned they valued their online representability, leading to design directions focussed on improving audio and video quality. The same theme did not seem to emerge in the second round and DNs explained that they could improve their online representability with interventions that did not require a completely new product. This leads to the question of how much value DNs see in the other themes, part of these values were validated in the final online feedback sessions, but should be confirmed with a targeted study which is not focussed on one specific concept design.

ATTAINABILITY OF MANUFACTURING, LOGISTICS AND BUSINESSMODEL

The calculations made in the manufacturing costs and business model make use of many estimates, this information is considered highly confidential and could not be retrieved in any way. Seeing how conceptual the final design is, there was no grounded reason to make the calculations more specific, but if the project is ever taken further, it is important to have a concept design closer to market ready, while having more accurate manufacturing and business data.

15.2.5. LOGISTIC CAPABILITIES AND PARTNERSHIPS REQURIED FOR MODULE DISTRIBUTION

Part of the business model assumes that the reference brand of Logitech can deliver modules to touchpoints where DNs are then able to buy them, seeing that buying online is not always an option. It also assumes Logitech can initiate relationships with coworking spaces.

Further research should map out the presence of these touchpoints and coworking spaces to get an idea of the reach of the network, it would then be able to asses whether the network actually complements the iFixIt network as was described in chapter 9.3.

15.3. Recommendations

Throughout the project many insights have been gathered, many of which have been explored to create a better picture of the current landscape of modular product design in PC peripherals and its implication on the reference brand of Logitech. Some insights that were deemed interesting or useful were not explored for the fact of time constraints or because they were out of scope. This subchapter discusses the most important recommendations for future research in the topic of modular design in PC peripherals.

15.3.1. A MORE RADICAL VIEW OF MODULARITY IN PC PERIPHERALS

Although the project has diverged and converged in terms of scope, and discovered many interesting possibilities through ideation, there still is a point to be made that the concept that was finally developed in the case study for DNs is quite grounded in the current capabilities of a reference brand like Logitech. It might be worthwhile to take a more radical look at the implementation of modular design, by for example spending more time exploring if more intrinsic forms of modularity like sectional modularity could successfully be implemented into a PC peripheral.

15.3.2. EXPANDING THE SCOPE TO NON-WESTERN CONSUMERS

The target group of Digital Nomads was chosen for this project for multiple reasons having to do with their needs and value tensions as well as their ability and motivation to change. The fact that the concept that is developed currently caters a group of western consumers in secluded places in the world begs the question whether it might not have been more interesting to design a product for the natural inhabitants of these places.

Products in design often have the habit of targeting groups that in some way resemble *Young Urban Professionals* because these kinds of groups are young, open to change and more than financially capable to change their consumer behaviour. Although one could argue that change often starts in these groups, it might also be interesting and more challenging to target groups who are less capable to change. Future research could investigate how able target groups with lesser intrinsic motivation for change are in adopting modular design, and whether modular design could maybe benefit them even more.

15.3.3. IMPLEMENTING THEORY ON CONSUMER BEHAVIOUR MORE STRONGLY

Chapter 7 explored how consumer behaviour research applied to modular design, and how it could be used to stimulate desired behaviour in DNs for repair and maintenance of the concept. In the end, only a part of the theory was applied to the concept. Taking another look at the behaviour side of modular design with the current state of the prototype would most likely result in useful feedback.

15.3.4. ONLINE PLATFORM - PARAMETRICALLY DESIGNED MODULES AND RATINGS

When developing the external modules for the hub, the thought came to mind that the size of certain modules would be dependent on the laptop of the user, and example being that the module would need to stick out more if the user has a laptop wider than the hub itself. One solution would be to provide parametrically designed solutions through the online platform that supports the hub's community. This way, DNs would be able to decide the size of the modules themselves or even select a specific template for their laptop model.

Another aspect of the online platform that was not thought out to the preferred extend is the rating and certification system that could be set in place to ensure high quality 3D printed modules. Seeing that the platform plays an important role in the acceptance of the hub, this should be explored further.

15.3.5. A HUB THAT HAS A DETACHABLE USB4 CABLE

The final prototype of the hub used an off the shelf USB-hub, which has a “link” cable that is directly connected to the board of the hub. Further iterations should investigate the benefits and downsides of making this cable detachable.

15.3.6. MAKE PORT MORE RELIABLE

The current design of the port was a result of an iterative process leading to a mechanism that is functional but not ideal. It considers certain rules for 3D printing, but also leaves out others, one of them being that corners should be rounded more, and chamfers should be present in spaces where tolerances are tight. Further research could go into how to make a port that provides the same or better interactivity while being slimmer, more durable and easier to use.

15.3.7. USING USE CUES TO IMPROVE USER EXPERIENCE OF REPAIR

The online feedback sessions with Digital Nomads confirmed the findings of Facilitated DIY Repair from the consumer behaviour chapter in the sense that consumers are reluctant on self-repair if it is unclear whether disassembling the product voids warrantee. One way to combat this would be through clearly informing the DN using an introduction flyer or information on setup.
A more natural way of setting clear boundaries for warrantee would be using clear use cues on the product, showing that the user is and is not allowed to do. One example would be to make the initial opening of the hub toolless, and use stickers, different kinds of bolts and colours to indicate what they are allowed to change in the internals. Further research could investigate which use-cues are clear from a communicative standpoint while also not hindering the design of the modular product.

15.3.8. PROVIDING INSTRUCTIONS ON HOW TO DESIGN AND PRINT MODULES.

The project did not go into much detail on what the open sourcing and instructions on designing modules should look like. It is however understandable that just publishing the CAD files of the interface does not mean people will start designing new modules by themselves.

15.3.9. MORE DETAIL ON RRCS

RRCs were assessed to be a party that could benefit significantly from modular product design, seeing that it would allow them to disassemble electrical devices more easily while also allowing for easier refurbishment, all without requiring the missing manufacturing licence. Although the RRCs are named in the flowchart of the repair for hub and modules, there is no further work on how the RRCs would then disassemble the hub, and whether the hub could be further designed to cater to their needs.

16. Conclusion

This project sought out to explore the wide design space of modularity and answer the following research question:

What role can modularity fulfil in computer peripherals, and how can it be used to improve consumer adoption of sustainable products?

This conclusion aims to answer this question based on the findings throughout the project which were formulated through literary research, expert interviews, iterative prototyping, multiple feedback sessions, and user tests.

The market of PC peripherals undergoes rapid change; the lifecycle of the products is short and there is a constant competition for innovation. Still, it seems that there is much to be gained from modular product design philosophies. Through mapping out the current landscape of modular design in PC-peripherals, it became clear that although there is plenty, most of it is clustered around the simplest and most extrinsic forms of modularity. This is not an issue, seeing that all forms of modularity can benefit the user in some way, it does however show that for a market where brands and manufacturers have a hard time standing out as “innovative” or “market leading”, a solid strategy on modularity seems to be untapped potential.

Modularity can be combined with design for open-source and standardisation to enable repair in places where logistical networks might normally not be able to supply, this could provide significant value to target groups like Digital Nomads and groups who permanently live in these secluded areas.

It should be acknowledged that applying more intrinsically modular design is not something a company can just try once without effort. It not only requires (re)designing a product from the ground up, but it also means updating and expanding both online and physical networks to enable the user to perform in the sustainable way you want them to behave. If a company only puts in half effort, it is most likely that the modular aspects of a design will not be leveraged to the benefit of any stakeholder, even resulting in a worse carbon footprint than integrated alternatives.

17. Appendices

17.1. Appendix A. Brand Analysis & scoping

Logitech is one of the best known companies in the market for computer peripherals. The mission of the brand is to “Extend human potential in Work & Play” (Logitech, 2025a), and it tries to achieve this by offering computer peripherals for a large variety of customers in different price segments. This brand analysis takes a look at both internal and external factors in order to get a comprehensive overview of how Logitech is perceived by consumers, competitors and distributors.

17.1.1. INTERNAL ANALYSIS

Logitech provides extensive coverage of internal goals and achievements through its investor relation platform (Logitech). The global presence and size of the company makes Logitech a well-known name in most of western households and offices. Logitech was rated as #20 of Forbes’s *Worlds best employers* and has stated it values its employees are at the core of its business (Logitech, 2024c).

17.1.1.1. Brand Family

The company Logitech houses multiple brands; Logitech, Logitech G, Streamlabs, Ultimate Ears, Astro Gaming, Blue Microphones (Figure 88). Logitech also acquired the streaming camera company MEVO and the earphone brand Jaybird, these brands have been completely integrated into Logitech and Logitech G. The different brands all have separate design departments that function independently.

Figure 88. The Logitech brand family (Logitech, 2022)

17.1.1.1.1. Logitech

The brand Logitech is responsible for selling most computer peripherals the company is known for. The brand has changed a lot in terms of product portfolio and identity in the last decade (Figure 89).

Figure 89. How the styling of Logitech products changed the last decade (Logitech, 2025a)

Not only has Logitech moved away from making only computer accessories, the brand has channelled much of its recent efforts into new areas of interest, such as tablet accessories, portable speakers and gaming equipment.

- *Alastair Curtis, Chief Design Officer of Logitech from 2013 to 2023 (Keh, 2022)*

The brand houses both a B2C and a B2B segment which operate separately in most departments. The B2C segment of Logitech is responsible for the development of most computer peripherals like keyboards, mice, headsets, webcams etc. The B2B segment, mostly stationed in the US, focusses on business solutions like conference call solutions and office management (Figure 90). Most main brand Logitech PC peripherals are configurable using the *Logi options+* software.

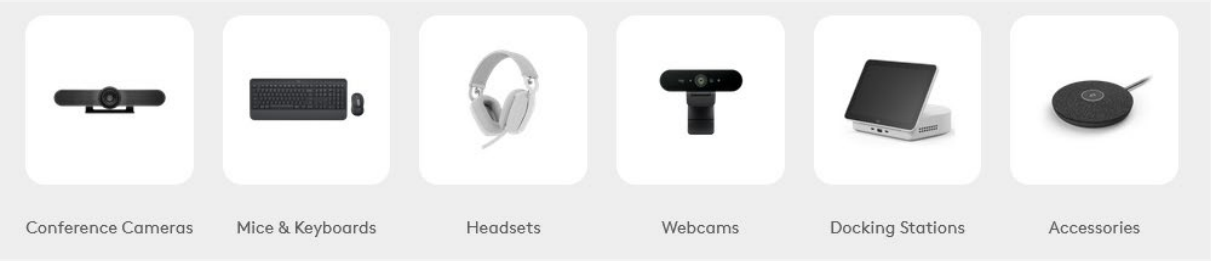


Figure 90. Products displayed on the website of Logitech for business (Logitech, 2025c)

17.1.1.1.2. Logitech G

Logitech G is the gaming segment of Logitech, it focuses on Gaming peripherals for PC and gaming consoles, it is also the segment responsible for simulator products for racing, flying and heavy equipment (Figure 91). Logitech G is separated from the main brand because it focusses on the dedicated audience of gamers, which has distinctly different requirements for peripherals than users of the Logitech main brand who are either casual or professional users. Examples of how the requirements differ are:

- Gamers often value lighter or adjustable mice while productivity mice are designed to be heavier for a feeling of quality.
- Many Logitech G products use sensors and switches with extremely high precision and low responsiveness with the aim of improving performance when gaming, many of the switches are tactile and produce a loud sound for feedback to the user. Most products from the

Logitech main brand do not require these levels of precision and are designed to be as quiet as possible.

- Logitech G products often have integrated RGB lighting which is fully customizable using software, main brand Logitech products often only have backlighting and indicative lighting.

This difference in style and features also applies to software, which is why Logitech G products mainly use the *G Hub* software which allows for hyper personalisation of the product experience.

Figure 91. Logitech G branded products (G)

17.1.1.1.3. Astro gaming

Astro gaming, acquired by Logitech in 2017 (Lu, 2017), sells premium gaming headsets and accessories. The brand is getting integrated into the Logitech G brand but the name is still present in products and software.

17.1.1.1.4. Stream Labs

Streanlabs, acquired in 2019, sells itself as easy-to-use streaming software that integrates into the most common used streaming platforms (Lu, 2019). Streamlabs is the only brand in the Logitech portfolio that is completely software focused.

17.1.1.1.5. Ultimate Ears

Ulimate Ears (also known as UE), acquired in 2008, makes durable portable speakers and accessories. The subbrand *ultimate ears professional* sells professional grade in ear monitors (Greenhalgh, 2008).

17.1.1.1.6. Blue Microphones

Blue Microphones, acquired in 2018, was a well-known brand for providing high quality microphone equipment for a decent price (Lawler, 2018). The Blue brand is getting more and more integrated into the Logitech brand, its name is still used for products that fell under the blue brand and is also used for the audio software Logitech provides with its higher end microphones and headphones.

17.1.2. INITIAL SCOPING OF LOGITECH PWS

Logitech is a large corporation with three main segments that have subdivided design and engineering teams: Logitech Personal Workspace Solutions (PWS), Logitech G (Gaming) and Logitech for Business. Teams from the three segments do not work together in product development and have limited contact; therefore, it is preferable to choose one single segment as the focus of the project. Seeing that both supervisors are industry experts who are familiar with the PWS segment, the project will focus on this segment and its associated product portfolio.

PWS contains most products one might associate with the main brand of Logitech:

- All non-gaming pointing devices and keyboards.
- Webcams.
- Tablet keyboards.

As seen in Figure 92 PWS is responsible for almost half of Logitech's net sales, Figure 93 shows the channel split between B2B and B2C. These two charts show that although PWS products could be considered as more basic Logitech products, they are, in fact, still the largest source of revenue. Logitech's CEO Hanneke Faber has come out stating that Logitech is working towards growing its B2B segment by expanding into medium to small business segments like education, healthcare and public sector.

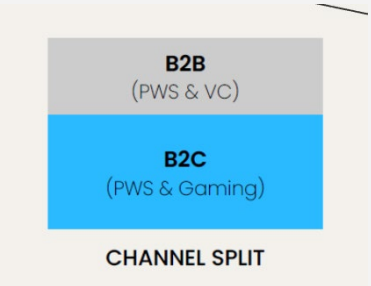


Figure 92. Net sales of Logitech in Fiscal Year 2024 (FY24)

Figure 93. Channel split between B2B and B2C FY24.

Teams from the three segments do not work together in product development and have limited contact; therefore, it is preferable to choose one single segment as the focus of the project. Seeing that both supervisors from Logitech in this project are part of the Logitech Personal Workspace Solutions (PWS) segment, the project will focus on this segment and its associated product portfolio.

17.2. Appendix B. Types of modular architecture

In order to get better insight into how modularity can benefit product design, it is important to explore what types of modularity exist, therefore part of this project was dedicated to create a so called “modularity map”. This map should for one guide the following steps of the project, showing what forms of modularity have and have not yet been applied in the market of PC peripherals. Secondly, the map will be a tool companies like Logitech could use in future endeavours to orient and explore new directions for modularity.

This chapter builds on work done by Eppinger and Ulrich (1995). Eppinger and Ulrich distinguish between three different segments in a modular system: chunks, architecture and the interface that is used between the two.
The physical elements of a product are typically organised into several major physical building blocks, called *chunks* (Eppinger & Ulrich, 1995). Each chunk is made up of a collection of components that implement a certain function into the product. The *architecture* of a product is the scheme by which the functional elements of the product are arranged (Eppinger & Ulrich, 1995). The interface of a chunk makes sure it physically fits into the architecture and arranges other functionalities like data transfer and power to the chunk.

Eppinger and Ulrich visualise these modular systems by using simplified schematics as seen in Figure 2.

