TU Delft

Product Journey Map

Playbook

Master thesis
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Foreword

The Product Journey Map playbook is the final result of my graduation project as part of the Strategic Product Design master's program at the Technical University Delft. The project was performed in collaboration with the TU Delft ReCiPSS team and the involved testing companies Castor Ventures and Gorenje. This project aimed to develop a design methodology to help industrial designers identify opportunities to slow down and/or narrow down and/or close resource loops by systematically mapping the products' lifecycles. Having gone through the Industrial Design Engineering Bachelor, Strategic Product Design master, and the Technology in Sustainable Development annotation program, this graduation project allowed me to combine the interests that I developed throughout my academic career. During this graduation project, I had the privilege to explore my interests with an amazing and passionate supervisory team and testing team. Therefore, I want to thank Professor Dr. Ir. Conny Bakker & Dr. Ir. Charlotte Kobus, Ph.D. candidate Ir. Nina Boorsma, Robin A. van der Torre of Castor Ventures and Dr. Aleš Mihelič & Simon Kotnik from Gorenje for all their help and support throughout this project.

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Structure

The playbook has been structured according to the 5 elements of method content by Daalhuizen. He advocates his five key elements to describe a design methodology's content being: the method rationale, the method framing, the method goal, the method procedure, and the method mindset. Each individual element represents a different aspect of the design methodology:

- ☐ The method rational section of the playbook will explain why the method's goal is relevant and meaningful.
- ☐ The method framing section of the playbook provides information on the context by describing how industrial designers and companies can appropriately use the method.
- ☐ The method goal section of the playbook outlines the method's goal it tries to achieve.
- ☐ In turn, the method procedure explains how the method contributes to reaching the method's goal.
- ☐ Lastly, the method mindset describes the users' beliefs and prerequisite knowledge needed in order to use the method properly and successfully.

Photo: Marjolein van der Veldt

Rationale

At this time, our linear economy urgently needs to transform toward a circular, less wasteful system to restrain the global environmental footprint of the products we use. There are three approaches to moving toward a circular economy: slowing resource loops, closing resource loops, and narrowing resource loops. Firstly, slowing resource loops extends a product's lifecycle through maintenance and repair, thereby extending the product's utilization period. Secondly, closing resource loops, through, for example, recycling, closes the loop between post-use and production, resulting in a circular flow of using fewer resources per product. Thirdly, narrowing resource loops refers to using fewer resources per product.

The PJM provides designers with the tools to extend a product's lifecycle and map the expected behavior, slowing down the material loop and putting the product center stage. Mapping a products' lifecycle is a complex endeavor. Therefore, the PJM analyses not the product as a whole but its sub-assemblies. Companies can use the PJM to close the material loop by identifying sub-assemblies that are not yet recycled. Moreover, the PJM links the stages in the products lifecycle to the actions performed by stakeholders. This way, designers can analyze the effects of changes made on the stakeholder(s) side and vice versa. Lastly, It can serve as input for other methodologies such as the life cycle assessment. These methodologies require product life cycle scenarios as input for their calculations. However, designers cannot use these methodologies to generate these scenarios that form the basis for their calculations.

Photo: Tom Fisk

Framing

The Product Journey Map is a planned visual rendering of the product's expected life cycle and underlying structure. It extends the product's life cycle, slowing down the material loop, and identifies opportunities to further close the material loop. The Product Journey Map is data-driven, meaning it requires industrial designers to have the following information:

- ☐ The bill of materials
- ☐ Sub-assembly names
- ☐ Sub-assembly primary material
- ☐ Sub-assembly weights
- ☐ Failure rates
- ☐ Environmental information on materials

Due to the necessary information to use the Product Journey Map, it is advised to use it in the later stages of the development cycle. As identified by Gorenje, designers would apply the Product Journey Map during or just before creating the product's life cycle assessments (LCA). During this stage, it can assist in conceptualizing ideal circular scenarios for products, and, at later stages of design, it helps substantiate decision-making for detailing the design directions.

Goal

The Product Journey Map provides insight into the flow of a product and its sub-assemblies throughout multiple usecycles by mapping different scenarios and stakeholders' roles. It helps create a viable circular system to increase resource efficiency and decrease environmental impact, slowing down, closing, and narrowing the resource loop.


Photo: Pixabay

Procedure

In the following steps, describe the method procedure. Steps 1-9 concern generating input, and steps 10-13 visualize the input.

