

Circularity in the Rail Sector – Focus: Rolling Stock



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Foreword by Jeannot Schroeder



Opportunities for a Circular Economy in the Train Industry

The transport sector, particularly trains and cars, presents significant potential for embedding circular economy principles into existing business models. While the train industry has long relied on repair and maintenance practices to extend the lifespan of equipment, the inherent value of the long-lasting, high-value assets involved creates an untapped opportunity for even more sustainable growth. By shifting from a shorter-term, product-focused approach to one that emphasizes long-term value generation, the industry can unlock significant benefits for both businesses and the environment. The next step forward is not limited to cost savings in manufacturing but extends to a **collaborative optimization with the entire supply chain**. A key focus should be **reducing the total cost of ownership** for rolling stock throughout its lifecycle. This requires new business models from solution providers, integrating digital data to enhance operational efficiency and accelerate the transition toward circular business models. The potential gains are substantial, and the journey toward a more sustainable, circular train industry is one we must embark on together.

We believe there is considerable room for improvement. Currently, around 36 million tons of finished goods circulate within the industry. Extending the operational lifespan of this stock by five years would result in a savings of 5 to 10 million tons of finished products, in the EU market alone. This demonstrates not only the economic potential but also the environmental importance of embracing circular practices.



Jeannot Schroeder, Founder
+ImpaKT

Remember, by moving towards a circular economy, economic and ecological goals are no longer in opposition, but aligned for mutual benefit. The potential gains are substantial, and the journey toward a more sustainable, circular train industry is one we must embark on together.

-Jeannot Schroeder, +ImpaKT

About H&Z

Management Consulting

Transformation with head, heart and hand. This is how the Munich-based management consultancy H&Z understands its mission. Initially, our focus was on purchasing & supply chain, but today our offerings also include technology & innovation, sales & service as well as strategy & business optimization.

500 consulting employees work within the H&Z Group; in the worldwide Transformation Network, as many as 700 consultants are available to our clients. They combine digital competence with process expertise and a proper dose of transformation. At H&Z, consulting is focused on medium-sized companies, but our clients also include 25 of the 30 DAX companies.

In thousands of projects across all industries, H&Z has trained and expanded its expertise in the management of change processes: that's why H&Z has been awarded several times as Hidden Champion.

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About Railsponsible

A H&Z Management Consulting initiative

Railsponsible is the industry initiative that drives sustainability in the railway sector. It aims to improve sustainability practices of companies in the railway sector and railway sector value chain. The initiative is open to all railway operators and companies across the railway industry value chain, along with key industry associations, that share its vision, mission and commitments.



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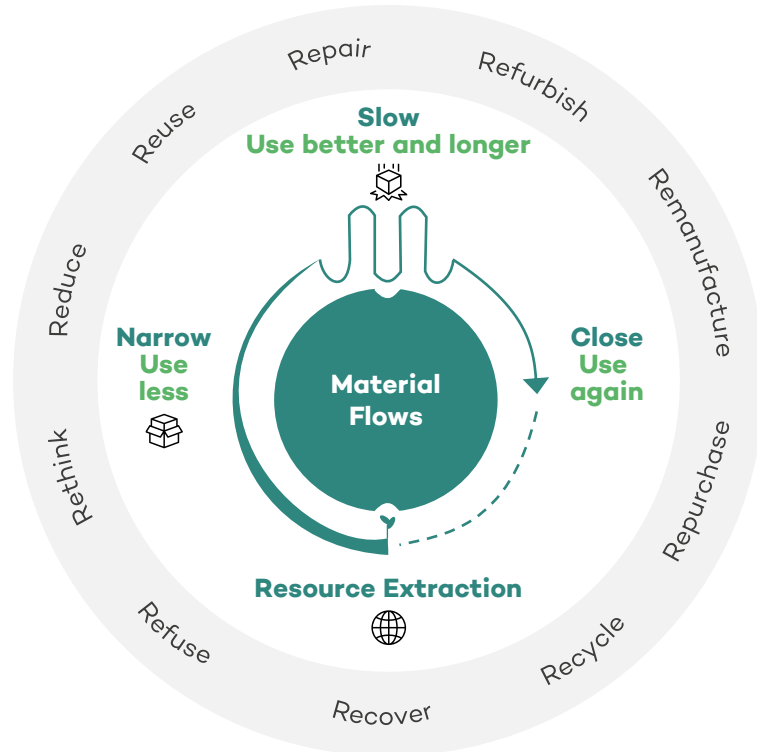
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Definition Circularity & business implications