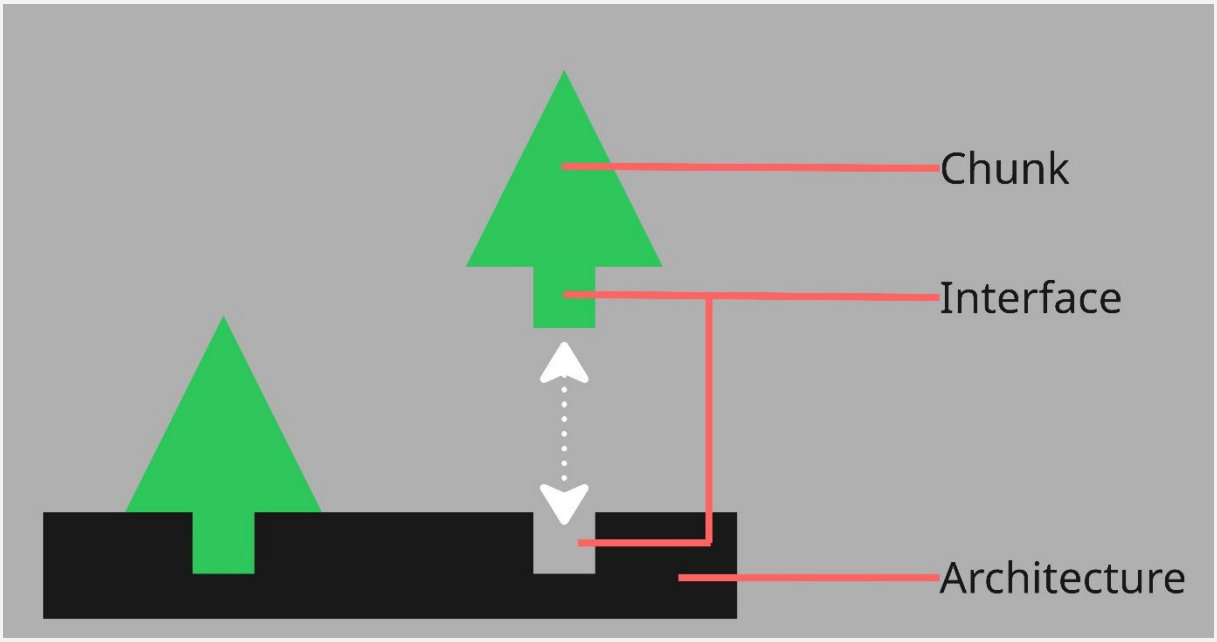


Figure 94. Segments in a modular system.

In their book *Product design and development*, Eppinger and Ulrich (1995) present three types of modular architecture: Slot-modular, bus-modular and sectional-modular. Mascitelli (2004) later added the three types of modularity called component sharing, component swapping and cut-to-fit modularity. These six types of modular architecture, plus the modular architecture type daisy chaining, are explained below.

With slot-modular architecture (Figure 95), each chunk shares and unique interface with the architecture, chunks cannot be swapped around. A chunk can however be switched with another chunk with the same interface. For example, a computer may have a SSD slot which can house a card of 2gb, that SSD card could, not taking into account the limitations of the architecture, be switched out for any other SSD card of any amount of storage.

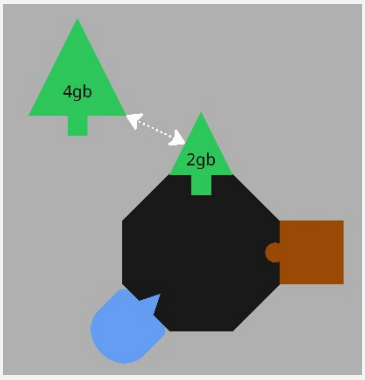


Figure 95. Schematic visual of slot-modular architecture.

With Bus modular architecture (Figure 96), there is a common *bus* to which the chunks connect via the same type of interface. Examples of products using Bus modular architecture are multi-socket extension leads (Figure 97) and server racks.

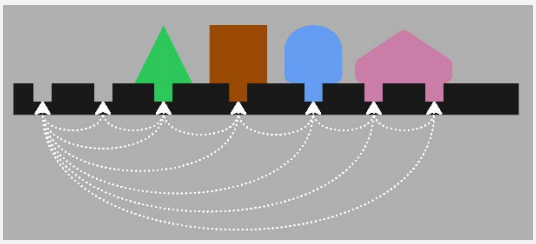


Figure 96. Schematic visual of bus-modular architecture.

Figure 97. Extension leads are a form of bus modular architecture.

Lastly, Eppinger and Ulrich mention Sectional modular architecture (Figure 98), in which the chunks themselves contain the required interfaces to attach other chunks. There is no single critical element to which all chunks need to be attached in order for the system to be functional. Examples of products using Sectional modular architecture are LEGO bricks, sectional sofas and certain piping systems (Figure 99)

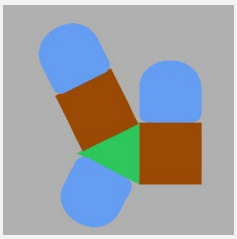


Figure 98. Schematic visual of sectional-modular architecture.

Figure 99. A piping system using a sectional-modular architecture.

Mascitelli (2004) added component sharing-modular as a form of architecture (Figure 100). Rather than providing a completely new type of architecture, this form of modularity provides an expansion on the concept of slot-modular architecture, the idea being that different products share a common slot and interface for a certain type of chunk so the chunk can be used on all the products.
Where component sharing-modular transcends the idea of slot-modular architecture is that sharing these interfaces and slots on different products can lower production costs and improve part availability. Using standardised bolts and screws can also be seen as a form of component sharing-modularity, here another benefit for a designer is simplified communication with manufacturers.

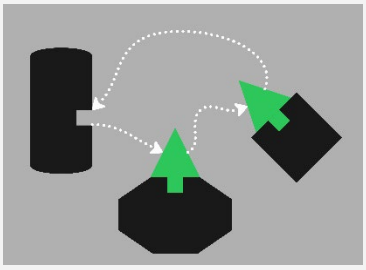


Figure 100. Schematic visual of component sharing-modular architecture.

In component swapping-modular architecture (Figure 101) there is only one place on the interface for chunks to interact with, although the workings of the system are the same as that of the bus interface, the fact that there is only one slot means the user needs to decide what chunk should be attached for the job they want to perform with the product.
The difference between the component swapping-modular architecture and the slot-modular architecture is that the component swapping-modular architecture allows for chunks that provide completely different functionalities to use the same interface.

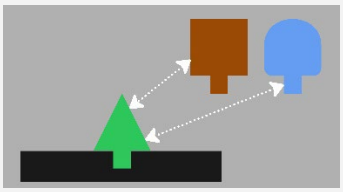


Figure 101. Schematic visual of component swapping-modular architecture.

Several smartphone companies have been actively experimenting with component swapping-modular architecture, some examples are the LG G5, Motorola Moto Z, HMD Fusion with the newest being the CMF Phone 1 and the Xiaomi concept phone. Two other example of component swapping-modular architecture are the grip slots of the Nintendo Switch (Figure 102) and faucet adapters (Figure 103).

Figure 102. Component swapping-modular slots on the Nintendo switch.

Figure 103. A faucet adapter allows for different modules with different functionalities.

Cut-to-fit modularity (Figure 104) is similar to the previous two categories from Mascitelli (2004), but in this case, one or more of the product's components are continuously variable within preset and practical limits. An example of cut-to-fit-modular architecture is how the fitting of a leg prothesis, which is personalised to a scan of the users stump, is fitted on a standardised leg (Figure 105).

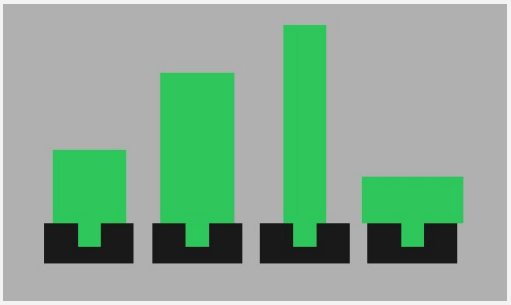


Figure 104. Schematic visual of cut-to-fit-modular architecture.

Figure 105. Fitting of a prosthetic leg.

Another well-known form of modularity, which was not described by Eppinger and Ulrich (1995) or Mascitelli (2004), is line-modularity, also known as daisy chaining (Figure 106). Daisy chaining linearly chains chunks together using an interface, often a cable. To make daisy chaining work the chunks need to be either autonomous or in connection with a hub that supplies them with the signal or power required to operate.

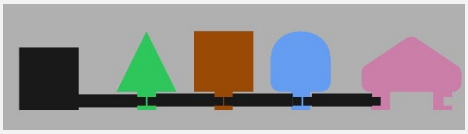


Figure 106. Schematic visual of line-modular architecture.

17.2.1. EXTRA TYPES OF MODULAR ARCHITECTURE

Some other types of modularity can be described that are either hybrids or derivatives of the core three types of architecture Eppinger and Ulrich (1995) described. Seeing that these types of modularity were not yet defined, they may change through the project.

In Semi-bus-modular architecture (Figure 107) the interfaces on the bus vary to accommodate for different types of chunks, often because the chunks have different sizes. The reason the interfaces are not the same is often because certain chunks require certain functionalities from the interface, it is then decided to apply some slight specialisation in the interface to reduce material, save costs or improve efficiency. An example of semi-bus-modular architecture is the Google Ara phone (Figure 108).

It could be argued that the Semi-bus-modular architecture is the same as separate bus and slot modular architectures, it is mentioned separately because in semi-bus-modular architecture the modules do interact with each other in a more integrated way than several separate architectures.

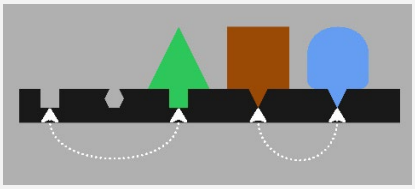


Figure 107. Schematic visual of semi-bus-modular architecture.

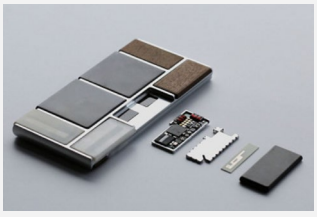


Figure 108. The Google Ara phone.

Semi-sectional-modular architecture (Figure 109) looks a lot like sectional modularity, except the difference is that the chunks on themselves are not modular, they require a segment to enable their modularity. Semi-sectional-modular architecture could be seen as a multidirectional form of daisy chaining. An example of Semi-sectional-modular architecture is aluminium extrusion frames (Figure 110).

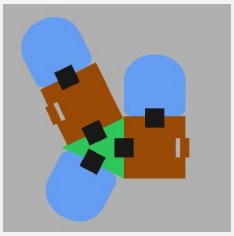


Figure 109. Schematic visual of semi-sectional-modular architecture.

Figure 110. Workstation constructed with aluminium profiles, connected through fasteners and connector elements.

The last form of modular architecture is hub-sectional-modular architecture (Figure 111). The difference from 'normal' sectional modular-architecture is that with hub-sectional-modular architecture there are one or more chunks that are critical, without these critical modules the system cannot function. This form of modular architecture is mostly seen in products that integrate electronic elements, where the designer has chosen for a centralised 'hub' chunk that houses most of the computation for the system, this makes sure not all chunks have to contain separate computing modules.

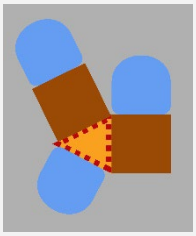


Figure 111. Schematic visual of hub-sectional-modular architecture.

17.2.2. NON-MODULAR ARCHITECTURE

It is difficult to exactly pinpoint when a systems architecture is or is not modular. The reason being that there are grades in which modularity can be applied. One could argue that a glued in battery is not modular, but compared to one that is soldered onto a motherboard it seems relatively easy to interchange. The term “Integrated” is often used as the opposite of modular, an integrated design (Figure 112) aims for parts be multifunctional to improve performance and efficiency (Mikkola, 2001). Consumers are often not expected to repair or replace chunks of integrated architecture without professional assistance seeing the level of complication it brings.

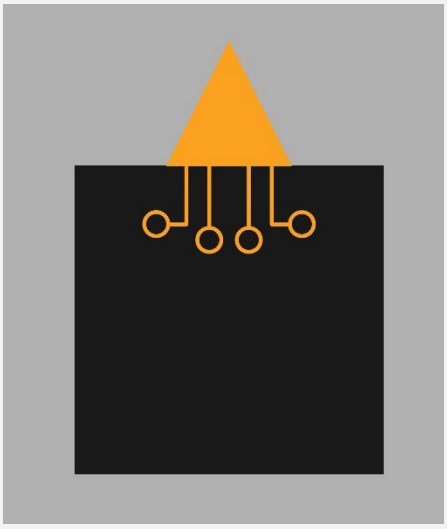


Figure 112. Schematic visual of Integrated architecture.

A type of architecture that could be considered non-modular is proprietary architecture (Figure 113), here chunks can be replaced, but only with the exact same type of chunk and interface. An example of proprietary architecture is how wireless earbuds fit into their case (Figure 114) and some chargers for wearables (Figure 115). If the product the case or charger is made for stops working, the case or charger becomes useless seeing that it cannot be used for any other product.

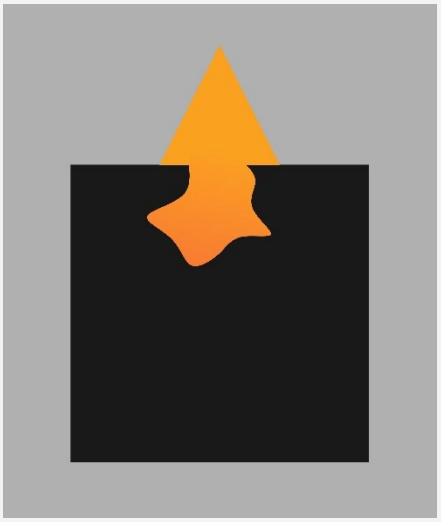
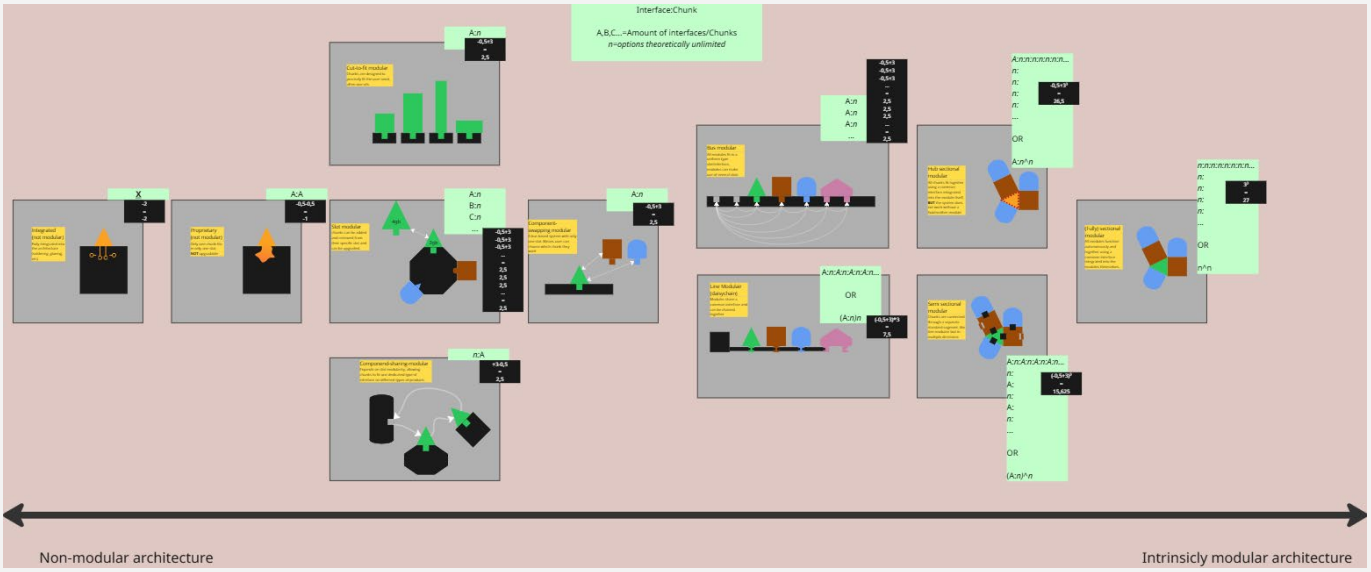


Figure 113. Schematic visual of proprietary architecture.

Figure 114. The case of Bluetooth earphones only fits the exact model of earphones they are designed for.

