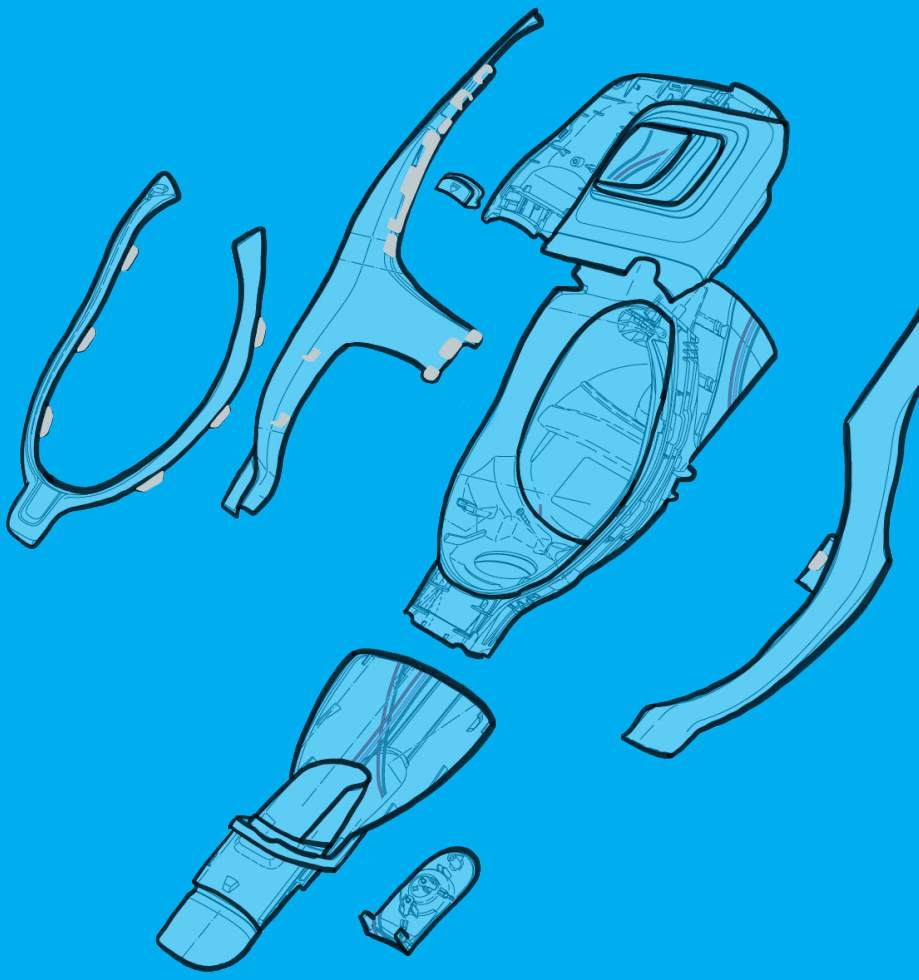
Reference book

Design for the French Repairability Index

for cordless vacuum cleaners



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Index

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.

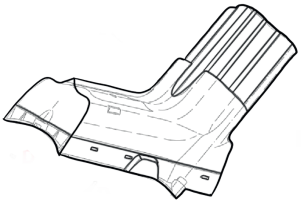
FRI criteria that score physical product characteristics:

- 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

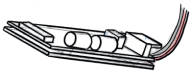
Priority parts

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".

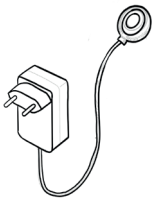
Motor



Battery



Printed Circuit Board



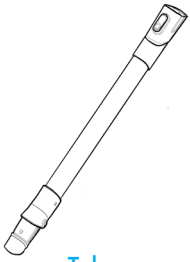
Battery charger

Active Nozzle motor

Active Nozzle motor belt

Switches

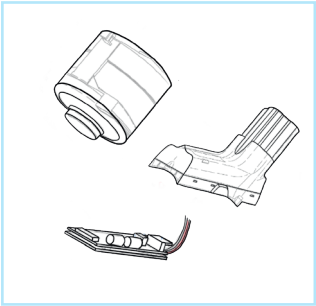
Nozzle



Tube

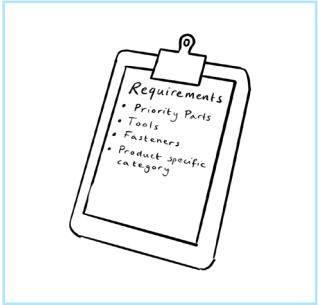
FRI guidelines
for the design process

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.