Step 1: Sub-assembly identification

This step identifies the sub-assemblies of the product. Sub-assemblies are part clusters that are easy to disassemble from a product, have limited connectors to the other components, and often support the same product function. The parts within these clusters tend to have a comparable life expectancy. The product architecture typically prescribes what the subassemblies of a product are. Note down the following information for the sub-assemblies in a table format (see figure 2):

- ☐ Name the sub-assemblies
- ☐ Determine the sub-assembly weights
- ☐ Specify the primary material(s) used

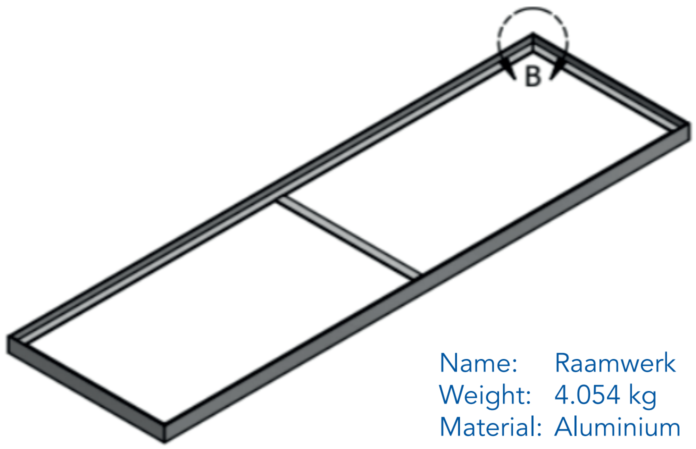


Figure 1: Example sub-assembly Castor Ventures.

Step 2: Creating the life cycle profile

This step creates the lifecycle profile of a product. A lifecycle profile describes how the product is used throughout its lifecycle. When creating the Product Journey Map, certain assumptions on the use of the product need to be made, as many potential use scenarios could occur. The lifecycle profile should follow the formula as described below:

[Product name] will undergo [number] use cycles of [number] years, resulting in a total lifecycle of [number] years if used under the following conditions: [insert conditions].

An example of life cycle profile for the Castor Ventures pushcart is as follows:

The Castor Ventures pushcart will have two use cycles of eight years, resulting in a total life cycle of 16 years if used under normal conditions. These normal conditions were outlined by Castor Ventures as follows: the product is used twelve hours a day, seven days a week, loaded to a maximum of hundred-fifty kg, and used at a temperature no lower than -30 degrees celsius.

Sub-assembly number	Sub-assembly name	Sub-assembly primary material	Sub-assembly weight	Key failure sub-assembly	High impact sub-assembly	Strategic discipline	Product obsolescence	End of life scenario use cycle 1	End of life scenario use cycle 2	End of life scenario use cycle 3
1										
2										
3										
4										
5										

Figure 2: Empty example of the PJM information table.

Sub-assembly number	Sub-assembly name	Sub-assembly primary material	Sub-assembly weight	Sub-assembly impact	Sub-assembly value
1	Sub-assembly A	Material A	X kg	100 CO2 kg/kg	€ 100
2	Sub-assembly B	Material B	Y kg	90 CO2 kg/kg	€ 90
3	Sub-assembly C	Material C	Z kg	80 CO2 kg/kg	€ 80
4	Sub-assembly D	Material D	C kg	70 CO2 kg/kg	€ 70
5	Sub-assembly E	Material E	V kg	60 CO2 kg/kg	€ 60

Figure 3: Highlighting the highest CO2 footprint, 80th percentile (yellow) and 90th percentile (red)

Step 3: Defining usecycle requirements

Define the state in which the products need to be at the beginning of each use cycle, e.g., new-state or used-state. Subsequently, define the requirements of the product at the beginning of each use cycle with regards to, for example, aesthetics and technology.

Step 4: Identify high-impact sub-assemblies

High impact sub-assemblies are sub-assemblies with a high CO_2 footprint. To identify high-impact sub-assemblies, the following calculations can be used. Please note that the calculation is an indication rather than an exact number:

Impact sub-assembly = embodied CO_2 material (CO_2/kg) * weight (kg)

If sub-assembly A has a material CO_2 footprint of 13.05 CO_2/kg, and has a weight of 4kg:

Impact sub-assembly = 52.9 CO_2/kg

Sub-assemblies are flagged when the sub-assembly has the highest CO_2 footprint value, where the 80th percentile colors yellow and the 90th percentile colors red. The high-impact sub-assemblies are visualized in the PJM with an icon (figure 3) (figure 4).