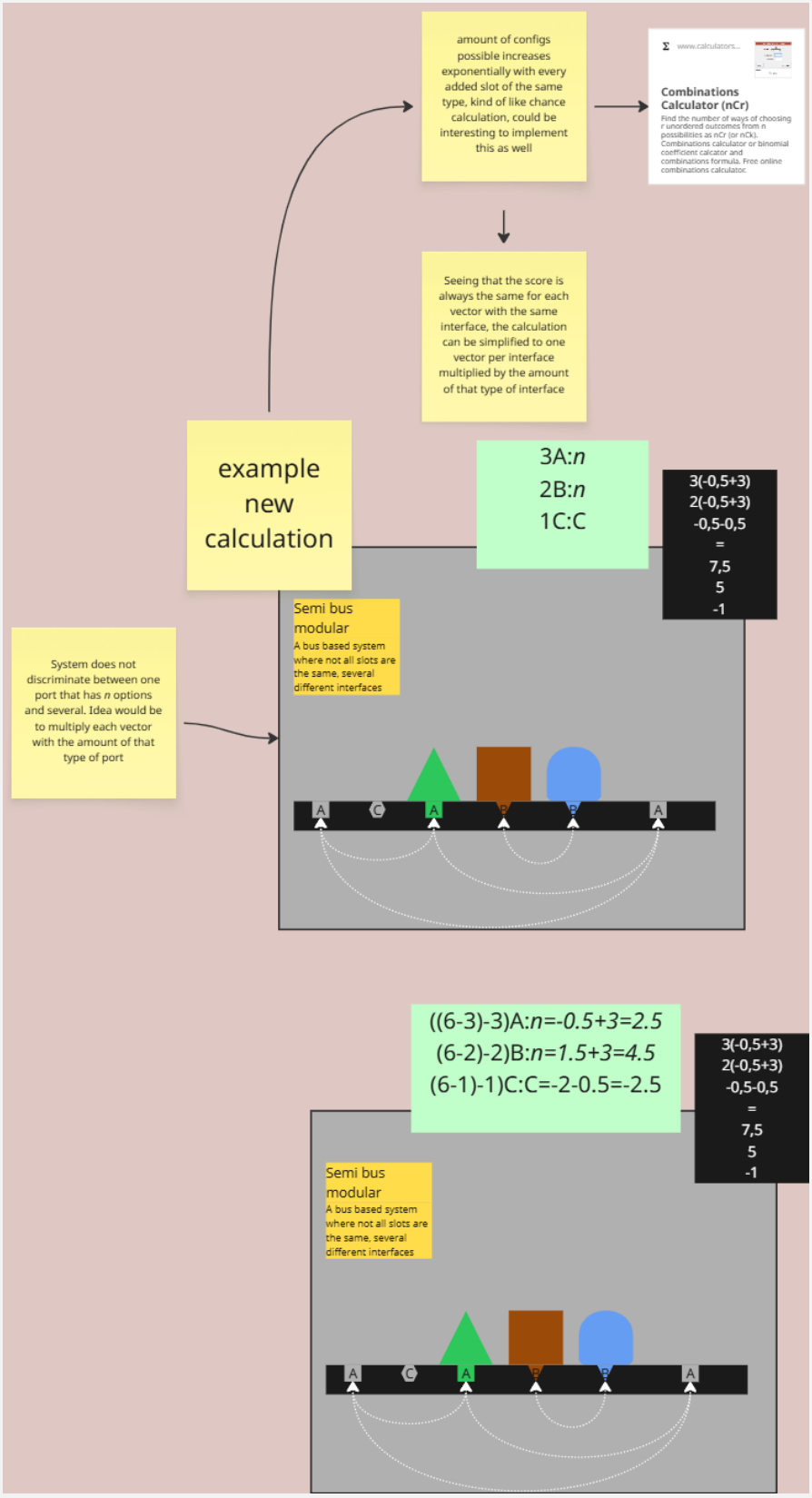
Figure 115. This charger only fits one type of smartwatch.

17.2.3. CALCULATING POSITION OF THE DIFFERENT FORMS OF MODULARITY ON MAP A



17.2.4. CALCULATION EXAMPLE

This is an example of the calculation that was part of the experiment of finding out whether it was possible to create an objective score for modular products, allowing designers to assess a product by looking at the ports and architecture and scoring a product accordingly. The calculations use a vector system; all vectors can be found in 0.



17.3. Appendix C. Modular phone designs

17.3.1.1. LG G5

Interface: Bottom bezel of phone

Modules: Camera + powerbank, speaker (B&O)

17.3.1.2. Motorola Moto Z

Interface: Pins on the back of the phone

Modules: Projector (Instashare), Camera (Hasselblad), Speaker (JBL), Battery pack (Incipio)

17.3.1.3. HMD Fusion

Interface: Pins on the back of the phone
Modules: Ring light, Survival (emergency button), game controller

17.3.1.4. CMF Phone 1

Interface: Bolt
Modules: Stand, lanyard, card case

17.3.1.5. Xiaomi concept

Interface: Pins on the back of the phone
Modules: Camera

17.4. Appendix D. DEPEST, SWOT & selecting target group

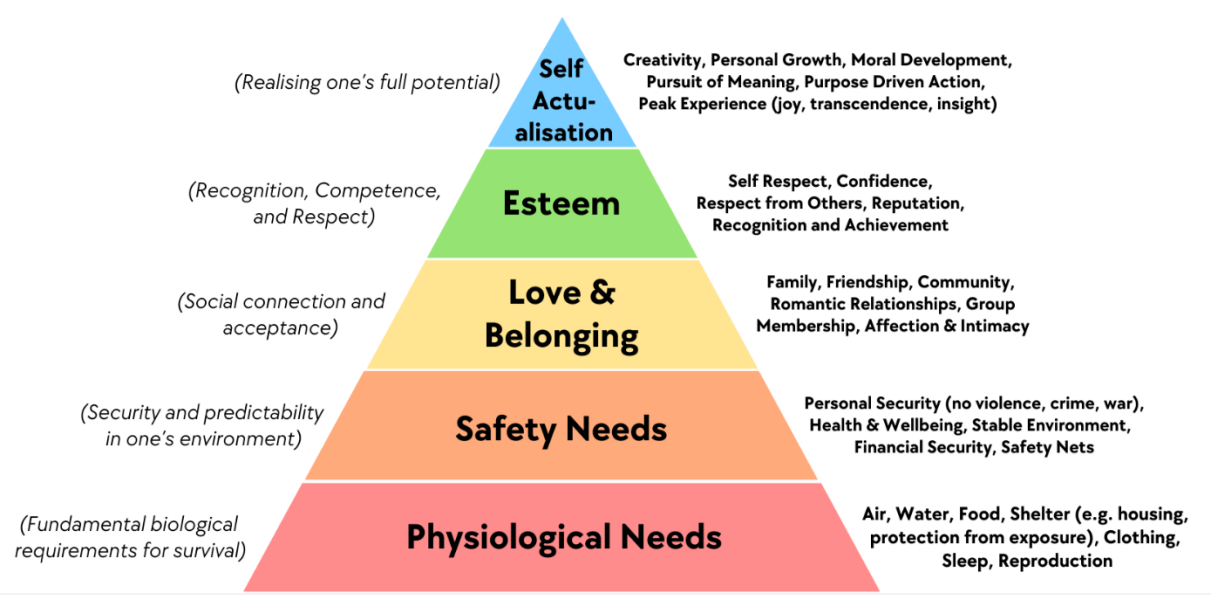
17.4.1. DEPEST ANALYSIS

Trends were initially clustered in their square. Afterwards clusters between squares were created with the aim of creating relevant target groups that fit the trends.


Demographic
Technology overstimulation
Population growth in western civilisation is slowing down
Ecological
Extending the life of electronics
Environmental impact of AI (McKinsey24)
General concern for climate change (Fuzr 100)
Right to repair
Pro-active recycling (FY24 IR)
Pro-active involvement on repair & recycle (FY24 IR)
Enabling reuse and repair (FY24 IR)
Design for durability (F
Design for prolonging use
Carbon transparency (FY24 IR)
Lowering Financial and Climate impact and improving existing processes
Chemical controll (FY24 IR)
Lower impact components (FY24 IR)
Lower impact materials (FY24 IR)
PVC-Free design (FY24 IR)
Low impact everything
Clean manufacturing (FY24 IR)
Low impact packaging (FY24 IR)
AI as enabled LCA's (FY24 IR)
Efficient/Smart distribution (FY24 IR)
Optimized architecture (FY24 IR)
Optimizing current ways of doing
Ergonomic PC peripherals and the need for them in pro digital jobs
Political
Tariffs (AID 2025)
Trump/Tariffs
War Ukraine
Increase in fake news/misinformation (Fuzr 100)
disconnection for safety
Privacy lawmaking (McKinsey24)
Digital minimalism
Economic
Value engineering (AID 2025)
Stockmarket emancipation
Logitechs focus on Chinese market
ReArm Europe will boost military industry
Logitechs growth in B2B (AID 2025)
Less spending on luxury items
High performance budget consumers
The end of airplane mode (The verge)
Increased cost of living (Fuzr 100)
Decreases in spending on home entertainment (Fuzr 100)
increased spending on children (Fuzr 100)
Decreases in spending on home decor (Fuzr 100)
increased spending on health/well-being (Fuzr 100)
Continued inflation (AID 2025)
increased spending on food/groceries (Fuzr 100)
increased spending on utilities (Fuzr 100)
Social
Digital escapists
Anti-materialsists
Professionalizing/Specializing/ optimizing PC workspace
Inclusivity and peace
Personal development and peace
Reducing screen time (Fuzr 100)
Embracing technology as the new reality
Ergonomic ultra-users (balance/avoid the MX vertical thing)
Advanced PC users (AID 2025)
Specialised work/game ingstations
Voice controlled & smart PC peripherals
Technological
Customizable PC peripherals
Smart workspace management (AID 2025)
Increased variety in types of interfaces
Future tech solving real problems
Ecoplastics in PC peripherals
Humanoid robots at work and in homes (Fuzr 100:14)
Home Clinic Hubs (Fuzr 100:85)
Vibroacoustic therapy (Fuzr 100:90)
Augmented wearable tech to boost physical performance (Fuzr 100:91)
Smart glasses 2.0 (Fuzr 100:17)
Cybersecurity risks (McKinsey24)
cyberattacks
spatial computing
Autonomous futures (Fuzr 100:12)
Companies develop AI strategies (Nouvo24)
AI compliance and regulations (McKinsey24)
Ergonomic design (AID 2025)
Increase electronic devices per person (AID 2025)
Seemless tech integration
AI integration in everything
Rapid wireless technologies (bluetooth, 5G, 6G)
Tech seemlessly integrating into daily life
Logitech expressionists
Brand ecosystem advocacy
On-the-go/digital nomads
Engagement through reinvention and fun
remote working
Reinventing well known experiences
Experience seekers
Need for fun
Need for love (Fuzr 100)
Need for fun and laughter (Fuzr 100)
Entertaining brands (Fuzr 100)
Awesperient at retail (Fuzr 100:61)
Need for lower-priced brands (Fuzr 100)
Multisensory marketing (Fuzr 100)
Social hobby apps (Fuzr 100:15)
Work resorts (Fuzr 100:4)
Innovative in flight experiences (Fuzr 100:27)
Age-concious design (Fuzr 100:78)
On-The-Go users (AID 2025)
Increase in work locations per person (AID 2025)
New (mobile & digital) ways of working (AID 2025)

17.4.2. SELECTION OF TARGET GROUP

To create the needs of each target group Maslows pyramid of needs was used.



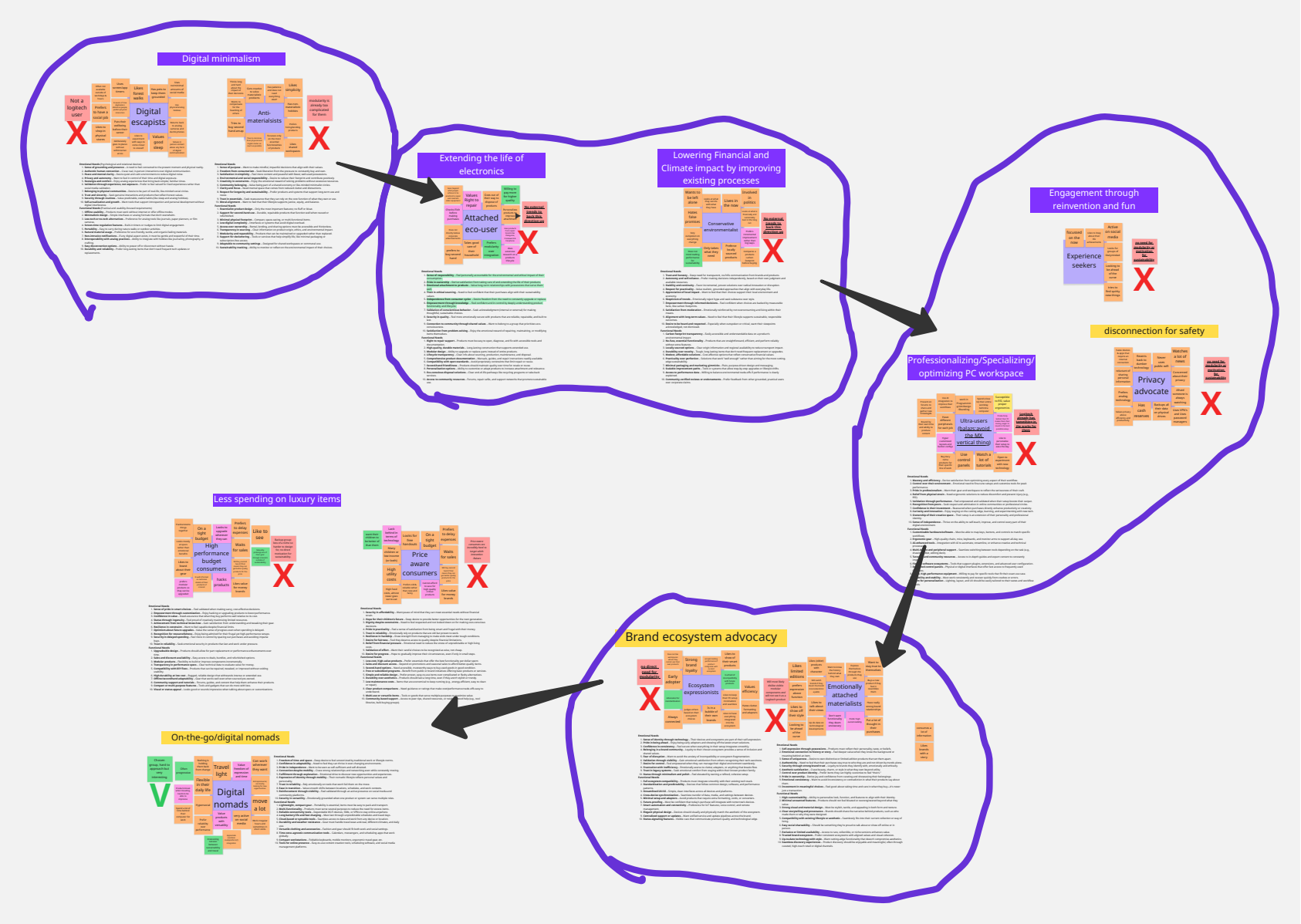
Visual starts in the top left and ends bottom left.

Orange post its are general characteristics and needs of a target group

Green post its link to a target groups sentiment to sustainability

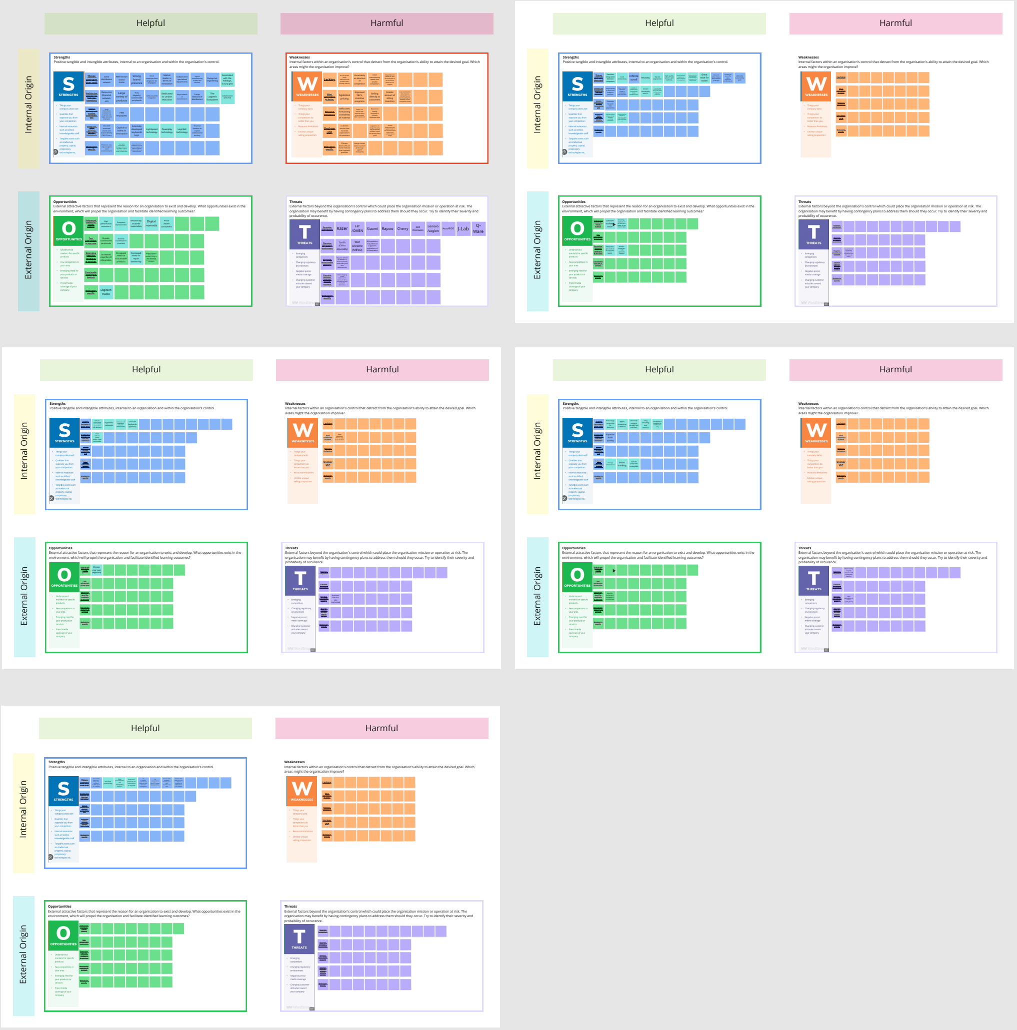
Pink post its refer to a target groups sentiment to modularity

Red post its show main reason a target group was not chosen


Digital minimalism
Not a logitech user
Likes Ecosia
Likes walks
Digital escapists
Values good sleep
Likes to shop in physical stores
Anti-materialists
Likes simplicity
modularity is already too complicated for them
Emotional Needs
Functional Needs
Extending the life of electronics
Attached eco-user
Lowering Financial and Climate impact by improving existing processes
Conservative environmentalist
Engagement through reinvention and fun
Experience seekers
Active on social media
disconnection for safety
Privacy advocate
Professionalizing/Specializing/ optimizing PC workspace
Ultra-users (balance avoid the MK-vertical thing)
Use control panels
Watch a lot of tutorials
Less spending on luxury items
Price aware consumers
Brand ecosystem advocacy
Ecosystem expressionists
Emotionally attached materialists
On-the-go/digital nomads
Digital nomads
Travel light

17.4.3. SWOT ANALYSIS

Created 5 different SWOT boards with the aim of creating a broad and complete view of all Strengths and Opportunities of Logitech as a company.