Circular economy is an economic model aimed at eliminating waste and promoting the continual use of resources. Unlike the traditional linear economy of "take, make, dispose," the circular economy focuses on designing products for longevity, reuse, and recyclability. Its goals include reducing environmental impact, conserving natural resources, minimizing waste, and creating sustainable growth by keeping materials in use for as long as possible through strategies like recycling, remanufacturing, and sustainable product design. This approach promotes economic resilience, innovation, and a transition to more sustainable consumption patterns.

We recommend three steps to achieve circularity, narrow, slow and close. In our first Whitepaper "Secondary Material Sourcing" we examine the concept in detail.

The current paper focuses on implementing these steps in the rail sector. More specifically we will give some insights on how embracing the principles of circularity can benefit operators financially through business model innovation.

Rolling stock is the lifeblood of the rail industry, with an estimated 36 million tonnes of finished goods currently in circulation in Europe alone. On average, procurement and leasing of rolling stock can account for 20-30% of an Operator's capital budget annually. Once maintenance and service costs are included, which could range from 10-15% of total yearly expenses, we are talking about a substantial portion of annual operating budgets.

Market Snapshot			
Rolling Stock type	Units EU	Unit weight (t)	Total weight (Mt)
Locomotives	24.800	150-250	5+
Light rail transit	20.800	17-50	1
Motorized passenger trains	34.100	100-800	15+
Unmotorized passenger cars	53.900	15-17	0,8
Freight cars	557.000	25-30	15+

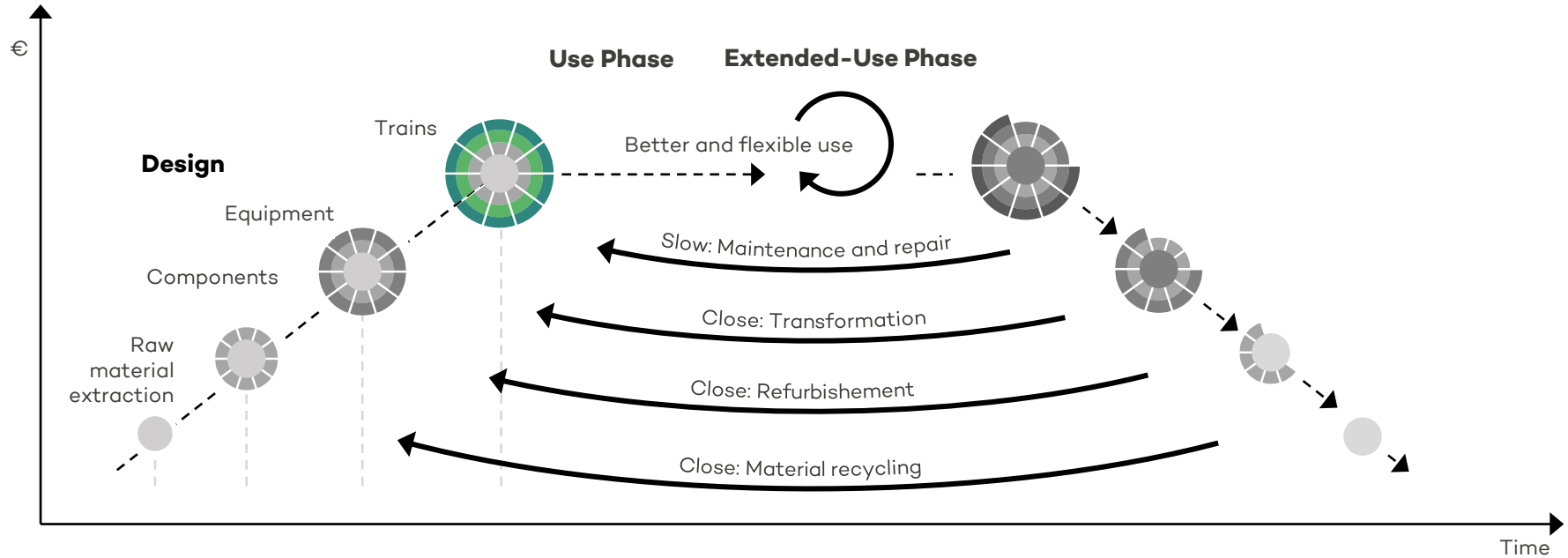
Rolling stock is inherently complex but in its complexity lies substantial opportunity

