Appendices

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name _____

initials _____ given name _____

student number _____

street & no. _____

zipcode & city _____

country _____

phone _____

email _____

Your master programme (only select the options that apply to you):

IDE master(s): ( ) IPD (★) DfI ( ) SPD

2nd non-IDE master: _____

individual programme: __ - __ - ____ (give date of approval)

honours programme: ( ) Honours Programme Master

specialisation / annotation: ( ) Medisign

( ) Tech. in Sustainable Design

( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair _____ dept. / section: _____

** mentor _____ dept. / section: _____

2nd mentor _____

organisation: _____

city: _____ country: _____

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

Digitally signed by Bas Flipsen
Date: 2021.03.12 16:56:38 +01'00'

chair _____ date - - signature _____

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: _____ EC

Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC

List of electives obtained before the third semester without approval of the BoE

YES all 1st year master courses passed

NO missing 1st year master courses are:

name _____ date - - signature _____

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: APPROVED NOT APPROVED

Procedure: APPROVED NOT APPROVED

comments

name _____ date - - signature _____

Initials & Name _____ Student number _____

Title of Project Improving repairability in cordless vacuum cleaners

Improving repairability in cordless vacuum cleaners — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 15 - 02 - 2021 — 28 - 09 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

In our current day and age, the lifetime of many types of electronic consumer goods is and has been decreasing. (Bakker, C., Wang, F., Huisman, J., & Den Hollander, M. (2014). This can be attributed, among other factors, to the low costs of new products compared to the costs of service and repair. Opportunity for service, repair, remanufacturing and refurbishment during the lifetime of products is often neglected during the design process. In order to effectively create a circular economy and sustainable society, the lifetime of these products needs to be prolonged and materials should be used in a way that they can be relooped infinitely.

Current trends

Consumers are demanding their products to be more sustainable, which is being heard by manufacturers like Philips. Who have taken considerable steps toward this goal through improving serviceability, repairability and durability in their products, using more recyclable materials, offering refurbished products, using more plastic free packaging, trying out new business models and reducing energy consumption of their products. At the same time development in regulations and norms on repairability is taking place. On national, EU and global levels stricter rules are drafted around labelling of products on aforementioned sustainable strategies. In november 2020 the European Parliament accepted a report on sustainable Single Market with the goal to boost sustainability by promoting reuse and repairs and by tackling practices that shorten the lifespan of products. This change will impact the removal of legal obstacles that prevent repair, resale, and reuse. France has been one of the forerunners in this transition and recently introduced a new repair index in January 2021 as an action because of their new anti-waste law. The index score is determined by factors like ease of disassembly, access to repair information, price and availability of spare parts. The European Parliament will be able to learn from this label and implement learned lessons into a EU wide label.

Serviceability and repair

One of the strategies for the circular economy is to increase the repairability of physical products. The EMF Circular Economy System diagram shows how repair is one of the inner loops of the model, the smaller the loop the smaller the amount of additional energy is needed to prolong a product's life. In 'Managing Design for Obsolescence' den Hollander describes how different strategies need to be combined to effectively create sustainable impact through circular product design. Expanding and improving knowledge on repairability in consumer electronics while taking into account the context of the product system and potential combinations with different sustainable strategies is therefore essential. Service is done by authorized service companies or the producers themselves, while the act of repair is carried out by parties with no professional service connection to the producer. (Re)designing for repair and serviceability has a strong focus on improving disassembly which also benefits refurbish- and re-manufacturability. Many different stakeholders participate in the described context. To ensure that products are efficiently and effectively improved in terms of service and repair the wants and needs of these parties need to be taken into consideration.

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introduction (continued): space for images

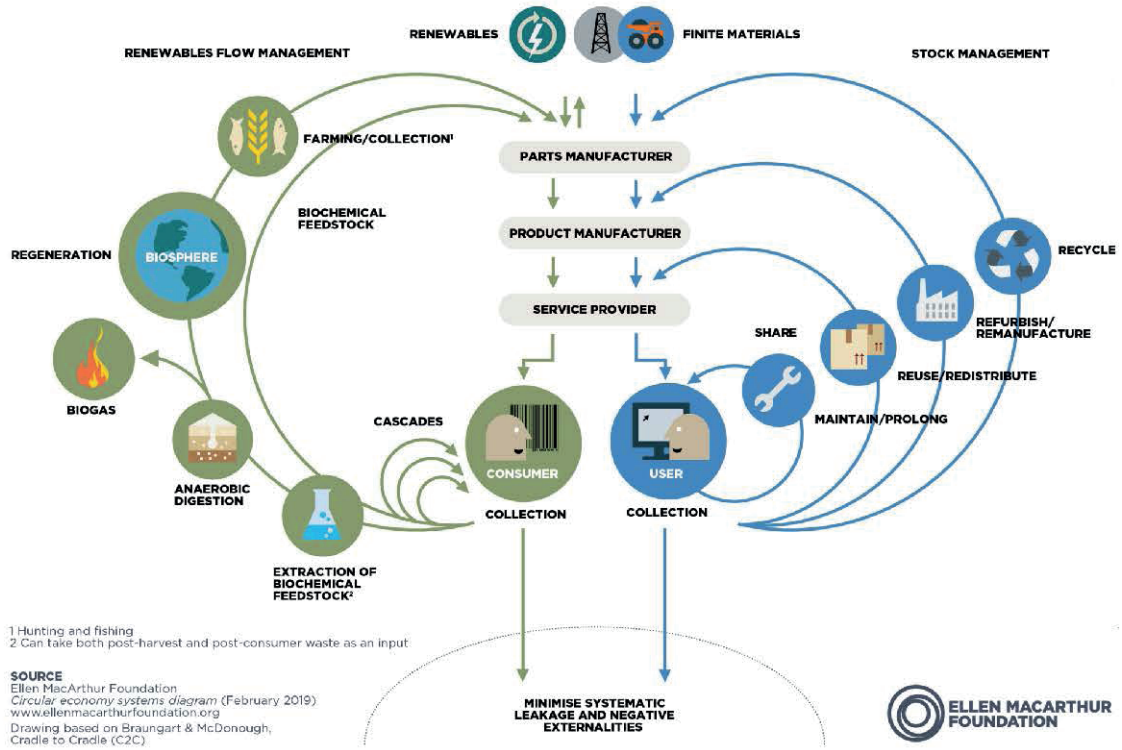


image / figure 1: The Ellen MacArthur Foundation Circular Economy System Diagram

User

What do they do: Buy, use and dispose of products
What they want: Their needs fulfilled through affordable, beautifull, easy to use, sustainable products
Current position: They vote with their money and decide which products are succesfull, citizen initiatives through petitions and voting in terms of government.

Manufacturer

What do they do: Produce components, parts and sometimes complete products (assembly)
What they want: Correct input, producing in bulk, generate profit.
Current position: Their current tools, machinery and producing pace are a limitation to improving sustainability in the current loop.

Retailers

What do they do: Sell products from Philips to consumers/users
What they want: To make profit of their goods and fullfill users needs while building and/or maintaining a brand-user relationship.
Current position: They decide what products they want to display in their (digital) stores.

