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D1.5 – VALUE CHAIN MAP IN A CIRCULAR ECONOMY PERSPECTIVE

WP 1: *DEVELOPMENT OF A JOINT CLUSTER PARTNERSHIP STRATEGY*

TASK 1.2.4: *DEFINITION OF ACTION PLANS FOR THE INVOLVED SMEs AND ANALYSIS OF THE VALUE CHAIN IN THE CIRCULAR ECONOMY PERSPECTIVE*

DELIVERABLE 1.5: *VALUE CHAIN MAP*

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DEM	Demonstrator, pilot, prototype	
DEC	Websites, patent fillings	
OTHER	Other	

DISSEMINATION LEVEL

Codes	Description	Check as appropriate
PU	Public	X
PP	Restricted to other programme participants (incl. Commission Services)	
RE	Restricted to a group specified by the consortium (incl. Commission Services)	
CO	Confidential, only for members of the consortium (incl. Commission Services)	

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Glossary

Abbreviation / acronym	Description
OEMs	Original Equipment Manufacturers
CE AP	Circular Economy Action Plan
ATAG	Air Transport Action Group
PMA	Pugh matrix analysis
CE	Circular Economy
SC5	Societal Challenge 5

Abstract

This public deliverable aims at the assessment of the Aviation sector value chain in the perspective of Circular Economy principles. The assessment of the value chain was realised according to the Circular Economy perspective (Redesign, Reduce, Reuse, and Recycle).

This report is advised to the EACP-EUROSME project involved companies as instrument for the beginning of the implementation process towards a Circular Economy business and the research for further financial support for projects funding.

1. INTRODUCTION

1.1 Purpose of this document

The deliverable D1.5 “Value Chain Map” addresses the development evolution of the Circular Economy in the EU and the main challenges European industries have to tackle in order to shift to a more sustainable business activity.

The document starts with a brief introduction to the Circular Economy in the EU context and the most recent adopted measures. Further, the report analyses the state of the art of the Aviation sector value chain and reports the recent approaches adopted by the main OEMs in the industry.

The deliverable also try to provide a proposal for the reconversion towards a more oriented circular economy business model in the Aviation sector.

Finally, the report provides highlights on the innovation and financial measures for sustaining Circular Economy projects.

1.2 Structure of the document

The document is structured in the following way:

- Chapter 2: Circular Economy in EU context;
- Chapter 3: Aviation sector value chain: state of the art;
- Chapter 4: The process towards a Circular Economy Value Chain Map in Aviation Sector;
  - ✓ Chapter 4.1: A proposal for the reconversion towards a more oriented circular economy business model;
- Chapter 5: Innovation and financing measures;
- Chapter 6: Conclusions.

2. Circular Economy in EU context

"The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages for Europe." ("Closing the loop – An EU action plan for the circular economy")

In 2015, the European Commission adopted an ambitious **Circular Economy Action Plan** (CE AP), which includes measures that will help stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs. The CE AP embraces the strategic approaches on ecodesign, on plastics and chemicals, a major initiative to fund innovative projects under the umbrella of the EU's Horizon 2020 research programme, and targeted action in areas such as plastics, food waste, construction, critical raw materials, industrial and mining waste, consumption and public procurement.

The CE AP covers the whole cycle: from production and consumption to waste management and the market for secondary raw materials and a revised legislative proposal on waste.

The actions envisaged in the CE AP will contribute to **"closing the loop"** of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy.

This action plan will be instrumental in reaching the Sustainable Development Goals (SDGs) by 2030, in particular Goal 12 of ensuring sustainable consumption and production patterns.

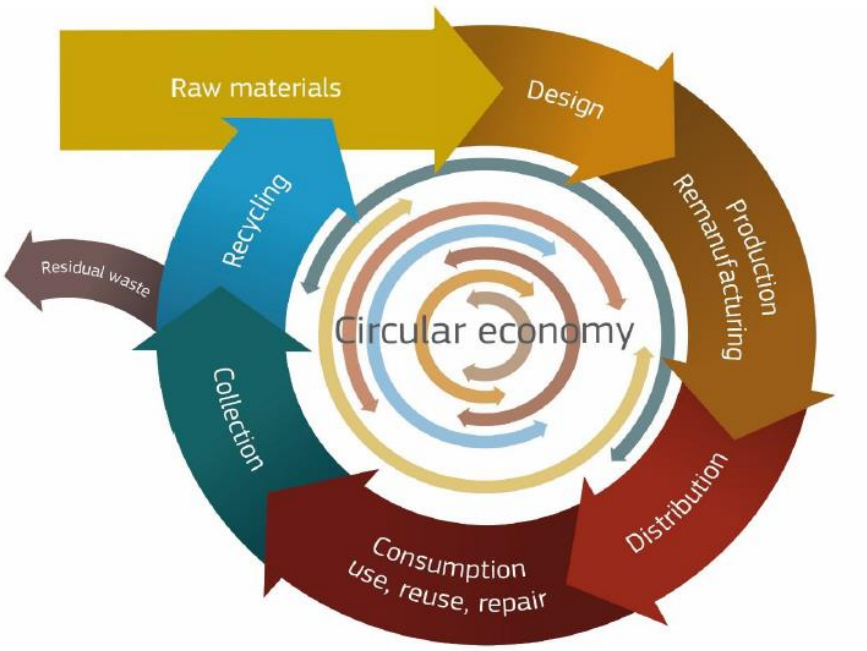


Figure 1: Conceptual design illustrating the Circular Economy in a simplified way

The **legislative framework on waste** has entered into force in July 2018. The aims of the framework regard targets for waste reduction and the establishment of an ambitious long-term path for waste management and recycling.