Helpful
Harmful
Internal Origin
External Origin
Strengths
Positive tangible and intangible attributes, internal to an organisation and within the organisation's control.
S
STRENGTHS
Weaknesses
Internal factors within an organisation's control that detract from the organisation's ability to attain the desired goal. Which areas might the organisation improve?
W
WEAKNESSES
Opportunities
External attractive factors that represent the reason for an organisation to exist and develop. What opportunities exist in the environment, which will propel the organisation and facilitate identified learning outcomes?
O
OPPORTUNITIES
Threats
External factors beyond the organisation's control which could place the organisation mission or operation at risk. The organisation may benefit by having contingency plans to address them should they occur. Try to identify their severity and probability of occurence.
T
THREATS
Razer
HP /OMEN
Xiaomi
Rapoo
Cherry
Lenovo /Legion
J-Lab
Q-Ware

Selected the most relevant Strengths and opportunities.

Linked the found Strengths and Opportunities back to the target group of Digital Nomads. Also created tensions this target group might experience (right).

17.5. Appendix E. Target group of DN: From Assumptions to confirmations

17.5.1. EMOTIONAL NEEDS

17.5.1.1. Trust in reliability – Rely emotionally on tools that won't fail them on the move.

Something most people can relate to is that things break when travelling, whether it's because you try to cram everything into a suitcase or your bag gets thrown around by baggage handling. Electronic products are especially sensitive during travel and often require a travel case or some other form of protection; even then, it's not guaranteed they will find their destination without damage.

Modularity – Sustainability
Knowing you can repair your modular PC peripherals wherever you go with off-the-shelf standardised parts removes the stress of moving.

Logitech Strengths
For a computer peripheral brand, Logitech is perceived as durable and reliable, still there is a long way to go.

17.5.1.2. Ease in transition – Value smooth shifts between locations, schedules, and work contexts.

Digital nomads travel around a lot and do not necessarily have a fixed workplace. Moving your office space from your residency to Social workspaces, planes, trains, and hotels can be complicated and stressful. The time you have to work is vital, and therefore it is important that you can instantly connect wherever.

Logitech Strengths
Logitech products are already perfectly catered to this need. Logitech mice and keyboards have top-of-the-line connection and multi-device support.

17.5.1.3. Security in versatility – Emotionally grounded when one product or system can serve multiple roles.

Due to the small amount of baggage these groups take with them, products need to be versatile and able to adapt to multiple roles. This gives digital nomads the confidence they need to go out and explore the world.

Modularity – Adaptability
Modularity plays well into the versatility digital nomads are looking for. Adapting a product to your needs and the situation at hand.

Logitech Strengths
Logitech products are already perfectly catered to this need. Logitech software allows users to alter the functionality of almost all buttons and interactions with the product to fit the specific use case a user is looking for.

17.5.2. FUNCTIONAL NEEDS

17.5.2.1. Multi-functionality – Products must serve several purposes to reduce the need for excess items.

Modularity – Sustainability
Integrating multiple products into one product can save on products bought/produced leading to less carbon emissions and less waste.

Modularity – Adaptability
Modularity plays well into the versatility digital nomads are looking for. Adapting a product to your needs and the situation at hand.

Logitech Strengths
Logitech products are already perfectly catered to this need. Logitech software allows users to alter the functionality of almost all buttons and interactions with the product to fit the specific use case a user is looking for.

17.5.2.2. Cloud-based or sync able tools – Seamless access to data and work from any device or location.

Logitech Strengths
Logitech offers cross-platform support and their products can use their internal storage to save any user profiles so that the user experience is the same on any computer.

17.5.2.3. Durability and weather resistance – Gear must handle travel wear-and-tear, different climates, and daily use.

Modularity – Sustainability
Modularity does not necessarily improve the durability of the product but making the product easy to disassemble and repair will improve its longevity. A modular peripheral could even be disassembled into a form that fits into a compact protective case.

Logitech Strengths
Logitech's Global presence strengthens the idea of repairing your mouse, keyboard, etc. wherever you are. Their partnetrship with iFixIt also strengthens their position.

17.5.2.4. Versatile clothing and accessories – Fashion and gear should fit both work and social settings.

Modularity – Adaptability
Modularity can bring the ability to personalize the product to a user's need in terms of aesthetics.

Logitech Strengths
Logitech is one of the industry leaders when it comes to Colour, Material, Finish (CMF) and knows how to make computer peripherals look appealing to the target user.

17.5.2.5. Compact workstations – Foldable keyboards, mobile monitors, ergonomic travel gear, etc.

Modularity – Adaptability
Making a modular PC peripheral could allow the user to decide how compact they need the product to be. Users could weigh out compactness to ergonomics and other factors.

Logitech Strengths
Logitech already caters to this need with foldable and compact keyboards and therefore knows how to develop sleek compact peripherals that still provide a pleasant user experience.

17.6. Appendix F. Interview script

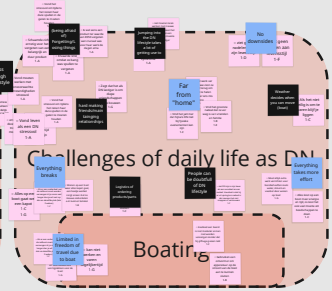
Number	Question
1	Do you consider yourself a Digital nomad?
1a	-> Why?
1b	-> What is your current job? -> Where do you currently work from?
1c	-> Are you self-employed?
1d	-> Where is the company you work for located?
1e	-> How often do you switch locations?
1f	-> Do you go between fixed locations or does the destination vary from time to time?
2	What were your reasons to choose [LIFESTYLE]?
3	What are to you the biggest benefits of [LIFESTYLE]?
4	What are to you the biggest downsides of [LIFESTYLE]?
5	Could you take me through an average day in your life as a [LIFESTYLE]?
6	Could you take me through the actions you take when traveling as a [LIFESTYLE]? Let them fill in the stages themselves and ask about the other stages if they skip them.
6a	Planning travel Picking equipment Travel Land
7	What luggage did you travel with?
8	What mode of transport did you use?
9	What does sustainability mean to you? What are the first things that come to mind?
9a	How do you consider sustainability in your daily life?

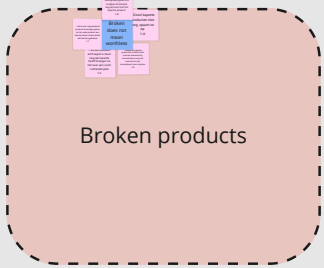
9b	How does sustainability apply to [LIFESTYLE]?
10	Do you ever repair or reuse products?
10a	What?
10b	Why?
10c	What happens if you cannot repair?/What happens to broken products?
11	What does modularity mean to you?
11a	Can you give me an example of modular product that you use?
12	Do you own modular products?
13	Do you use computer peripherals as a [LIFESTYLE]?
13a	Which peripherals bring you the most issues?
13b	If no but before yes?- do you miss it?
14	(If Workationist) Does your use of computer peripherals differ between home, office and workation? Why?
	EXPLAIN PROJECT
15	Questions concerning why they chose their specific PC peripherals.
16	Do you know any other Digital Nomads?
16a	Could you help me reach other Digital Nomads?

17.7. Appendix G. Thematic analysis

Iteration 1

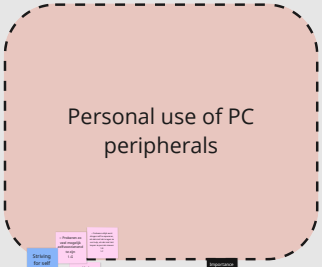

Planning visits to clients
DN Apps
Planning visit


Boating
Challenges of daily life as DN

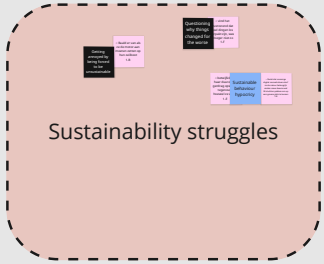

Broken products

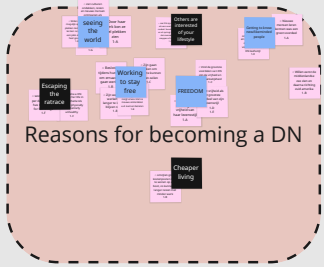

Packing before travel

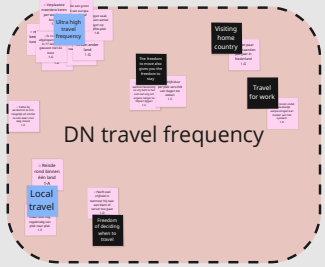

working from (co-)working space


Personal use of PC peripherals

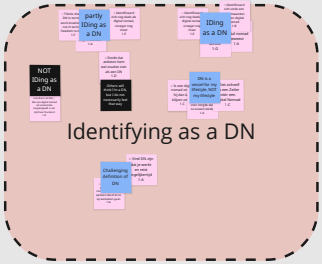

Sustainable use of products

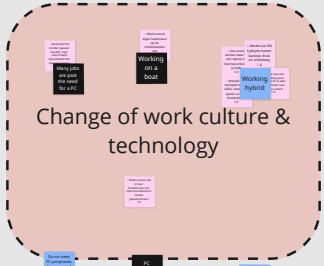

Sustainability struggles

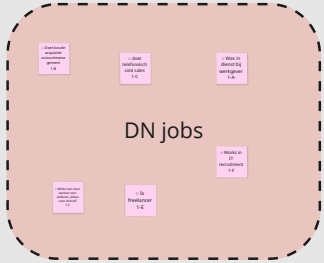

Reasons for becoming a DN

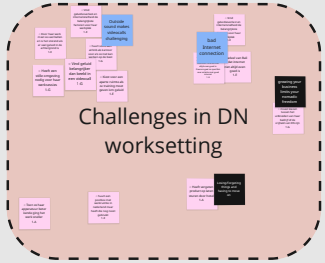

DN travel frequency


Sustainability initiatives

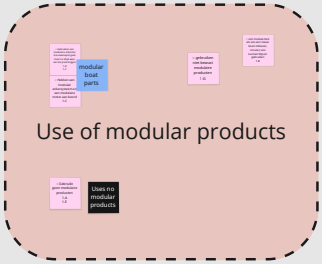

Identifying as a DN

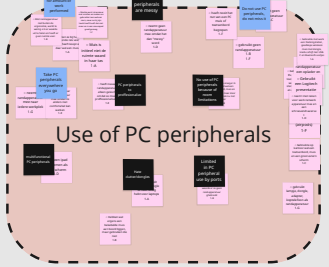

Change of work culture & technology

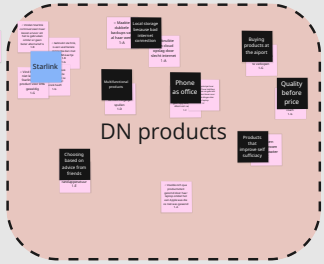

DN jobs

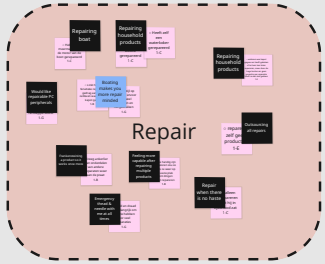

Challenges in DN worksetting

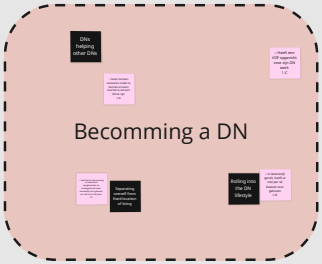

Travel habits

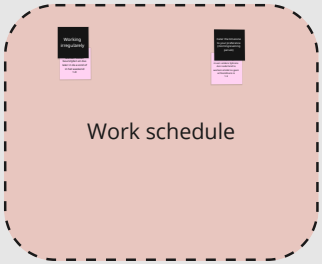

Use of modular products

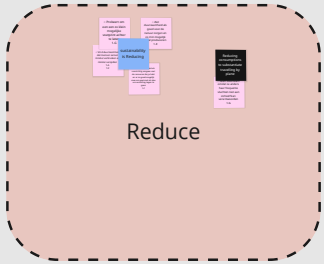

Use of PC peripherals

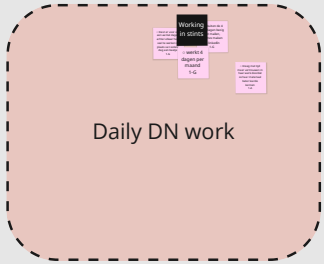

DN products

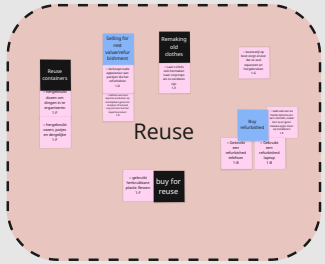

Repair


Becomming a DN


Work schedule


Reduce


Daily DN work


Reuse

Iteration 2

Striving for self sufficiency

Everything takes more effort

GOAL:
Striving for self sufficiacy

Ultra high travel frequency

Take PC peripherals everywhere you go

Train is annoying

Working hybrid

ISSUE:
Travelling at high frequencies is stressfull when you need to take a lot of things with you

Job type and frequency based packing

Minimalist packing

DNs are sustainably minded

sustainability is Reducing consumption

Sustainable behaviour hypocricy

DILEMMA:
Wanting to compensate for traveling emissions

Broken does not mean worthless

DN lifestyle getting in the way of sustainability

Limited in freedom of travel due to boat

seeing the world

No downsides

FREEDOM

GOAL:
Freedom

Local travel

Getting to know new/likeminded people

DILEMMA:
Need for social contact but far from home and moving all the time

Ultra high travel frequency

Far from "home"

Everything takes more effort

SKILL/MINDSET:
Living remotely makes you creative and solution oriented

modular boat parts

Everything breaks

Boating makes you more repair minded

Starlink

ISSUE:
Bad internet makes DN life impossible

bad Internet connection

Buy refurbished

Selling for rest value/refurbishment

GOAL:
Not wanting to waste anything

IDing as a DN

Outside sound makes videocalls challenging

ISSUE:
Outside sound makes it hard to commuicate and portrays you unproffessionally

DN is a vessel for my lifestyle, NOT my lifestyle

seeing the world

Working to stay free

LEARNING:
DN as a vessel for lifestyle, not the lifestyle itself

partly IDing as a DN

Challenging definition of DN

Do not need PC peripherals for amount of work performed

Do not use PC peripherals, do not miss it

LEARNING:
PC Peripherals are not needed in many professions, when you are only behind a pc a few hours a day they are completely unessecary

Iteration 3

Tension: *Minimalist travel vs Work related pc peripherals*

DNs want to take as little as possible with them, some do not need PC peripherals, some don't even need a PC. For the DNs that **do** need them due to their profession (ergonomics/professional appearance), it's frustrating to bring so much clutter with you everywhere you go, especially because they want to be as free as possible.