Philips

What do they do: Design, produce and sell consumer lifestyle products
What they want: To design profitable, beautiful products, that work (and thus fulfill users needs) and improve positive sustainable impact.
Current position: They have the power to generate change through design, are limited by laws and regulations and need to answer to the needs of users.

Legislation

What do they do: Test products and grant labels on safety, efficienty etc.
What they want: To guarantee that their labels are trustworthy
Current position: They are strict on existing norms and collaborate with companies on to be developed norms.

Government

What do they do: Set rules on importing products, safety and sustainability.
What they want: Safe products for citizens and achieving sustainability goals
Current position: The EU is accelerating development new regulation and laws, while on national level this change is currently less rapid.

image / figure 2: Important stakeholders and their current position in the described context

Initials & Name _____ Student number _____

Title of Project Improving repairability in cordless vacuum cleaners

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

This graduation project aims to improve Philips' rechargeable floor care products in terms of sustainability and focuses on two cordless vacuum cleaners in their current portfolio. The scope of this case study ranges from analysis of regulation on repairability of this product group to the physical embodiment of these products and lastly the design process through which they are created. A large portion of the Philips canister vacuum cleaner portfolio is made of a high percentage of recycled material (>90%). This is also being explored for the sticks product group, while repair- and serviceability can also be enhanced. Since rechargeable floor care products contain batteries with voltages around 25V, service or repair currently is advised to be carried out by professional personnel

Philips wishes to prepare their product portfolio for more advanced repair and serviceability requirements and labels that will be introduced in the near future.. This project tries to contribute to future proofing the product portfolio by creating and suggesting new design guidelines, taking into account the developments of regulations concerning repairability and durability on national and EU level. In the analysis phase tools like the Disassembly Map (De Fazio, 2019) will be used in order to map the serviceability of the two Philips products. Based on the analysis of the physical products, potential to improve the original design through a concept will be explored. This in turn will be done in collaboration with Philips' innovation and design department taking into account the current design development process.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The goal of this graduation project is to rate and document the serviceability of rechargeable floorcare products of Philips, compare their existing products to those of competitors, generate advice and suggestions for a physical redesign, update and shape guidelines for service and repair in new product design taking the developments on repairability and durability in national and European law into account.

Deliverables:
A documented serviceability rating (based on current and future labels) of 2 rechargeable stick products from Philips and 2 to 5 rechargeable stick products from competitor brands. Achieved through: Disassembling the products and documenting this process in combination with analysis tools like the Disassembly Map.
An overview of the to be implemented EU regulations concerning repairability and durability. Achieved through: Researching current developments and to be expected outcomes through interviews and literature research.
A physical redesign improving serviceability of one of Philips' rechargeable floor care products balancing the high economic costs of changes in physical design and achieving the highest possible amount of sustainable impact. Achieved through: Solving problems found in the previously executed rating and analysis through embodiment changes and in collaboration with the Product Development team.
A simplified version of the Disassembly Map which will cost less time to learn and use by Philips workers. Achieved through: Analysing projects in which the Disassembly Map is used and testing iterations with the Philips PD team.
An implementable addition on improving serviceability in the current design process. Design guidelines for to be designed rechargeable sticks products in order of improving repairability in the future. Achieved through: Forming a hypothesis for new guidelines and testing these during the physical redesign process in collaboration with the Product Development teams at Philips.

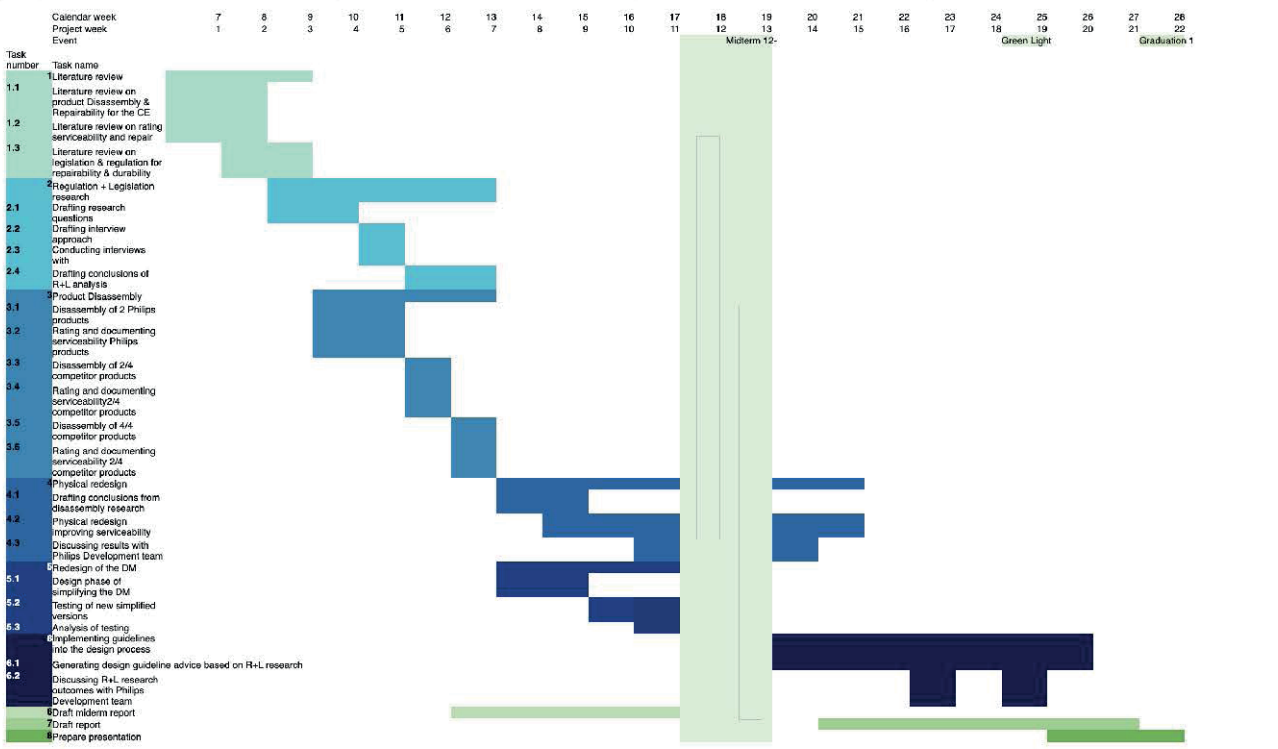
Initials & Name _____ Student number _____

Title of Project Improving repairability in cordless vacuum cleaners

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and 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 activities.

start date 15 - 2 - 2021 28 - 9 - 2021 end date



Within the Gant Chart two innovation frameworks, also known as 'double diamonds', describe the processes of two big creation deliverables. That of improving the current stick design of Philips in terms of serviceability and that of proposing an update to the current Philips design process in terms of developing products that meet stricter regulation on service and repair.