Among the main targets, the waste proposal include:

- A common EU target for recycling 65% of municipal waste by 2035;
- A common EU target for recycling 70% of packaging waste by 2030;
- Recycling targets for specific packaging materials:
  - ✓ Paper and cardboard: 85%
  - ✓ Ferrous metals: 80%
  - ✓ Aluminium: 60%
  - ✓ Glass: 75%
  - ✓ Plastic: 55%

- ✓ Wood: 30%

- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2035;
- Separate collection obligations are strengthened and extended to hazardous household waste (by end 2022), bio-waste (by end 2023), textiles (by end 2025);
- Minimum requirements are established for extended producer responsibility schemes to improve their governance and cost efficiency;
- Prevention objectives are significantly reinforced, in particular, requiring Member States to take specific measures to tackle food waste and marine litter as a contribution to achieve EU commitments to the UN SDGs.

In January 2018 the European Commission adopted the **latest set of measures**, including:

- The **"EU Strategy for Plastics in the Circular Economy"** to transform the way plastics and plastics products are designed, produced, used and recycled. By 2030, all plastics packaging should be recyclable. The EU foresees different actions to achieve this goal;
- A **"Communication on options to address the interface between chemical, product and waste legislation"** that assesses how the rules on waste, products and chemicals relate to each other;
- A **"Monitoring Framework on progress towards a circular economy"** at EU and national level;
- A **"Report on Critical Raw Materials and the circular economy"** that highlights the potential to make the use of the 27 critical materials in our economy more circular;

In 2018, the European Commission adopted other ambitious initiatives in the context of the Circular Economy Action Plan:

- A proposal for a **"Directive on the reduction of the impact of certain plastic products on the environment"** - implementation of the EU Strategy for Plastics in the Circular Economy;
- A proposal for a **"Regulation setting minimum requirement to boost the efficient, safe and cost-effective reuse of water for irrigation"**;

Circular Economy Stakeholder Platform

The EC has implemented a Circular Economy Stakeholder Platform.

The European Circular Economy Stakeholder Platform is a virtual open space which aims at promoting Europe's transition to a circular economy by facilitating policy dialogue among stakeholders and by disseminating activities, information, and good practices on the circular economy.

http://circulareconomy.europa.eu/platform/

Stakeholders can take part in the Platform by participating in the annual conference and by interacting on the website to look for good practices, to engage with other stakeholders and to share their own good practices and events.

3. Aviation sector value chain: state of the art

Aviation is a sector in which European public and private stakeholders provide world leadership, generating wealth and economic growth, contributing significantly to the balance of trade and European competitiveness, providing highly skilled jobs and innovation, fostering Europe's knowledge economy through substantial R&D investments and contributing in many ways to global safety, security and self-reliance.

In 2016, the Air Transport Action Group (ATAG) pointed out that nearly 63 million jobs are supported worldwide in aviation and related tourism. Of this, 9.9 million people work directly in the aviation industry. Moreover, it evaluated that if aviation were a country, it would rank 21st in the world in terms of gross domestic product (GDP), generating $664 billion of GDP per year, considerably larger than some members of the G20. Furthermore, as reported by the High-Level group on Aviation Research in its "Flightpath 2050 Europe's Vision for Aviation" in 2011, over the past 40 years, the European aeronautic industry has successfully raised from a niche sector to a world-leading industry. This achievement has been possible through collective European efforts encompassing public and private, major companies, thousands of SMEs, academia and research laboratories.

Furthermore, Aviation is at the hearth of the EUROPE 2020 strategy and is a vital facilitator of European integration and cohesion by providing essential transport links. In addition, the forecasts about the future of the sector are more than favourable.

The High-Level group on Aviation Research expects that the European industry will be strongly competitive having a share of more than 40% of its global market. The Airbus 2017 Global Market Forecast "Growing Horizons 2017-2036" foresees a demand for 34,900 new aircraft by 2036 with an increase of 3.3% of the total air traffic only in Europe. The Boeing "Current market outlook 2017-2036" foresees an average of 7,530 new aeroplanes that will be delivered Europe by 2036 with an increase of 1.7% of the GDP and of 3.7% of the air traffic.

In this fast-changing context, the aircraft manufacturers (OEMs) will need to increase supply speed to accomplish the customers' desiderata. The supply chain management has become a key factor for major manufacturers from aviation industry.

The progresses performed in aviation industry in the recent years, have increased the risk level. Supply chains became vulnerable to the disruptions that occurred during the production process. Within the development programs of the new generations of aircrafts, the producers had as a main objective to reduce the time of the products release on the market and to share the higher costs for development with suppliers. These new programs involve the development of complex technology projects to increase aircraft operating efficiency by 15 to 20%.

The introduction of innovations (composite, low fuel consumption engines, avionics, electrical systems, etc.) and in some cases transformation of the former factories into independent companies have further amplified the complexity of the production chain. Despite the positive effects, this new approach has generated more problems in the production process. Among the main challenges of the OEMs can be represented the following:

- Difficulties in the manufacturing processes;
- Difficulties due to the need of risk-sharing suppliers;
- The limited experience to manage the complex programs;
- The existence of a fairly long period between the planning and actual availability of the new capacities;
- Fast and effective training deficit to expand workforce;
- Issues related to production quality and reliability of some of the materials available.

Globally, the airline industry value chain comprise all phases directly or indirectly involved in meeting customer requirements. This network of production usually involves many actors with different functions.

There are also several categories of suppliers participating in the development of aircraft, classified in many levels:

- The **Original Equipment Manufacturers (OEMs)** - these are the companies that assemble large aircraft components and provide final products to customers. Their work involves: design, development and manufacturing or complete assembling of the aircraft as well as their testing (transport planes, fighter jets, helicopters, etc.). The main OEMs on the aviation industry global market are: Airbus - Europe and Boeing - USA, followed by Bombardier - Canada, Embraer - Brazil and United Aircraft Corporation of Russia;
- **First-tier suppliers** - they are the direct OEM suppliers. First-tier suppliers manufacture / assemble major sections, aircraft systems (including engines, avionics, aircraft interior, landing gear, etc.). First-tier suppliers are companies like Leonardo in Italy, Dasa in Germany and Casa in Spain. Prime contractors are also the engine manufacturers such as Rolls Royce, Pratt & Whitney and General Electric;
- **Second level suppliers** - usually are the key suppliers of the tier I (first-tier suppliers). These are commonly small and medium-sized companies. Second-tier supplier delivers complex manufacturing products obtained from his own production or a variety of other external providers. E.g. Sonaca Montreal, Areola;
- **Third level suppliers** - perform special components and specific processes, e.g. raw materials, electronic components, etc.

