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Appendix A: Project Brief

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

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

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Ouwehand 7204
Initials	D.S.
Given name	Daniel
Student number	

IDE master(s) IPD ✓ DfI SPD

2nd non-IDE master

Individual programme *(date of approval)*

Medisign

HPM

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	A.R. Balkenende	dept./section	Circular Product Design
mentor	S.M. Persaud	dept./section	Design for Sustainability
2nd mentor	Simon Kuppens		
client:	Signify		
city:	Eindhoven	country:	Nederland
optional comments			

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

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Digitally signed by Ruud Balkenende - IO
Date: 2024.06.09 14:27:03 +02'00'

Name Ruud Balkenende Date 9 Jun 2024 Signature

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, 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 conditional requirements into account, can be part of the exam programme ____ EC

★	**YES**	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Name K. Veldman Date 13 Jun 2024 Signature K. Veldman

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen
Digitally signed by Monique von Morgen
Date: 2024.07.02 10:17:53 +02'00'

Name Monique von Morgen Date 2 Jul 2024 Signature

DESIGN FOR our future

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Personal Project Brief – IDE Master Graduation Project

Name student Daniël Ouwehand **Student numbe**r

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title The balance between reduce, repair, and recycle of the Philips Luma luminaire family.

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)

The increase in electronic products results in an increase in waste, mostly containing valuable materials. To create a circular economy for these products, certain problems should already be addressed during the design phase. This can be done by using an `R' Framework. Multiple `R' Frameworks exist and they provide a great handle when enhancing the circularity of a product (Vogiantzi & Tserpes, 2023). For this project, we will focus on the core 3R Framework (Reduce, Reuse, & Recycle).

The Philips Luma LED luminaire family (Figure 1) is a family of luminaires designed by Signify for outdoor use on streets and roads. These luminaires contain a lot of different valuable materials and are produced in high quantities, making the reduce and recycle aspects very interesting. They are sold mainly as a B2B product and are expected to survive the outdoor environment for around 50 years, highlighting the importance of their durability and repairability.

Signify wants to explore further opportunities to improve the sustainability aspects of this type of luminaire by looking at the trade-offs between lowering overall impact, repairability, and recyclability.

Within this domain, Signify will want to reach their sustainability goals, as well as keep clients happy by producing innovative and reliable products. Clients are interested in value for money, sustainability, and low installation and maintenance/operating costs. The people who install the luminaires want it to be easily installable and relatively maintenance-free. For recycling companies, the different materials must break apart within their respective category. Please find a stakeholder map in Figure 2.

→ *space available for images / figures on next page*

introduction (continued): space for images



image / figure 1 The Luma Gen2 Luminaire

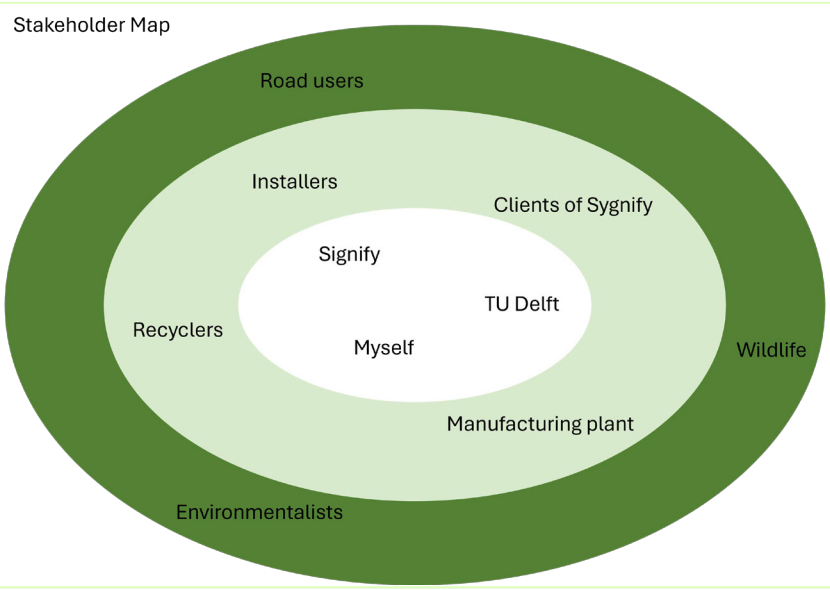

image / figure 2 Stakeholder Map

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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)

Signify has designed its road luminaires with a focus on repairability. This has potentially negatively affected the overall impact and recyclability of the luminaire.

It is unclear which design decisions negatively impact material usage, repairability, and recyclability and how they are influenced by each other.

This creates a knowledge gap within the design process, resulting in a product that is not optimally designed for a circular economy.

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:

I will develop a series of design guidelines focused on reducing, repairing, and recycling of road luminaires, and integrate these into a design concept that demonstrates improved circularity.

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)

With information from literature and stakeholder interviews, I will develop a Product Journey Map. This allows me to define the Strategic Sustainability Goals.
Afterward, I will disassemble a luminaire and create a disassembly map. If needed according to the PJM, I will shred a luminaire and create a recyclability map. Together with the existing LCA, I can make a Product Architecture Map with layers of reduce, repair, and recycle.
This PAM allows me to identify obstacles within the 3R domain. During a co-creation session, we will turn these obstacles into ideas using How-To's. These ideas, together with existing guidelines from research, can be rewritten into guidelines using the Signify guideline format.

With these guidelines and the current design requirements, I will make several concepts for the Luma. These will be rated using weighted objectives. This process allows me to iterate on the concepts and the design guidelines. The best concept will be prototyped and tested with stakeholders, resulting in a final design including optimized guidelines.

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	21 mei 2024
Mid-term evaluation	22 juli 2024
Green light meeting	30 sept 2024
Graduation ceremony	28 okt 2024

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:

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)

Sustainability has always been a big part of the IDE curriculum and has interested me since. I have also been part of Forze, the hydrogen-powered race car student team, in which I had to convey the message of sustainability within transport to the general public. This required me to think on a bigger scale than just product level, which is something that I was looking for in a potential project. Since a big focus of this project is the creation of guidelines, I can focus the aspects of sustainability on a larger, more impactful scale.

Furthermore, I have always been interested in products that have lighting or some other kind of electronics integrated into them. Last year I took the course “Lighting Design” and I love experimenting with making my own luminaires.

The project will also consist of different solution spaces integrated into a final concept. Therefore it is not a straightforward design process, but it enables different points of view on the problem and solution. I am very curious how this will play out, and it will put my own IPD skills to the test. It will also keep the project exciting and fluid.

Appendix B: Hotspot Map

General project information

Brand name	Signify
Product category	Oudoor Luminaires
Authors	Daniel Ouwehand
Date	Jun/24
Location	Eindhoven

Overall HotSpot Results

Total:		**Average:**		
- time to disassemble	542 sec	- time per step	10,8 sec/step	
- number of tasks	86	- force	2	[1=low .. 5=high .. 10=extreme]
- number of steps	50	- accessibility	2	[1=clear .. 5=moderate .. 10=difficult]
- number of tools	4	- positioning	5	[1=easy .. 5=moderate .. 10=difficult]