The analysis of the stick vacuum cleaners will result in ways to improve the current Philips design in terms of serviceability and repair. Reviewing of literature, disassembly tests and rating of the products on the current regulations, make up the discovery phase. After which the prospected development of laws and standards are used to define in what way the product can be improved. In the development phase ideas are generated and selected while finally the concept is tested and iterated on in the deliver phase.

At the same time the current Philips design process analysed. As their products need to meet requirements on service and repair, the design process will have to be updated to take this change into account. Outcomes of the first innovation framework will be compared to their designated place in the design proces. Based on this comparison it will be researched if and how this process can be tailored to produce better serviceable and repairable products. In the discover phase, corresponding literature will be reviewed and service center workers will be interviewed. In the define phase the current design process is compared to the found opportunities for improvement of the first double diamond process. After this follows the develop phase in which ideas are generated and tested with the design team, while in the last phase this is iterated on and reviewed.

Initials & Name _____ Student number _____

Title of Project Improving repairability in cordless vacuum cleaners

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

Ever since starting my design education I have known that I wanted to contribute to a better future through design for sustainability. The most praised industrial design products are durable, high-quality problem solving objects. Durability and quality have been fading to the background in design ever since we became used to our prêt-à-jeter society. Reclaiming these design traits also grants enormous potential of lowering CO2 emissions, which pose the biggest threat to our world at the moment in the form of climate change.

In my education I have taken different perspectives to the circular economy, from embodiment design and circular business models to sustainable consumer behaviour. In this project I want to combine my experience with user-oriented physical product design, which I gained in the master programme Design for Interaction, with aforementioned knowledge on design for circularity.

In this project I want to:

- Deliver high quality deliverables which have the potential to improve processes and products.
- Gain practical hands-on repair and disassembly skills in the aforementioned specific product group.
- Experience and partake in the company culture and collaborative approach used in professional product development teams, for example through organising creative sessions and meetings.
- Gain more insight and hands on experience on the process of (circular) embodiment design and manufacturing in a company like Philips.
- Gain more insight on and contribute to (the development of) regulations and laws on physical products in the light of the circular economy.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name _____ Student number _____

Title of Project Improving repairability in cordless vacuum cleaners

Philips Speed Pro Max Disassembled

Component List

1. Tube
2. Nozzle
3. Bucket
4. Handheld assembly
5. Battery
6. Switch handle panel
7. Rubber button
8. Button sheet
9. Exhaust Grill Cap
10. Motor & PCBA assembly
11. Side panel left
12. Side panel right
13. Handle grip
14. UI Panel
15. Inner exhaust gril assembly
    15 a. Visual
    15 b. Inner visual cap
    15 c. Inner sound reflector
16. Handhelt inlet
17. Nozzle base
18. Nozzle assembly
19. Nozzle tube panel
20. Nozzle top panel
21. Nozzle brush assembly
22. Nozzle clear cover
23. Nozzle tube
24. Active Nozzle assembly
25. Active Nozzle belt
26. Nozzle corner panel 1
27. Nozzle corner panel 2
28. Nozzle wheels
29. Nozzle motor
30. Nozzle PCBA
31. Filter
32. Nozzle corners small 1
33. Nozzle corners small 2
34. Nozzle front ridge

II Philips Speed Pro Disassembled

Component List

1. Handheld assembly
2. Bucket
3. Handle slider panel
4. Handle panel
5. Panel left
6. Panel right
7. Frame
8. Motor assembly
9. Battery
10. PCBA
11. Nozzle subassembly
12. Tube
13. Clear front ridge
14. Top cover
15. Brush
16. Active Nozzle motor belt
17. Motor Axis 1 + 2
18. Active Nozzle PCBA
19. Nozzle Motor
20. Nozzle Motor assembly
21. Nozzle Clear top panel
22. Rear cover
23. Nozzle tube

III

Dyson V11 Disassembled

Component List

1. Bucket
2. Filter
3. Bucket shoot
   4a. Handhed subassembly
4. Inner filter cannister
   5a. Cyclone assembly
5. Cyclone mesh
6. Cyclone bottom
7. Ring
8. Flower assembly
   8a.Flower bottom
9. Flower middle
10. Flower top
11. Flower stem
12. Red seal
13. Grey seal
14. Battery
15. Motor
16. Tube
17. Nozzle
18. Handheld
19. Nozzle assembly
20. Brush
21. Bottom part felt
22. Active Nozzle assembly
23. Active Nozzle assembly top
24. Active Nozze assembly cilinder
25. Top panel
26. Bottom panel
27. Clear cover
28. Switch pressure button
29. Nozzle Front ridge
30. Motor cover

VI Miele Triflex HX1 Pro Disassembled

Component List

1. Battery
2. Dust bucket
3. Front panel
4. Ring panel
5. Side panels
6. Brush cover
7. Motor
8. Handheld
9. Filter
10. Tube
11. Nozzle assembly
12. Nozzle motor
13. Top cover
14. Brush
15. Active Nozzle assembly
16. Active Nozzle background
17. Active Nozzle panel
18. Motor rubber
19. Active Nozzle belt
20. Active Nozzle belt 2
21. Nozzle motor
22. Handheld PCBA

IV Rowenta Air Force 560 Aqua Flex Disassembled

Component List

1. Handle cover part
2. Nozzle part 1
3. Nozzle part 2
4. Rear embodiment part
5. Top embodiment 1
6. Top embodiment 2
7. Nozzle tube 1
8. Tube
9. Motor rear embodiment
10. Motor
11. Bucket
12. Battery
13. Battery embodiment
14. Handle lid
15. PCBA
16. Rubber component
17. Battery assembly
18. Handheld assembly
19. Brush cover
20. Tube
21. Nozzle assembly
22. Nozzle body
23. Clear cover
24. Wheels
25. Brush cover 2
26. Bottom panel
27. Nozzle top cover
28. Nozzle brush
29. Active Nozzle assembly
30. Active Nozzle belt
31. Nozzle motor
32. Switch pressure button

Component List

1. Dust bucket
2. Top panel 1
3. Top panel 2
4. Top ring
5. Side panel 1
6. Side panel 2
7. Mirrored casing parts
8. Switch assembly
9. Motor assembly + PCBA
10. Filter
11. Battery
12. Tube
13. Nozzle
14. Active Nozzle belt
15. Nozzle tube assembly
16. Clear top cover
17. Top cover
18. Brush
19. Small top panel part
20. Active Nozzle belt
21. Active Nozzle axis
22. Nozzle motor

VII

Transcribed interviews

Assessment test 1
Question: Did you find it easy to make an assessment?

What I had to fill in was clear. But especially to find out how many disassembly steps were needed was difficult in my opinion.

Question: What did you use or do to find these Disassembly steps?

Watch the Disassembly video a lot of times. And take notes where the steps ended. I found out later that in the Annex there was a better explanation of the definition of the disassembly steps. First I did not understand this well. It was good to read up on this halfway during the test. I wrote down all the steps in short words, like 'Philips screwdriver' or ' a component is going away', ' screws are extracted'. I had a feeling about what a disassembly step was, I thought that putting away a tool and using your hands would be a step but that wasn't the case. So later I took those steps out.