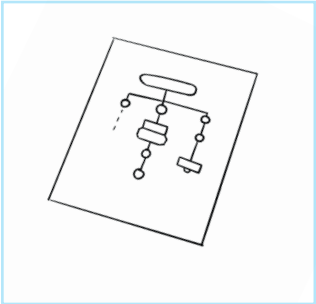
1. Determine the priority parts

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

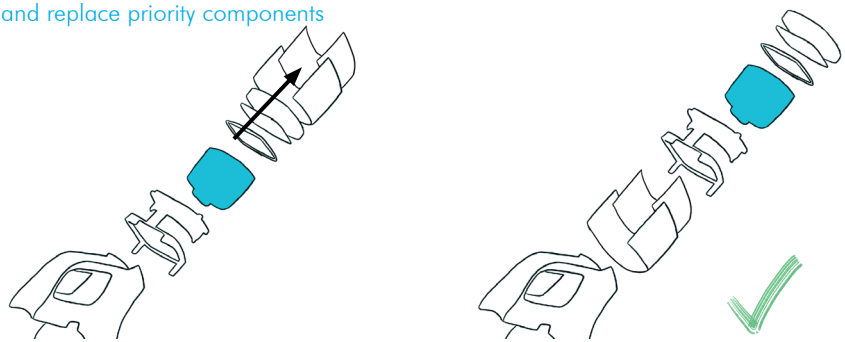
for product architecture

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.

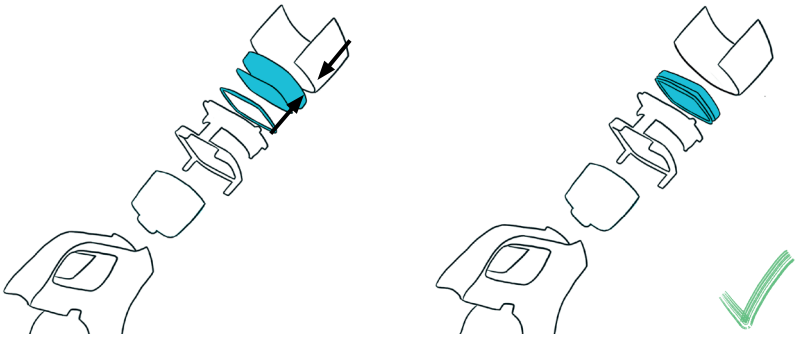
When a priority component is located deep in the product it means that many actions need to be carried out to reach the product. Not only does this increase the amount of disassembly steps but also the risk of fasteners and components breaking during the repair.

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

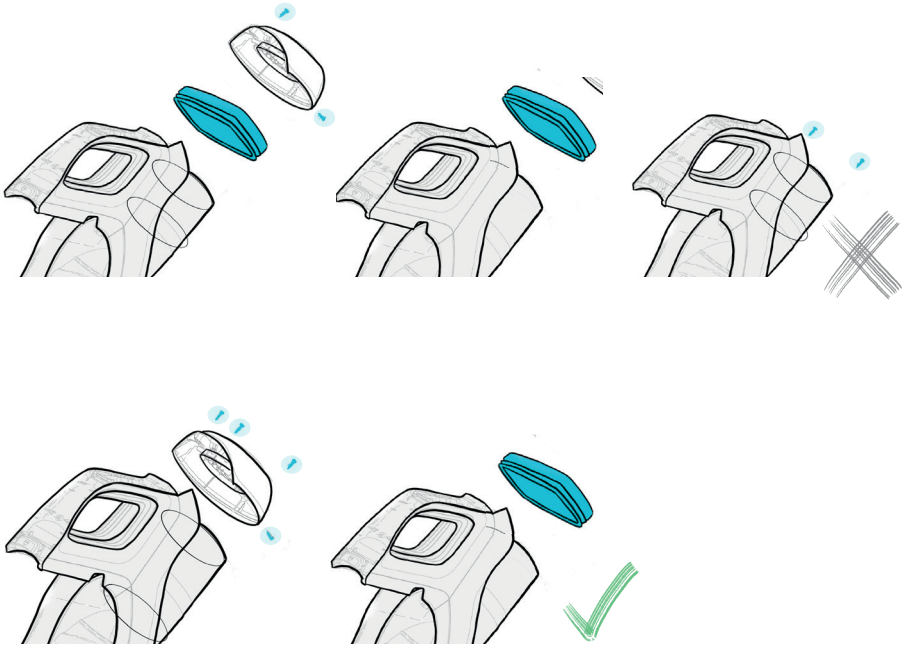


- **Clumping** parts together and creating subassemblies can help surface priority parts and decrease disassembly steps