	General			Activity					Accessibility			Functional		Material		HotSpot Indicators				
Step number	Name	Subasssembly?	Part of ...	Type of activity	Required tool	Tool size	Task frequency	Total time to disconnect (sec)	Force	Accessibility	Positioning	Failure Likelihood	Functinoal relevance	Material group	Weigth (g)	Time	Activity	Priority part	Environmental	Economic	Notes
1	Main Body	no										level 0 -	level 2 -	Aluminium	2761						
2	Spigot clamping bolts	no	main assembly	Unscrew	Screwdriver	A6	2	30	level 1 -	level 0 -	level 2 -	level 0 -	level 2 -	Steel	50						
3	Spigot clamps	no	main assembly	Remove	Hands		2	4	level 0 -	level 0 -	level 1 -	level 0 -	level 2 -	Stainless Steel	26						
4	Spigot	no	main assembly	Remove	Hands		1	5	level 0 -	level 0 -	level 1 -	level 0 -	level 2 -	Aluminium	858						
5	Post Clamp bolts	no	main assembly	Unscrew	Screwdriver	A4	2	30	level 1 -	level 0 -	level 1 -	level 0 -	level 2 -	Stainless Steel	26						
6	Lid pins	no	main assembly	Other	Proprietary t	Hamm	2	20	level 2 -	level 0 -	level 2 -	level 0 -	level 1 -	Stainless Steel	3,4						Press fitted springy steel
7	Lid assembly	yes	main assembly	Other	Hands		1	3	level 0 -	level 0 -	level 0 -										Opening of the Lid
8	Lid	no	Lid assembly	Remove	Hands		1	4	level 0 -	level 0 -	level 0 -	level 0 -	level 2 -	Aluminium	1094						
9	Hinge Starlock	no	Lid assembly	Other	Pliers		1	8	level 1 -	level 1 -	level 2 -	level 0 -	level 1 -	Stainless Steel	0,2						
10	Hinge	no	Lid assembly	Remove	Hands		1	3	level 0 -	level 0 -	level 0 -	level 0 -	level 1 -	Aluminium	67						
11	Earth wire bolt	no	Lid assembly	Unscrew	Screwdriver	T15	1	4	level 0 -	level 0 -	level 0 -	level 0 -	level 1 -	Stainless Steel	1,5						
12	Lib bar bolt	no	Lid assembly	Unscrew	Screwdriver	T15	1	10	level 0 -	level 0 -	level 0 -	level 0 -	level 0 -	Stainless Steel	1,5						
13	Lid bar	no	Lid assembly	Remove	Hands		1	4	level 0 -	level 1 -	level 1 -	level 0 -	level 0 -	Stainless Steel	7,3						
14	Locking bar bolts	no	main assembly	Unscrew	Screwdriver	T15	2	20	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Stainless Steel	3,4						Somehow 2mm longer than all others
15	Locking bar	no	main assembly	Remove	Hands		1	3	level 0 -	level 0 -	level 0 -	level 0 -	level 1 -	Stainless Steel	16,5						
16	Lid Seal	no	main assembly	Remove	Hands		1	4	level 0 -	level 0 -	level 0 -	level 1 -	level 2 -	Rubber	66						Silicon
17	Lid bar slit bolt	no	main assembly	Unscrew	Screwdriver	T15	1	10	level 0 -	level 0 -	level 1 -	level 0 -	level 0 -	Stainless Steel	1,5						
18	Lid bar slit	no	main assembly	Remove	Hands		1	3	level 0 -	level 0 -	level 1 -	level 0 -	level 0 -	Stainless Steel	30						
19																					
20	Driver Module	yes	main assembly	Unplug	Hands		1	20	level 1 -	level 0 -	level 1										
21	Driver box top	no	Driver Module	Disconne	Hands		1	2	level 0 -	level 0 -	level 0 -	level 0 -	level 0 -	No-to-low relevant							
22	Driver box top	no	Driver Module	Remove	Hands		1	4	level 0 -	level 0 -	level 1 -	level 0 -	level 0 -	Thermoplastic	113						
23	Driver screws	no	Driver Module	Unscrew	Screwdriver	T15	2	20	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Steel	2,5						
24	Driver Connectors	no	Driver Module	Unscrew	Screwdriver	Small f	10	20	level 0 -	level 1 -	level 1 -	Moderate precision									Disconnect wires going into driver
25	Driver Connectors	no	Driver Module	Disconne	Lever / Pryba	Small	2	20	level 1 -	level 0 -	level 1 -	level 0 -	level 2 -	Other Electronics	81						Disconnect connector from box bottom
26	Driver	no	Driver Module	Remove	Hands		1	3	level 0 -	level 0 -	level 0 -	level 2 -	level 2 -	PCB	522						
27	Driver box bottom	no	Driver Module	Remove	Hands		1	4	level 0 -	level 0 -	level 0 -	level 0 -	level 1 -	Thermoplastic	105						
28																					
29	Driver connector Starlock washer	no	main assembly	Other	Lever / Pryba	Small	4	32	level 1 -	level 1 -	level 2 -	level 0 -	level 1 -	Stainless Steel	0,8						
30	Driver/power	yes	main assembly	Remove	Hands		1	4	level 0 -	level 0 -	level 0 -										
31	Earth wire bolts	no	Driver/power con	Unscrew	Screwdriver	T15	2	20	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Stainless Steel	3						

32	Driver/power connector	no	Driver/power con	Unplug	Hands		1	4	level 0 -	level 1 -	level 0 -	level 0 -	level 2 -	Main functionality							Disconnect at main plug
33	Driver/power	no	Driver/power con	Disconne	Lever / Pryba	Small f	4	20	level 0 -	level 1 -	level 2 -	level 0 -	level 0 -	Other Electronics	53						Disconnect from holder
34	Driver/power holder	no	Driver/power con	Remove	Hands		1	5	level 0 -	level 0 -	level 0 -	level 0 -	level 1 -	Thermoplastic	15						
35	Driver/LED connector ass.	yes	main assembly	Remove	Hands		1	4	level 0 -	level 0 -	level 0 -										
36	Rubber bushings	no	Driver/LED connec	Remove	Pliers	Small	2	10	level 0 -	level 0 -	level 1 -	level 0 -	level 0 -	Rubber	0,6						
37	Spring plates	no	Driver/LED connec	Remove	Pliers	Small	2	20	level 0 -	level 0 -	level 1 -	level 0 -	level 0 -	Stainless Steel	1,2						
38	Con. LED side	no	Driver/LED connec	Unplug	Screwdriver	Small F	2	20	level 0 -	level 0 -	level 2 -	level 0 -	level 2 -	Other Electronics	45						Disconnect plug to the LED
39	Con. power side	no	Driver/LED connec	Unplug	Screwdriver	Small F	1	10	level 0 -	level 0 -	level 2 -	level 0 -	level 2 -	Main functionality							
40	Con. power side	no	Driver/LED connec	Disconne	Screwdriver	Small f	1	2	level 0 -	level 1 -	level 0 -	level 0 -	level 2 -	Other Electronics	12						
41	Driver/LED con.	no	Driver/LED connec	Disconne	Screwdriver	Small f	4	20	level 0 -	level 1 -	level 2 -	level 0 -	level 0 -	Thermoplastic	15						
42																					
43	Main power connector	no	main assembly	Unscrew	Hands		1	2	level 0 -	level 0 -	level 0 -	level 0 -	level 2 -	Other Electronics	131						Wire connector. Can be disassembled but out of scope.
44																					
45	Glass clamp bolts	no	main assembly	Unscrew	Screwdriver	T15	4	40	level 0 -	level 0 -	level 2 -	level 0 -	level 1 -	Stainless Steel	6						
46	Glass clamps	no	main assembly	Remove	Hands		4	8	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Steel	26						
47	Glass panel	no	main assembly	Remove	Hands		1	5	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Glass	564						
48	Glass seal	no	main assembly	Remove	Hands		1	3	level 0 -	level 0 -	level 1 -	level 2 -	level 1 -	Rubber	54						Silicon
49	LED housing	no	main assembly	Disconne	Lever / Pryba	Small F	2	10	level 0 -	level 0 -	level 1 -	level 0 -	level 0 -	Thermoplastic	72						Material?
50	LED Module screws	no	main assembly	Unscrew	Screwdriver	T15	2	20	level 0 -	level 0 -	level 2 -	level 0 -	level 1 -	Stainless Steel	1,5						
51	LED Module	yes	main assembly	Remove	Hands		1	5	level 0 -	level 0 -	level 2 -										
52	Light Blocker	no	LED Module	Remove	Hands		1	5	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Thermoplastic	13,9						PC
53	Lens	no	LED Module	De-glue	Lever / Pryba	Small F	1	10	level 0 -	level 0 -	level 1 -	level 0 -	level 1 -	Thermoplastic	42,6						PMMA
54	LED + PCB	no	LED Module	Remove	Hands		1	5	level 0 -	level 0 -	level 1 -	level 2 -	level 2 -	PCB	47,2						PCB printed on Alu

Appendix C: Interview notes Product Manager Outdoor at Signify

This appendix contains confidential information. Contact the supervisors if access is required.

Appendix D: Interview notes Product Marketeer at Signify

This appendix contains confidential information. Contact the supervisors if access is required.

Appendix E: Interview notes Repair Crew

This appendix contains confidential information. Contact the supervisors if access is required.

Appendix F: Interview notes WEEE Recycler

Visit 30-5-24 – main communication with the Managing Director

Visit insights 30-5
• The asphalt in drivers is a big problem. It can only be separated by using nitrogen. They are working on a solution to improve this process.
• Cables should ideally be separated from the devices. They will go to a partner for further processing. If not separated, shredder.
• Batteries and other critical components are manually taken out of the stream before processing. This is not 100%. They will manually disassemble big stuff. Small electronics will go to another plant.

Material purity
• Powder coating is not an issue. It burns away in the melting pot.
• They can reach near 100% purity.
• They can separate different grades of aluminium at HKS.

Disassembly
• Certain B2B products are disassembled before recycling. This can either be done beforehand by the supplying company, or at the recycling plant.
• Deal is usually made with the manufacturer or a 3rd party

Visit 17-6-24 – main communication with the Process Controller
• The recycler will make a cost estimation to see if it is worth it for them to disassemble the luminaire. If there a lot of luminaires, they will probably end up in the shredder because they don't have the time and resources for disassembly.

• Materials:
    o Glass is fine as long as it breaks into pieces of 10-30mm. Smaller will go to waste.
    o Powder coating can be a problem if it changes the density or the eddy current of certain aluminum fractions. However, chances are small. Will burn away in the smelter.
    o Aluminum, 5 times more valuable than iron
    o Stainless Steel manual
    o sink/float cutoff 1.1
        PC sinks > waste
        PMMA sinks > waste
        Silicon sinks > waste
    o Wires etc > copper is a problem for other fractions
• Purity of aluminum fraction = 95%
• The shredder can handle bigger luminaire is the casted aluminum is thin enough to break apart.