1. Design Complexity and lack of standardization is a critical factor in managing railway fleets. Each usage segment (passenger, freight) includes numerous models from different manufacturers with versions customized for specific markets and energy sources (electric, battery etc.). This creates significant complexity in standardization, as even within the same model family, modules are not fully interchangeable. Estimates suggest that operational costs, heavily influenced by rolling stock condition, could be reduced by **20-30%** with more efficient designs that look circular principles into account.

2. Longevity: Rolling stock is designed to last 30-35 years and requires significant maintenance investment. By some calculations, around 50-60% of a train's total ownership cost comes from maintenance and overhauls. Increasing modularity and ease of repair could reduce these costs, extend asset life, and cut down on waste.

3. Use Any inefficiency in use, when the rolling stock is not rolling, requires additional stock to manage the load (passenger or freight). The need for additional equipment is reduced by improving logistics and increasing run time.

Think in value

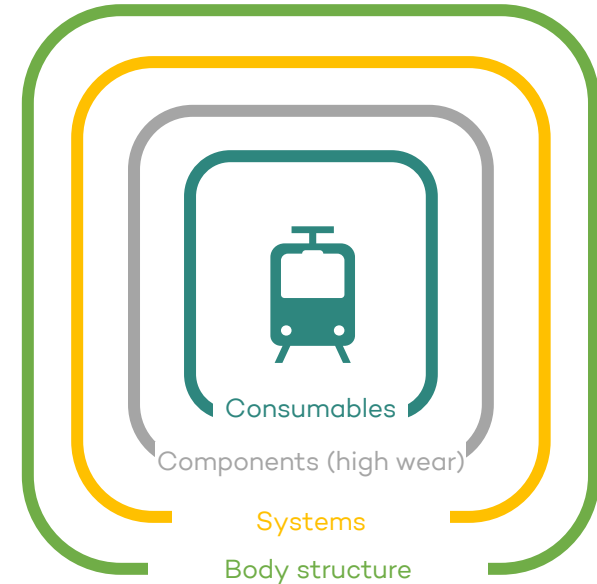


The **value hill** illustrates the business opportunities of circularity by **retaining value at its highest possible level** on the hill for as long as possible. When applying it to rolling stock we can say that we want to keep the rolling stock rolling.