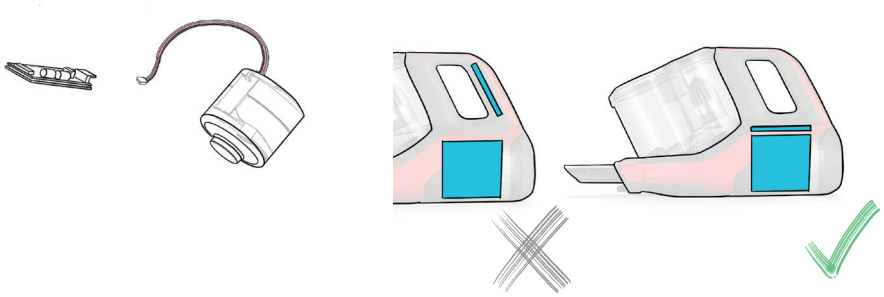


FRI guidelines
for product architectur

- **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.

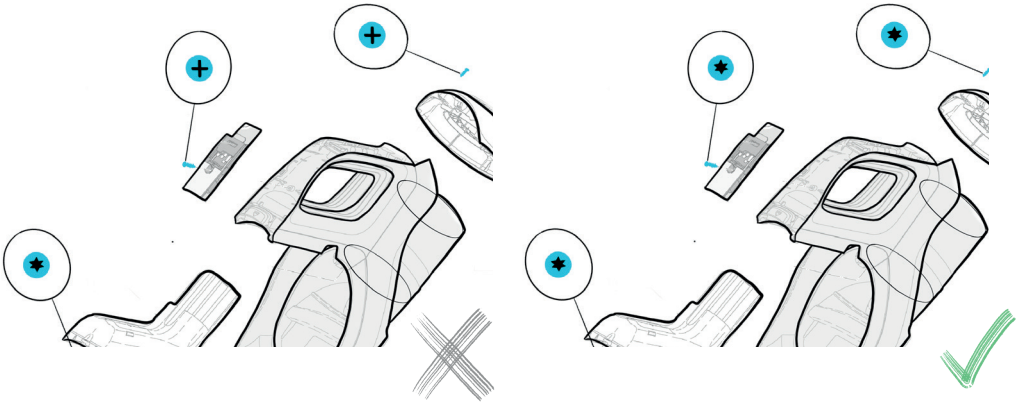


FRI guidelines
for fasteners

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

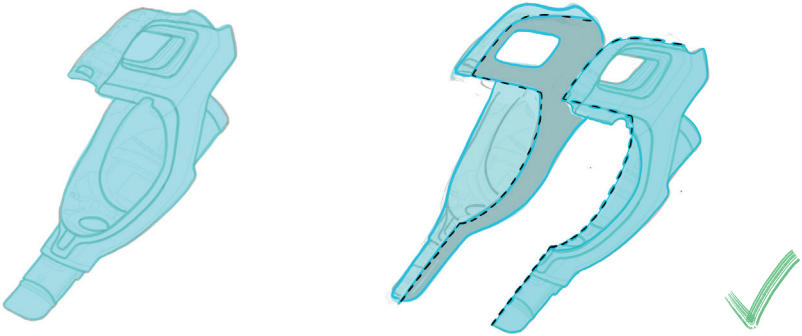


Use of adhesives in cordless vacuum cleaners is discouraged when designing for repair and FRI. They tailor seamless design but have many trade offs. Most adhesives are non removable or reusable is and when adhesives can be softened this time process is intensive.

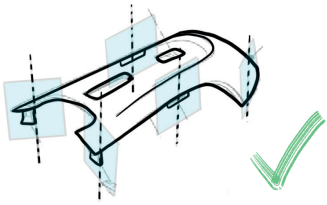
FRI guidelines
for fasteners

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.



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.