PHILIPS

Making circular innovation work
Design for disassembly

Thijs Maartens and Francesco De Fazio
Philips Engineering Solutions
14/10/2021

innovation you

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Today’s agenda

Who we are

Our circular revenues and requirements framework

Design for disassembly and its importance

Main challenges and strategies to overcome them

Our assessment methods and design tools

Case study

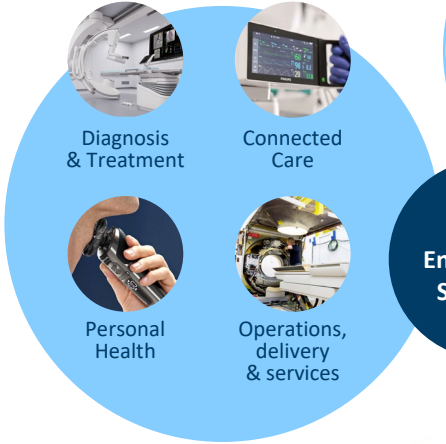
Our expertise beyond disassembly

Thijs Maartens
Sustainability Competence Lead

Francesco De Fazio
Circular Product Designer

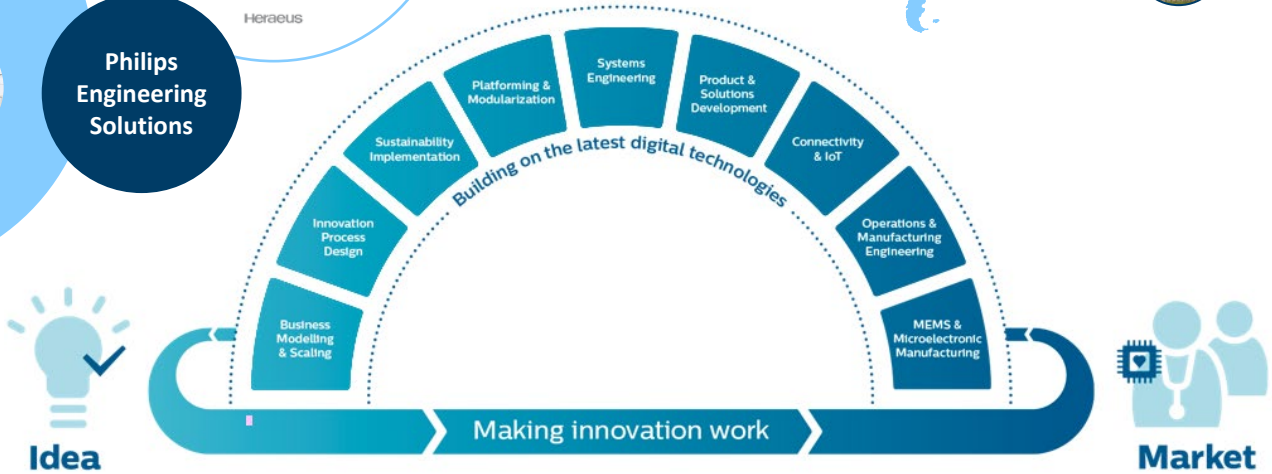
Philips **Engineering Solutions**

Philips businesses



External customers

Philips Engineering Solutions



Philips ambitious **sustainability targets** for 2025

Health and well-being for all

- We improve the **health and well-being** of 2 billion people per year through meaningful innovation
- As part of this, we enable **access to care** for 300 million people in underserved communities

Circular economy

- We generate 25% of our **revenue** from circular products, services and solutions
- We **close the loop** by offering a trade-in on all professional medical equipment, and take care of responsible repurposing*
- We further embed **circular practices** at our sites** and continue to put **zero waste to landfill**

Climate action

- We reduce our **CO_2 emissions** in line with a 1.5 °C global warming scenario, for example by further improving the energy efficiency of our products during the customer use phase
- We source 100% of our electricity and over 75% of our total energy consumption from **renewable sources**

Partnerships

- We team up with our partners to deliver sustainable value and drive global change
- We improve the lives of 1 million workers in our **supply chain** and reduce its environmental footprint

Enablers

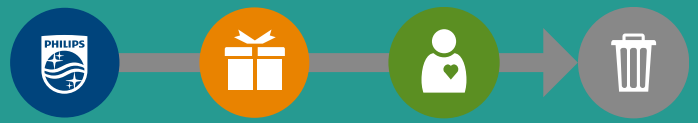
- We design 100% of our products in line with **EcoDesign** requirements, with 'EcoHeroes' accounting for 25% of hardware revenues
- We embed sustainable practices in our ways of working, as defined by the **Philips Business System**

* either refurbished at Philips, or locally recycled in line with Philips policies
** including non-manufacturing sites, such as large offices, warehouses and R&D facilities

Circular design requires **a mind shift**

Circular design is about **creating value** for customers and business in a **resource-constrained** world.