Besides these major players from the industry who are directly involved in the production process, research institutions, universities and government institutions have also an important role.

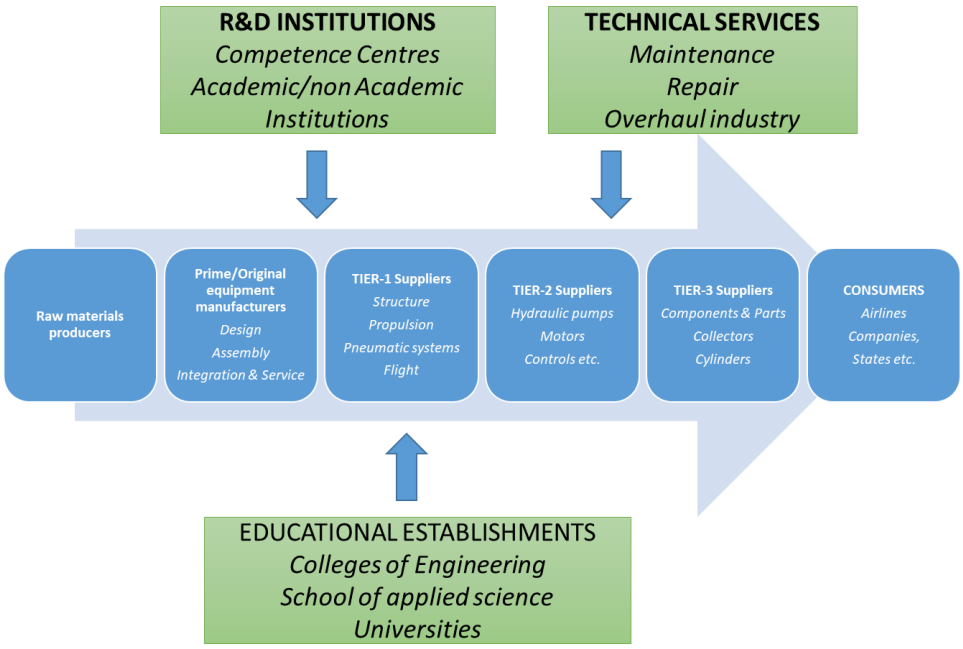


Figure 2: The Aerospace Supply Chain (*Source: ICM Industrial. IRM Aerospace Technology & IP Databank*)

To develop aircraft programs increasingly more complex and with deadlines which become more stringent regarding the manufacture of the components and systems, the manufacturers have introduced new strategies in the aircraft programs supply chain. These strategies resulted in a higher level of outsourcing the activities entrusted to the first level and second level suppliers, which in turn have to deal with challenges in terms of performance, reliability and financial risks. Thus in the context of market globalization, the new strategies adopted by the main OEMs aim principally to reduce the number of suppliers by selecting only some intermediary companies which offer integrated solutions and can manage with the other subcontractors.

The aerospace industry has refocused in the recent years towards a new supply chain structure which is based on an extensive process outsourcing. OEMs have established a new form of partnership which involves more complex work packages compared to the previous programs but are designed to reduce costs and delivery time component (Responsibility made by Airbus Group, 2013). The new supply chain is based on a number of levels. The OEMs select their suppliers according to their strategies and the fulfilment of the required standards set in the aviation industry. These strategic partners are primarily intended to assemble the different

parts and subsystems produced by second-tier suppliers. At the same time, the new work packages are considering sharing risks with suppliers. The suppliers become responsible for the entire scope of the work packages, including their supply chains. To facilitate the working way under the new programs, the selected suppliers are involved earlier, compared to the previous programs to participate in the definition and development of systems and components for the new aircraft and to agree on a set of details for the package work. This reduced a significant part of the cost of production and their delivery time. The figure below shows as an example the case of Airbus with specific reference to the A350XWB Program.