Think in layers

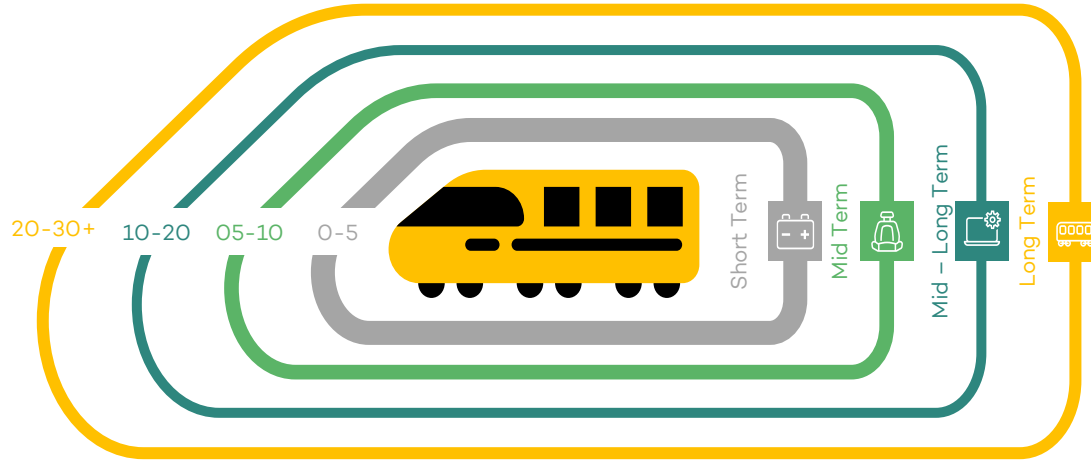
As Steward Brand explained in its book “How Buildings Learn”, a long-lasting product, like a train, consists of different layers of products, all having significantly different life spans. For example, lubrication oils will be replaced regularly during regular intervals, while the wheels, will last several years. Design for disassembly and modularity are key business strategies to guarantee efficient maintenance, repair and upgrading. Indeed, research by the Ellen MacArthur Foundation shows that modular design can reduce production costs by up to **30%**. In rolling stock being able to change car modules could allow an easy switch between e.g. passenger and freight transport according to demand, maximizing efficiency.

Modularity can also reduce waste and extend the life span of the train, keeping it in the highest point of the value hill – at its maximum value generating capacity for the longest time possible. Design for disassembly can prevent the composite parts of the train from falling down the value hill as the product is disassembled.



Focus on layers

Estimated Primary use time (in years)



Short Term	Mid Term	Mid-Long Term	Long Term
Lights, Filters, Sanitation, fluids	Components and parts with significant wear	HVAC, Electronics, Displays	Body Structure

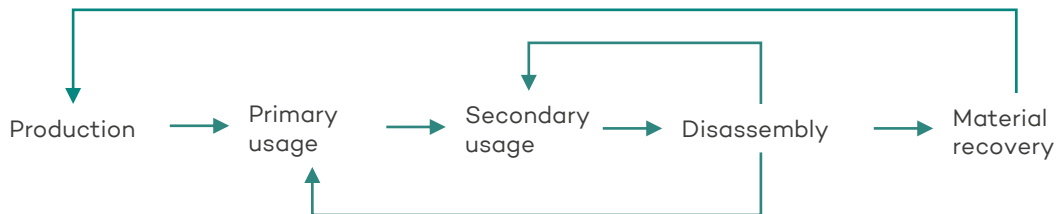
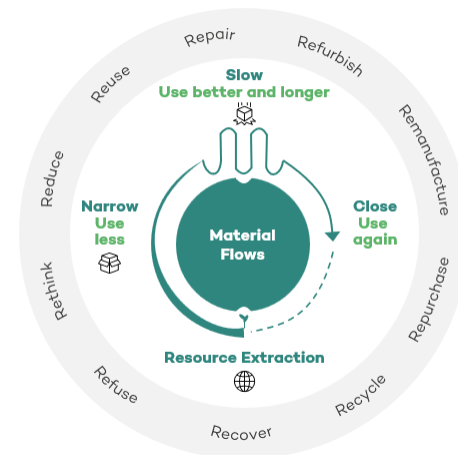
Thinking in layers allows us to see rolling stock and its complexity in a different light. Whilst there are huge variations in estimated primary use time, we have a tool to understand and manage the complexity of rolling stock and a way in to consider circular economy principles for different use times and to think better use.