Step 5: Identify the key replacement sub-assemblies

Key replacement sub-assemblies are defined as sub-assemblies with a high-replacement frequency and can be inferred from field data. Sub-assemblies categorized as key failure sub-assemblies often include moving sub-assemblies and sub-assemblies that have to endure heavy loads. An icon that visualizes this category in the PJM can serve as an indicator or starting point in the active approach of this tobe PJM (figure 4)

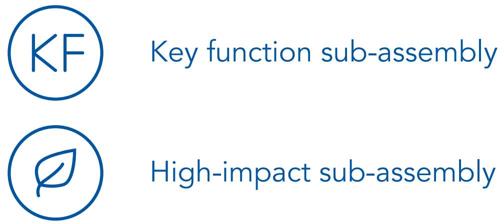


Figure 4: Icons sub-assembly categorizations

Step 6: Determine the obsolescence types

This step identifies the obsolescence type of the sub-assemblies. First, define the strategic discipline of the sub-assembly. When companies design sub-assemblies for operational excellence, they design them for longevity, meaning the sub-assembly will function for as long as possible. Hence sub-assemblies designed for operational excellence will most likely undergo functional obsolescence. If companies design sub-assemblies for customer intimacy, they are designed to satisfy the users' desire for newness or overcome a lack of attachment to the product. Hence sub-assemblies designed for customer intimacy will most likely undergo emotional obsolescence. Sub-assemblies designed for technological leadership are constantly at the state-of-the-art level. The introduction of new or upgraded versions of the sub-assembly is frequent. These new versions are solutions to the problems the former sub-assembly has previously solved. Therefore, sub-assemblies designed for technological leadership will most likely undergo technological obsolescence.

Step 7: Determine the End-of-Life scenario

Assign End-of-Life options to the sub-assemblies. The following rules of thumb can be followed: (1) Sub-assemblies that are prone to face technological obsolescence are candidates for upgrading operations at the end of predefined lifecycles; (2) Sub-assemblies that are prone to emotional obsolescence need to be replaced with aesthetically different ones or upgraded to give a completely new look; (3) Sub-assemblies prone to face functional obsolescence are candidates for reuse. (4) Functional obsolescence tends to happen later than technological and emotional obsolescence. If product sub-assemblies are replaced, specify their EoL scenario; will they undergo recycling, remanufacturing, or combustion (figure 6)?

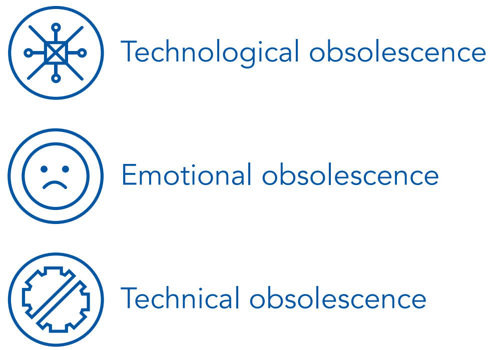


Figure 5: Icons for obsolescence types

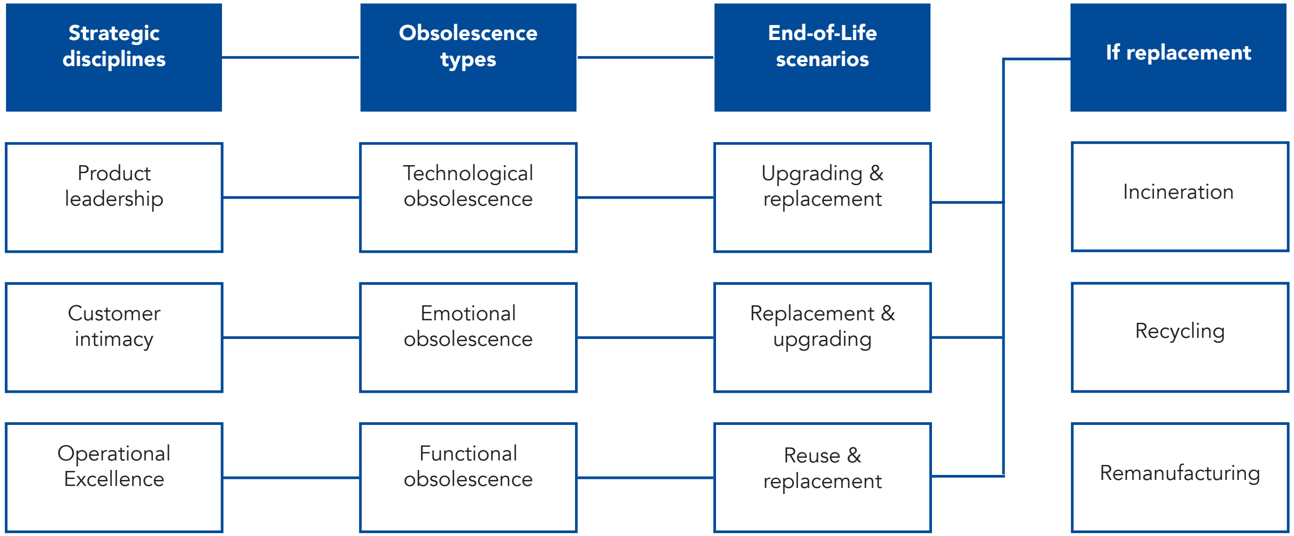


Figure 6: Overview of the synergy between strategic disciplines, obsolescence types, and end-of-life scenarios.