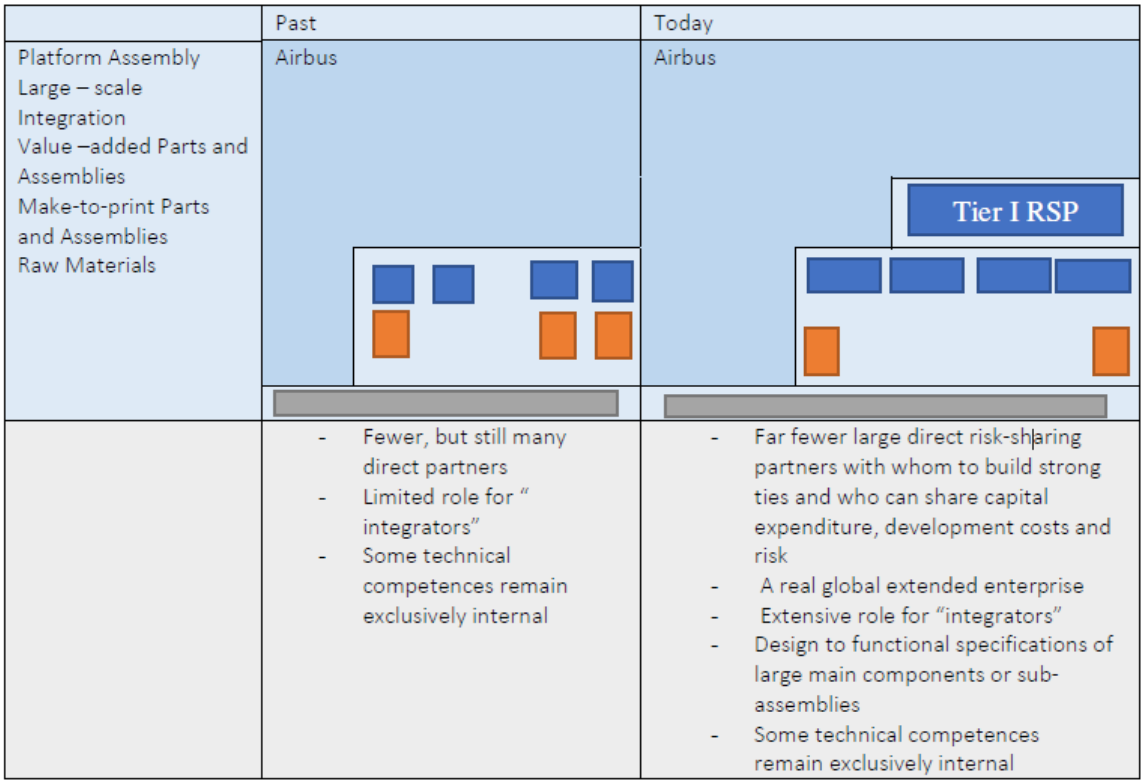


Figure 3: Airbus sourcing principles enhanced responsibilities A350XWB Program
(Source: 2014 Corporate Responsibility & Sustainability Report)

Thus, among the key supply chain management solutions adopted by Airbus are the following:

- Optimizing work modality with suppliers during the new program development;
- More comprehensive and integrated work packages;
- Involving the suppliers more earlier in the process of development aircraft program;

- Closer collaboration with suppliers, sharing key processes and IT instruments, such as Digital Mock up;
- Selected suppliers fulfil qualities such as: expertise in aerospace, defence and security; ability to get involved in the program during the development stage; the critical size and ability to complete the proposed work package;
- Creation of a risk profile for each supplier and elaboration of an action plan to each partner, to support the measures of increase capacity and improve their performance;
- Alignment the priorities between the OEM and suppliers to strengthen the management of the program;
- Watchtower – implementing a monitoring system for the operational financial performance statements and main suppliers, and those who are subject to financial risks;
- Performing audits and evaluations of the suppliers to ensure that they fulfil supply the OEM's specific requirements;
- Procurement academy – introduction of trainings for suppliers that cover a range of supply chain solutions needs.

The lessons learnt during the Airbus aircraft program can represent the state-of-art of the modern value chain of the Aviation sector and the starting point to move forward towards a more sustainable industry and to improve the supply chain performance of the future aircraft programs.

4. The process towards a Circular Economy Value Chain in Aviation Sector

A new aircraft has an estimated design life of 20 to 30 years, after which is historically either store or demolished and recycled [1]. Storing the aircraft is rather expensive. However, the actual service-life is declining with planes as young as 15 years or less are being scrapped [11] [14]. In the past, ageing planes were defined by calendar years and operating hours. Nowadays, exists sophisticated models to analyze the relative value of an aircraft to determine service life. Estimations state that between 8,500-12,500 planes will be at the end-of-service life within the next 20 years. [3] [5] [6] [10] [11] [14]

Among the main challenges facing the aircraft industry there are the lack of relevant directives, size of treated materials from end-of-life products, complexity in fleet recycling process, multi-level relationships among partners and players.

The aerospace sector produces a variety of different types of waste that can be significantly decreased thanks to the adaptation of the Circular Economy's strategies.

The above mentioned concerns are nowadays becoming more important, however, they still have to be sufficiently addressed. As regards this problem, many documents about the future of European industry, underline the importance to shift to a new structure of the value chain that should be more environmentally friendly, for instance:

- the "Aviation strategy for Europe", among its objectives to maintain high EU standards stresses the importance of building a resilient Energy Union and a more effective Climate Change policy;
- the "Renewed EU Industrial Policy Strategy" presented in September 2017 by the Commission straight to undertake a new series of actions on Circular Economy.

The Aerospace sector presents a global value chain that is not environmentally sustainable yet.

Looking beyond the current industrial model and value chain, a Circular Economy approach aims to redefine growth, focusing on positive society-wide benefits.

The transition to a Circular Economy does not only involves adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

There are some interesting examples of initiatives in these fields such as the Aircraft Fleet Recycling Association (AFRA) and Tarmac (Aircraft Storage Company), dedicated to sustainable aircraft recycling and disassembly and the ICAO Committee on Aviation Environmental Protection (CAEP) that is undertaking work to support environmental sustainability beyond the production and utilization of aircraft and to provide best practices on recycling processes. Another interesting experience of end-of-service-life handling is also represented by the project "Process for Advanced Management of End-of-Life of Aircraft" (PAMELA).

AFRA

In 2006, Boing launched the AFRA initiative with ten other founding members. The aim was to be proactive on recycling of aircraft to hinder the development of a political or legal problem and develop industrial standards that could be the basis for government action. [8] AFRA has promoted best practice within end-of-life and has developed a series of guidelines on best management practices (BMP). [11] Three versions have been published and merged in one covering all aspects of best practice around aircraft end-of-life processes and service. The final documents aim is to reach 90% recycling. [9]

PAMELA

The first major study on aircraft recycling was initiated by Airbus in 2005. PAMELA was a dismantling demonstration project carried out with support from several partners and the European Commission. The objectives of PAMELA were to: 1) demonstrate full-scale experimentation on aircraft where 85% could be recycled, reused or recovered, 2) set up a standard for environmentally responsible management at the end-of-life, and 3) develop an international network of partners to further disseminate this topic [7]. The project demonstrated the possibility of recycling up to 85% of plane components - a significant advance from the earlier rate of 60% and a reduction in landfilled waste [7]. The project showed that a **material mapping in the design phase** would support high value recycling and would eliminate the need for spectrometric analysis. Further, the complexity in **material composition and assembly** was highlighted as an obstacle to achieve higher recycling rates [7].