From linear design…



Take, make, waste

to circular design

Up to **80%** of products environmental impact are determined at the design phase

The Circular Economy **Framework**

Circular-ready requirements	Circular revenue models							
	Circular software		Circular service		Circular hardware			
	Optimizing resource use	From analogue to digital	Performance and access	Upgrades	Commercial returns	Refurbishing	Parts harvesting	Recycled content
1. Easy to clean, sterilize and restore aesthetic state								
2. Secure and private exchange								
3. Easy to assess and track performance								
4. Easy to disassemble, repair and re-assemble								
5. Modular design for forward and backward compatibility								
6. Standard, durable element selection								
7. Sustainable material selection								
8. Easy to dismantle back into pure materials								

Critical Some impact Minor impact

Design for **disassembly**

Disassemble (and reassemble) a product to…

- Destructive
- Mostly automated
- Focused on materials liberation and sorting

Repair

Upgrade

Refurbish

Recover

Recycle

Designing the product in such a way that the product and its parts can be

- disassembled **and reassembled**,
- in a **non-destructive way**,

to enable product life extension strategies like repair, refurbishment, reuse/recovery activities (partial or full).

Adapted from EN45554

Design for **disassembly** is fundamental to:

1. Make new designs **future proof**, by anticipating possible future regulations

2. Improve **quality** and **efficiency** of existing operations (e.g. repair and refurbishment)

3. Enable **new circular business models**, making them economically feasible

4. Answer to growing **consumers interest** for more sustainable and long lasting products

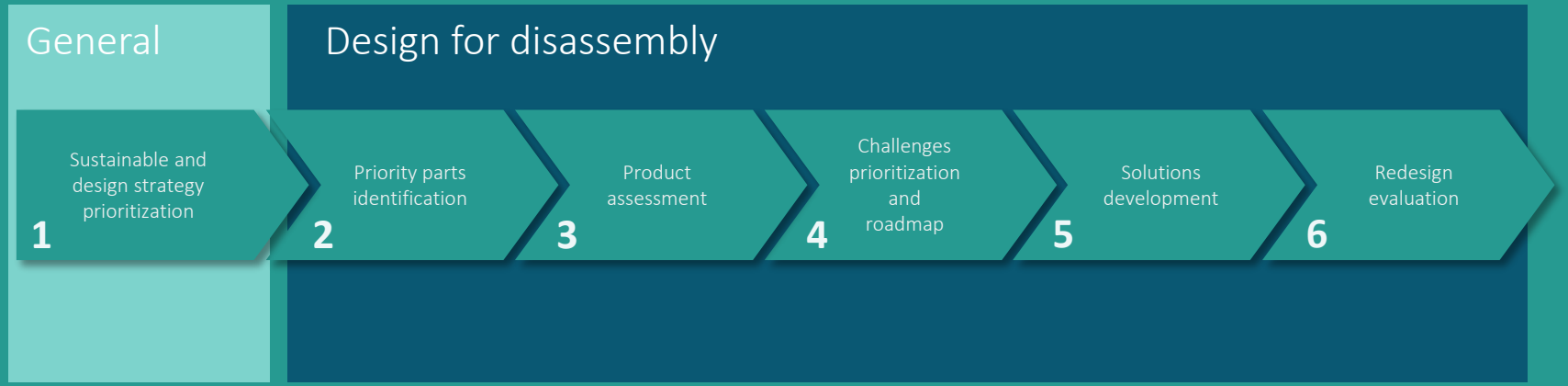
The key **challenge**

How can we make circular design **economically** and **strategically** interesting?

- By using a comprehensive process
- By selecting the correct sustainable and design strategy
- By identifying cost effective redesign solutions
- By considering the Total Cost of Ownership
- By intervening from the earliest stages of the design process
- By prioritizing our battles

A challenging, but necessary **balance**.