Question: Do you think you generated a reliable score?

I think I did! I could always make more steps of it. In the video a pincer was used, but this was not necessary so I did not count it as a step. If I would have to give proof I would make a manual with pictures that are more clear and put emphasis on the end of a step, something like that.

Assessment test 2

Question: Did you find it easy to make an assessment?

I thought it was doable. It is easy but you need to understand everything very well and you need to research it very well. I first looked at all the information and then went into the details. There are a lot of rules on what a disassembly step is and what is not. The combination of the video and the manual, which is not super clear, I used to form these steps. There are a lot of exceptions and things that are not intuitive.

Question: What did you use or do to find these Disassembly steps?

I made notes. And I first read the whole manual because I find this important. Like when setting up a tent, I want to know what is coming. After this I watched the disassembly video. After that I read the definition of a disassembly step and I did not really understand it. After that I thought I understood the definitions and I watched the video again. I wrote down what I saw in the video and at the same time tried to number the steps. I would pause the video in between.

Question: Do you think you generated a reliable score?

I now see that I forgot to add a step.. I think I could defend my assessment with my notes and I think that all the information is in my notes. I am definitely sure about the tool rating that I did. I am also pretty sure about my assessment of the reusability of fasteners because I watched the video closely.

Assessment test 3

Question: Did you find it easy to make an assessment?

You really have to understand well how the Disassembly Map works and how it is put together. But also how the product works and how it is taken apart. If you are the designer of the product you probably have a much better knowledge about the build-up. I could fill in the excel very quickly after I made the Disassembly Map. Since I could easily read all the information that I needed from the Miro map. You can count steps very quickly. Without the Miro I would have tallied them? But you need extensive knowledge on how the product is built up to do so.. Calculating disassembly steps without a visual overview is very complex.

Question: What did you use or do to find these Disassembly steps?

I first made a Disassembly Map and after that I filled in the Excel. I found it hard to understand that a tool change is also a disassembly step and not just extracting a component. I added descriptions of the component in the map because I did not like looking at the component list and number each time. I don't know how I would have found the disassembly steps if I did not have the Miro tool, then I would have needed to make my own method and first think about how I would have done that. The boxes in the Miro made it clear for me what a disassembly step was.

Question: Do you think you generated a reliable score?

I think I did but I don't know how they would check it. Who is going to check my assessment and understand the product on the same level that the designer does? It will be easy to cheat with in my opinion. I think that if my score would be checked the government would also need instructions on how to read the Disassembly Map.

Assessment test 4

Question: Did you find it easy to make an assessment?

Looking back on it now it is easy. But you first had to understand how the framework of the Disassembly Map was set up. The excel sheet was very limiting, you could not detail your answers, it is very straight forward. In the fasteners I thought you have to look at component level. But the problem lies in the parts in between the components. But you can't say that in the sheet. If you have a visual overview, like the Miro map, you can easily fill in the excel.

Question: What did you use or do to find these Disassembly steps?

First I needed to understand what the product build up was like to make the Disassembly Map in Miro. After that I quickly filled in the FRI excel. Without the map I would have needed to make my own method before I could fill in the excel, I don't know how I would have approached that.

Question: Do you think you generated a reliable score?

I think that each assessment will be different based on the person that is making it. I can imagine that someone else has made a very different map. I know how to defend my assessment because I have the Miro map, I can explain my choices with it. It gives me support. There are so many personal interpretations and assumptions that I have made in my assessment. If the French government would provide a tool like this with the assessment sheet then at least everyone would be using the same method that then could be compared. I think that would lead to more honest ratings. I would use my Miro as proof and also provide a disassembly video to check for the authorities. If I could use this together with other colleagues we could better discuss because we are using the same tool. And if we use it together the results would probably become more reliable.

VIII Notes usability test 1

DEFINITIONS

FRENCH REPAIRABILITY ASSESSMENT PHILIPS SPEEDPRO MAX

① disassembly sequence:
order of steps needed to remove part from product
↳2 ↳3

② STEP:
operation that finishes with the removal of a part or a component, and/or with a change of tool.
↳3

③ component/(part):
may include one or several parts

! STEP COUNTING

✓
removal of part
removal of subset
change of ~~tool~~
unplug equipment of mains
↳ assume this is the case

✗
grab tool
put tool down (hand & fastener are not tools)
remove fastener

steps required to disassemble parts

TOOLS

FASTENERS

BATTERY : 3 STEPS

1. Disconnect from mains
2. Removal of bucket part
   - ~~Change~~ Grab tool ~~to~~ Philips #1 screwdriver
   - remove 3 screws D
   ~~3. change tool to flat screwdriver~~
   ~~4. remove UI panel by lifting it up w/ flat screwdriver~~
   ~~3. remove battery by moving it backwards~~
   ~~3. change tool to small flat screwdriver~~
3. ~~4.~~ remove battery ~~by using small flat screwdriver to unclick bottle panel, lift up battery~~ by moving it backwards.

IX Notes usability test 1

MOTOR : 12 STEPS

- grab flat screwdriver
1. remove handle panel by lifting it up with small flat screwdriver
2. change tool to philips screwdriver
   - remove screw E
3. remove UI panel by lifting it up from PCB
   - grab tool philips screwdriver
   - remove screw F on top of exhaust grill
4. change tool to flat screwdriver
5. remove rubber part (friction interface) with flat screwdriver
   - ~~remove screw~~
6. change tool to philips screwdriver
   - remove screw G under rubber part (and screw cone)
7. remove exhaust grill with hands
8. remove visual cap ~~with hands~~
9. remove ~~sound reflector~~ visual cap inner with hands
10. remove sound reflector with hands
11. remove exhaust filter with hands
    - grab tool philips screwdriver
    - remove 2 screws H
    - remove 2 fasteners: disconnect 2 small connectors from PCB
    - grab tool flat screwdriver
    - ~~remove~~ unstuck PCB by lifting it if unstuck with flat screwdriver
    - remove fastener: disconnect battery connector by pushing with thumb on backside of PCB and...
    - grab tool: flat screwdriver
    - lift with flat screwdriver
12. remove motor assy

PCBA: 4 STEPS

step 1-3 from MOTOR removal. philips screwdriver, 2 screws with philips screwdriver, flat screwdriver

- remove 2 fasteners: disconnect 2 small connectors from PCB.
- grab tool flat screwdriver
- unstuck PCB by lifting it if unstuck with flat screwdriver
- remove fastener: disconnect battery connector by pushing with thumb on backside of PCB and...
- grab tool: flat screwdriver

X Notes usability test 2

~~battery~~ PCBA & motor

1. bucket
2. schroevendraaier (philips → special)
   3 schroeven eruit → battery met 1 stap eruit
   ↳ extra
3. platte schroevendraaier
   → paneel eraf
4. schroevendraaier (ph)
   → plastic los (maar niet verwijderd → later wel
5. zelfde schroevendraaier (ph)
   → schroefje los
6. platte schroevendraaier
   → rubber los (met tijm?)
7. ph schroevendraaier
   → schroefje los
   ↳ onderdeel eraf (achterkant)
(8.) ↳ onderdeel los (2x subset?)
8. schroevendraaier (ph)
   ↳ 2 schroeven los