Common to the initiatives is that all increase the recycling rates, decrease the landfill needs and have fostered a market for reuse of components. The area is still not regulated and legislative instruments can be used to set the lowest common denominator for ensuring minimum requirements. Despite the achievements, the aircraft industry still has challenges defining responsibilities and determining how to communicate information, e.g. material compositions, etc.

To make the Aerospace industry more resilient it will be important to introduce in all the phases of the value chain the following Circular Economy core concepts:

- **Redesign**: managing the waste sustainably by preventing waste through the redesign of all the parts making them recyclable in the future and by separating the waste correctly;
- **Reduce**: reducing the consumption of aviation fuel, monitoring it through the earth observation technology;

- **Reuse**: bringing waste back into a new production cycle including procedures to reuse and recover spare parts;
- **Recycle**: recycling or upcycling waste into new uses – for this, items and aircraft parts designed with eco-designed approaches, which take the entire life cycle of products into account, should be favoured.

4.1 A proposal for the reconversion towards a more oriented circular economy business model

After a brief introduction on the state-of-the-art of the Aviation industry value chain and first experiences in the adoption and experimentation of Circular Economy in this field, this chapter aims at proposing a model for the transformation process from a “business as usual” to a “circular business”.

In literature it is possible to encounter two principles on how economy can be described: as a linear system or as a circular system. The linear economy is commonly described as a “take-make-dispose system”, where one uses resources for manufacturing a product, uses that product and disposes it after a period of usage. This is how material usage is today and functionality processes look like, in most companies of the manufacturing industry. Many theorists emphasize, that the linear way of business is not sustainable in the long-term perspective, because of the limitations of the linear model of resource consumption. (Yuan, Bi, Moriguichi 2006).

It is possible to observe today many companies that are starting to address the Circular Economy in their operations. Every company can adjust their own business model for approaching a circular system, and there are no specific guidelines and strategies to follow. However, there are orientations and methods that help companies with linear economy systems to think and act differently, and eventually change their business model. The sustainable dimension has to be integrated with the primary goal of a business to create value (economic value), also in terms of growth, for its stakeholders. Addressing Circular Economy principles can also become an opportunity to create new values for the business.

A circular system can make improvements in many fields. Remanufacturing parts of products for example with additive manufacturing as a method is one way of keeping the material and products in a circular loop. This can lead to better assessments when selecting materials and improvements in the product design. Improvements in product design can be the standardizations of components, a design for easier

disassembly for products and/or components and flows with purer materials which are desired within a company (Ellen MacArthur Foundation 2014).

A circular economy starts at the very beginning of a product's life. Both the design phase and production processes have an impact on sourcing, resource use and waste generation throughout a product's life.

In this perspective, at single business level, here it is proposed a process for the evaluation and adoption of Circular Economy principles composed in five steps. The first two steps regard data collection. Data collection includes the interviews, observations and data resources (academic and research papers, documents and reporting papers from companies and other literature review). The other steps are represented by the analysis of data, the concept development and the results received from empirical studies. The process itself is a circular one and rarely or never linear and straightforward with its steps. (Eriksson & Kovalainen (2008)).

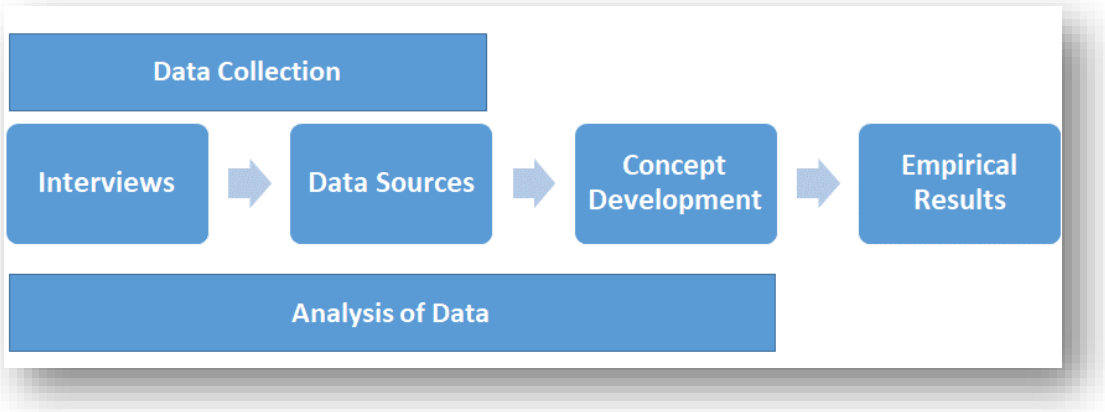


Figure 4: Research process for our business development *(Source: Eriksson&Kovalainen, 2008)*

In the **first step**, a pre-study can be implemented with interviews. The interviews represent a good approach of gathering data. The interviews can be done with managers and some key employees at the company in different departments. In this phase it is also possible and useful to involve different operators of the value chain if possible. The interviews can be structured or unstructured with open questions. This approach is useful mainly for identifying potential needs.

In this early investigation phase, it is possible to get knowledge about Circular Economy concepts understanding by the involved actors. From this first pre-

investigation an approach of the lifecycle can be implemented for the products manufactured.

The **second step** of data sources contributes to the integration of the first one. At this stage a document review can be implemented, both internal and external.

Regarding these first two steps, it is useful to use many different sources in order to increase the reliability. Different data should be collected from documents and interviews to find similarities and differences. Very important information collection is represented by some interviews with managers and regular employees where he or she has 20 years of working experience in the specific (aerospace) industry or similar, they have a specialized competence and expertise in their respective field. How the specific product is manufactured from minor material parts, repaired, used, shipped and sold is data that can be collected from different sources, mainly from interviews and document reviews. It is also useful to collect statistical data based from historical product management, to understand the current reality of internal process of the specific product and eventually use in the results of the CE targeting process.

The **third step** consists in concept development. In this phase concepts are developed including alternative business models and which position in the value chain and what type of business the analysed organisation/entity can adopt. Indeed, different current business cases can be investigated.