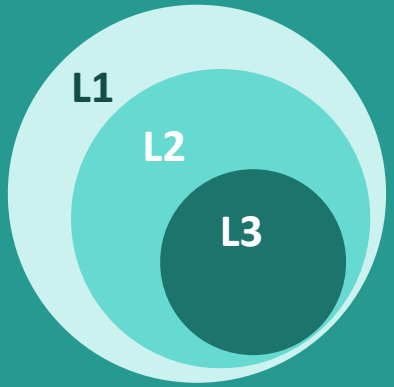
Our **process** to identify and develop optimized solutions



What is the most **suitable** sustainable strategy?

Explanatory examples:

L1	**Sustainable strategy**	Energy efficiency, harmful substances avoidance, durability, Reuse, Repair, Refurbishment, Recovery, Recycling
L2	**Design strategy**	Design for disassembly, diagnostics, dismantling, sustainable material selection, easy to clean, modularity, standardization, energy efficiency, reliability
L3	**Design focus area**	Replaceable battery, more efficient charger or supply unit, recycled plastic for bottom housing, gaps avoidance in specific cover



What is the most **suitable** sustainable strategy?

Methods	Scope
Product lifecycle flow	• Map current supply chain, End of Life scenarios, stakeholders and their needs • Identify causes of End of Life and types of obsolescence
LCA	Identify most relevant contributors to the product environmental impact (looking at both product lifecycle phases and parts level)
Boundaries identification	Identify boundaries conditions determined by regulatory, quality or safety constraints
Business modeling	Identify financially sustainable strategies

Design strategy

Sustainable strategy

Example

1 Sustainable and design strategy prioritization → 2 Priority parts identification → 3 Product assessment → 4 Challenges prioritization and roadmap → 5 Solutions development → 6 Redesign evaluation

Design for disassembly

Priority parts identification

Priority parts

To assess the ability of a product to be repaired, reused or upgraded, a list of priority parts must be established.

It is necessary to prioritize parts because **not all will be equally relevant** to repair, reuse, or upgrade.

Adapted from EU standard EN45554

1 Sustainable and design strategy prioritization
2 Priority parts identification
3 Product assessment
4 Challenges prioritization and roadmap
5 Solutions development
6 Redesign evaluation

Priority parts identification

CE strategy	Definition of priority	Examples of sources to be used for the identification of priority parts
Repair	Parts with a high average occurrence of • Malfunctioning • Complete failure • Replacement	• Field call rates • Repair kits consumptions rates • CoNQ reports • Return Good Analysis • FMEA
Upgrade	• Parts that can extend product life and avoid consumer replacement • Parts subject to rapid technological changes • Parts with high potential to be replaced with enhanced functionality or capacity, that can increase product value over time.	• Parts upgrade plan (If available) • Technology roadmaps • Practical insights collected from Service (Repair, Refurbishment, Recovery) organizations. • User studies to identify main reasons behind obsolescence and product end of life causes
Refurbishment	• Parts that must be disassembled and/or replaced for refurbishment purposes (cosmetics, hyenine, functionality) • Parts with the highest consumer value perception (aesthetic/perception refurbishment)	• Refurbishment process check lists, workflows, protocols • Practical insights from refurbishment centers • Analysis of the state of returned units (e.g. commercial returns) • User studies to identify main reasons behind obsolescence and product end of life **causes**
Parts reuse, Recovery	Parts with high potential for reuse/recovery: • high request from spare parts organization • high BoM cost • part lifetime longer than product lifetime	• Parts recovery process check lists, workflows, protocols • Spare parts demand data • Practical insights collected from parts recovery and spare parts organizations • Product BOM • Remaining useful life assessment data

1 Sustainable and design strategy prioritization
2 Priority parts identification
3 Product assessment
4 Challenges prioritization and roadmap
5 Solutions development
6 Redesign evaluation

Design **guidelines** and assessment **metrics**

What is it?
Intuitive guidelines, which can guide designers in identifying key design focus areas to enhance disassembly, define design ambitions and prioritization.

When it can be used?
In very early stages of the design process, where high level design ambitions can still be defined and integrated in the product value proposition.

How does it work?
The material can be used to carry out a high level assessment of a current design and identify the design ambition for the future product generation. They can be used as design sprints material, but also during design reviews, later in the design process.