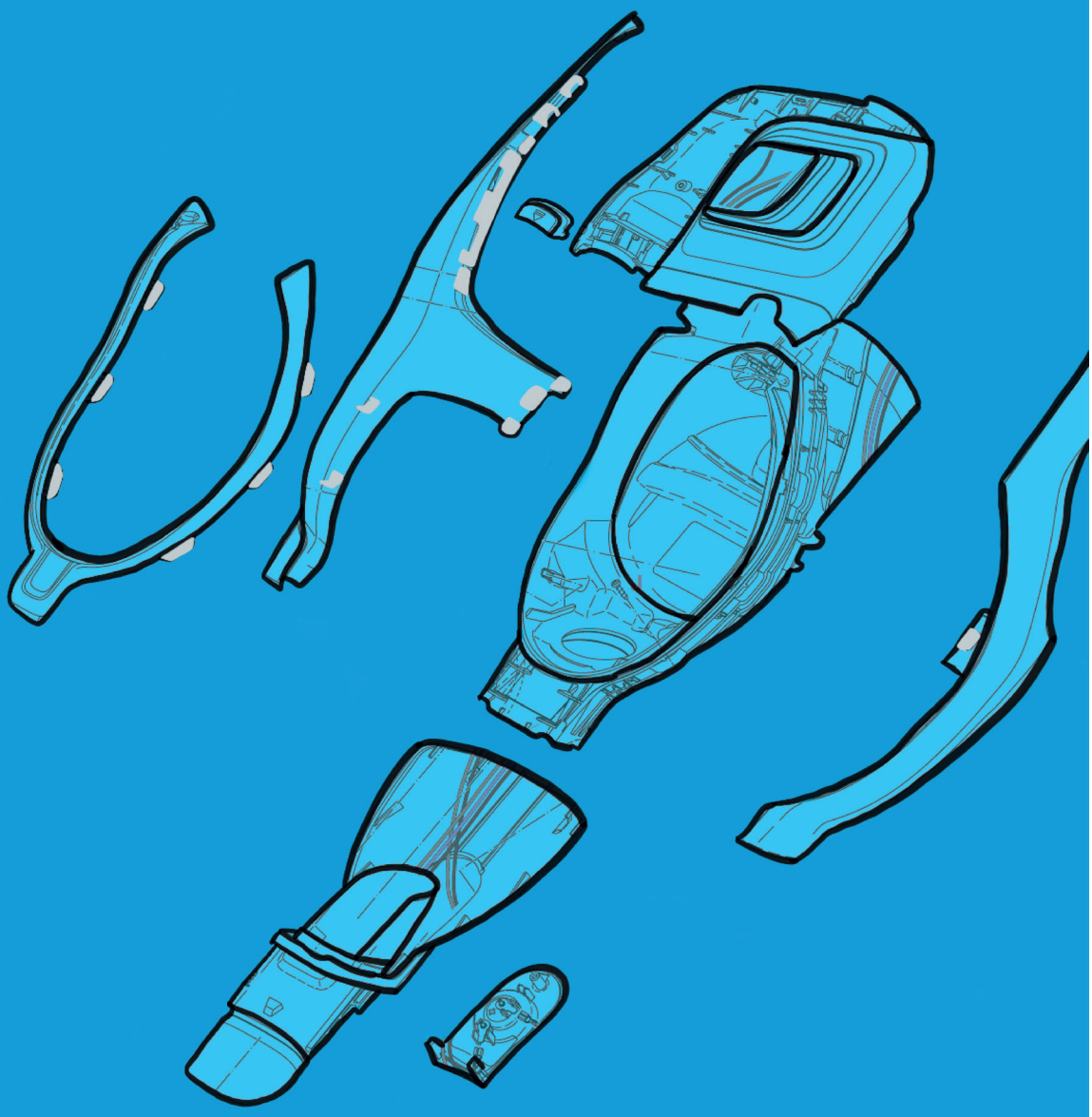
(~~9~~.) wissel gereedschap → stekkers los
10 platte schr. dr.
   → PCB eruit
   + motor

~~tzx~~ ~~torpex~~?

Reference book

Design for the French Repairability Index

for cordless vacuum cleaners



by Lotte Fonteijne

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Introduction

This booklet was created with the goal of providing guidelines to achieve a high French Repairability Index score for cordless vacuum cleaners. These guidelines only consider the physical characteristics, in terms of the FRI, of a product. It's contents were summarized from the findings of a case-study on the repairability of six cordless vacuum cleaners. The guidelines are best used by designers of (cordless) vacuum cleaners in the early stages of the development processes, when fasteners and product architecture are not definitely defined yet.

- **The first part gives insight on what approaches can be taken to design for repairability**
- **The second part explains what priority components are and how they can be defined.**
- **The third part describes design guidelines for FRI in four categories:**
  - Design process
  - Product architecture
  - Fasteners
  - Product specific criteria

1. How the FRI measures repair

Since the Industrial Revolution, Western societies have been adopting a single use, throw-a-away culture. Research has even shown that the lifetime of electric and electronic consumer goods has been decreasing in the last decade (Bakker, C., Wang, F., Huisman, J., & Den Hollander, M. (2014). As a reaction designers, users and repairers of consumer goods have been trying to battle this development. Design for repair is a promising strategy for this problem and is an example of how product lifetime can be extended.

In 2021 the French government adopted the French Repairability Index (FRI), a repair scoring framework which generates a score for five groups of Energy related Products (ErP's). In 2022 the legislation will become active for (cordless) vacuum cleaners and there is a chance of the FRI being extended to a European level. Understanding how to design repairable products, which grant high FRI scores is therefore of high importance. More information on FRI, the assessment sheet and instructions for assessment can be found on their website: www.indicereparabilite.fr

Before products can be improved and become more repairable, we need to define how repairability is measured in the FRI. The French scoring framework uses five categories in which many different criteria are considered. The guidelines described in this booklet only touch on four criteria that affect the physical characteristics of cordless vacuum cleaners.

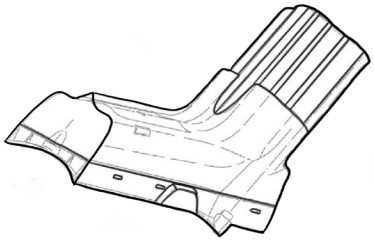
FRI criteria that score physical product characteristics:

- Amount of disassembly steps to obtain priority parts
- Types of tools needed to obtain priority parts
- Re-usability of fasteners
- Product category specific criteria, determined by the FRI

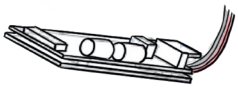
Priority parts

At the moment of writing this booklet (August 2021), the priority parts for cordless vacuum cleaners are not yet defined for the FRI. This list will be made public before the start of 2022. Priority parts or priority components are the most important parts of a product to consider when it comes to service, repair and upgrade. The most important components for repair need to be easy to extract and replace. The EN 45554 states that : "It is necessary to prioritize parts because not all will be equally relevant to repair, reuse, or upgrade. The parts that have been prioritized are considered priority parts".