For the **evaluation of the business cases** it is necessary to **identify a set of parameters that should reflect both Circular Economy as well as sustainable continuation of business development and growth.** An example of several parameters that can be used are provided below:

- **Usage of recycled materials** - higher recycling rate is evaluated as positive in the assessment of the specific business case;
- **Usage of unsustainable materials** – the capacity to avoid dependency of unsustainable materials is evaluated as positive in the assessment of the specific business case;
- **Usage of Advanced Manufacturing** – if relevant for the specific business, a model would score better depending if they had more possible opportunities to use additive manufacturing and less if they only had limited applications that would require it;

- **Percentage of lifecycle** - when a certain model is having a larger part of the total lifecycle of a product then that model will be evaluated as positive in the assessment of the specific business case;
- **Product oriented** - this measurement is related to the PSS theory and is an evaluation of a certain business model is focusing on satisfying their customers need by producing a product. If the business model is focused on production of new products with no development or aftermarket services it gets a plus in this category while if it only focuses on doing repairs and development it gets a minus;
- **Service oriented -** for achieving a product service system the production of value can not only be achieved through machining but also through development. If a business model is having the a focus on product development, need finding, support and aftermarket remanufacturing then it gets a plus but if it mostly focuses on the products they are producing it gets a minus;
- **Turnover** - to measure the impact on the possible increase in turnover that the company can do if only a certain business model is used;
- **Margins**: to show the possibility a certain model for a company has for providing a higher margin;
- **Capital intensiveness** - to evaluate how large of an initial investment it would take to create the necessary investment to have a certain business model working. If a model has a higher need for capital and is harder to be implemented than the comparison, the model would get a lower evaluation;
- **Implementation time** - to evaluate how the implementation time would influence the value of a certain model over another model. A shorter implementation time is evaluated more positively;
- **Dependence on supplier** - to evaluate the risk that is involved with having few suppliers to choose from for the core components of the products. If there are a limited number of suppliers then there is no competitiveness to force the price down because of the limited market. And if a supplier would have financial difficulties then it could jeopardize deliveries. If the suppliers are few and their products are vital for the company this will be evaluated with a lower scoring.

Other parameters can be introduced based on the importance for the specific business model.

The **fourth step** shows the results which were received from the concept development. The business cases can be ranked using the Pughs matrix. (Cervone Frank, 2009). Pugh matrix analysis (PMA) is used to compare different options which are based on selected criteria. PMA and its usage in research context are described as where it “can be used in situations where there is more than one factor that may be the significant driving force in a project. Using the PMA process helps the project team select the best possible option or options when there are a large

number of good alternatives, and potentially many intervening factors, that must be taken into account." (Cervone Frank, 2009).

PMA is a simple matrix and effective in using to evaluate business, technology related or other topic which involves different options or actions and the need is to compare them. With PMA the need of complex mathematical formulas are not necessary and minimized.

The next step in PMA is to define a relevant baseline which all the chosen factors can be compared to. The baseline could either be the current product or service in the company or one of the alternative factors that is identified in order to design a new product or service. After defining the baseline next step is to evaluate each of the factors in comparison to the baseline by noting it with better (+1), the same (0) or worse (-1). This evaluation gives a direction for if the selected factors are better, same or worse than the baseline factor (Cervone Frank, 2009).

	Factor 1 no jargon	Factor 2 services	Factor 3 searching	Total +	Total -	Overall Total	Weighted Total
Weight	4	4	2				
Prototype 1	+1	0	0				
Prototype 2	-1	0	-1				
Prototype 3	+1	+1	0				

Figure 5: Example pugh matrix with team member *(Source: Eriksson&Kovalainen, 2008)*

The different factors to assess the concept can be chosen in order to allow the evaluation of key aspects such as sustainability, technical advantage, business model etc. The most common business case used inside the enterprise can be set as the baseline in the PMA. The other developed business cases will be compared with this baseline. The PMA will be implemented in order to assess the ranking of all the business cases. The evidence of the ranking can also result in a new business case that can see the integration of two or more business cases as the final result of the analysis.

Reaching Circular Economy (CE) has not one final solution but rather a number of different options including the key aspects such of sustainability, technology and business. A company needs to be systematic when they evaluate their own road towards CE because they have their own unique products, manufacturing methods, value chain etc. They have their own vision of how success is reached, awareness of where they are today and multiple options for improvements. The suggested improvements should be evaluated on their potential return on investment and their flexibility.

5. Innovation and financing measures

The transition towards Circular Economy cannot be seen as targeted actions affecting a specific business, each phase of the value chain and key sectors. It is mandatory to have a systemic view towards a systemic change. In this context, it is necessary to create the conditions under which a circular economy can flourish and resources can be mobilised.

In this panorama, innovation will play a crucial role towards CE change. In order to rethink our ways of producing and consuming, and to transform waste into high value-added products, we will need new technologies, processes, services and business models which will shape the future of our economy and society. Hence, support of research and innovation will be a major factor in encouraging the transition; it will also contribute to the competitiveness and modernisation of EU industry.

Different instruments has been already developed at EU level in order to support financially this transition.

5.1 Horizon 2020 and the evolution in Horizon Europe R&I framework programmes

Horizon 2020 has been instrumental to the shift towards a more sustainable economy – towards circular economy.

For example, Horizon 2020 has a relevant role in implementing the EU Raw Materials Initiative and the European Innovation Partnership (EIP) on Raw Materials. Particularly the Societal Challenge 5 on climate action, environment, resource efficiency and raw materials (SC5) has helped to respond to the challenge of securing the sustainable access to raw materials. Other major contributing parts

of Horizon 2020 include the SPIRE Public Private Partnership on energy efficient raw materials production and the Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing work programmes.

More than €200 million has so far been invested in R&I actions under the SC5 developing and demonstrating sustainable production of primary and secondary raw materials in the EU. Raw materials topics under the SC5 are successfully attracting industrial participation: 43% of funding goes to private companies, compared to an average 28% in SC5 as a whole.