LEARNING:
PC Peripherals are not needed in many professions, when you are only behind a pc a few hours a day they are completely unessecary

ISSUE:
Travelling at high frequencies is stressfull when you need to take a lot of things with you

Tension: *Inconsistent working environments*

Not being dependent on a location and using that to travel creates the challenge of constantly finding a quite place with good internet from where you can work comfortably and professionally

ISSUE:
Outside sound makes it hard to commuicate and portrays you unproffessionally

ISSUE:
Bad internet makes DN life impossible

Tension: *Sustainable nomads taking planes*

Being relatively sustainably minded and wanting to make an impact, but having a lifestyle that has you traveling all over the world.

DILEMMA:
Wanting to compensate for traveling emissions

GOAL:
Freedom

GOAL:
Striving for self sufficiacy

GOAL:
Not wanting to waste anything

Opportunity: *Self sufficient solution focussed nomads*

Due to DNs working remotely in places where recources are often more scarce than in their home country they resort to improvising when they get confronted by a problem (like a product breaking).

SKILL/MINDSET:
Living remotely makes you creative and solution oriented

GOAL:
Striving for self sufficiacy

Tension: *No one single home*

Even though DNs pride themselves in their freedom of work and travel, they still have a need for:
1) Social interaction
2) A place they can call home (home base)
These two things are harder to achieve as a DN because the high frequency of travel.

NEED:
Having a "home base" from home

ISSUE:
Travelling at high frequencies is stressfull when you need to take a lot of things with you

DILEMMA:
Need for social contact but far from home and moving all the time

Iteration 4

Tension: ***Minimalist travel vs Work related pc peripherals***

DNs want to take as little as possible with them, some do not need PC peripherals, some don't even need a PC. For the DNs that **do** need them due to their profession (ergonomics/professional appearance), it's frustrating to bring so much clutter with you everywhere you go, especially because they want to be as free as possible.

LEARNING:
PC Peripherals are not needed in many professions, when you are only behind a pc a few hours a day they are completely unessecary

ISSUE:
Travelling at high frequencies is stressful when you need to take a lot of things with you

9

Phone as office | Multifunctional products | Hate clutter/dongles | multifunctional PC peripherals | PC peripherals to proffesionalize | PC peripherals are messy

Many jobs are past the need for a PC | Separate packaging for delicate electronics | Becoming an expert packer | (being afraid of) Forgetting/Losing things

Tension: ***Inconsistent working environments***

Not being dependent on a location and using that to travel creates the challenge of constantly finding a quite place with good internet from where you can work comfortably and professionally

ISSUE:
Outside sound makes it hard to commuicate and portrays you unproffessionally

10

ISSUE:
Bad internet makes DN life impossible

10

11

Local storage because bad internet connection | No use of PC peripherals because of room limitations

Other interesting notes that did not fit in

growing your business limits your nomadic freedom

Buying products at the aiport

Quality before price

Tension: ***Sustainable nomads taking planes***

Being relatively sustainably minded and wanting to make an impact, but having a lifestyle that has you traveling all over the world.

DILEMMA:
Wanting to compensate for traveling emissions

11

10

GOAL:
Freedom

10

9

GOAL:
Striving for self sufficiacy

GOAL:
Not wanting to waste anything

10

9

Reducing consumptions to substantiate travelling by plane | buy for reuse | Remaking old clothes | Reuse containers | Emergency thead & needle with me at all times | Repair when there is no haste

Outsourcing all repairs | Feeling more capable after repairing multiple products | Frankensteining a product so it works once more | Repairing household products | Would like repairable PC peripherals | Repairing boat

Plane as nr.1 mode of transport | Being more aware of your surroundings and taking responsibility | Progression through education and community | Importance of sustainable awareness | Repairing locally | justifying travel through comparisson

Opportunity: ***Self sufficient solution focused nomads***

Due to DNs working remotely in places where recources are often more scarce than in their home country they resort to improvising when they get confronted by a problem (like a product breaking).

SKILL/MINDSET:
Living remotely makes you creative and solution oriented

GOAL:
Striving for self sufficiacy

10

Products that improve self sufficiacy | Remoteness makes you more creative with repairing | Holding onto things just in case | Being able to provide | Taking action

Tension: ***No one single home***

Even though DNs pride themselves in their freedom of work and travel, they still have a need for:
1) Social interaction
2) A place they can call home (home base)
These two things are harder to achieve as a DN because the high frequency of travel.

NEED:
Having a "home base" from home

ISSUE:
Travelling at high frequencies is stressful when you need to take a lot of things with you

DILEMMA:
Need for social contact but far from home and moving all the time

Working irregularely | Working in stints | hard making friends/maintaining relationships

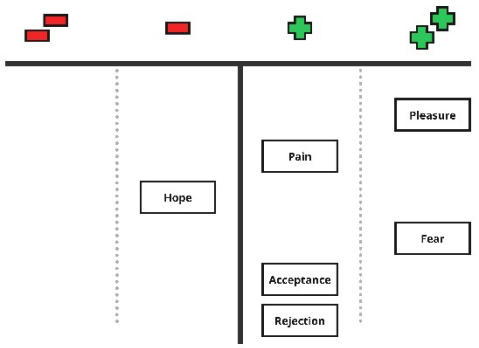
People can be doubtfull of DN lifestyle | complicated Logistics of ordering products/parts | Separating oneself from fixed location of living

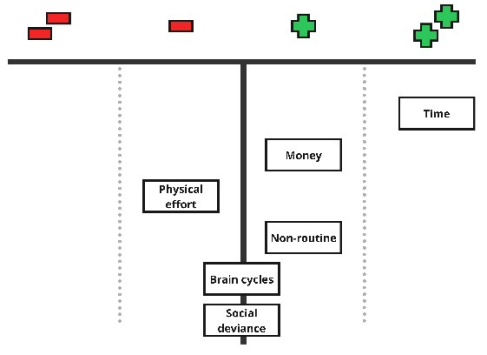
17.7.1. TABLE OF FINAL ITERATION 5

Theme	THE CHALLENGES OF THE DIGITAL NOMAD LIFESTYLE					THE CHALLENGES OF THE DIGITAL NOMAD LIFESTYLE				DIGITAL NOMADS TAKING PRIDE IN SELF SUFFICIACY	
Category	HARD TO FIND COMFORT IN CHANGING ENVIRONMENTS		SUSTAINABLE NOMADS TAKING PLANES			NO ONE SINGLE HOME		MINIMALIST TRAVEL VS WORK RELATED PC PERIPHERALS		SELF SUFFICIENT NOMADS	
Sub-Category	Outside sound makes it hard to commuicate and portrays you unproffessionally	Bad internet makes DN life impossible	Wanting to compensate for traveling emissions	Freedom	Not wanting to waste anything	Having a "home base" from home	Need for social contact but far from home and moving all the time	Travelling at high frequencies is stressful when you need to take a lot of things with you	Many PC Peripherals are not needed in many professions, when you are only behind a pc a few hours a day they are completely unessecary	Living remotely makes you creative and solution oriented	Striving for self sufficiacy
Codes	*Outside sound makes videocalls challenging	*Uses Starlink *Cannot work with bad Internet connection	*DN is sustainably minded *Sustainability is Reducing consumption *Sustainable behaviour hypocricy *Broken does not mean worthless *DN lifestyle getting in the way of sustainability	*Freedom is the biggest benefit *Limited in freedom of travel due to boat *Seeing the world is the reason for becoming DN *Sees no downsides to being a DN	*Buys electronics refurbished *Selling for rest value/refurbishment	*Having a homebase far from home	*Ultra high travel frequency *Local travel *Getting to know new/likeminded people *Far from "home"	*Job type and frequency based packing *Working hybrid *Ultra high travel frequency *Take PC peripherals everywehere you go *Train is annoying *Minimalist packing	*Do not need PC peripherals for amount of work performed *Do not use PC peripherals, do not miss it	*Everything takes more effort *modular boat parts *Everything breaks *Boating makes you more repair minded	*Striving for self sufficiency *Everything takes more effort

17.8. Appendix H. Calculation of DNs position in FBM

All factors and core motivators were analysed and placed on an axis based on their positive/negative impact on the DNs ability to change behaviour towards modular product design:



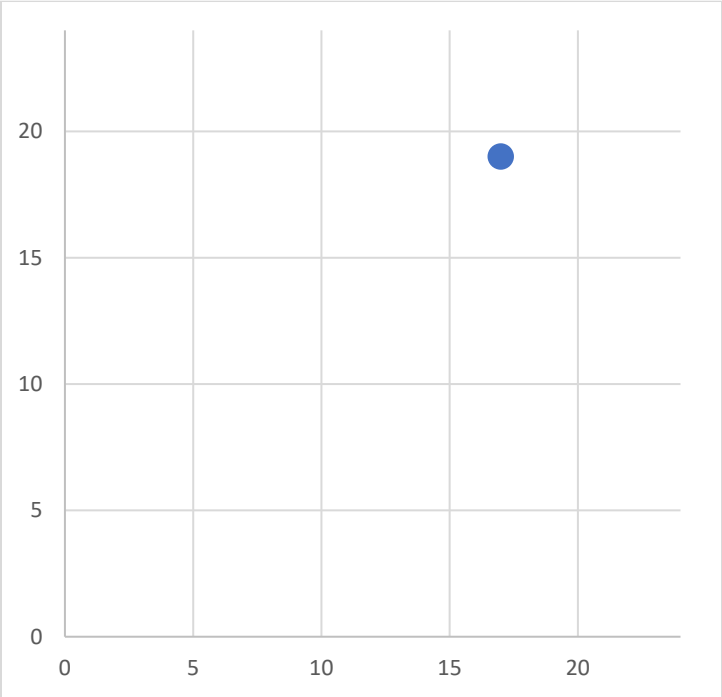


Based on this positioning the factors and core motivators were assigned a score.

Ability	Score
Time	4
Money	3
Physical effort	2
Non-routine	3
Brain cycles	2,5
Social deviance	2,5
Total	17
Max	24

Motivation	Score
Pleasure	4
Pain	3
Hope	2
Fear	4
Acceptance	3
Rejection	3
Total	19
Max	24

Based on the scores of each separate factor and core motivator, a total score per axis was calculated, this score was then plotted over a chart based on the lowest score (0) and maximum score (24).


20
15
10
5
0
0
5
10
15
20

17.9. Appendix I. List of requirements and considerations

17.10. Appendix J. Ideation

17.10.1. DIRECTION 1: IMPROVE ONLINE REPRESENTABILITY

The first direction that was explored during ideation was looking into how the digital representability of DNs could be improved. This direction focused on improving either the audio quality or video quality of DNs so that they could represent themselves more professionally and consistently in an ever-changing work environment. Solutions that were explored contained but were not limited to:

- Video improvement solutions
- Audio improvement solutions
- Light improvement solutions

The ideas in this direction, of which part is displayed in Figure 116, varied greatly. Most often, the aim of the ideas was either to improve the general quality of the recording devices used by DNs (better webcam, better microphone) or to control the surroundings of the workspace (extra lighting, portable studios).

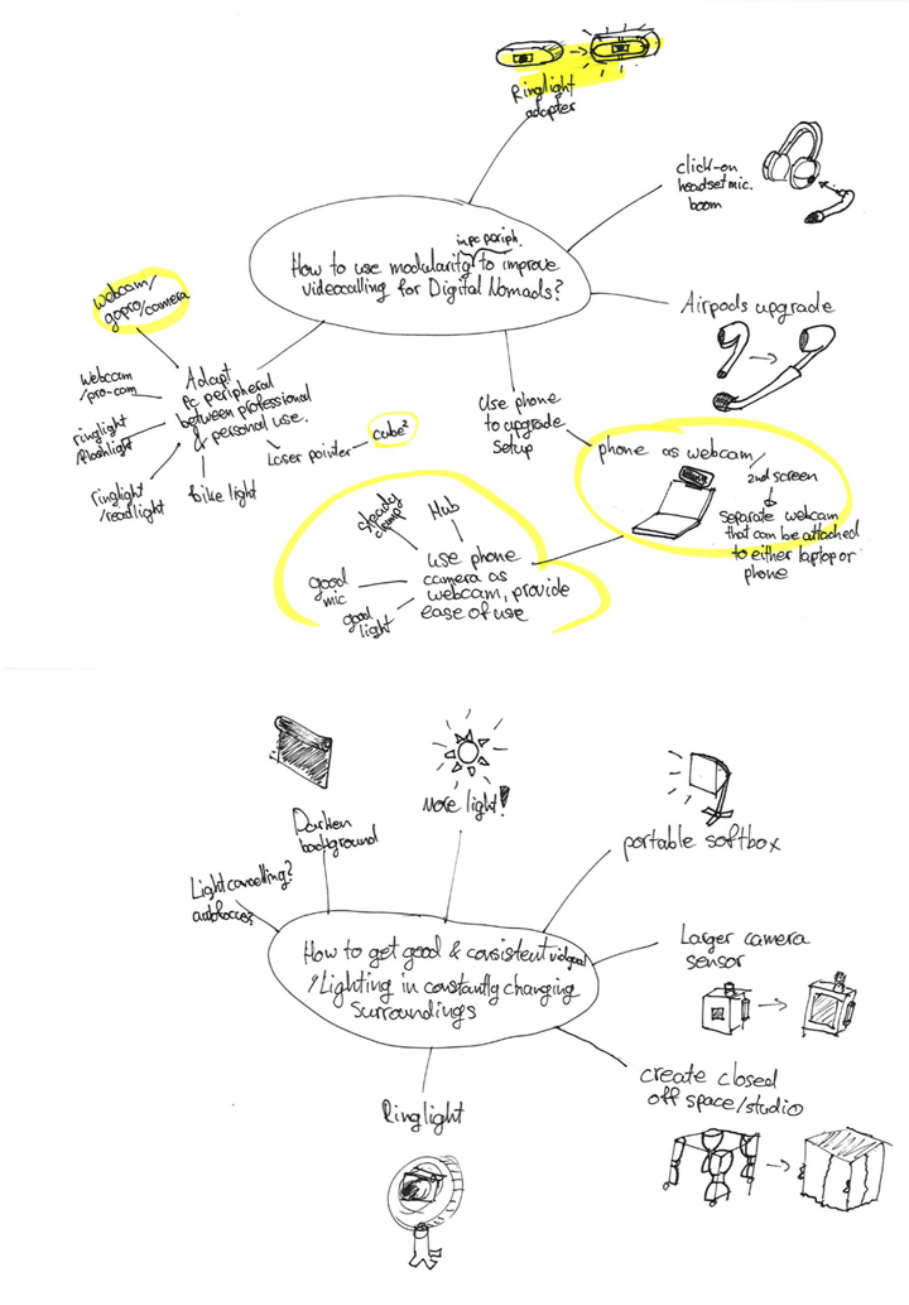


Figure 116. Ideas aimed to improve online representability of DNs.

17.10.2. DIRECTION 2: MAKING PRODUCTS BOTH COMPACT, MINIMALIST AND MULTIFUNCTIONAL

The second direction focusses on the issue of compact versus multifunctional. The tension between these two desires is interesting and deserves a separate look.

The ideation started with ideas that integrated several functionalities into one product. This approach did not work, it seemed to result in the exact opposite of the project goal, creating “Frankenstein” products that looked like a multifunctional black box that would be impossible to repair. An example was the *Logitech media hub,* a swiss army knife of online representability integrating a screen, webcam, microphone, lighting and storage in one (Figure 117).

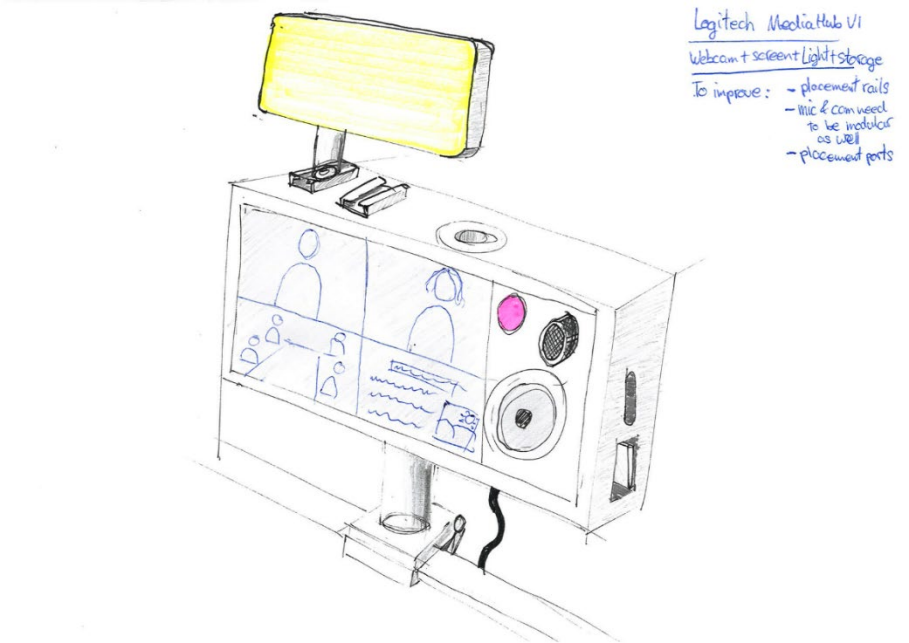


Figure 117. Sketching an idea that incorporated many functionalities lead to a "frankenstein" design; a black box.