Appendix G: Current end-of-life scenarios

Scenario 1: Best case scenario (figure 1)
- Old luminaires are dropped off at an external party.
- The external party fully disassembles the luminaires.
- Parts get reused or recycled in the proper fractions.

Drivers
- Full disassembly takes a lot of manual labor, which is expensive. SROI (Social Return on Investment) might be a motivator for the external party.

Sustainable Impact
- Almost all materials are fully recycled, except for the non-recyclables.

Source: (Product Manager at Signify, personal communication, 10 June 2024) & (Product Marketeer at Signify, personal communication, 26 June 2024)

Scenario 2: In-between scenario A (figure 2)
- Old luminaires are collected or dropped off at a recycling company.
- They get fully disassembled.

Drivers
- Some recycling companies disassemble before. recycling. This depends on the value and disassembly time.

Sustainable Impact
- Almost all materials are fully recycled, except for the non-recyclables.

Source: Repair crew, personal communication, 12 June 2024

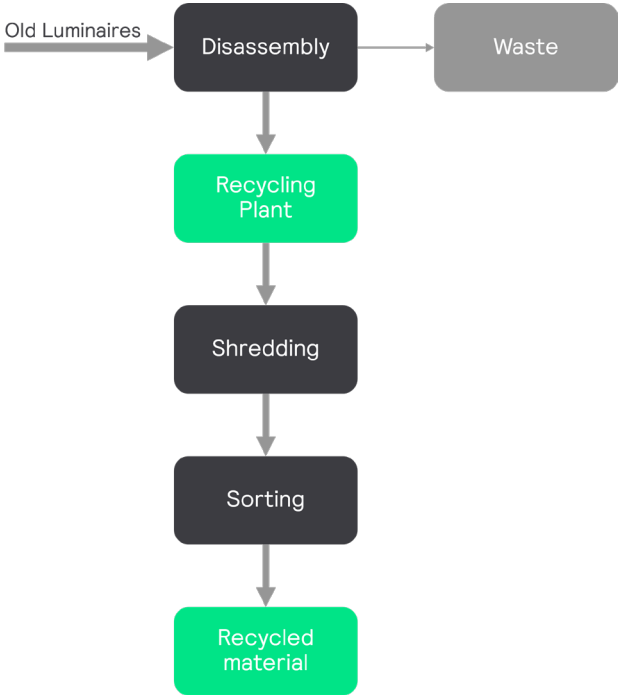


Figure 1: Best case end-of-life scenario.

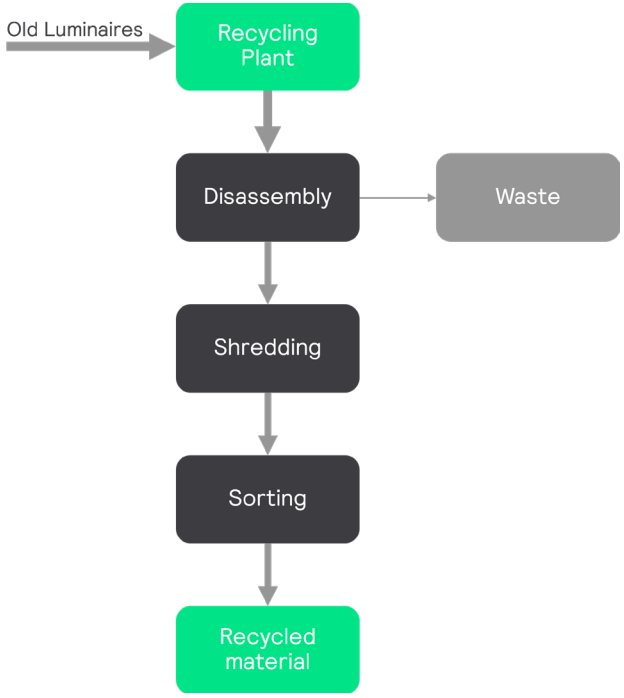


Figure 2: In between end-of-life scenario A.

Scenario 3: In-between scenario B (figure 3)
- Old luminaires are collected or dropped off at a recycling company.
- The recycling company partially disassembles the luminaire.
- Until enough purity is reached (95%).
- Until valuable materials are scavenged.
- Remainder goes into the shredder.

Drivers
- The recycling plant has a 95% pure aluminum stream. The weight of the Luma and the value of the aluminum, make disassembly economical.

Sustainable Impact
- Lots of materials are recycled, except for the non-recyclables & the non-aluminum materials that join the 95% aluminum stream.

Source: Process Controller at WEEE recycler, personal communication, 17 June 2024

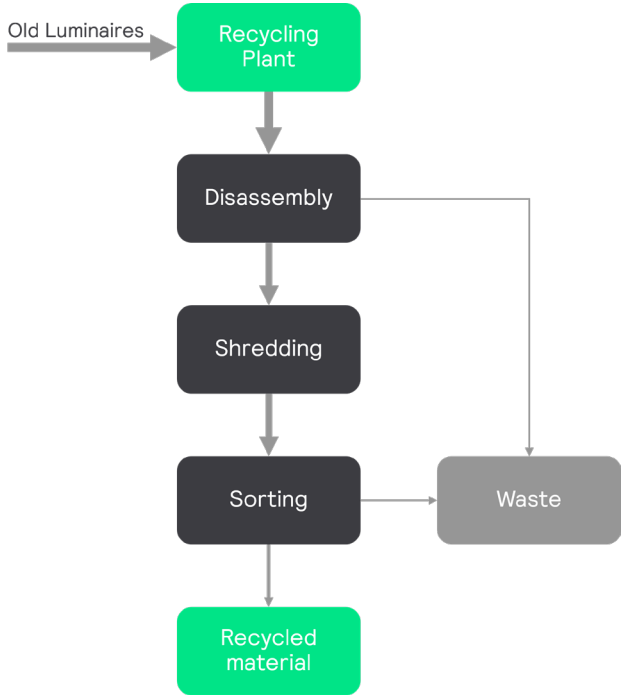


Figure 3: In between end-of-life scenario B.

Scenario 4: Worst case scenario (figure 4)
- Old luminaires are collected or dropped off at a recycling company.
- They go straight into the shredder.

Drivers
- If disassembly takes too much time, there is no more economical value in doing it.

Sustainable Impact
- The Luma enters the normal recycling process, starting with the shredder. Depending on the fragmentation and separation process, some material will be lost.

Source: Process Controller at WEEE recycler, personal communication, 17 June 2024

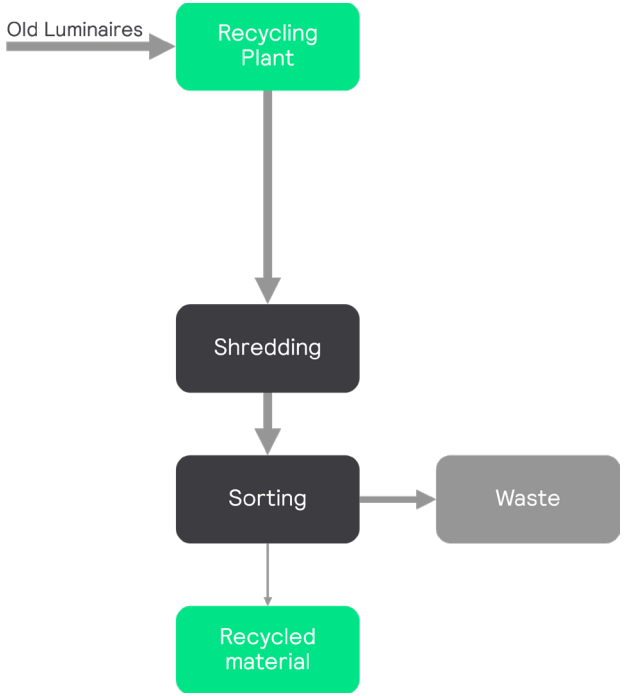


Figure 4: Worst case end-of-life scenario.