The Horizon 2020 work programme 2016-2017 has included a major initiative: "Industry 2020 in the circular economy", which granted over €650 million for innovative demonstration projects that support the objectives of the circular economy and industrial competitiveness in the EU in a wide range of industrial and service activities, including process industries, manufacturing, and new business models. It has also explored a pilot approach to help innovators facing regulatory obstacles (e.g. ambiguous legal provisions), by setting up agreements with stakeholders and public authorities ("innovation deals").

Nearly 1 billion from Horizon 2020's final Work Programme (2018-2020) will be invested into research, innovation and financing of projects and initiatives that will support our circular economy ambitions on different Pillars of the framework programme. In this last period, more than €250 million will be dedicated to the actions on raw materials, including more than €100 million under a Circular Economy Focus Area.

The European Commission has published recently a policy booklet "Report on Horizon 2020 R&I projects supporting the transition to a Circular Economy" presenting a selection of its research, science and innovation on climate change adaptation.

The objective of the report is to provide a snapshot of the numerous projects resulting from the calls for proposals of 2016-2017 in the Horizon 2020 priorities "Industrial leadership" and "Societal Challenges" that are contributing to the circular economy strategy.

Without aiming to be exhaustive or exclusive, the 156 listed projects represent a good sample of actions financed by Horizon 2020 in the different stages of a circular economy (production, consumption and waste).

The spectrum of priorities contemplated by the selected projects are very diverse and address more sustainable production in all kind of industrial processes, new

bio-based and biodegradable products, substitution or recovery of raw materials, conversion of CO2 packaging, plastics, etc.

Only two projects regard the Aviation sector but focused on biofuel. Several projects addresses automotive sector – that potentially can be studied for the technological transfer in the Aviation sector.

Thus, a lot of space under EU Horizon 2020 and the new Horizon Europe may be reserved for circular economy innovation projects.

Indeed, two specific areas of intervention are expected under the Horizon Europe Pillar 2 “Global Challenges and Industrial Competitiveness” for CE, i.e. “Circular industries” under “Digital and Industry” cluster (expected budget € 15 billion) and “Circular systems” under “Food and Natural Resources” cluster (expected budget € 10 billion). But circular economy topics will be also addressed on other transversal topics related to sustainability and resource and energy efficiency (for example, under the cluster “Climate, Energy and Mobility”, but also under the same interested cluster above-mentioned).

5.2 Cohesion Policy and other EU programmes

Important R&I funding opportunities are also available under the Cohesion Policy: the circular economy is one of the priorities highlighted by Member States and regions in their Smart Specialisation Strategies. The Commission will offer further support to them, including through the Smart Specialisation Platform.

The development of the circular economy will also require public and private sources of financing to scale up improved technologies and processes, develop infrastructure and increase cooperation between actors in the value chain. Significant support for these objectives will come from EU funding programmes such as Cohesion Policy, LIFE and COSME. For example, Cohesion Policy funds are directed towards a growing number of programmes supporting the circular economy, including support for reuse and repair, improved production processes, product design and SMEs. The Commission will assist Member States, regions and local authorities in strengthening their circular economy approach in this context through targeted outreach.

5.3 Other financing instruments and the Circular Economy Support Platform

Private finance needs to be directed towards new opportunities created by the circular economy. For the financial sector, such projects can differ significantly from "business as usual".

The European Fund for Strategic Investments (EFSI) is an initiative to help overcome the current investment gap in the EU. Jointly launched by the European Investment Bank (EIB) Group and the Commission, it aims to mobilise private investment in projects which are strategically important for the EU. Together with the European Investment Bank (EIB), and the European Investment Advisory Hub, the Commission will carry out outreach to encourage applications for funding, and support the development of projects and investment platforms relevant to the circular economy, e.g. in the areas of plastics recycling or mineral. Work will be done to develop cross-sectoral clusters and pool resources to formulate projects with a European dimension.

Linked to EFSI, a platform to support the financing of circular economy was launched together with the Commission's first report on the implementation of the Circular Economy Action Plan. The platform brings together the Commission, the EIB, financial market participants and businesses to increase awareness of the circular economy business logic and improve the uptake of circular economy projects by investors.

The platform has a three-pillar structure:

- The coordination and awareness raising pillar will share best practices amongst potential project promoters and other stakeholders. It will analyse the characteristics of circular economy projects and their particular financing needs, advice on improving their bankability, as well as coordinate activities regarding financing of the circular economy. In this context, a Support to Circular Economy Financing Expert Group has been set-up. The first meeting of this expert group was held on 2 October 2017;
- The advisory pillar will be used to develop circular economy projects and to improve their bankability prospects;
- The financing pillar will explore whether a dedicated financing instrument for circular economy projects is needed.

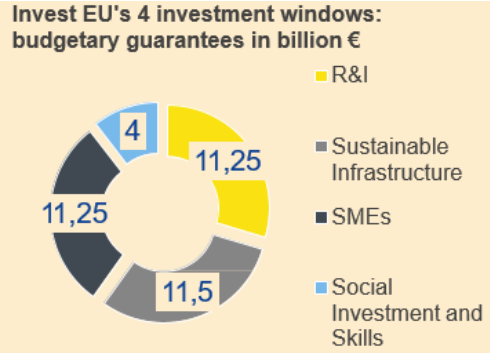
The financial instruments deployed under Horizon 2020 will continue through specific instruments also under the new Horizon Europe programme.

InvestEU instruments will be launch under the new programme that will contribute to stimulate more investments in research and innovation, notably by the private sector. Any potential market distortion will be avoided because the intervention will only address financing gaps in R&I delivery chain, notably due to high risk.

The support will be provided through:

- InvestEU Fund;
- InvestEU Assistance;
- InvestEU Portal.

InvestEU leverages an estimated € 200 billion of investments into R&I.



5.3.1 EIB lending to the Circular Economy

Recently EIB has financed circular economy investments in a large number of projects, as shown in the table below, which summarises past EIB CE lending history in the period 2013 – 2017.