The approach that seemed to work best was to take PC peripherals and strip them to bare bones products, with the aim of finding the bare minimum parts and functionalities of a product. This way, all non-critical parts could be assessed on necessity and useful modules could more easily be created Figure 118.

Figure 118. Ideas generated by stripping PC peripherals to their bare bones, and then using modules to build them back up.

17.10.3. DIRECTION 3: MAKING DNS FEEL MORE AT HOME, CREATING COMMUNITY

Direction 3 had the aim of creating a feeling of a trusted environment for DNs during work. The ideas in this direction investigated how the DNs workspace could be expanded in terms of customizability and ergonomics without taking up space that cannot be afforded in their traveling lifestyle. Some ideas also explored creating communities through sharing and rental services (Figure 119).

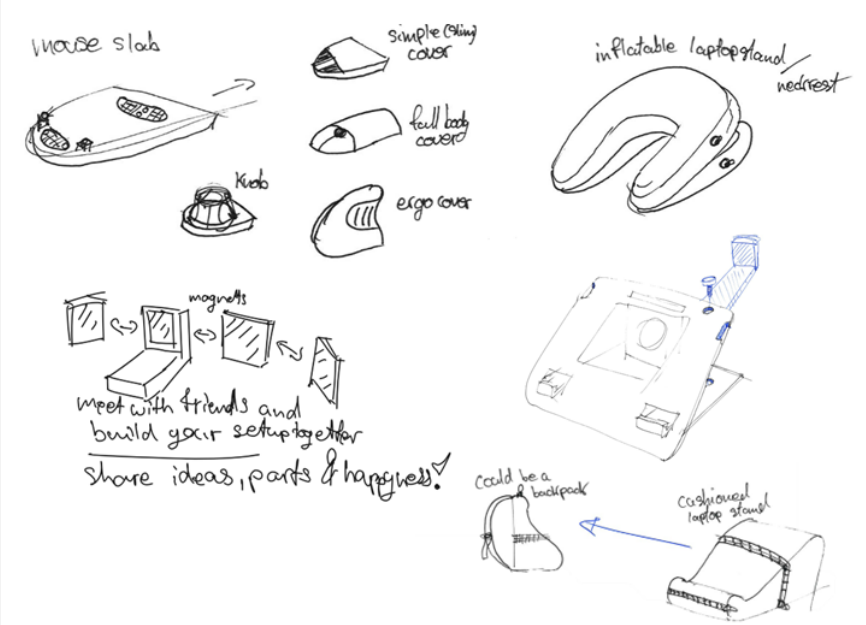


Figure 119. Ideas aimed at shaping DN communities and making DNs feel more at home.

17.10.4. DIRECTION 4: ARCHITECTURE FOCUSED IDEATION

Direction 4 mostly took inspiration from the modularity maps and products in the modularity database, looking into how different forms of modular architecture can be applied to PC peripherals. The most interesting aspect here was to apply types of modular architecture that were not yet present in the database for PC peripherals (like cut-to-shape)(Figure 120), this was a way to continuously generate novel ideas.

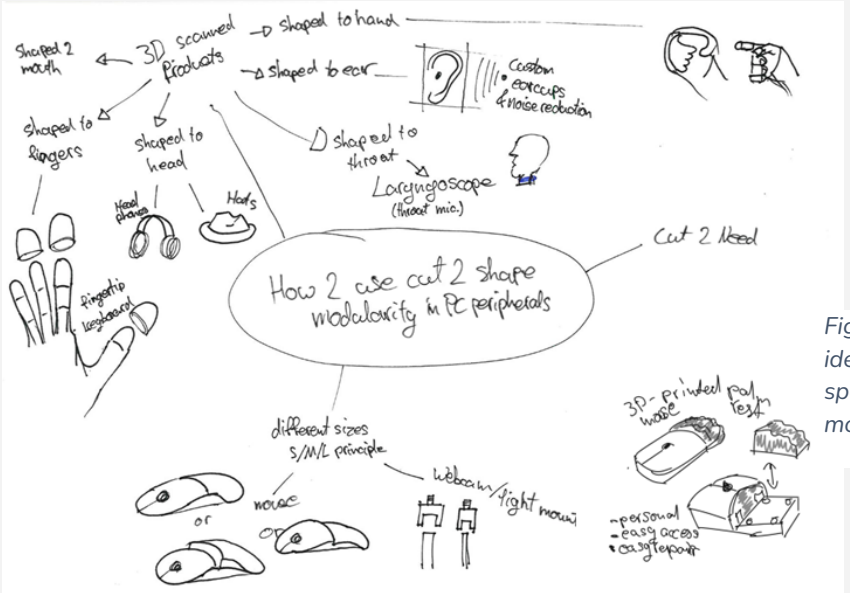


Figure 120. Example of an ideation session focussed specifically on cut-to-shape modularity.

17.10.5. DIRECTION 5: MATERIAL FOCUSED IDEATION

Lastly, some ideation sessions focused on material exploration, with the aim of letting go of the limitations of common use materials for PC peripherals like injection moulded plastics. Some examples of directions that were explored were: Fabrics, wood, clay and inflatables (Figure 121).

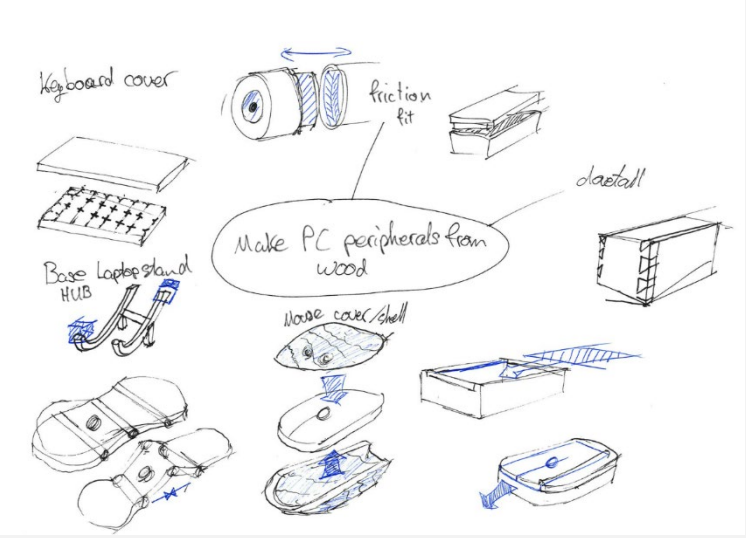


Figure 121. Ideation session exploring the use of wood in PC peripherals.

17.11. Appendix K: Concept development

The three ideas that were discontinued from development after rough selection.

17.11.1. CONCEPT E – MODULAR FULL-SIZE MICROPHONE

Concept E concerned a modular microphone that contained one core module which could then be expanded to the needs of the user (Figure 122).

Figure 122. Visual of the modular full size microphone concept.

The Idea was assessed to be inspirational and lacked fit to the Logitech PWS product portfolio.

17.11.2. CONCEPT F - WEBCAM X ACTIONCAM

The Webcam X actioncam was developed from an idea to a more concrete vision. The idea explored what parts of the webcam could be made modular so the user would be able to transform the webcam into an action cam at will (Figure 123).

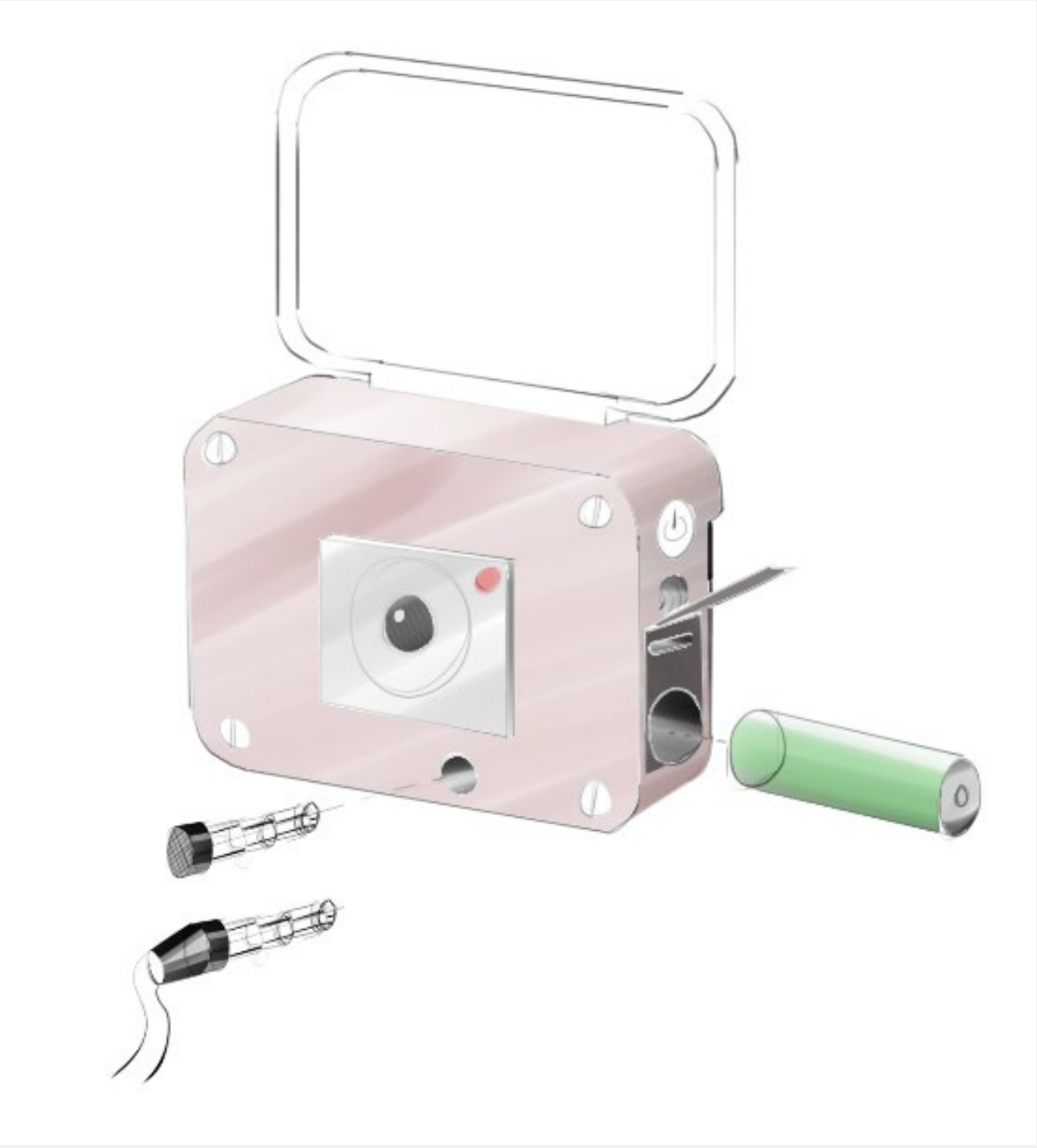


Figure 123. Sketch of the Webcam X actioncam concept.

The result was considered to be lacking interesting implementations of modularity, rather focussing on standardization. There were also unanswered questions about how camera sensors could be made repairable without sending the product to a specialist.

17.11.3. CONCEPT G – LOGITECH CUBE SQUARED

Concept was based on the cube idea, exploring how the functionalities of the cube product could be expanded to provide more value in a small package (Figure 124).

Figure 124. Digital sketch of the Cube squared concept.

In discussion with industry experts who are familiar with Logitech products the idea was assessed to be irrelevant for the future of the company, holding on to a product that is 10+ years old and long taken out of production.

17.12. Appendix L: Choosing concept - weighed criteria in detail

Overview of the 10 requirements:

Nr.	Theme	Weight	Requirement / consideration
R1	Innovation	20	Products design should be inspiring and advocate for the future of modular design.
R2	Sustainability	15	The application of modular parts in the product should have a positive effect on the products carbon footprint over the use-phase period of the product compared to an integrated alternative.
R3	Innovation	5	The application of modular parts should provide a benefit that cannot be attained using software functionality alone.
R4	Sustainability	15	Modular parts and tools needed to repair the product need to be accessible to the user (widespread availability, low cost, etc.), exceeding the services already provided by iFixIt.
R5	Sustainability	5	Repairs and replacements to the products' most resource-intensive parts should be performable by the user.
R6	Sustainability	10	Repairs and replacements to the product's parts with the highest failure rate should be performable by the user.
R7	Sustainability	5	The batteries of the product should be safe yet easy to remove by RRCs and the end-user.
R8	User experience	15	Product should be worthwhile to bring for Digital Nomads (by for example playing into the factors of professional relevance, size and amount of use).
R9	User experience	5	Product should clearly communicate its benefits to the Digital Nomad's lifestyle through its design.
R10	Sustainability	5	The product's modular design should prevent premature replacement.

Scale per requirement:

	Scales		
Nr.	0 value	5 Value	10 value
R1	No inspiration; trivial or missing modularity.	Contains innovative aspects, but unclear or limited potential.	Groundbreaking modular vision; strongly inspires Logitech's future.
R2	No LCA benefit; modularity increases impact.	Some potential benefits, but limited or unproven.	Clear, measurable reduction in impact over use-phase vs. integrated alternative.
R3	Only software-like benefits; hardware adds no value.	Tangible but modest benefits beyond software.	Unique benefits that software alone cannot achieve (e.g., physical adaptability).
R4	Proprietary, costly, or unavailable parts/tools.	Some availability, but limited reach, cost, or ease.	Widely available, affordable, standardized, easy for all users; beyond iFixIt.
R5	Users cannot repair key resource-heavy parts.	Some major components replaceable, but limited or complex.	All high-resource parts user-repairable with minimal tools and clear guidance.
R6	High-failure parts inaccessible for repair.	Some repair possible, but difficult or incomplete.	All common failure parts easily replaceable by user with intuitive design.
R7	Battery sealed/glued; unsafe or non-removable.	Removable, but requires skill or has safety risks.	Safe, tool-light removal for both RRCs and users, with robust safety design.
R8	Irrelevant to nomads (bulky, niche, low utility).	Some nomad benefits, but limited professional or lifestyle value.	Lightweight, compact, multifunctional, and highly relevant to nomadic work/life.
R9	No clear benefits for nomads in design.	Benefits exist but implicit; require explanation.	Design clearly communicates lifestyle benefits (visual cues, branding, usability).
R10	No effect on lifespan; replacement inevitable.	Some lifespan extension, but limited or unclear.	Strong prevention of premature replacement (upgrades, modular repairability).