Appendix: H: Shredder Experiment Report

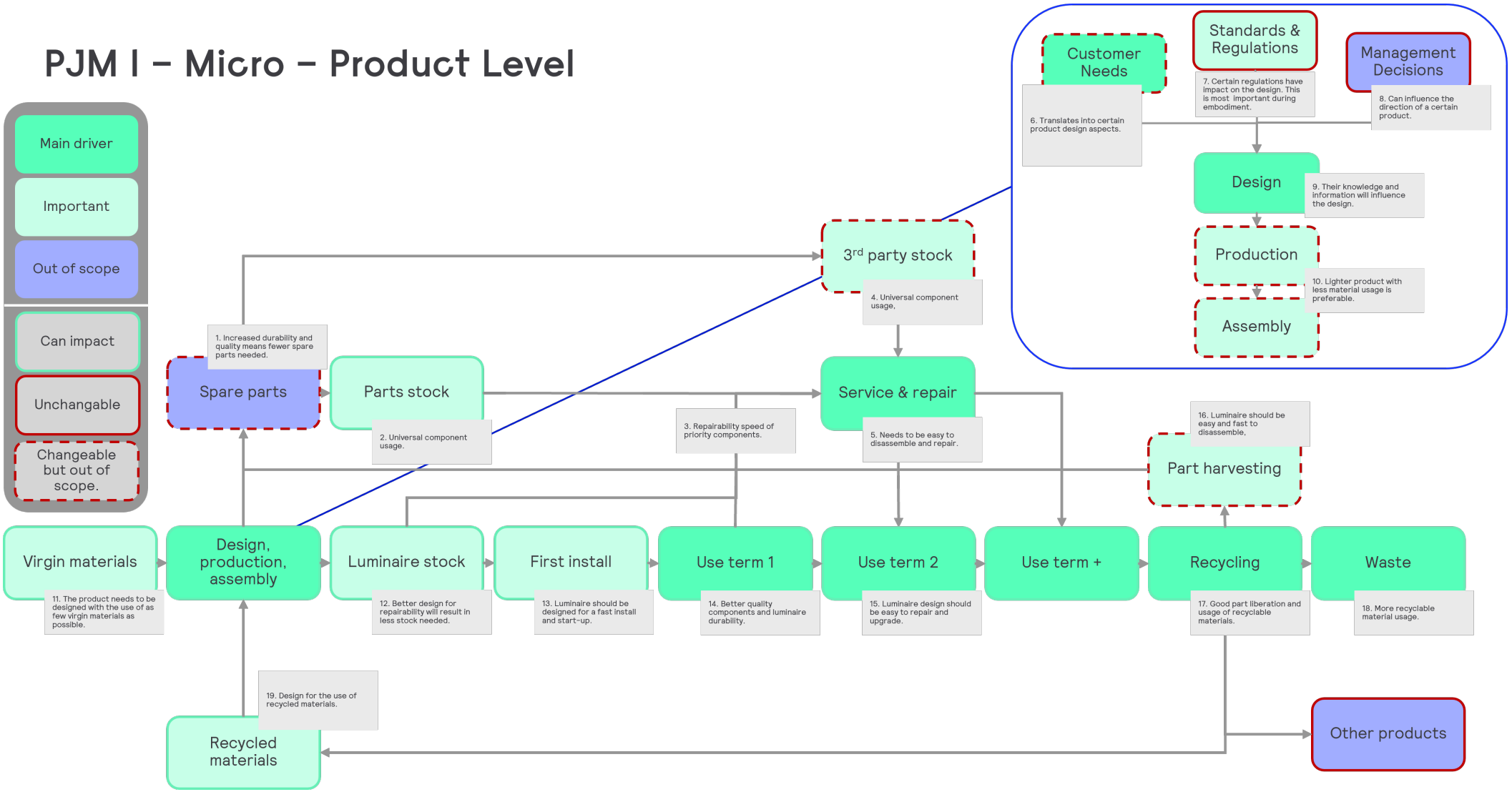
This appendix contains confidential information. Contact the supervisors if access is required.

Appendix I: Product Journey Maps

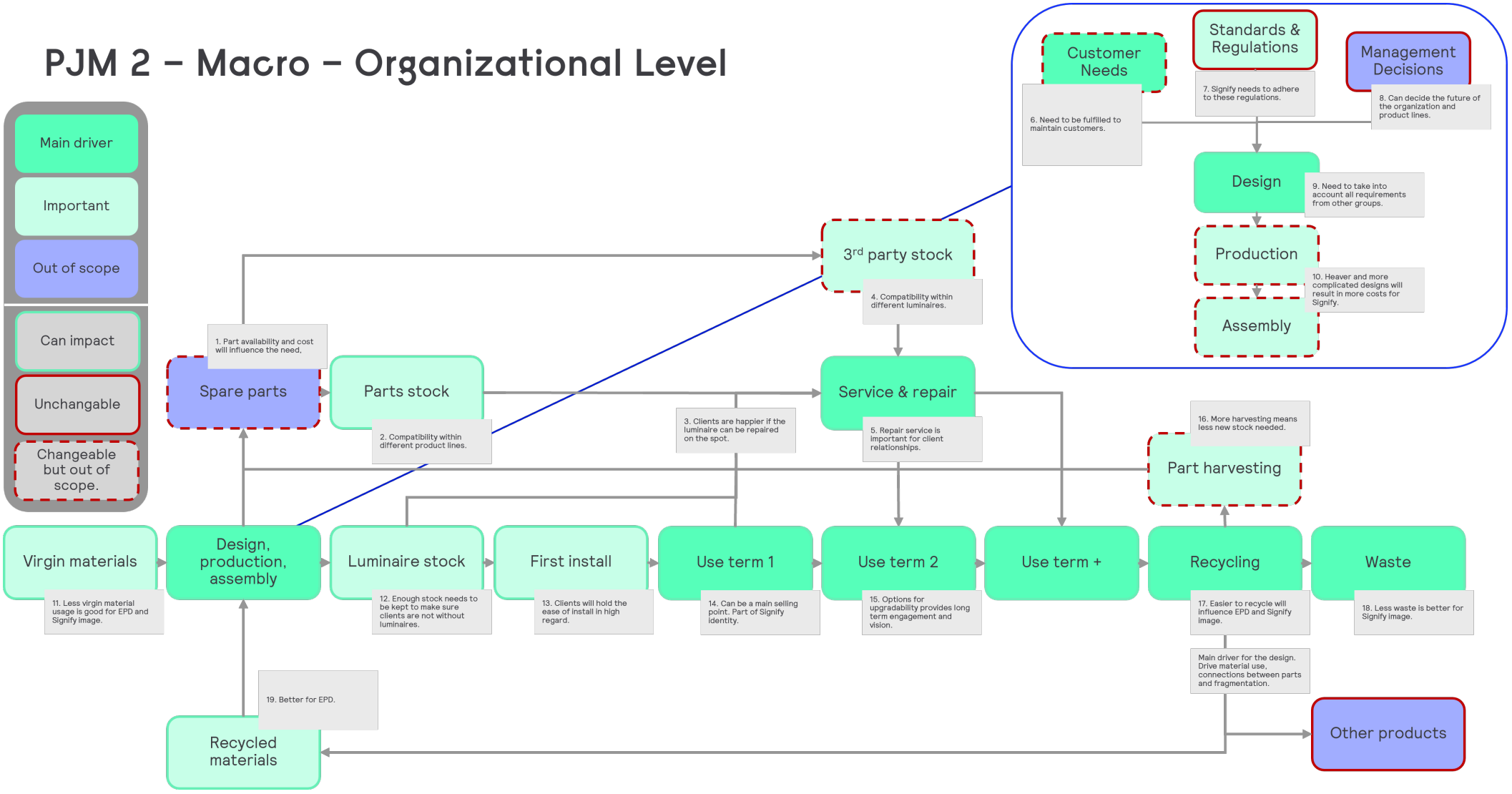
Important insights from research & interviews have been displayed in the following Product Journey Maps. These PJMs show all steps that occur before, during, and after the lifecycle of the product. The important stakeholders, struggles, and pain points have also been identified. To show the impact and drivers on different levels of the system, PJM have been created on micro, macro, and meta level.

The legend on the left of the PJM shows the impact of different drivers on the project and whether they can be influenced or not.