12 main design guidelines families

1	Disassembly depth minimization	2	Fasteners and connectors removability and reversibility	3	Type of tools
4	Accessibility	5	Fast and easy disconnection of connectors, cables and fasteners.	6	User ergonomics
7	Parts robustness	8	Ease of handling	9	Mistake proofing and intuitiveness.
10	Ease of recovery, configuration, calibration and verification.	11	Safety	12	Diagnosability

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Interactive material for initial engagement sessions

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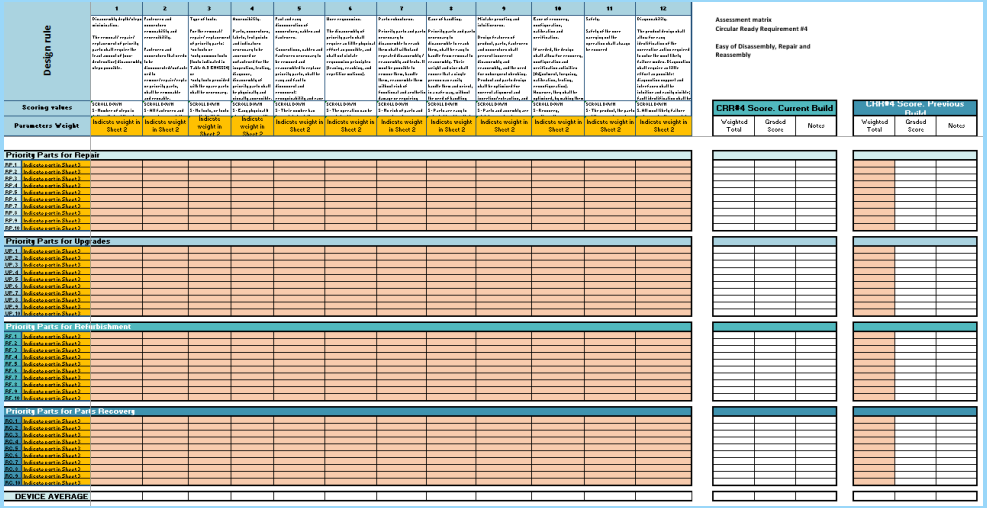
Assessment metrics for design review sessions



Disassembly **Map**

What is it?

Modelling method, based on latest standards and research on the assessment of product reparability and upgradability (e.g. EN45554 and French Repair Index). It can be used to identify key design features hindering disassembly.

When it can be used?

In early stages of the design process, when design changes are still possible, by assessing either initial CAD's, prototypes, previous design generations, competitors.

How does it work?

By visually representing the architecture of a product, describing disassembly precedence and dependencies of components and operations necessary for their complete non-destructive removal.

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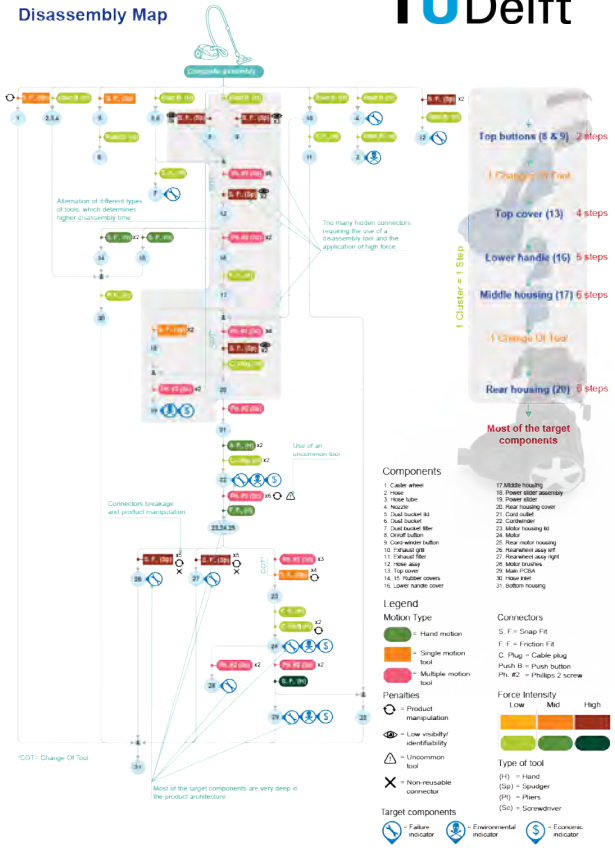
Presented at the EGG 2020 conference and in an article for the Journal of Clear Production Elsevier: https://doi.org/10.1016/j.jclepro.2021.128552



Circular Redesign **Focus Point** tool

What is it?
Tool that guides designers in selecting focus points for redesigning devices for part harvesting and recycling.