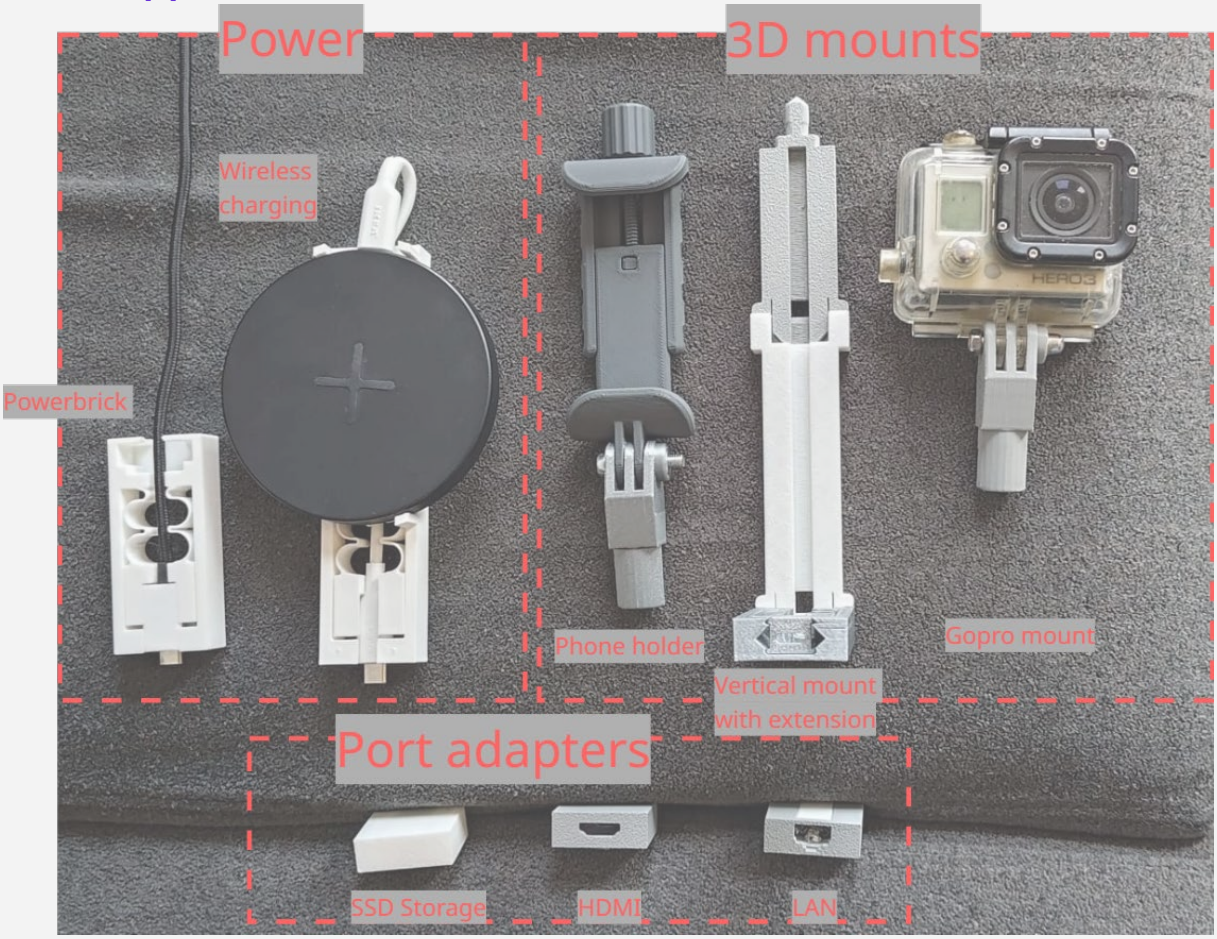
Score of all requirements, including weight:

		Score			
Nr.	**Weight**	**Modular LED light**	**Modular Lavalier micropho**	**Hackable laptop stand**	**Versatile modular mous**
R1	**20**	5	2	8	10
R2	**15**	7	6	4	6
R3	**5**	8	4	10	9
R4	**15**	7	5	8	5
R5	**5**	8	5	10	8
R6	**10**	9	8	10	9
R7	**5**	8	7	10	9
R8	**15**	6	7	9	6
R9	**5**	10	8	7	8
R10	**5**	10	9	9	7
		78	61	85	77
		710	555	805	750
Total	100				
Total Inn	25				
Total Sus	55				
Total UX	20				

17.13. Appendix M: Bill Of Materials (BOM) of prototype

Part number	Material prototype ►Material final product	Manufacturing	QTY.	Mold cost est. ($)	Mold cost per part	Production cost	Production cost per part	Production cost per product	Purchase costs per product
Hub bottom plate	PLA►PCR ABS	Injection molded	1	32898,23	3,29	135605,08	13,56	13,56	
Hub top plate	PLA►PCR ABS	Injection molded	1	20135,15	2,01	92284,69	9,23	9,23	
Module dock	PLA►PCR ABS	Injection molded	4	15453,68	0,39	11198,00	1,12	4,48	
Cable tensioner R-handed	PLA►PCR ABS	Injection molded	2	13199,16	0,66	11221,73	1,12	2,24	
Cable tensioner L-handed	PLA►PCR ABS	Injection molded	2	13199,16	0,66	11221,73	1,12	2,24	
Link hole cover	PLA►PCR ABS	Injection molded	2	8695,75	0,43	11356,14	1,14	2,27	
Connector	PLA►PCR ABS	Injection molded	2	16820,24	0,84	12181,45	1,22	2,44	
Main board	Multiple►Sustain aCircuits	Inkjet print	1						20,00
Link cable (USB4)	Multiple	Multiple	1						5,00
USB-C male-female (USB4)	Multiple	Multiple	1						5,00
USB-C male-female (USB3.2 PD)	Multiple	Multiple	1						3,00
USB-C male-female (USB3.2 Gen2x2)	Multiple	Multiple	1						2,00
USB-C male-female (USB3.2 Gen2)	Multiple	Multiple	1						1,00
B18.6.7M - M3 x 0.5 x 20 Type I Cross Recessed FHMS -- 20N	Stainless steel 304	Multiple►PVC-free	8						0,05
B18.6.7M - M3 x 0.5 x 6 Type I Cross Recessed FHMS --6N	Stainless steel 304	Multiple►PVC-free	9						0,05
B18.6.7M - M3 x 0.5 x 5 Type I Cross Recessed FHMS --5N	Stainless steel 304	Multiple►PVC-free	10						0,05
B18.2.4.1M - Hex nut, Style 1, M3 x 0.5 --D-N	Stainless steel 304	Multiple►PVC-free	36						0,05
Folio panel L	PVC►TPU	Injection molded	6	26523,90					
Folio panel S1	PVC►TPU	Injection molded	5						
Folio panel S2	PVC►TPU	Injection molded	10						
Folio vegan leather fabric	(el)PVC►TPU	Sheet extrusion	2		2,65	11590,51	1,16	6,95	
Belt	Nylon	Multiple	1						2,00
Buckle	POM	Injection molded	1						2,00
			108	146925,272	10,93779	296659,33	29,665933	43,418693	40,2

17.14. Appendix N: Module overview



17.15. Appendix O: Structure for physical validation

Number	Question
Intro	Thank you for helping me with my project! *Small introduction if necessecary* Some months ago, I interviewed 11 Digital Nomads to find out what their life looks like and to see what problems occur in their lifestyle. Based on that and other research, I have developed a concept product. *Explain concept product:* • *Shape and size* • *Unfolding* • *Attaching modules* • *Placement underneath the laptop* • *Functionality as a stand* Please remember that there are no wrong answers, I am really looking for your honest opinion, it is perfectly fine if you do not like the idea, I am hoping to understand why you like or dislike the product and its features. Do you have any questions before we start?
0	**SIGN IC FORM**
	START OF OBSERVATION
1	**Exploring product** *Please envision that you are a Digital Nomad working from a destination of your choosing for a minimal period of 3 months, you bought this product to help you improve your productivity on the go.* ***Show examples of modules***
1a	-> Where would you prefer to buy the hub

1b	-> The hub has 4 ports for modules, two on the sides and two on the back, how many modules would you buy with the hub? Which ones?
1c	-> Would you bring extra modules for specific situations, if so, which ones?
2	*The interface that lets modules interact with the hub is open source, this means that all schematics and instructions for building modules are free to use for consumers and manufacturers. You could therefore also 3D print your own modules.*
2a	Please pick your top three decisions for how to acquire new modules **SEE MIRO**: • I would buy modules online from the Logitech brand • I would buy modules in store from the Logitech brand • I would buy modules online from a 3rd party brand • I would buy modules in store from a 3rd party brand • I would have modules 3D printed and have them shipped to me • I would have modules 3D printed and have them shipped to me
3	*The hub is designed so that the internals can easily be replaced when one part is broken* ***SHOW VIDEO***
3a	Please pick the statement that fits best with what you would do if a part in the module breaks: • I would buy the new part and repair it myself • I would have a friend repair it for me • I would go to a professional repair shop to have it repaired • I would not repair the hub
4	*Now some more general questions about the product*
4a	-> The Folio cover serves as a cover and laptop stand, the buckle also allows you to attach the hub to baggage and gather your work supplies into one package. Would you rather have the hub with the folio that folds into a laptop stand or without? Why?
4b	-> Would the Hub provide you with more freedom to work and live? If so, why?
4c	-> Thanks to the modularity in the hub you can combine multiple devices into one package, Would this package:

	• Save space • Keep space the same • Take up more space.
4d	-> Can you explain if and how the hub could provide you with a more consistent working environment?
4e	-> Would the hub be worth packing?
4f	-> Do you see any issues with the current design of the hub when used in the lifestyle of Digital Nomads?
5	*Lastly I have some questions on setting the price for this product, the base hub. Consider Logitech build quality.*
5a	-> Q1. At what price would you consider the product/service to be priced so low that you feel that the quality can't be very good (too cheap)?
5b	-> Q2: At what price would you consider this product/service to be a bargain—a great buy for the money (Cheap/good value)?
5c	-> Q3: At what price would you say this product/service is starting to get expensive—it's not out of the question, but you'd have to give some thought to buying it (Expensive/high side)?
5d	->Q4: At what price would you consider the product/service to be so expensive that you would not consider buying it? (Too Expensive)

Appendix P: Project Brief

Personal Project Brief – IDE Master Graduation Project

Name student	Stan Zwanenburg	Student number	4,883,098

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title Revolutionizing computer peripherals: exploring modular design

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Modular design aims to develop product architecture consisting of physically detachable units for rapid product development, ease of assembly, servicing, reuse, recycling and other product life cycle objectives (Gu et al., 1997).

Design for modularity is often perceived as the opposite of design for integration. Where integration focusses on having parts be multifunctional to improve performance and efficiency, modularity focusses on the parts autonomy to improve scalability and upgradability (Mikkola, 2001). Modularity can also enable new product variations, more rapid assembly and simple disassembly to improve the product lifecycle (Machado & Morioka, 2021).

Modularity does not have to be physical; software can be programmed in specialized modules to increase efficiency and upgradability, organisations are often structured in modules (departments) to promote specialisation and efficiency (Langlois, 2002) and biologists refer to modularity as one of the key factors in an organisms capability to evolve (Zelditch & Goswami, 2021). This project focuses on physical modularity, where a physical product contains modules that provide it with certain functionality.

The use of modularity in peripheral electronics has not yet been fully embraced. Logitech is one of the most well-known players in the market of computer peripherals and has explored the use of modularity in several ways; From customizable headphones for children to expandable speakerphone sets and an adaptive gaming kit for less abled. Where these products use modularity to an extent, their core functionality is not to be modular.

→ *space available for images / figures on next page*

introduction (continued): space for images

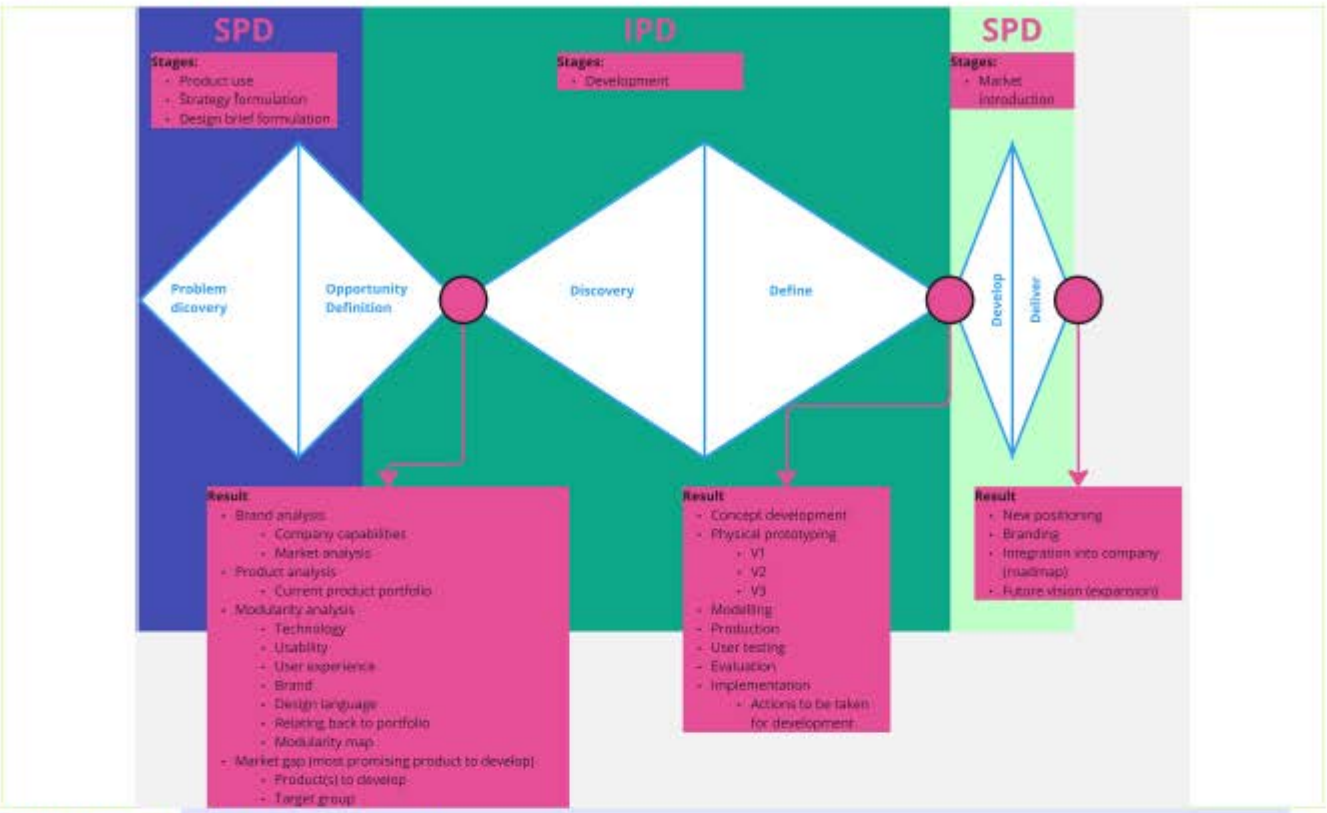


image / figure 1 Initial planning of project

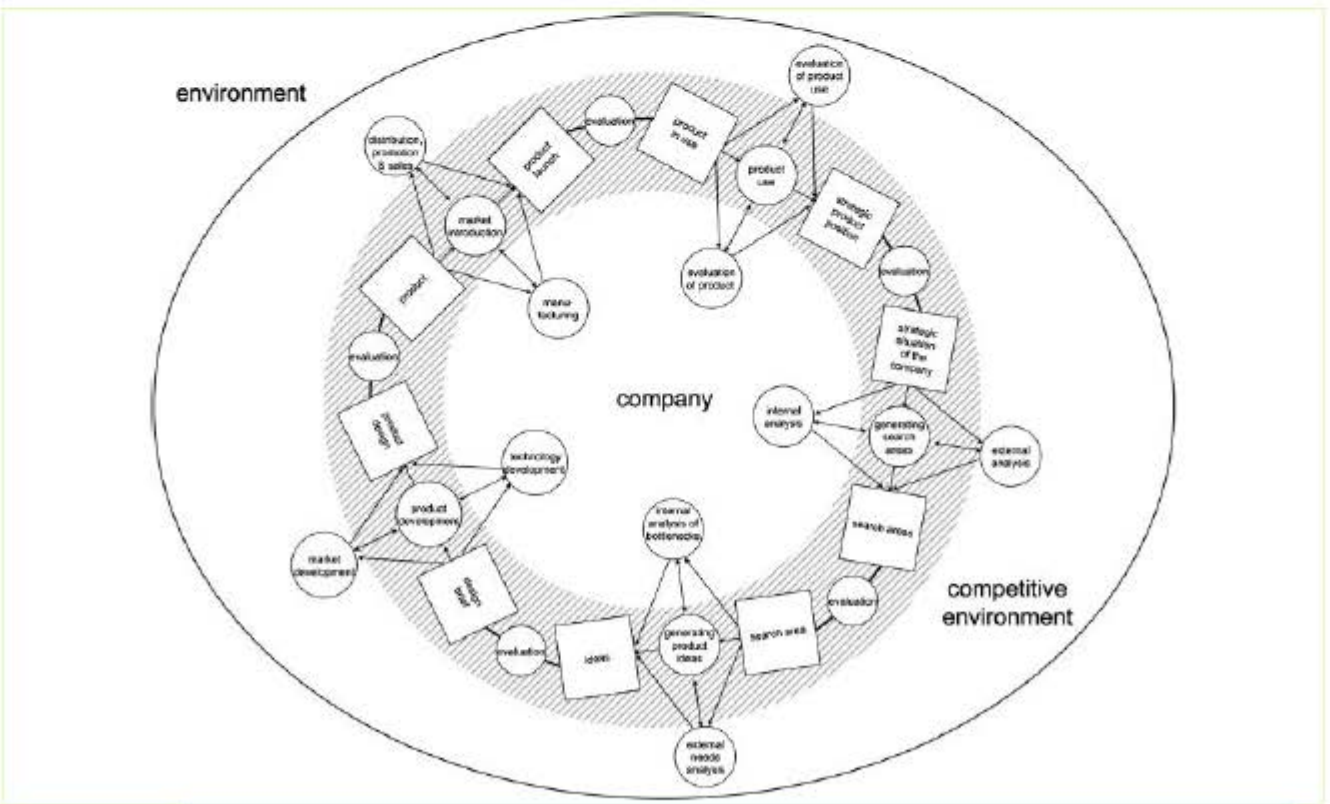


image / figure 2 Visual of the Delft Innovation method (Buijs, 2012)

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Although Logitech has proven to be on the forefront of computer peripheral development in terms of both technology and sustainability, the use of modularity in their products has been somewhat limited, the reason being that consumer electronics that have modularity as one of their main drivers have not yet been proven to be successful compared to their integrated counterparts (Agrawal et al., 2016).