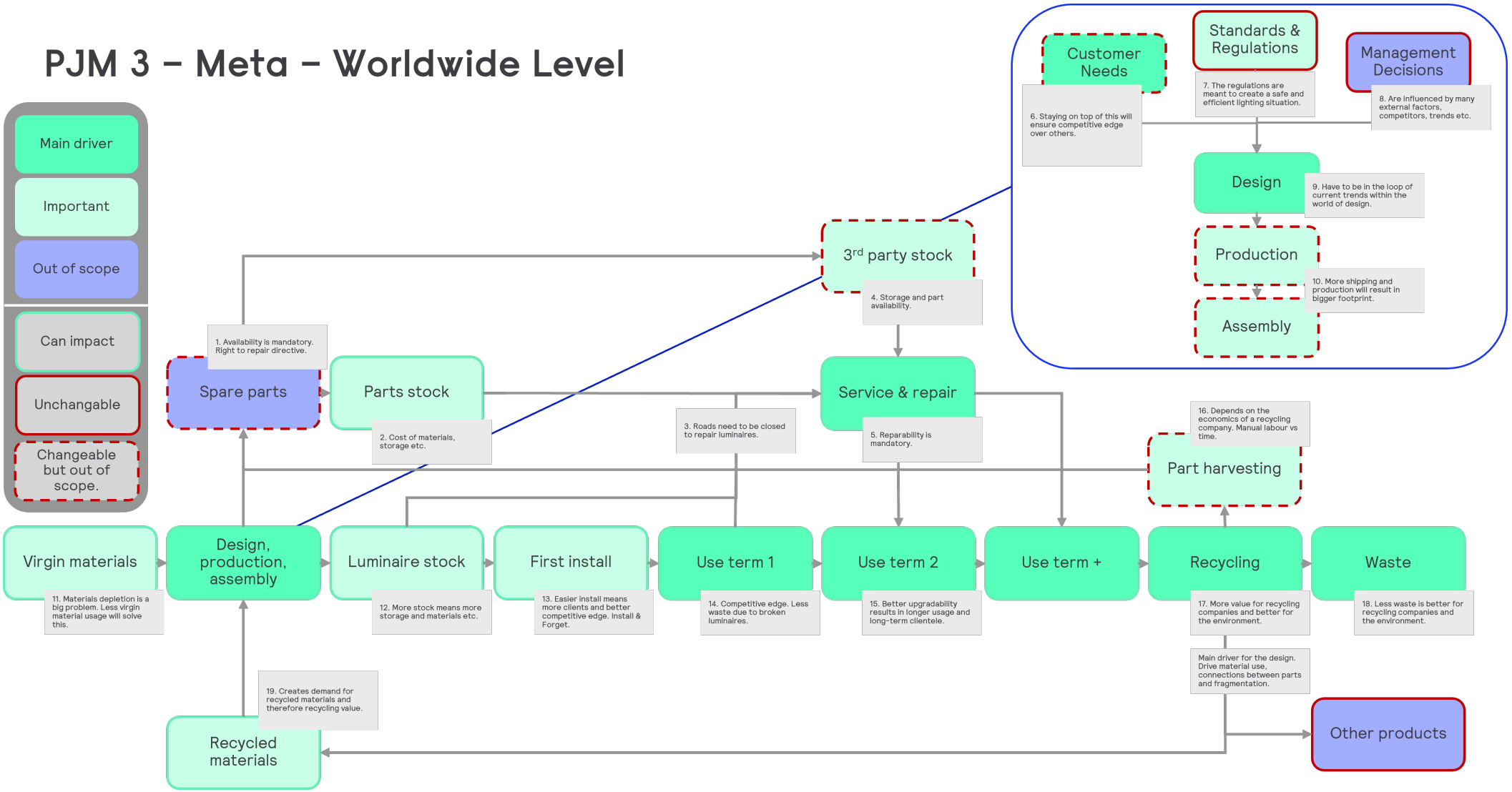
PJM I – Micro – Product Level



PJM 2 – Macro – Organizational Level



PJM 3 – Meta – Worldwide Level



Appendix J: Design Directions



Appendix K: C-Boxes

y >	Feasibility	Repairability	Value for customers	Innovativeness	Simplicity	Recyclability	Reliability/quality /performance	Easy to implement
Feasibility								
Repairability								1
Value for customers	3							
Innovativeness								
Simplicity								
Recyclability		5			2			
Reliability/quality /performance				4				
Easy to implement								

Pictures of the C-boxes confidential information. Contact the supervisors if access is required.











Appendix L: Results from the second brainstorm

Attaching the L2 to the housing

Clamp between lid & gasket

Idea

Use the pressure of the closing lid and the flexibility of the gasket to fix the L2 and glass panel in place.

Pros

- No screws needed
- Easily swappable

Cons

- Gasket can lose elasticity over time
- Limited lid designs



Attaching the L2 to the housing

Corner fixation (picture frame)

Idea

Use a shelf spring when components to clamp everything under a ridge.

Pros

- No screws needed
- Will fail apart during shredding

Cons

- More difficult to repair
- Needs a complex housing design



Attaching the L2 to the housing

Alu-alu crush fit

Idea

Use an aluminum component to sandwich everything together. It uses a soft TPU to snap in place.

Pros

- No screws needed
- Fixed fitting in place

Cons

- Difficult to repair
- Requires more aluminum



Attaching the L2 to the housing

Plastic bushing with screw

Idea

Instead of threading in the aluminum, press fit a plastic bushing in / under it in the aluminum and screw into that.

Pros

- Should fail apart during shredding
- Easy to assemble
- Easy to repair

Cons

- Be proud to left corner bolts during shredding
- Can weaken with repeated use



Attaching the L2 to the housing

Plastic nuts

Idea

Use plastic nuts on top of aluminum inserts.

Pros

- No corrosion
- Easy design change
- Good for repeatability & recyclability

Cons

- Less strength, more difficult to torque
- Extra tab aluminum threads needed



Attaching the L2 to the housing

Snap fit

Idea

Use snap fits to hold the L2 in place.

Pros

- No screws needed
- Easily swappable

Cons

- Will require the reflector to include these snap fits
- Can break off during repair



Attaching the U to the housing

Wire

Idea:

Use two interlocking edges on the to be connected parts and run a wire through.

Pros:

- Will fall apart as soon as the wire snaps

Cons:

- Difficult design
- Repeatability



Attaching the U to the housing

Plastic crush ribs

Idea:

Use crush ribs in the plastic to attach the components to aluminum poles.

Pros:

- No screws needed
- Easily reappable

Cons:

- Requires top mounted U and glass
- No high tensile strength



Attaching the U to the housing

Gearfray

Idea:

Similar to the current Gearfray box design, but then without top cover. The platform can still use the current electrical connectors.

Pros:

- Simplified design
- Better accessibility

Cons:

- Still uses wires



Attaching the U to the housing

Breadboard

Idea:

The electrical components will receive an extension with breadboard for connections. These pins can be mounted on the specified pins of a breadboard.

Pros:

- Easy individual component swap

Cons:

- Vulnerable to misalignment
- Requires electrical component modification



Attaching the U to the housing

Crush Ribs

Idea:

Use crush ribs in the plastic to attach the components to aluminum poles.

Pros:

- No screws needed
- Easily reappable

Cons:

- No high tensile strength



Attaching the U to the housing

Clamping in between poles

Idea:

Use the flexibility of a plastic edge to wedge itself between 2 identifying aluminum poles.

Pros:

- No screws needed
- Easily reappable

Cons:

- Might crush



Driver platform connection to housing

Plastic bushing with screws

Idea:

Instead of threading in the aluminum, press fit a plastic or rubber bushing in the aluminum and screw into that.

Pros:

- Should fall apart during shredding
- Easy to assemble
- Easy to repair

Cons:

- No proof it will come loose during shredding
- Can weaken with repeated use



Driver platform connection to housing

Wire

Idea:

Use new interlocking edges on the to be connected parts and run a wire through.

Pros:

- Will fall apart as soon as the wire snaps

Cons:

- Difficult design
- Repairability



Driver platform connection to housing

Plastic nuts

Idea:

Use plastic nuts on top of aluminum threads.

Pros:

- No corrosion
- Easy design change
- Good for repairability & recyclability

Cons:

- Less strength, more difficult to torque
- Extra aluminum threads needed



Driver platform connection to housing

Slide in

Idea:

Slide the whole driver platform assembly into the aluminum.

Pros:

- No screws needed
- Easily swappable

Cons:

- More difficult design
- Specific platform design



Driver platform connection to housing

Shape features in aluminum

Idea:

Make features in the aluminum with the shape of the driver platform to keep it in place. Can be done from both sides.

Pros:

- No screws needed
- Easily swappable

Cons:

- Vibration resistance
- Will only fit a specific driver combo



Attaching the driver to the driver swap platform

Slide in

Idea:

Slide the whole driver into the platform assembly.

Pros:

- No screws needed
- Easily swappable

Cons:

- More difficult design
- Driver needs an edge



Attaching the driver to the driver swap platform

Plastic plugs

Idea

Use plastic plugs that attach against or below the driver platform.

Pros

- No screws needed

Cons

- Can weaken after repeated re-use
- Not incredibly strong



Attaching the driver to the driver swap platform

Wire

Idea

Use new interlocking edges on the to be connected parts and run a wire through

Pros

- Will fail apart as soon as the wire snaps

Cons

- Difficult design
- Repairability



Attaching the driver to the driver swap platform

Plastic screws

Idea

Use plastic screws instead of iron screws

Pros

- Easy design change

Cons

- Less strength, more difficult to torque



Enabling top view access to priority components

Sliding lid (drawer)

Idea

Slide the lid forwards instead of hinging it.

Pros

- Not a lot of space needed for the hinge
- Can be fully opened or removed

Cons

- More weight on the outer side when opened
- Difficult gasket layout



Attaching the driver to the driver swap platform

Snap fit

Idea

Use snap fits to hold the driver in place

Pros

- No screws needed
- Easily swappable
- No driver modification needed

Cons

- Can break off during repair



Enabling top view access to priority components

Sideway opening (book)

Idea

Open the lid towards the side. Fold the luminaire open like a book.

Pros

- All components can live in the same plane
- Components can be mounted on lid or bottom

Cons

- Asymmetrical design
- Limited space for hinge



Enabling top view access to priority components

Reversed opening

Idea:

Instead of opening the lid in the front, open it from the back.

Pros:

- More workspace near the driver side

Cons:

- More weight on the outer end, resulting in more strength needed



Enabling homogeneous housing function

Weakening the aluminum

Idea:

Use modifiers to weaken the aluminum around certain components and screws. This way you can ensure that the screws break first.

Pros:

- Easy to incorporate
- Favorable cost

Cons:

- Can weaken total structure



Enabling top view access to priority components

Bottom opening

Idea:

Fold down the bottom instead of folding open the top.

Pros:

- More space when repairing on the spot

Cons:

- No top view, but partially side view
- All components need to be mounted the lid. Can become heavy



Enabling homogeneous housing function

Composites/delamination

Idea:

Use a composite that delaminates when recycled.