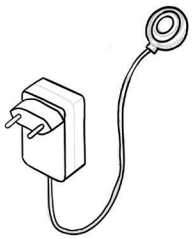
Motor



Battery



Printed Circuit Board



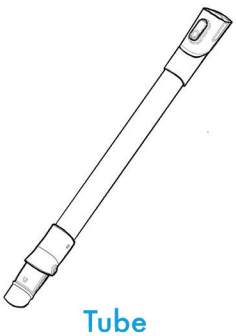
Battery charger

Active Nozzle motor

Active Nozzle motor belt

Switches

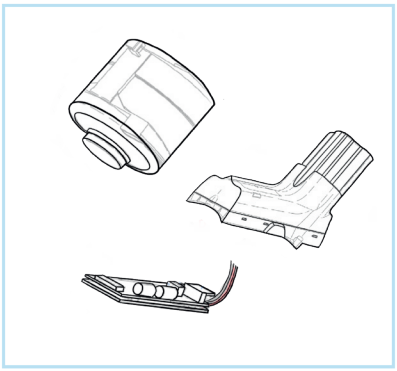
Nozzle



Tube

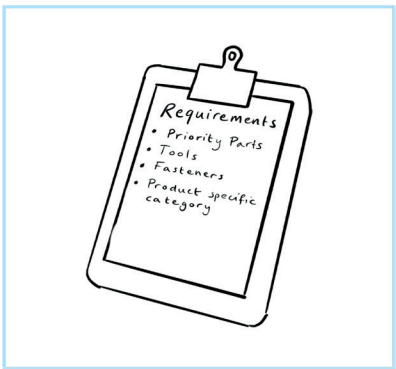
FRI guidelines
for the design process

The priority parts of a cordless vacuum cleaner should be easy to reach and replace. This can be achieved through the product's architecture and smart use of fasteners. But first the following three steps need to be implemented in the design process.



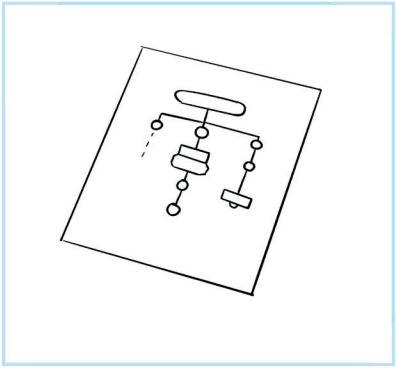
1. Determine the priority parts

If the list of priority parts is not already provided by the FRI a preliminary list needs to be made. This can be done by looking at a similar product group that is already active in the FRI and looking at literature on the topic. For cordless vacuum cleaners the list on the previous page can be used.



2. Define requirements for Disassembly steps and fasteners

A maximum amount of disassembly steps should be set for each priority part. By doing this boundaries are set and can be evaluated at the end of the design process. The same should be done with the degree of reusability of fasteners and the types of tools needed for the disassembly. It should be opted to only use fasteners that are reusable and removable and basic tools (see EN 45554 for the list of tools that are defined as basic).



3. Choose a validation system

User tests in the master thesis 'Improving repairability in cordless vacuum cleaners' have shown that a system is needed to correctly assess disassembly steps, types of fasteners and tools. The Adapted Disassembly map in Miro can be used for this (found here: FIXME) or a different system can be created.

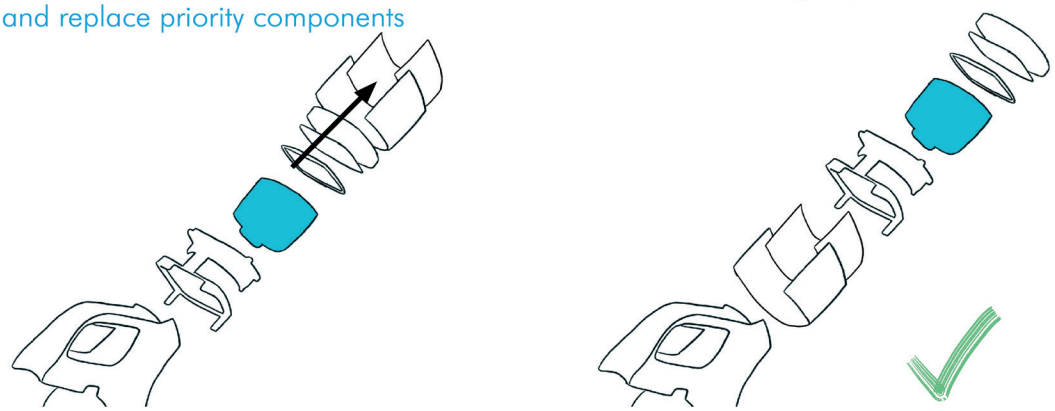
FRI guidelines
for product architecture

The goal is to create a product architecture that requires the least amount of disassembly steps (or the number previously defined in the requirements) to obtain the priority parts. The least amount of disassembly steps results in the highest FRI score for this criteria. A disassembly step is defined by the FRI as "an operation that finishes with the removal of a part, and/or with a change of tool". Fasteners and connectors are not seen as parts and hand aren't considered to be tools.

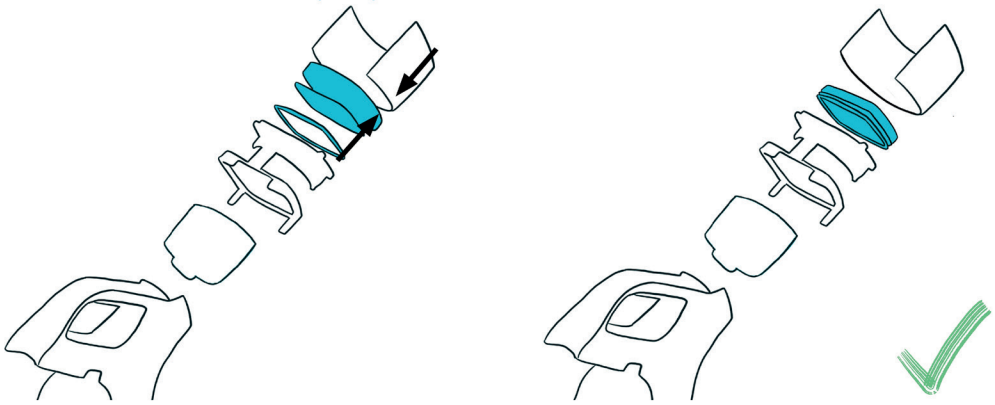
When a priority component is located deep in the product it means that many actions need to be carried out to reach the product. Not only does this increase the amount of disassembly steps but also the risk of fasteners and components breaking during the repair.