Modularity is a broad term, making it hard for a brand to know where to start and where to go. This project explores what forms of modularity exist and uses the brand of Logitech as the main point of reference to develop product concepts that apply modularity effectively.

The question that arises is: what role can modularity fulfil in computer peripherals, and how can it be used to improve consumer adoption of the Logitech brand?

Answering this question could help Logitech with developing its products so that they benefit consumers in a way that is sustainable and effective.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Investigate and create a vision of modularity through an innovative prototype that Logitech can use for the future of modular product design.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

The project will follow the product innovation process by Buijs (Buijs, 2012). This process fits the project well seeing that it looks to internal and external factors to develop innovative new concepts and incorporates valuable segments for both masters of SPD & IPD:

1. The existing product portfolio and strategy of Logitech will be analysed.
2. A detailed analysis of modularity will be conducted, resulting in a "modularity map" and target groups.
3. Using the results from the initial analysis, a design brief is written for a modular prototype product that fits Logitech and the needs of the future consumer.
4. Different ways of filling in the design brief are explored through brainstorming and prototyping.
5. The prototypes are developed and their functionalities are explored and evaluated.
6. Lastly a plan is written on how to introduce the new modular product into the existing product portfolio.

Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a kick-off meeting, mid-term evaluation meeting, green light meeting and graduation ceremony. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	12 Mar 2025
Mid-term evaluation	25 Jun 2025
Green light meeting	13 Oct 2025
Graduation ceremony	2 Dec 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:
Project will have workweeks of 36 hours.

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

I have been using Logitech products my entire life, to me the brand is a combination of innovation and user centred design. When I heard that Logitech was interested in exploring modularity in their products I was instantly engaged seeing that I could combine my personal affinity to the brand with my critical view on product design. I believe the application of modularity in consumer electronics has focussed too much on either sustainability or playfulness and that there should be a way to apply it so that consumers are willing to choose for the modular option because it is better in ways they actually value.

With this project I want to improve my individual project management skills. Previous individual projects (both for study and private) have shown that I can struggle with staying motivated, I have seen significant improvements in the last years, but I understand that the graduation project is more of a challenge than all others I have encountered until now.

18. References

- Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of environmental psychology*, *25*(3), 273-291.
- Agrawal, V. V., Atasu, A., & Ülkü, S. (2016). Modular Upgradability in Consumer Electronics: Economic and Environmental Implications. *Journal of Industrial Ecology*, *20*(5), 1018-1024. https://doi.org/https://doi.org/10.1111/jiec.12360
- ÅVIK, B. K., & TURIKBAYEV, D. (2023). Digital Nomadism: Exploring Origins, Theory and Work-Life Balance. https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://uia.brage.unit.no/uia-xmlui/bitstream/handle/11250/3145176/no.uia%253Ainspera%253A229115244%253A48354400.pdf%3Fsequence%3D1%26isAllowed%3Dy&ved=2ahUKEwju5pHfmfGOAxXT3AIHHSDSI8EQFnoECBkQAQ&usg=AOvVaw27KLRK8htXYDt366GZdZuP
- Bayraktaroğlu, S., & İdemen, E. (2024). Redefining repair as a value co-creation process for circular economy: Facilitated do-it-yourself repair. *International Journal of Design*, *18*(1), 1.
- btarunr. (2011). *Logitech Introduces K270 Wireless Keyboard*. Tech powerup. Retrieved 28/11 from https://www.techpowerup.com/144720/logitech-introduces-k270-wireless-keyboard
- Buijs, J. (2012). The Delft Innovation Method A Design Thinker's Guide to Innovation. DS 71: Proceedings of NordDesign 2012, the 9th NordDesign conference, Aarlborg University, Denmark. 22-24.08. 2012,
- Ceylana, H. H., Koseb, B., & Aydin, M. (2014). Value based Pricing: A Research on Service Sector Using Van Westendorp Price Sensitivity Scale. *Procedia - Social and Behavioral Sciences*, *148*, 1-6. https://doi.org/https://doi.org/10.1016/j.sbspro.2014.07.013

- Chen, Y.-S., & Chang, C.-H. (2013). Greenwash and green trust: The mediation effects of green consumer confusion and green perceived risk. *Journal of business ethics*, *114*(3), 489-500.
- Dekker, M. (2016). *Elementary Ergonomics*. TU Delft. Retrieved 29/11 from https://ocw.tudelft.nl/course-lectures/ergo-l6-use-cues-obs-research/
- Delavani, E., & Linando, J. A. (2025). Freelancers in the Creative Industries An In-Depth Analysis of Flexibility and Uncertainty. *Organization and Human Capital Development*, *4*(1).
- Ebert, T., Jayanathan, S., Cuccaro, L., Guzzo, R., Schischke, K., & Sanchez, D. (2024). Product Design Strategies for Decarbonization and Resource Efficiency. 2024 Electronics Goes Green 2024+(EGG),
- Ekaterina Chevtaeva, B. D.-G. (2021). Digital nomads' lifestyles and coworkation. *Journal of Destination Marketing & Management*, *21*. https://www.sciencedirect.com/science/article/abs/pii/S2212571X21000810
- Elevated-systems. (2021, 15/9). *Prototyping Framework Laptop Expansion Cards* https://www.youtube.com/watch?v=0_uOzNt-xwY&t=7s
- Eppinger, S. D., & Ulrich, K. (1995). Product design and development.
- Epstein, & Seymour. (2003). validity of CEST, Cognitive-Experiential Self-Theory of Personality. *VOLUME 5 PERSONALITY AND SOCIAL PSYCHOLOGY*, 159.
- Fairphone. (2025). *Story*. Retrieved 22/10 from https://www.fairphone.com/en/story/
- Fogg, B. (2009). *A behavior model for persuasive design* Proceedings of the 4th International Conference on Persuasive Technology, Claremont, California, USA. https://doi.org/10.1145/1541948.1541999
- Framework. (2025). *Expansion Card*. Retrieved 22/10 from https://community.frame.work/c/developer-program/expansion-card/90

- G, L. Gaming Mice. https://www.logitechg.com/en-us/products/gaming-mice.html
- Greenhalgh, J. (2008, 14-08-2008). *Logitech to Acquire Ultimate Ears, Leader in Professional In-Ear Monitors and Consumer Earphones for Music Listening* https://ir.logitech.com/press-releases/press-release-details/2008/Logitech-to-Acquire-Ultimate-Ears-Leader-in-Professional-In-Ear-Monitors-and-Consumer-Earphones-for-Music-Listening/default.aspx
- Gu, P., Hashemian, M., Sosale, S., & Rivin, E. (1997). An Integrated Modular Design Methodology for Life-Cycle Engineering. *CIRP Annals*, *46*(1), 71-74. https://doi.org/https://doi.org/10.1016/S0007-8506(07)60778-1
- iFixIt. (2025). *Logitech G Pro Gaming Mouse Feet - Genuine*. https://www.ifixit.com/en-eu/products/logitech-g-pro-gaming-mouse-feet-genuine
- Intel. (2025, 07/22). *Thunderbolt™ Share - Licensed Configurations & Hardware Requirements* https://www.intel.com/content/www/us/en/support/articles/000099003/software.html#primary-content
- Keh, P.-R. (2022, 23-08-2022). *Makeover: Logitech rebrand as 'Logi' with a new logo and accessory line*. https://www.wallpaper.com/design/makeover-logitech-rebrand-as-logi-with-a-new-logo-and-accessory-line
- Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental education research*, *8*(3), 239-260.
- Langlois, R. N. (2002). Modularity in technology and organization. *Journal of Economic Behavior & Organization*, *49*(1), 19-37. https://doi.org/https://doi.org/10.1016/S0167-2681(02)00056-2
- Lawler, R. (2018, 31-07-2018). Blue Microphones sells to Logitech for $117 million. *Engadget*. https://www.engadget.com/2018-07-30-blue-logitech-acquisition.html?_fsig=9B0z_Xs8dPbykgAkMIl58g--%7EA

- Lithner, D., Nordensvan, I., & Dave, G. (2012). Comparative acute toxicity of leachates from plastic products made of polypropylene, polyethylene, PVC, acrylonitrile–butadiene–styrene, and epoxy to Daphnia magna. *Environmental Science and Pollution Research*, *19*(5), 1763-1772.
- Logitech. *Logitech Inverstors Relations*. https://ir.logitech.com/home/default.aspx
- Logitech. (2022). *FY22 Impact Report*. https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.logitech.com/content/dam/logitech/en/sustainability/pdf/resources/fy22-impact-report-portrait.pdf&ved=2ahUKEwig4-P__tmMAxXWgf0HHae4N9kQFnoECBIQAQ&usg=AOvVaw1AWEAOdIppmlAQB-55--3o
- Logitech. (2024a). *FORM 10K*. https://s1.q4cdn.com/104539020/files/doc_financials/2024/ar/logitech-10-k-2024.pdf
- Logitech. (2024b). *FY24 Impact Report*. Logitech. https://impactreport.logitech.com/#page=1
- Logitech. (2024c). *Logitech Named World's Best Employer by Forbes* https://www.logitech.com/blog/2024/11/14/logitech-named-worlds-best-employer-by-forbes/
- Logitech. (2025a). *ANALYST AND INVESTOR DAY 2025* https://s1.q4cdn.com/104539020/files/doc_presentations/2025/03/Logitech-AID_Master-Slide-Deck_PDF_250305.pdf
- Logitech. (2025b). Designing a Positive Future- FY25 IMPACT HIGHLIGHTS. https://impactreport.logitech.com/#page=1
- Logitech. (2025c). *Logitech for business*. Retrieved 22/04/2025 from https://www.logitech.com/en-us/business.html
- Logitech. (2025d). *Logitech Repair Hub*. Retrieved 19/5 from https://www.ifixit.com/collaborations/logitech-eu
- López, A. M. (2025). *Share of digital nomads worldwide as of June 2025 by annual income* (https://www.statista.com/statistics/1298865/digital-nomads-by-income-level-worldwide/

- Lu, B. (2017, 11-08-2017). *Logitech acquires Astro Gaming* https://ir.logitech.com/press-releases/press-release-details/2017/Logitech-Acquires-ASTRO-Gaming/default.aspx
- Lu, B. (2019, 26-09-2017). *Logitech Agrees To Acquire Streamlabs, Adding Streaming Tools to its Gaming Offering* https://ir.logitech.com/press-releases/press-release-details/2019/Logitech-Agrees-To-Acquire-Streamlabs-Adding-Streaming-Tools-to-its-Gaming-Offering/default.aspx
- Machado, N., & Morioka, S. N. (2021). Contributions of modularity to the circular economy: A systematic review of literature. *Journal of Building Engineering*, *44*, 103322. https://doi.org/https://doi.org/10.1016/j.jobe.2021.103322
- Mair, T. (2022). *repairable & recyclable kara coffee machine sets a sustainable standard for appliance design*. Designboom. https://www.designboom.com/design/repairable-recyclable-kara-coffee-machine-sustainable-standard-appliance-design-thomas-mair-12-04-2022/
- Mannetti, L., Pierro, A., & Livi, S. (2004). Recycling: Planned and self-expressive behaviour. *Journal of environmental psychology*, *24*(2), 227-236.
- Marx, S. M., Weber, E. U., Orlove, B. S., Leiserowitz, A., Krantz, D. H., Roncoli, C., & Phillips, J. (2007). Communication and mental processes: Experiential and analytic processing of uncertain climate information. *Global environmental change*, *17*(1), 47-58.
- Mascitelli, R. (2004). *The lean design guidebook: everything your product development team needs to slash manufacturing cost*. Technology perspectives.
- Maxwell, E. (2006). Open Standards, Open Source, and Open Innovation: Harnessing the Benefits of Openness. *Innovations: Technology, Governance, Globalization*, *1*(3), 119-176. https://doi.org/10.1162/itgg.2006.1.3.119
- Mevo. (2022). *3D Printable Files*. Retrieved 26-8 from https://help.mevo.com/hc/en-us/articles/6321647393300-3D-Printable-Files

- Mevo. (2025). *Mevo is Public Now*. Retrieved 22/10 from https://github.com/usemevo-com/source-code
- Miguel, C., Lutz, C., Perez-Vega, R., & Majetić, F. (2025). "Alone on the road": Loneliness among digital nomads and the use of social media to foster personal relationships. *Media, Culture & Society*, *47*(3), 546-566. https://doi.org/10.1177/01634437241290087
- Mikkola, J. H. (2001). *Modularity and interface management of product architectures* (Vol. Supplement). https://doi.org/10.1109/PICMET.2001.952259
- Myers, T. A., Nisbet, M. C., Maibach, E. W., & Leiserowitz, A. A. (2012). A public health frame arouses hopeful emotions about climate change: A letter. *Climatic change*, *113*(3), 1105-1112.
- Myskiv, G. (2025). Digital Nomads as a Contemporary Trend in the Global Labor Market. *Economics, Finance and Management Review*(2 (22)), 94-108.
- Neumann, B. R., Cauvin, E., & Roberts, M. L. (2012). Management control systems dilemma: Reconciling sustainability with information overload. In *Advances in Management Accounting* (pp. 1-28). Emerald Group Publishing Limited.
- Parliament, E. (2025). *New design requirements and consumer rights for electronics pursuant to Directive* https://www.europarl.europa.eu/legislative-train/theme-a-europe-fit-for-the-digital-age/file-design-requirements-and-consumer-rights-for-electronics
- Passchier, J. (2025). *Staatssecretaris van Milieu: 'Ik haatte bedrijven als Fairphone'*. Retrieved 15-10 from https://androidworld.nl/achtergrond/staatssecretaris-van-milieu-ik-haatte-bedrijven-als-fairphone/
- Philips. (2025). *Fixables*. Retrieved 08/07 from https://www.philips.cz/c-e/fixables
- Preethish. Kumar, M., Usha. B, A., Basavaraj. G, N., Mohan. B, A., Prithvi, G., & Rajkumar. (2024, 20-21 Sept. 2024). Empowering Consumers and Sustainability: A Global Review of Right to Repair

Policies. 2024 International Conference on Distributed Systems, Computer Networks and Cybersecurity (ICDSCNC),
- Red-dot. (2012). *Logitech Cube* https://www.red-dot.org/project/logitech-cube-29214
- Sánchez, D., Proske, M., & Baur, S.-J. (2022). *LIFE CYCLE ASSESSMENT OF THE FAIRPHONE 4*. F. IZM. https://www.fairphone.com/wp-content/uploads/2022/07/Fairphone-4-Life-Cycle-Assessment-22.pdf
- Shi, T., Huang, R., & Sarigöllü, E. (2022). Consumer product use behavior throughout the product lifespan: A literature review and research agenda. *Journal of Environmental Management*, *302*, 114114. https://doi.org/https://doi.org/10.1016/j.jenvman.2021.114114
- *Swiftpoint ProPoint*. Retrieved 11/06 from https://www.swiftpoint.eu/products/ergonomic-mice-propoint
- Torres. (2025, 05/09/2025). Fully functional ultra-compact Bluetooth mouse is smaller than an AirPods Pro case https://www.yankodesign.com/2025/05/09/fully-functional-ultra-compact-bluetooth-mouse-is-smaller-than-an-airpods-pro-case/
- Van Boeijen, A., Daalhuizen, J., Van Der Schoor, R., & Zijlstra, J. (2014). *Delft design guide: Design strategies and methods*.
- van den Berge, R., Magnier, L., & Mugge, R. (2021). Too good to go? Consumers' replacement behaviour and potential strategies for stimulating product retention. *Current Opinion in Psychology*, *39*, 66-71. https://doi.org/https://doi.org/10.1016/j.copsyc.2020.07.014
- Wade-Benzoni, K. A., Tenbrunsel, A., & Bazerman, M. (1997). Egocentric interpretations of fairness as an obstacle to the resolution of environmental conflict. *Research on negotiation in organizations*, *6*, 189-208.
- White, K., Habib, R., & Hardisty, D. J. (2019). How to SHIFT Consumer Behaviors to be More Sustainable: A Literature Review

and Guiding Framework. *Journal of Marketing*, *83*(3), 22-49. https://doi.org/10.1177/0022242919825649

- Zelditch, M. L., & Goswami, A. (2021). What does modularity mean? *Evolution & Development*, *23*(5), 377-403. https://doi.org/https://doi.org/10.1111/ede.12390

19. Table of figures

19.1. Tables