Pros:

- Will fall apart very easily

Cons:

- Difficult manufacturing
- Connections and strength



Enabling top view access to priority components

Split design (current)

Idea:

Use the current design, make 2 separate compartments for the L2 and driver components.

Pros:

- Less risk of tracking as something around the L2 during normal repair

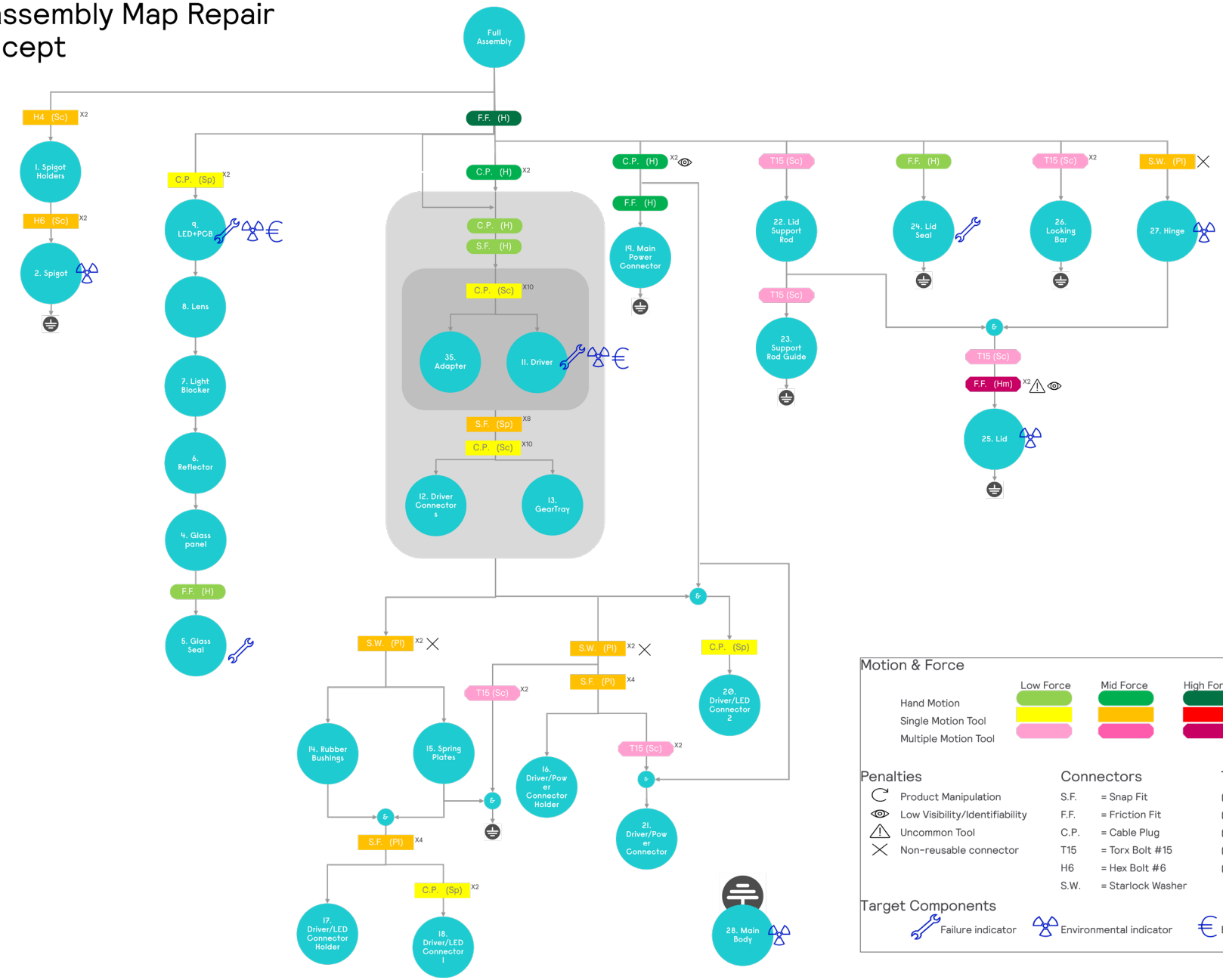
Cons:

- More complicated design
- No easy L2 repair



Appendix M: Concept Disassembly & Recyclability Maps

Disassembly Map Repair Concept



1. Spigot Holders
2. Spigot
3. Glass Clamps
4. Glass Panel
5. Glass Seal
6. Reflector
7. Light Blocker
8. Lens
9. LED+PCB
10. N.A.
11. Driver
12. Driver Connectors
13. GearTray
14. Rubber Bushings
15. Spring Plates
16. Driver/Power Connector Holder
17. Driver/LED Connector Holder
18. Driver/LED Connector 1
19. Main Power Connector
20. Driver/LED Connector 2
21. Driver/Power Connector
22. Lid Support Rod
23. Support Rod Guide
24. Lid Seal
25. Lid
26. Locking Bar
27. Hinge
28. Main Body
35. Adapter

Motion & Force

	Low Force	Mid Force	High Force
Hand Motion			
Single Motion Tool			
Multiple Motion Tool			

Penalties

- Product Manipulation
- Low Visibility/Identifiability
- Uncommon Tool
- Non-reusable connector

Connectors

S.F.	= Snap Fit
F.F.	= Friction Fit
C.P.	= Cable Plug
T15	= Torx Bolt #15
H6	= Hex Bolt #6
S.W.	= Starlock Washer

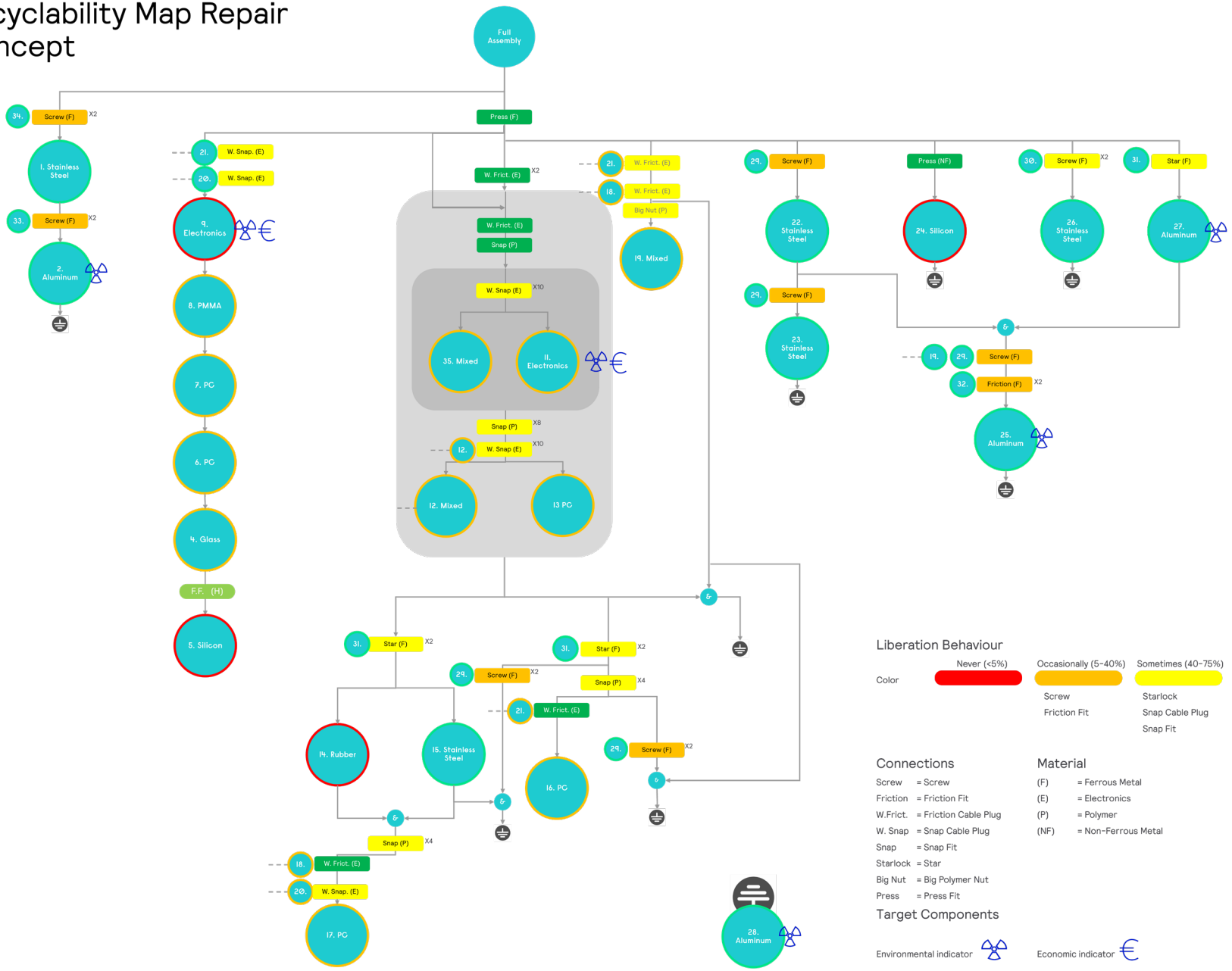
Tool Type

(H)	= Hand
(Sp)	= Spudger
(Pl)	= Pliers
(Sc)	= Screwdriver
(Hm)	= Hammer

Target Components

Failure indicator · Environmental indicator · Economic indicator

Recyclability Map Repair Concept



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24. Lid Seal
25. Lid
26. Locking Bar
27. Hinge
28. Main Body
29. T15 Bolt 12mm
30. T15 Bolt 14mm
31. Starlock Washers
32. Spring Steel Pins
33. A6 Hex Bolt
34. A4 Hex Bolt
35. Adapter