The following product architecture strategies improve repairability and FRI scores:

- **Surfacing** priority parts can decrease the amount of disassembly steps needed to reach and replace priority components



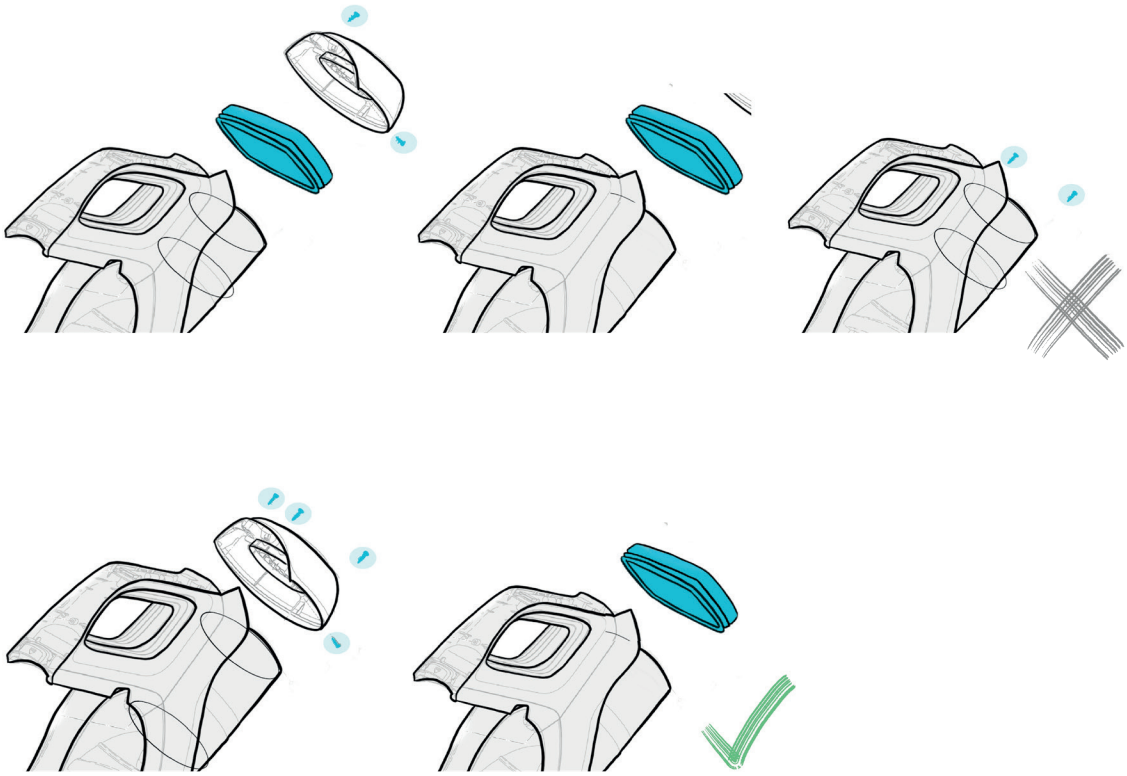
- **Clumping** parts together and creating subassemblies can help surface priority parts and decrease disassembly steps



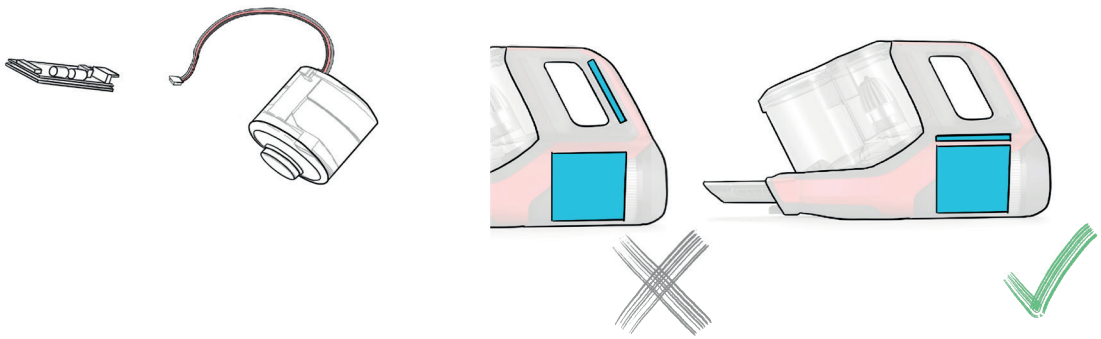
FRI guidelines

for product architectur

- **Levelling** of the same type of fasteners, like the same type of screw, can decrease the amount of disassembly steps needed to obtain a priority part. The example below shows how two disassembly steps being decreased to one by bringing four screws together on the same level in the product architecture. This is only valid when the next action would be use of another tool. In which case it should first be tried to use the same type of fasteners. See the example for standardizing of fasteners on page 8.



- Making priority parts **seperable** from each other improves non destructive disassembly. Or place priority components close to each other to decrease disassembly steps.

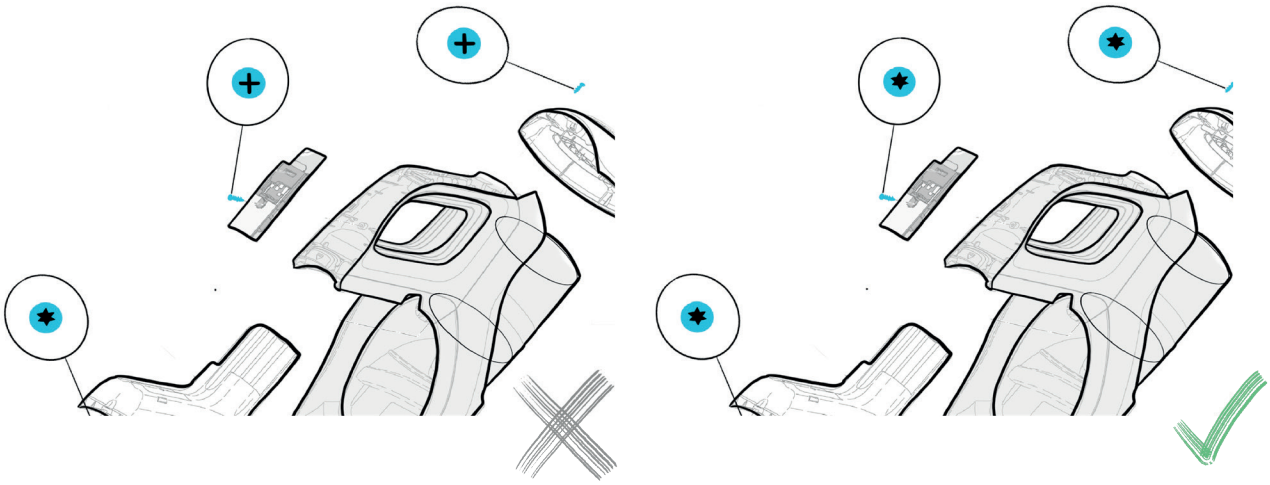


FRI guidelines
for fasteners

Fasteners have a large influence over the repairability of a product. They influence the time that it takes to reach and replace priority components but they also influence (non-) destructive disassembly and reassembly. To test if fasteners are suitable for repair they should be tested during disassembly and reassembly. By limiting the different types of fasteners in a product, repair time decreases. It is advised to only use fasteners that can be undone by using 'basic tools' which are defined in EN45554. The types of fasteners that are used most often in cordless vacuum cleaners are: screws, adhesives, snap fits and friction fits

Screws are highly effective for non-destructive and successful repair. They have a high reusability. Trade offs are higher cost compared to snap or friction fits and more notable in the design compared to snap or friction fits. Different types of screws should be limited in design for FRI as a different screwhead would need a change of tools, which adds to the amount of disassembly steps.