Think in use



In the circular economy, thinking in terms of usage is crucial because it prioritizes keeping and reusing products and components over merely recovering materials at the end. Designing with multiple use phases in mind - where products are built to be maintained, reused, repurposed, or refurbished - keeping them at the highest possible point of the value hill for the longest time, maximizes the value extracted from each item while minimizing waste. This

approach is significantly more efficient than recycling alone, which often involves energy-intensive processes and potential material degradation. According to a study by the Ellen MacArthur Foundation, extending the life of products through reuse can save up to **80% of the energy** typically required for manufacturing new goods. By designing for multiple lifecycles, e.g., Secondary usage, businesses can reduce environmental impact, and lower operational costs.



Primary usage: main function of the product

Secondary usage: function a product can fulfil after it has served the primary function

Rolling stock lifecycle costs depend on a multitude of factors. Over its lifetime maintenance cost can match the initial buying costs. If power is included, the operating costs far outweigh the initial buying costs.

Extending the use phase of rolling stock during its operational life is a vital strategy within the circular economy, focusing on maximizing the asset's value and minimizing waste. Predictive maintenance plays a key role here; by utilizing data analytics and advanced sensors, operators can monitor the condition of train components in real-time and address issues before they cause major failures. Estimates suggest this

approach can reduce maintenance costs by up to 30% and decrease unplanned downtime by 50%. Additionally, efficient usage practices, such as optimizing train schedules and load management, can prolong the lifespan of critical components by reducing wear and tear. Such strategies could extend the operational life of rolling stock by 10-15 years, significantly cutting down on the need for new manufacturing and resource extraction, thus aligning with the principles of the circular economy by conserving resources and reducing emissions.