Liberation Behaviour

	Never (<5%)	Occasionally (5-40%)	Sometimes (40-75%)	Often (75-95%)	Good (>95%)
Color		Screw Friction Fit	Starlock Snap Cable Plug Snap Fit	Big Polymer Nut	Friction Cable Plug Press Fit

Connections

Screw	= Screw
Friction	= Friction Fit
W.Frict.	= Friction Cable Plug
W. Snap	= Snap Cable Plug
Snap	= Snap Fit
Starlock	= Star
Big Nut	= Big Polymer Nut
Press	= Press Fit

Material

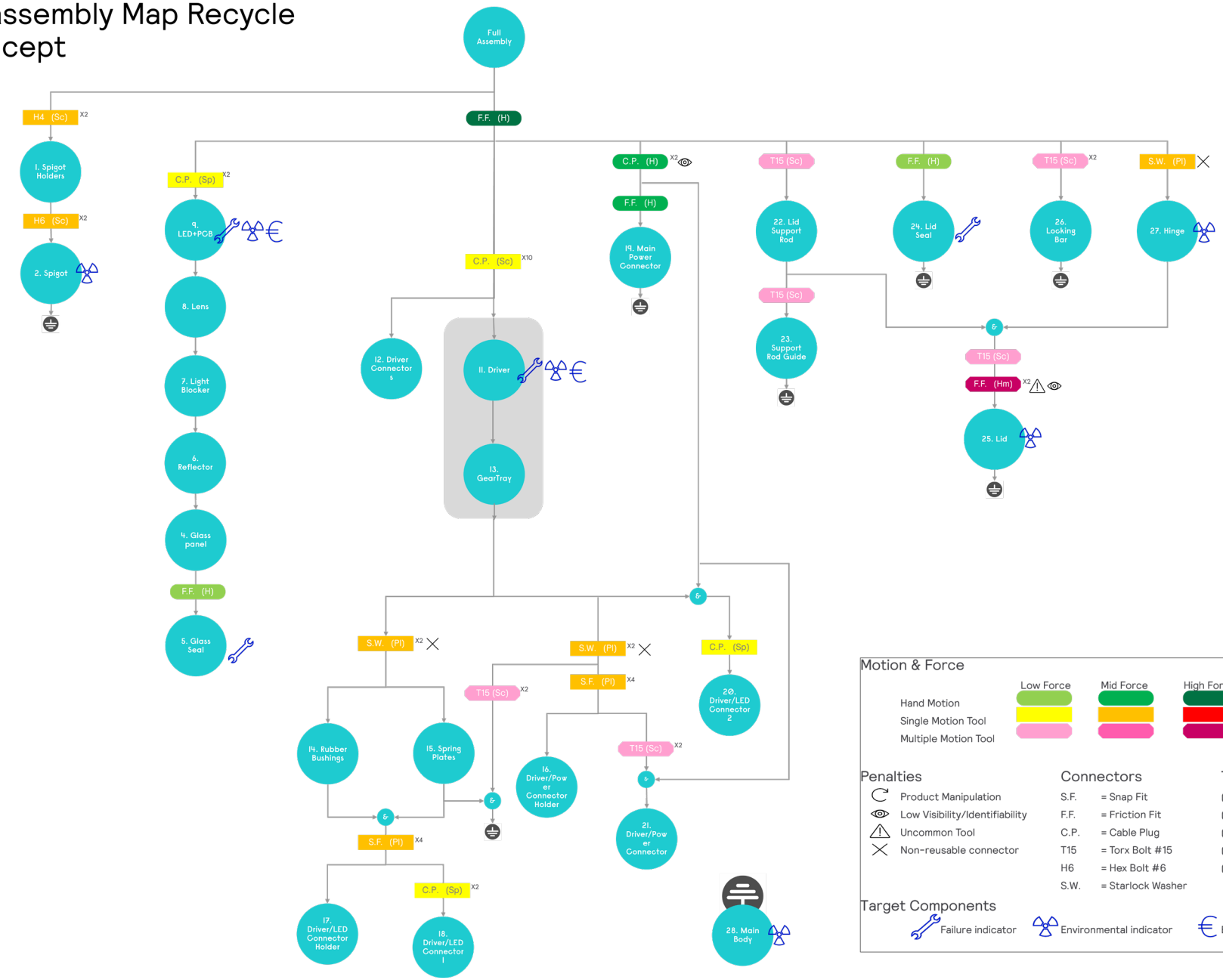
(F)	= Ferrous Metal
(E)	= Electronics
(P)	= Polymer
(NF)	= Non-Ferrous Metal

Target Components

Environmental indicator

Economic indicator €

Disassembly Map Recycle Concept



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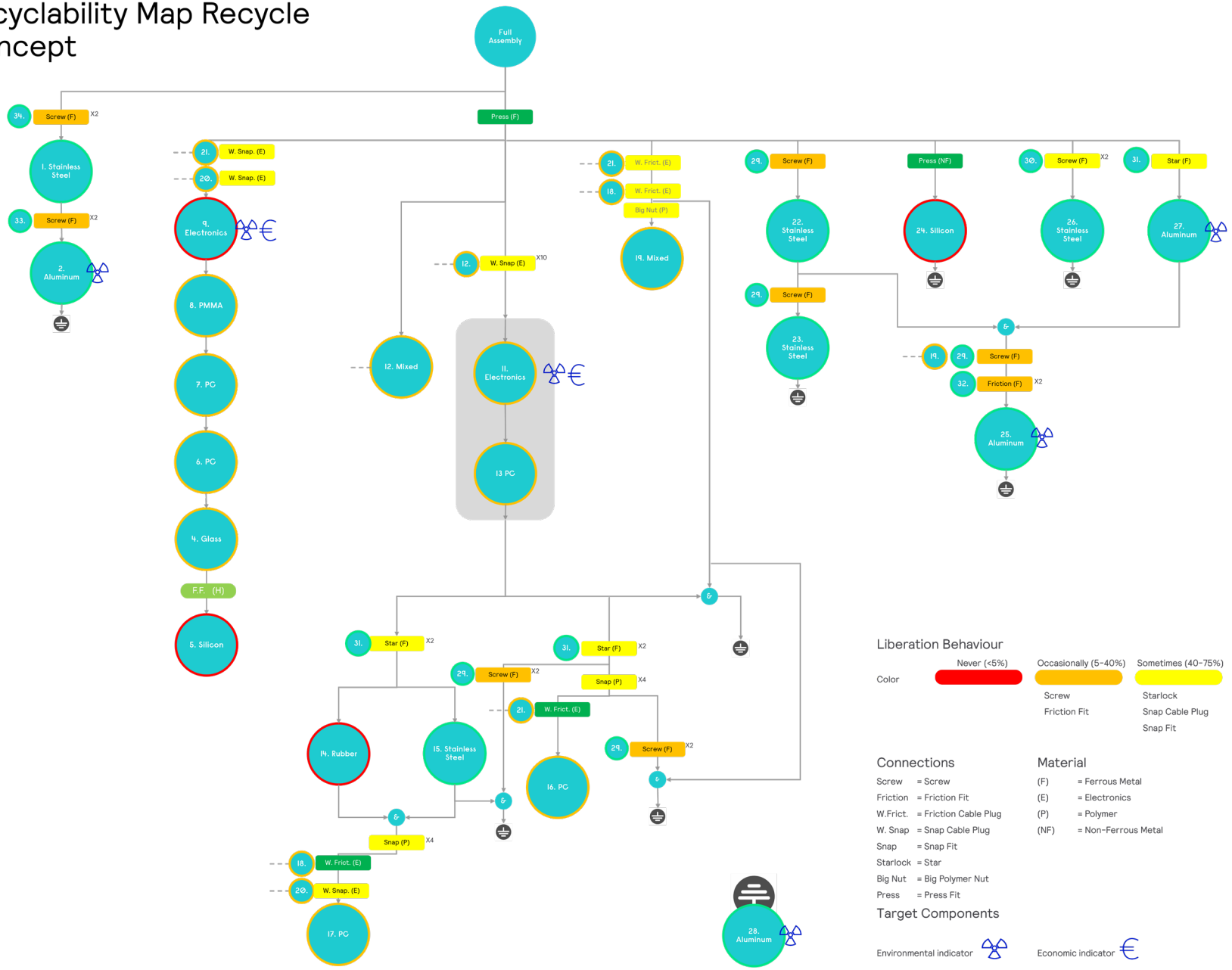
Failure indicator · Environmental indicator · Economic indicator