When it can be used?
In the early stages of the design process, when it is decided what part of the device to focus on for redesign.

How does it work?
Through the assessment of the device on a component level, a set of outputs is generated which are split in the category's disassembly effort and potential gain. Utilising this division, a new metric is used to score the focus points for redesign.

INPUT												OUTPUT												Redesign focus Points				
												Disassembly effort			Potential Gain									Circular Redesign Necessity Scores				
Parts	Architecture		Disassembly					Material			Economic	Effort			Environmental			Economic						Normalised		Redesign Necessity		Ranked
Name	Subassembly	Parts to remove	Task frequency	Time (s)	User	Component intact	US-cleaning possible	Material Group	Material Specific	Mass (g)	Part economic value (€)	Parts to remove	Disassembly depth	Total disassembly time (s)	Carbon footprint (gCO2e)	GRM (yes/no)	Recycling (yes/no)	Material worth (€)	Recycling profitable	MRR/MRRP	Part reuse possible	Part reuse profitable	PRR/PRRP	Normalized Effort (disassembly time)	Normalised Gain (environmental)	GRN score	Normalised GRN score	Rank

Provided — Calculated

Ligtelijn, S. (2021). *The Circular Redesign Focus Point tool A novel method to determine focus points for redesigning surgical devices for circularity [Delft University of Technology]. https://repository.tudelft.nl/islandora/object/uuid:4225ff65-1860-49e7-b832-85990261a605*

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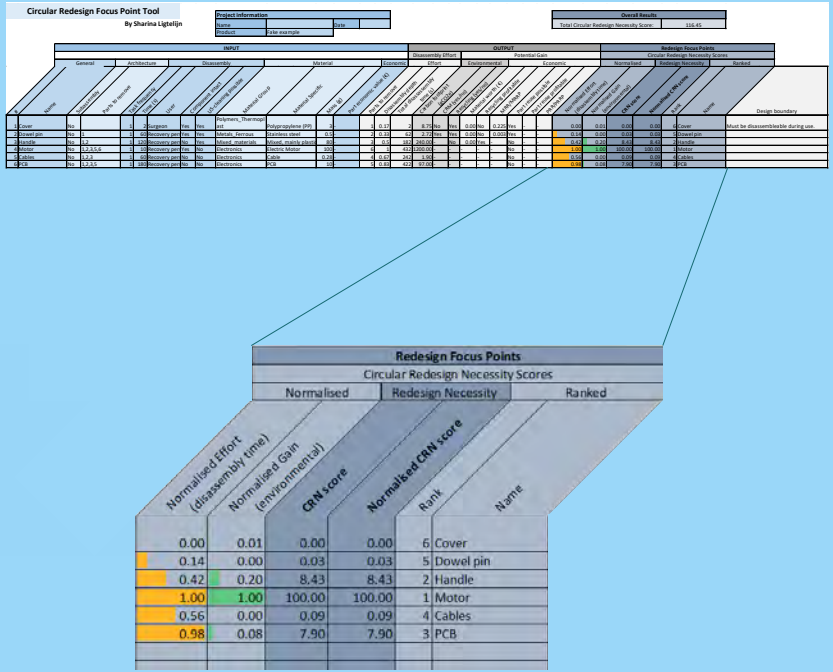

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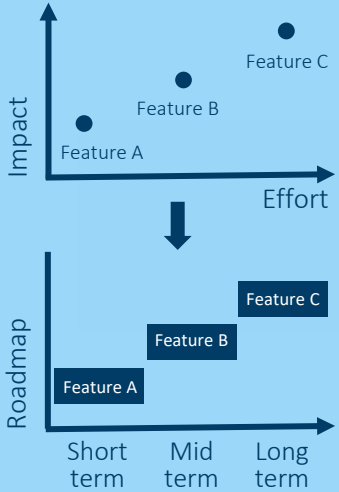
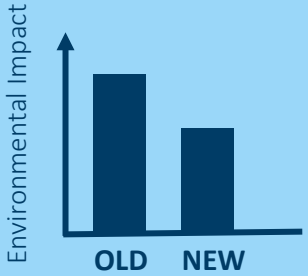
Planning and execution