Step 8: End of life scenario checklist

The End-of-Life scenario checklist is an extra tool to help designers make the right decisions on end-of-life scenarios and check the feasibility. It has to be noted that this list is not exhaustive. Firstly, it is a requirement that the company has a program to retrieve the products or sub-assemblies from the market.

→ In case of direct reuse:

- ☐ Does your company provide instructions and protocols to the relevant departments or third parties to check the quality of the to-be reused sub-assembly?
- ☐ Does the sub-assembly have a longer than average category lifespan, and is the sub-assembly design optimized for longevity?

- ☐ Does the user experience noticeable degradation of the sub-assembly, and is it likely to significantly affect product acceptance?
- ☐ Does failure increase the lifecycle cost above the replacement to prevent it would cost?
- ☐ Is the disassembly and reassembly of the sub-assembly optimized for time, cost efficiency, simplicity, and tool availability?

⊕ In case of upgrading:

- ☐ Does your company provide instructions and protocols to the relevant departments or third parties for the upgrading of the sub-assembly?
- ☐ Does the sub-assembly allow for enhancing its functionality or cosmetic condition?
- ☐ Has new technology been introduced to the market that renders the sub-assembly and the product technologically obsolete?
- ☐ Will the user experience worsen if the sub-assembly is not upgraded?
- ☐ Is it likely to significantly affect product acceptance?
- ☐ Does your company have the means to facilitate the upgrading of the sub-assembly?
- ☐ Is the upgrading of the sub-assembly optimized for time, cost efficiency, simplicity, and tool availability?

⇄ In case of replacing:

- ☐ Does your company provide instructions and protocols to the relevant departments or third parties for the replacement of the sub-assembly?
- ☐ Does the replaced sub-assembly enhance the functionality or aesthetic condition of the product?
- ☐ Does your company produce spare sub-assemblies to facilitate the replacement?
- ☐ Is the sub-assembly standardized and fit for forward or reverse compatibility?
- ☐ Is the replacement of the sub-assembly optimized for time, cost efficiency, simplicity, and tool availability?

In case of recycling:

- ☐ Does your company provide instructions and protocols to the relevant departments or third parties for the recycling of the sub-assembly?
- ☐ Are general recycling processes available for the materials in the sub-assembly?
- ☐ Does your company have the infrastructure to facilitate the recycling process?
- ☐ Does the sub-assembly fall apart into separate homogeneous or compatible material fragments during the shredding process, like using resource-efficient joining techniques (e.g., clips, screws)?
- ☐ Which fraction of the material value, by cost price, can be recycled?
- ☐ Is the recycling of the sub-assembly optimized for time, cost efficiency, simplicity, and tool availability?

In case of remanufacturing:

- ☐ Does your company provide instructions and protocols to the relevant departments or third parties for the remanufacturing of the sub-assembly?
- ☐ Does your company list what sub-assemblies make the remanufacturing operations feasible and viable?
- ☐ Does the product's design allow for returning its state to as-new product specification by fully disassembling, testing, replacing, and cleaning components to result in a new product with a warranty?
- ☐ Which fraction of the material value, by cost price, can be remanufactured?
- ☐ Is the remanufacturing of the sub-assembly optimized for time, cost efficiency, simplicity, and tool availability?

In case of sub-assembly harvesting:

- ☐ Does your company provide instructions and protocols to the relevant departments or third parties for the harvesting of the sub-assembly?
- ☐ Does your company list which sub-

assemblies should be harvested?

- ☐ Is the harvesting of the sub-assemblies optimized for time, cost efficiency, simplicity, and tool availability?

Step 9: Determine use cycles

Determine how many usecycles each sub-assembly will last using the information generated in the previous steps. For example, sub-assemblies as key failure sub-assemblies or prone to emotional obsolescence will likely need replacement first. On the other hand, sub-assemblies prone to functional obsolescence will last more usecycles.

Step 10: Define the product life cycle stages

Using the information from the previous steps, create a horizontal timeline and define the product life cycle stages, e.g. production, transportation and recovery, indicating where in time these activities will take place.

Step 11: Creating swimlane visualization

Create a swimlane for each sub-assembly (figure 8). At the beginning of each swimlane, indicate the sub-assembly categories as determined in step 4. Place the icons for the EoL scenarios, shown in figure X, at the appropriate stages. If a sub-assembly is replaced, the timeline needs to kink downwards, indicating the placement of a new sub-assembly (figure 8).