- Standardizing fastener types so no tool change needs to occur, decreasing the amount of disasembly steps



Use of adhesives in cordless vacuum cleaners is discouraged when designing for repair and FRI. They tailor seamless design but have many trade offs. Most adhesives are non removable or reusable is and when adhesives can be softened this time process is intensive.

FRI guidelines
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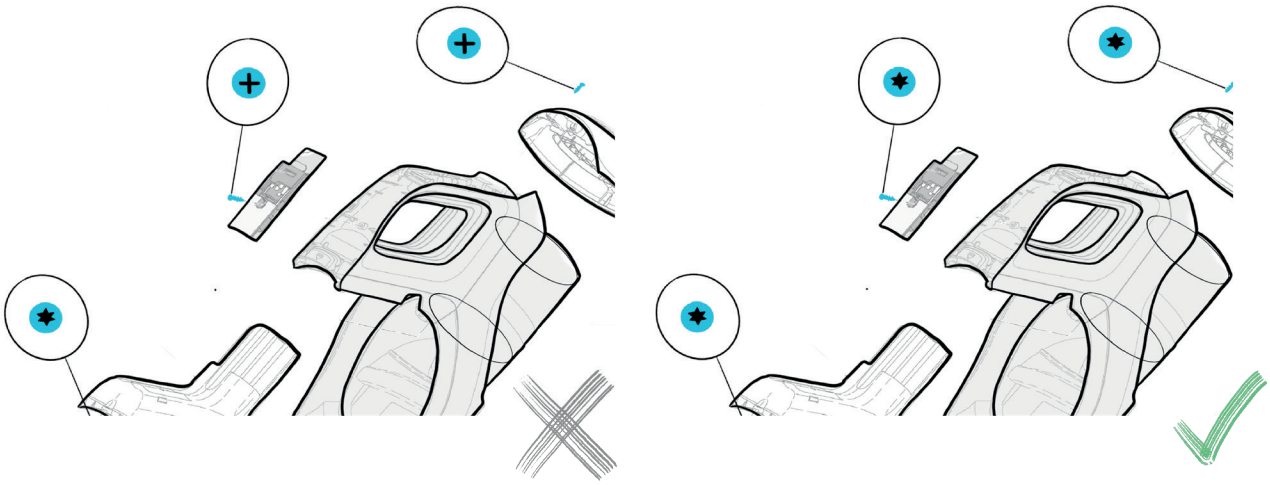

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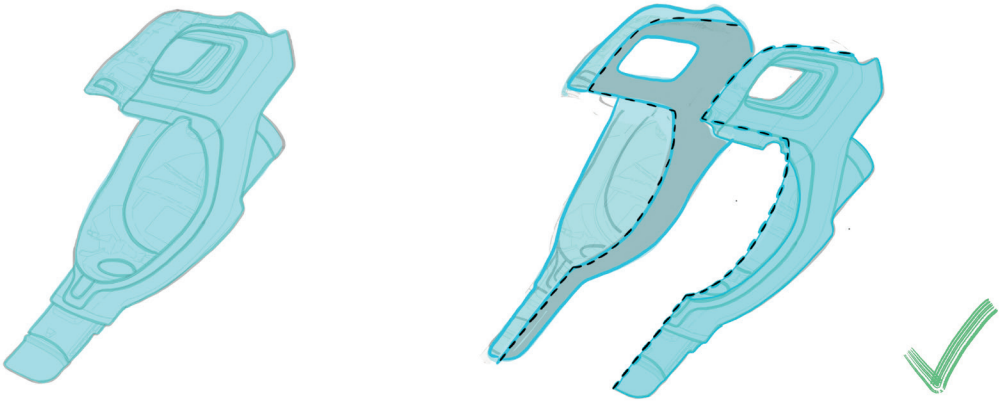
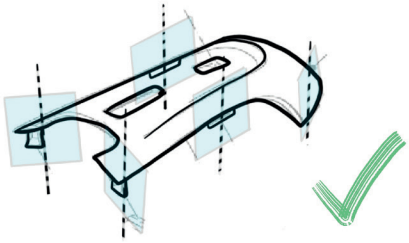
FRI guidelines
for fasteners

Snap fits and friction fits can be successful fasteners in disassembly and reassembly processes. But when these fasteners are not designed for non-destructive disassembly they can warp, bend and break. This often has the result that a new component is needed for the repair. The success of these fits depends on their shape, the type of material they are made of, what kind of motion is needed to undo them and how easily they can be used in reassembly. Since new snapfits always need to be designed 'from scratch' (Sodhi, R.S., 1999) it is crucial to test these fasteners for successful dis- and reassembly.

- Use mirrored outer casing parts with screws instead of one piece casings to avoid snapfits



In the case study it was found that the use of snapfits with different directions of extraction on a component increase the risk of them breaking or warping during disassembly. It is therefore recommended to place snapfits in such a way that they share a plane in which they need to be moved for disassembly.



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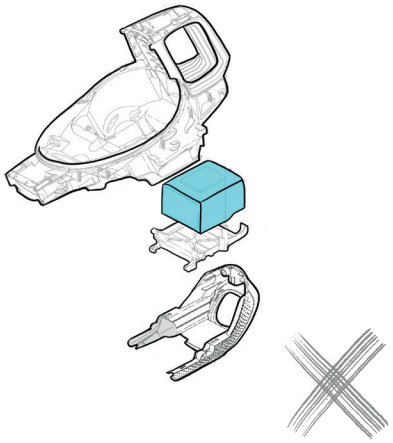
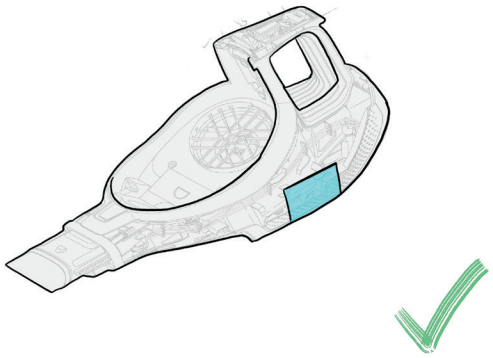
FRI guidelines

for product specific category

The fifth FRI category scores criteria that are product group specific. At the time of writing this manual these criteria are still unknown. The product category that is already active and most similar to that of cordless vacuum cleaners is the product category of battery powered lawnmowers. For this group the criteria in the fifth category that is scored on, is use of a multi-product battery. The Bosch Unlimited Serie 8 cordless vacuum cleaner has such a battery, which can be also used on power drills and other appliances. A first step towards multi product batteries being possible is to:

- Place the battery outside the casing makes it easier to extract and replace and gives opportunity for multi-product batteries.





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