4 Challenges prioritization and roadmap



5 Solutions development

6 Redesign evaluation



Examples of evaluation parameters:

- Environmental impact
- Operation time improvements
- Labor cost savings
- Operation success/efficiency rate
- Repair score

Case study

Practical applications: **Vacuum Cleaners**

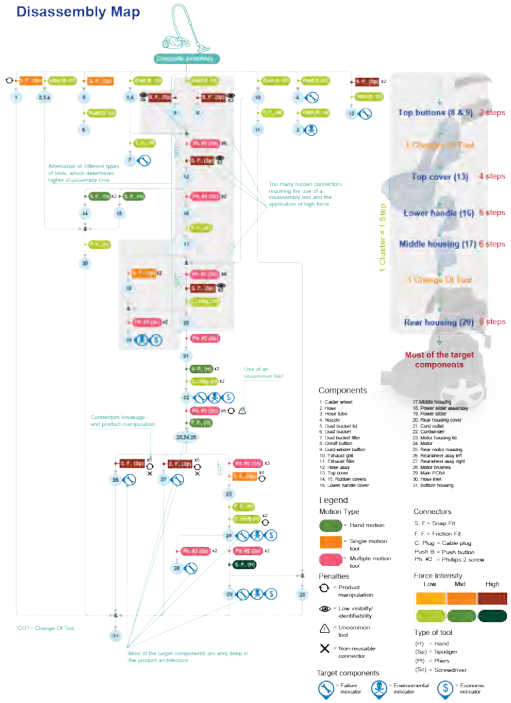
1 Priority parts identification

Strategy:	**Repair**	**Parts recovery**	**Potential reuse to decrease environmental impact**
Identification method:	Field call rates data (not shown). List shown is from Cordella et al., 2019.	High embodied economic value, using HotSpot Mapping tool	High embodied environmental impact, using HotSpot Mapping tool
Motor	Target	Target	Target
PCBA	Target	Target	Target
Power cable/ cord winder	Target	Target	Target
Motor brushes	Target	Target	
Filter	Target		
Nozzle	Target		
Hose	Target		
Power slider PCBA			Target
Metal hose attachment			Target

Practical applications: **Vacuum Cleaners**

2 Product Assessment

Disassembly Map



eDiM (Ease of Disassembly Metric)

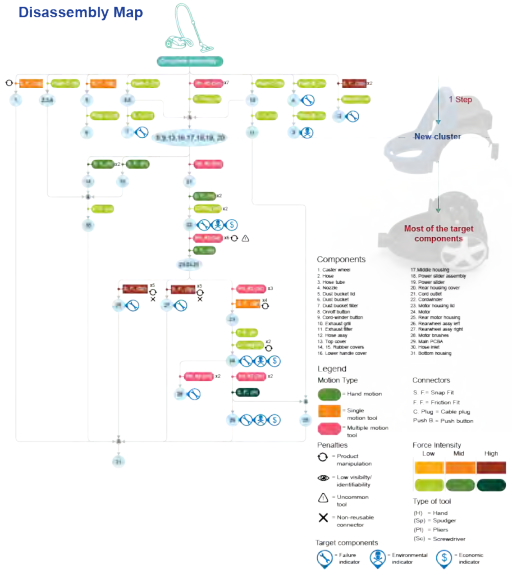
Part	Steps (n.)	Tool change (n.)	Connections (n.)	eDiM (s)	% of total eDiM	% of total connectors
Nozzles	1	0	1	6	0,7	1,2
Hose	1	0	3	21	2,3	3,5
Filter	2	0	2	13	1,4	2,3
Cord-winder	12	7	31	396	43,3	36
Wheel	14	8	43	539	59	50
Motor	16	9	48	576	63,1	55,8
PCBA	17	10	51	616	67,3	59,3
Motor brushes	17	10	50	607	66,4	58,1

Tool developed by the EC JRC. Vanegas et al. (2018)

Practical applications: **Vacuum Cleaners**

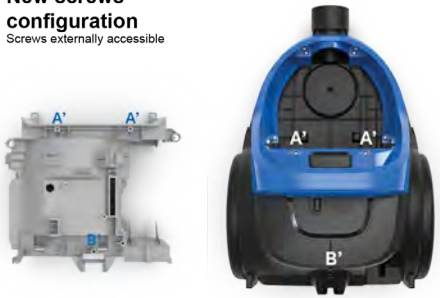
5 Redesign

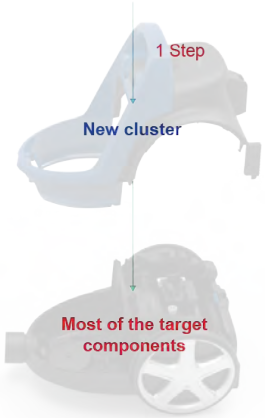
Disassembly Map



Original screws configuration
Screw hidden beneath plastic casings.