Step 12: Indicating bottlenecks

The bottleneck indicator indicates potential pain points that have been identified during the creation of the PJM. A bottleneck in the use phase might be high failure rates. Additionally, in the transport phase bottlenecks include the transport being expensive, slow or even impractical due to product dimensions. Place the bottleneck icon at the appropriate stage in the sub-assemblies lifecycle. In the bottleneck lane, provide a short description of the bottleneck (figure 9).

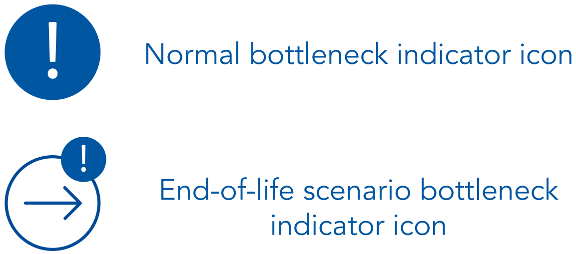


Figure 7: Overview of bottleneck indicator icons.

Step 13: Assigning stakeholder roles

For each stage, on the same vertical line, write down the actions required by the stakeholders in a verb-noun combination. Find the stakeholders needed to complete the actions. At the bottom of the PJM, create a swimlane for each identified stakeholder, order the activities appropriately and place the activities in the right order (figure 9).