Predictive Maintenance

Reduce unplanned downtime and wear and tear

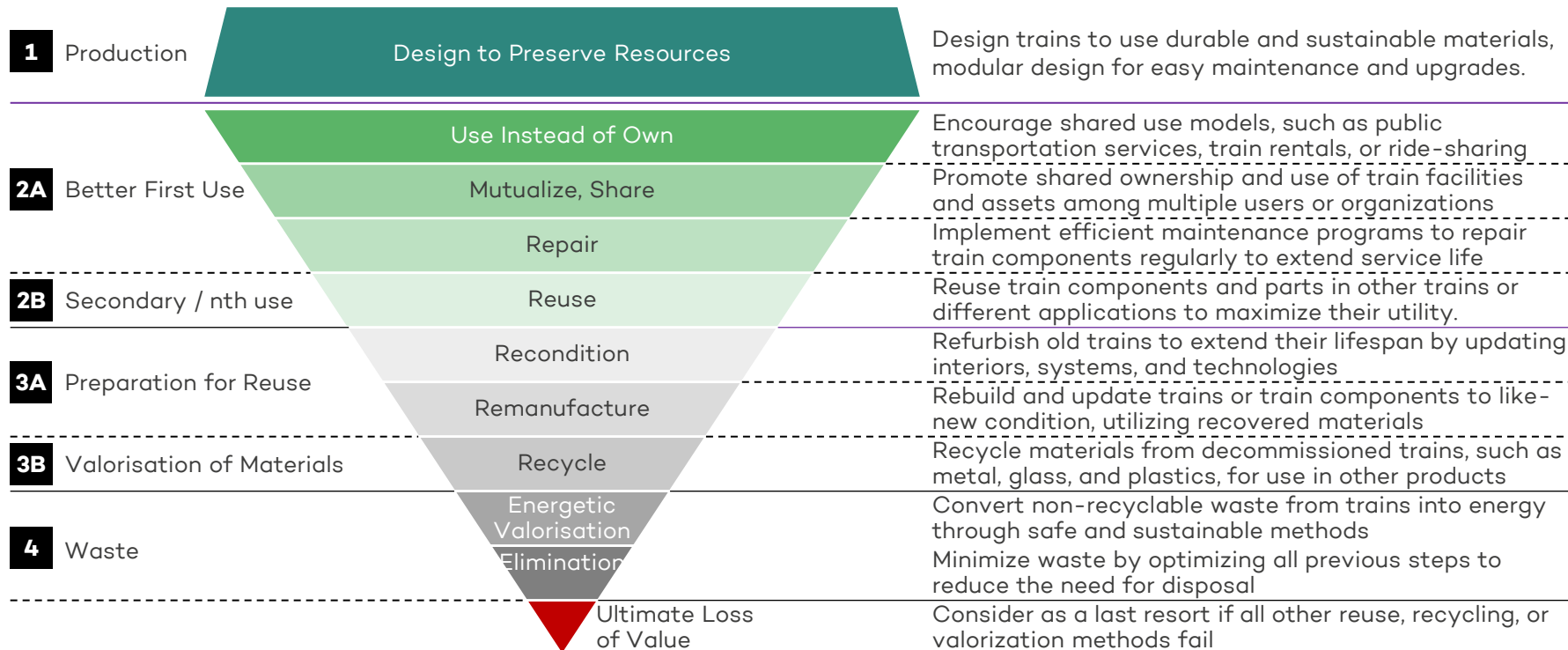
Upgrades

Upgrade components regularly to minimize the need for switching the entire train

Share

Incorporate shared use models to use the existing fleet efficiently and reduce the overall need for stock

Think in design



Focus on design



Design for disassembly

A fundamental strategy for the economic success as it facilitates repair and maintenance, refurbishment, recycling and obsolescence.

Design for easy maintenance

Streamline the number of spare parts, design for easy access and rapid replacement.

Design for interconnectivity

Make sure the components can interconnect with other products and can be swapped out easily.

Fulfill secondary usage requirements

Adapting products for secondary usage in the production saves energy and resources down the line.

Design for refurbishment

Design the product for replacement of worn parts and for upgrading over time

Input Materials

Limit the raw material input by increasing the number of refurbished parts or increasing the recycle content.

Remember, the success of your circular business model starts with the product design

Railponsible Supplier Award 2024: Innovation in Circular Economy

- Railponsible's Annual Supplier Award highlights **best practices in sustainability** throughout the supply-chain
- This year's focus highlighted **Innovation in Circular Economy**
- Out of the many applications, **three entries stood out** for the innovation, scalability and circularity and have been included as our case studies for this paper
- This paper will serve as the foundation of **Railponsible's new working group on Circular Economy in Rail** – if you are interested in learning more, please get in touch with us

Case study 1



Winner Railponsible Supplier Award 2024

Lucchini RS is streamlining the return of scrap/end-of-life products to its plant in Italy to give them a second life. The project introduces a new role dedicated to coordinating the return of end-of-life railway components, improving circularity and reducing CO2 emissions. The initiative focuses on using high-quality recycled steel to minimize the need for virgin materials and lower the carbon footprint.



Case study 2



Runner-up Railponsible Supplier Award 2024

Prysmian has validated the use of recycled polyethylene (LDPE) for signaling cable sheaths, making it the first cable supplier to do so. The inner sheath is made from 100% recycled PE, and the outer sheath from a 50% recycled mix. This innovation reuses plastic waste from households and industry, reducing landfill and energy consumption while promoting a circular economy.



Case study 3



Applicant Railponsible Supplier Award 2024

Schijvens Corporate Fashion, a family business since 1863, focuses on sustainability by producing circular corporate fashion. They use 50% recycled textiles and 50% recycled polyester, eliminating the need for new raw materials. Their innovative process includes collecting and recycling old corporate clothing to create new fabrics. This initiative has significantly reduced water usage, CO2 emissions, and energy consumption. Schijvens aims to produce fully sustainable collections by 2028 and currently, 78% of their collections are made from sustainable materials.



Future outlook and action plan



- In the circular world business models and the roles of companies within a supply chain change
- Supply chains will become Supply networks. Implementing secondary use phases will turn buyers into sellers down the road
- Models liked renting components will thrive, deepening the relationship between suppliers, manufacturers and operators

We suggest the following action plan:

- 1** Know what you have. Implement detailed product passes and plan for a better use and later reuse of the resources
- 2** Deepen relationships with your suppliers and industry peers, in order to implement more profitable long term circular business strategies
- 3** Build trust in your partners and exchange circular product information in a standardised format



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