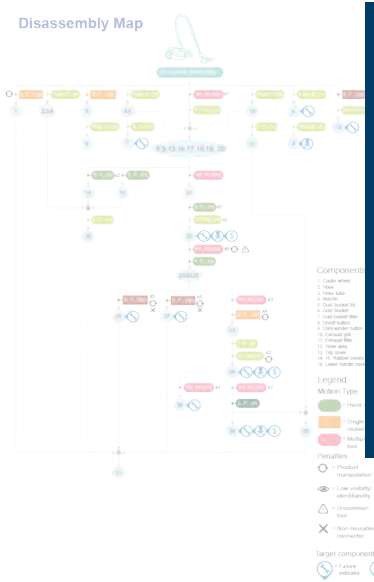
New screws configuration
Screws externally accessible

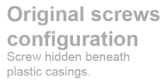


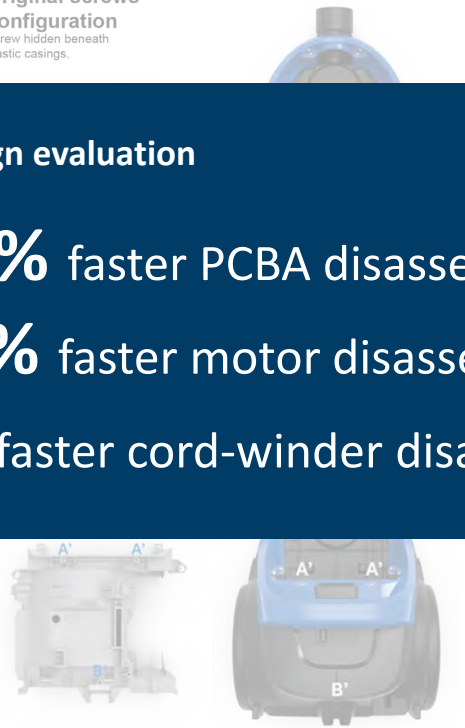


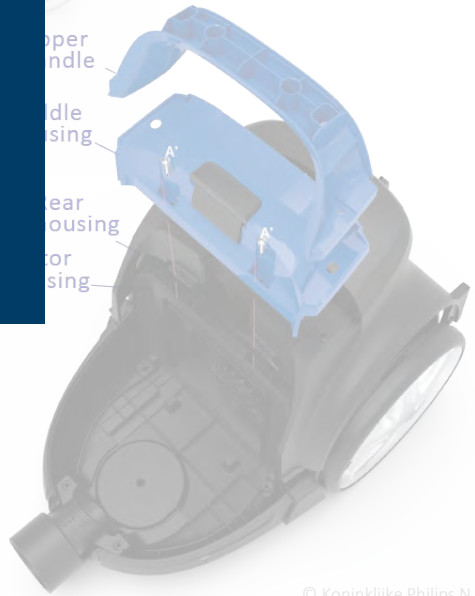
Practical applications: **Vacuum Cleaners**

5 Redesign









6 Redesign evaluation

+40% faster PCBA disassembly

+40% faster motor disassembly

+60% faster cord-winder disassembly

Type of products we worked on

Consumer products

Personal care products

Medical devices

Big medical equipment

Surgical devices

Organizations that are adopting our design for disassembly tools/methods:

IFIXIT

TU Delft

PHILIPS

npk design

VANBERLO

Fraunhofer IPA

BeSafe®

Beyond disassembly

- Design for Recycling
- Sustainable Materials Selection
- Life Cycle Assessment
- ESG/CE Roadmaps
- ESG/CE Transformation programs
- CE Business Modeling
- CE Value Proposition Creation
- CE Community Engagement and Trainings
- CE Reverse Logistics
- CE Metrics and Dashboards

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Francesco De Fazio
Circular Product Designer

Let's drive circular innovation **together**!

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