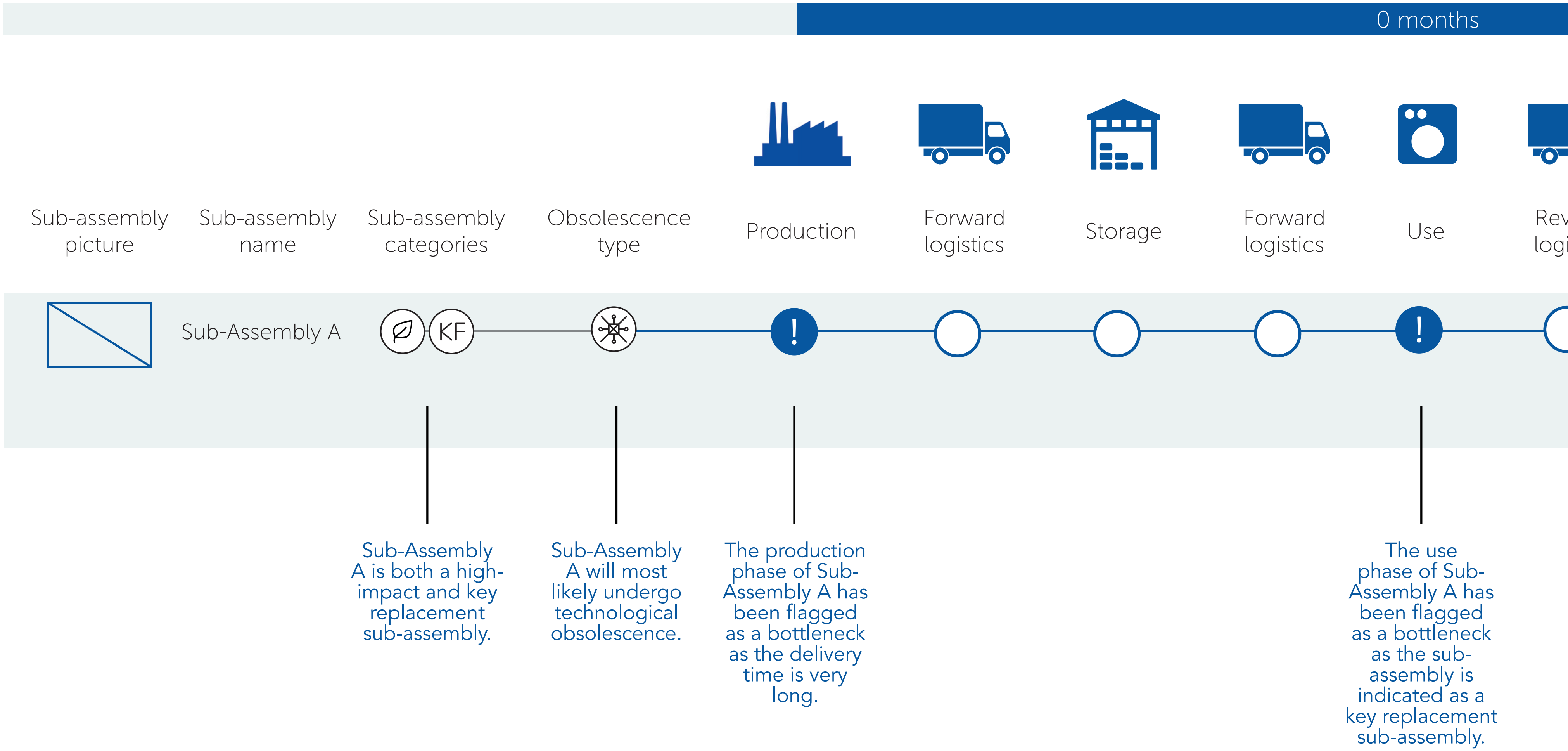
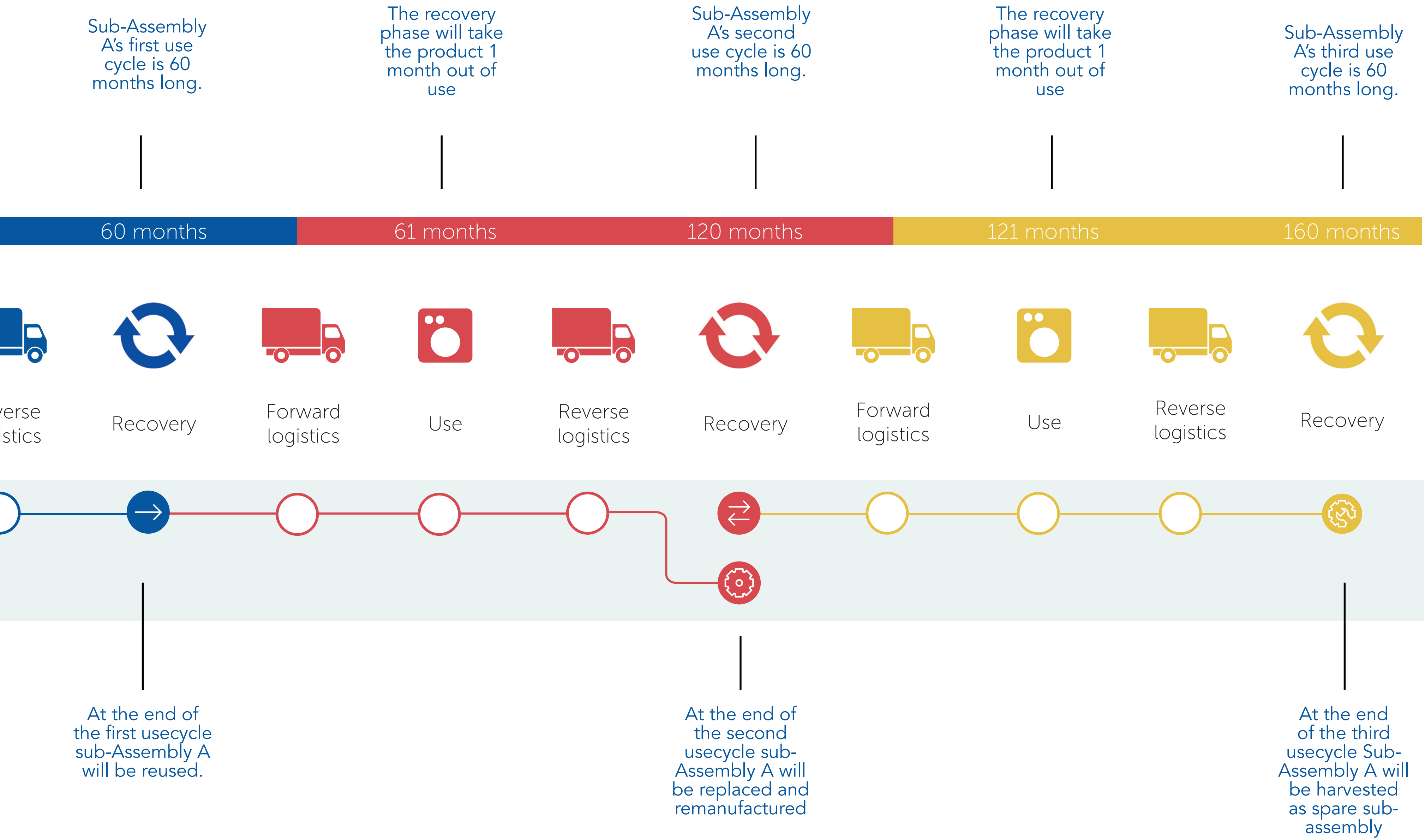


Figure 8: Deep analy



ysis of PJM swimlane

Interpretating

The visualization should be read as a timeline, as this is the best way to convey the story of the product journey. By reading each swim-lane as a timeline, users can identify what happens to the sub-assembly. The required stakeholder actions are paired vertically to each step. By actively changing the sub-assembly journey section of the PJM, users can see how this will impact the stakeholder's side of the PJM.

Every swimlane reads from left to right, providing the user with the following information: to which categories does the sub-assembly belong, what happens to the sub-assembly over time and what will be the end of life scenario or the form of obsolescence. With this information in mind, designers can decide which part of the journey they would like to change using the active approach. Furthermore, designers can directly project the changes to the sub-assembly on the organization structure that facilitates the product journey and vice versa.