Recyclability Map Recycle Concept



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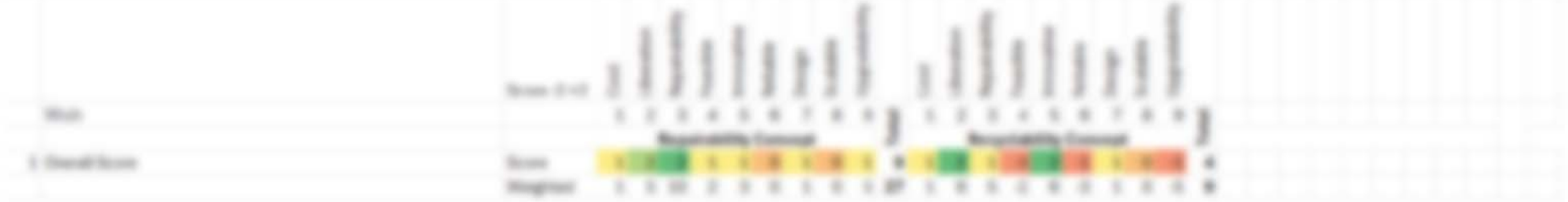
Target Components

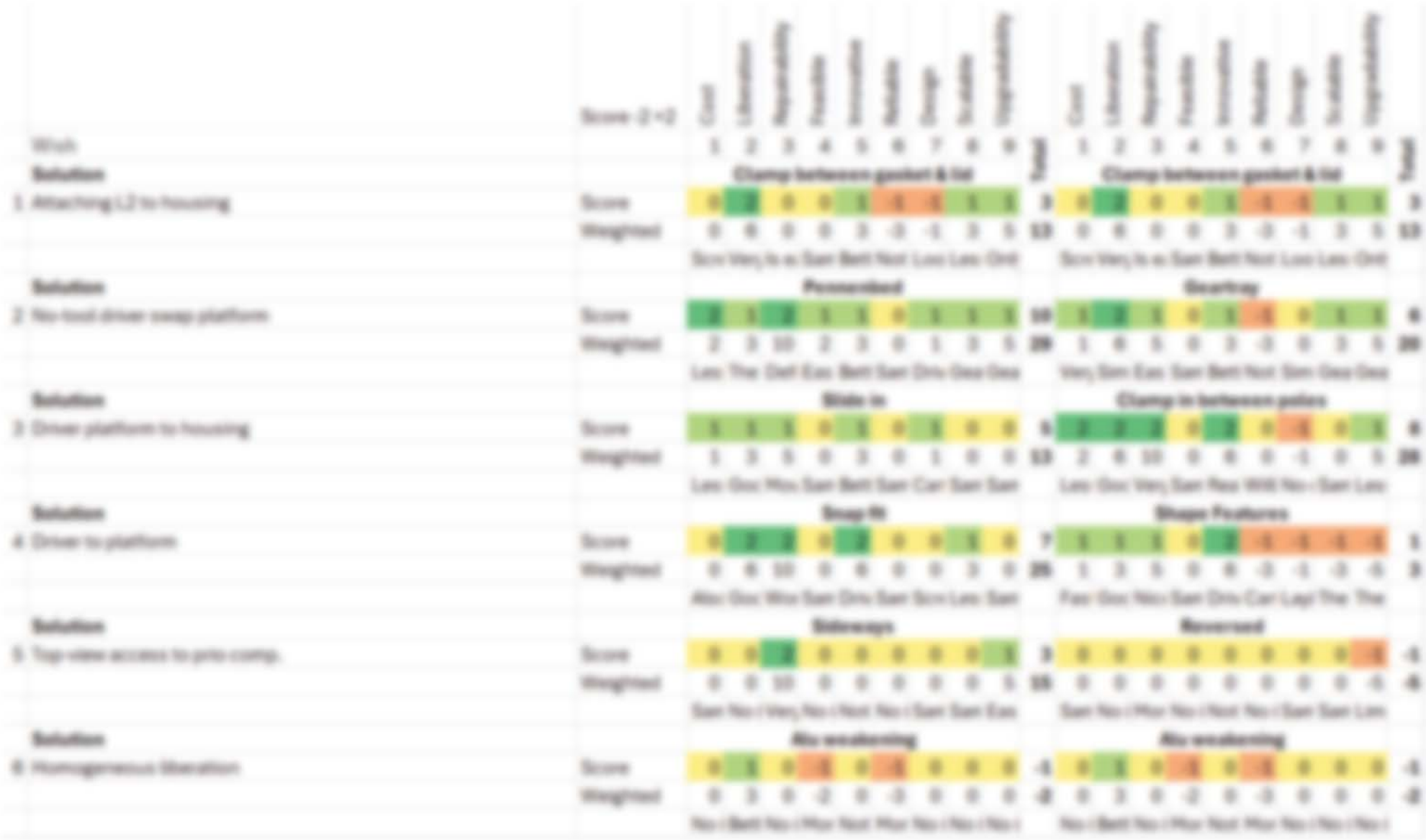
Environmental indicator

Economic indicator

Appendix N: Pugh Ranking

Wishes	Weight (1-5)	Rationale
1. Cost should be as low as possible.	1	Less important during this stage of the redesign.
2. Part liberation during shredding should be as high possible.	3	Ties into recyclability. Main subject of the project.
3. Overall repairability should be as high as possible.	5	Ties into repairability. Main subject of the project.
4. The design should be feasible (simple-ish).	2	The design should be feasible. Not too important as this is a concept design.
5. The concepts should show innovative solutions.	3	As this is a concept design that aims to inspire, innovative solutions should be presented.
6. Should be as reliable as possible.	3	Ties into the quality, durability, and performance possibilities. Important to take into account but can be refined during embodiment.
7. The look and feel should add to the perceived customer value.	1	Less important for this project.
8. The design should be scalable.	3	Since the Lumo is a product family, design should be scalable. Can be done afterwards.
9. The concept should provide good upgradability.	3	How easy is it to upgrade parts? Depends on the difficulty of component interfaces.





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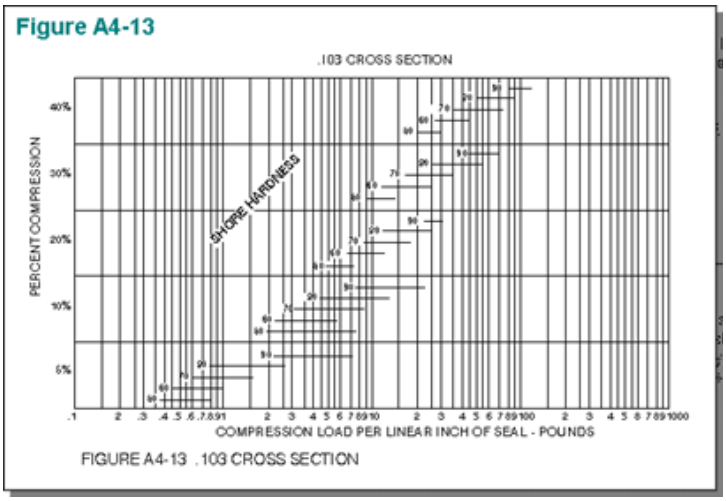
Appendix O: Cooling calculations

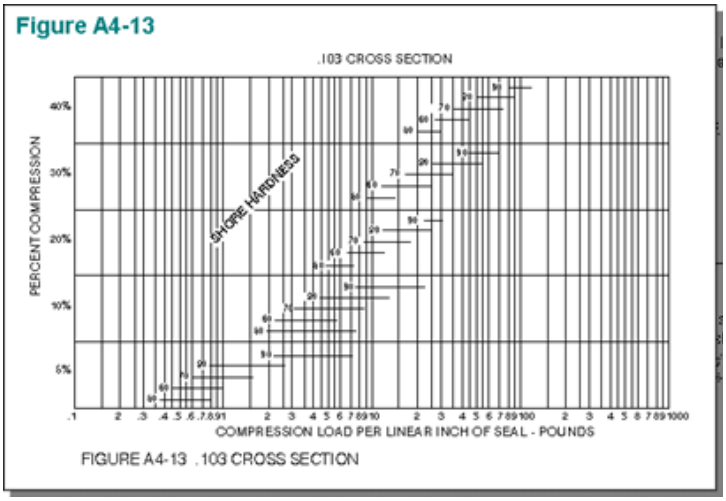
This appendix contains confidential information. Contact the supervisors if access is required.

Appendix P: Glass seal force calculations

Initial parameters:
Seal area cross section = 80 mm2 = 0.124 inch2
Seal perimeter = 680 mm = 26.8 inch
Around 15% compression needed (Mechanical Engineer at Signify, personal communication, 23 October 2024)
Reference hardness: Shore 50A

Compression charts for solid o-ring:





(University of Chicago, 2012)

For 0.103 cross section area: 15% compression → around 3 lb per inch

For 0.139 cross section area: 15% compression → around 1 lb per inch

Interpolation for 0.124 cross section area: 15% compression → around 1.85 lb per inch

x seal perimeter → 1.85 * 26.8 inch = 49.6 lbs = 22.6 kg = **221 N** of force needed