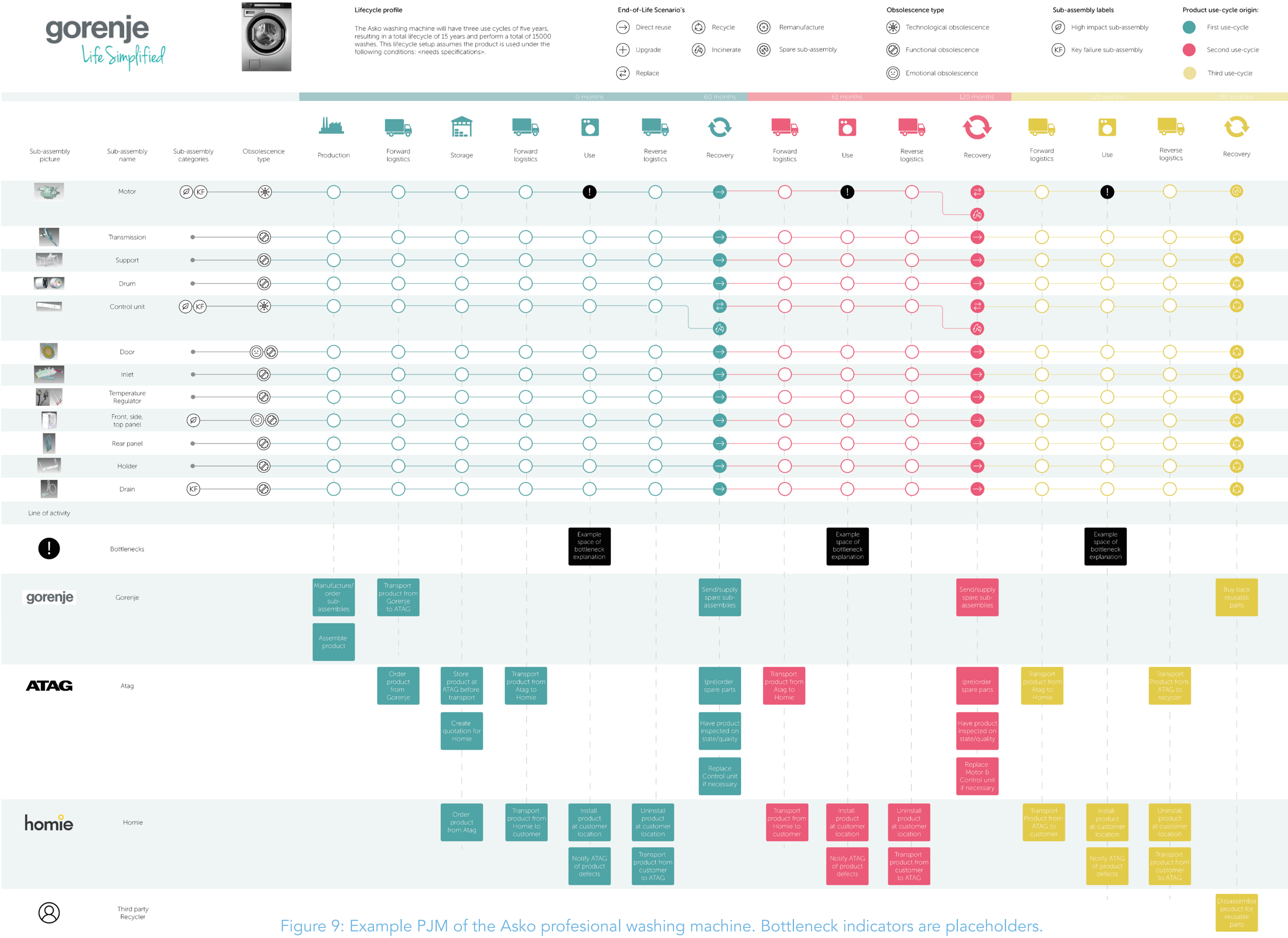


Figure 9: Example PJM of the Asko profesional washing machine. Bottleneck indicators are placeholders.

Mindset

Creating the PJM requires the users to take a long-term view, focusing on what happens over several use cycles. To utilize the PJM to its full potential, designers must have prerequisite knowledge of the following topics and concepts:

- ☐ The product to be mapped.
- ☐ The strategic disciplines.
- ☐ The product obsolescence types.
- ☐ Optional EoL scenarios.
- ☐ Information databases (Granta Edupack).
- ☐ Circular economy concepts like use cycles and life cycles.

During the prototyping sessions, the parties involved concluded that the following departments would most likely use the PJM: R&D department, program management department, repair department, and, if the company has one, the sustainability department.

Photo: Akil Mazumder

Conclusion

The earlier a company sets goals for circular design, the more influence it can have in planning ideal scenarios for its products and sub-assemblies. Current journey mapping methods are aimed at mapping material flows, customer experiences, or value streams. They do not (1) put a product center stage, (2) link required actions of stakeholders to the product and its design, and/ or (3) show opportunities to attune a product's behavior to be more circular, based on real data. The Product Journey Map allows companies to create an overview of the lifecycle flow of a product and its sub-assemblies. It specifies the actions sub-assemblies require throughout different use cycles stages and which stakeholders are required to optimally make the circular system work. The Product Journey Map is a novel design method with the potential of being valuable to design teams at companies, as identified by Gorenje and Castor Ventures. Additional testing will allow for the optimization of the procedure, data requirement, and method visual. Further testing of different products will also help adapt the method to the needs of a wide range of products.

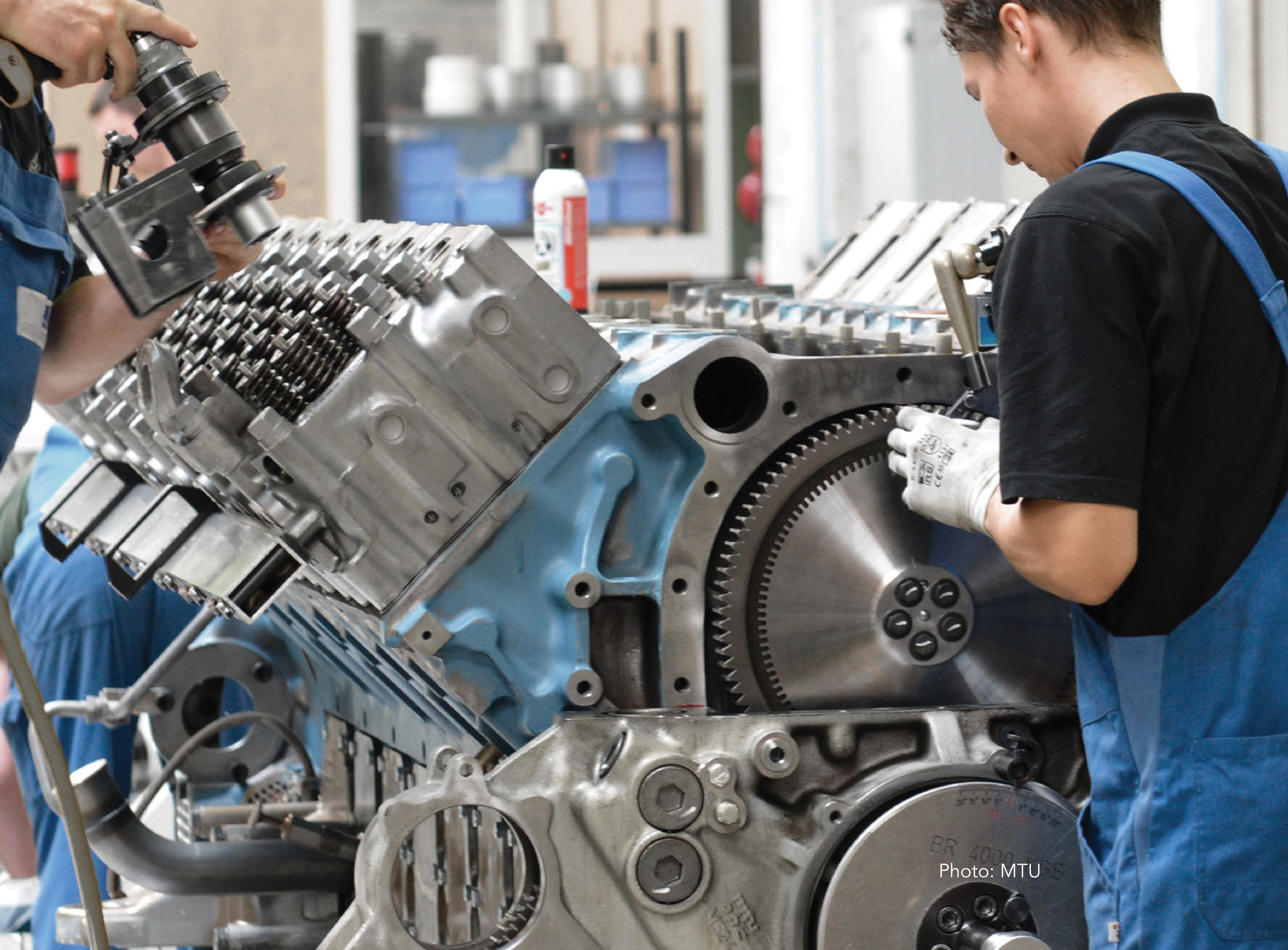


Photo: MTU