Sector	CE lending 2013-2017 (EUR m)	Share
Industry and services sector	706	33%
Water management sector	554	26%
Agriculture and bioeconomy sector	366	17%
Waste management sector	331	16%
Mobility	95	5%
Urban development sector	50	2%
Energy sector	14	1%
Total CE lending	**2116**	100%

Table 1 - EIB CE lending in the period 2013-2017 (signed operations)

EIB-financed CE operations range from more traditional recycling projects to innovative sharing and leasing business models. Some recent CE project examples are presented in the table below.

Project
***Ecotitanium*:** This project comprises the first EU industrial plant to recycle and re-melt aviation-grade scrap titanium metal and titanium alloys, which today has to be exported outside Europe. The project will thereby enable the recycling of valuable metal scraps from European manufacturing sources and reduce dependence on imported titanium. **http://www.eib.org/projects/pipelines/pipeline/20150454**
Novamont renewable chemistry: This project concerns the development of innovative bioplastics and biochemical based on renewable resources and which are biodegradable and compostable. Novamont's holistic approach and vision for the bioeconomy, where the business model includes local agriculture as well as the reuse of by-products, is producing positive results for material innovation, and is opening up opportunities in the market and larger economy. **http://www.eib.org/en/projects/pipelines/pipeline/20150447**
Recycled paper circular economy Spain: This project enables a containerboard production plant to use more recycled fibre as raw material, improving the management of natural resources, following the principle of the circular economy. **http://www.eib.org/projects/pipeline/2016/20160096.htm**
CDP climate change Investment Platform: This is a risk-sharing investment platform under development together with the Italian National Promotional Bank (CDP) that, among other things, focuses on CE projects sourced by intermediary commercial banks. The investment platform is supported with a guarantee under the European Fund for Strategic Investments (EFSI).
Omnicane carbon burn-out: This project comprises the construction of two sugar refineries with related sugar handling and storage facilities, and the expansion of a sugar mill. The project will enable the reuse and recycling of all by-products in the process. **http://www.eib.org/projects/pipelines/pipeline/20080291.htm**
Rabobank Impact Loans I - III: A series of intermediated loans to finance small and medium-sized investments with a high degree of positive social impact and high sustainability, including CE investments, primarily in the Netherlands. The investments are promoted by SMEs and mid-caps that are frontrunners in sustainability/social impact performance. **http://www.eib.org/projects/pipelines/pipeline/20140615**
Belfius Smart Cities, Climate and Circular Economy: This bank-intermediated framework loan targets areas including CE projects for public promoters in Belgium. The defined eligibility criteria assist

the intermediary bank in sourcing and screening project eligibility. http://www.eib.org/en/projects/pipelines/pipeline/20150899

Green Metropole Fund: The project consists of a loan to a regional investment platform sponsored by the Port of Amsterdam and managed by e3 Partners, a Dutch private fund manager. The EIB loan will leverage the other investors' investment capacity for SMEs and small projects, mainly in the important sectors of the circular economy, renewable energy and energy efficiency, and to a lesser extent also in advanced materials and smart technology. http://www.eib.org/en/projects/pipelines/pipeline/20170094?f=search&media=search

Romania Recycling and Circular Economy Project: The project comprises investments to increase the promoter's capacity for: (i) the collection of recyclable materials; (ii) the production of Polyester Staple Fiber from PET flakes; and (iii) the recycling of waste electric and electronic equipment in Romania in support of the transition to a circular economy and the attainment of national recycling targets.

Ultimaker: Ultimaker is recognised as a highly innovative manufacturer that develops 3D printers and associated materials in the consumer-oriented desktop printer segment, as well as open-source software to operate the printers. 3D Printing, the additive manufacturing process that "prints" objects, is transforming the way we make things. While not all products can currently be produced by the technology, it is easy to imagine a large percentage of our goods being 3D printed, absorbing a big chunk of production into the circular economy. http://www.eib.org/en/infocentre/press/releases/all/2016/2016-205-eib-supports-ultimakers-3d-printing-technology

De Lage Landen (DLL) Circularity L4SMEs-Midcaps: This project comprises the first intermediated loan to cofinance the expansion of DLL's circular economy finance solution: i.e. DLL's second and third life equipment financing. This circular leasing facility provides customers access to equipment finance along multiple stages in the life cycle of the asset and facilitates the remanufacturing or refurbishment of used assets through DLL's Life Cycle Asset Management (LCAM) programme. By offering these financing solutions, DLL encourages SMEs and mid-caps to use (lease) rather than own (purchase) their assets and helps its partners to transition from selling an asset to selling a service, leading to more sustainable circular-focused business models. http://www.eib.org/en/projects/pipelines/pipeline/20170989?f=search&media=search

5.3.2 Project eligibility, screening and assessment

Eligibility of circular economy projects

The circular economy is in line with the EIB's public policy goal to promote environmental protection and resource efficiency, and it generally supports climate action. Some CE projects may include innovative features and thus be considered

eligible under the innovation goal. Depending on the size of the promoter, CE projects may also be eligible under SME and mid-cap finance.

Nevertheless, the risk features derived from the new financing models discussed above may result in a sub-investment grade risk profile. This also holds true for projects carried out by small and poorly capitalised promoters of projects that may also be technically unproven and commercially uncertain.

Furthermore, new sharing/leasing business models in which customers no longer purchase goods directly would require new or adapted risk assessment and financing approaches.

Project screening and assessment

A project is deemed to contribute to the circular economy if it falls under any of the following **Circularity Categories**:

- **Circular design and production -** Application of reduce/recycle strategies in design/production phases:
  - ✓ Design for modularity, easy repair, disassembly and recycling, and longer product life;
  - ✓ Substituting virgin materials with secondary/recycled materials;
  - ✓ Reducing input of hazardous substances to facilitate reuse and recycling;
  - ✓ Development/deployment of innovative materials and process technology that increase circular resource efficiency;
- **Circular use and life extension** – Application of reuse / repair / repurpose / refurbish / remanufacture strategies in use phase:
  - ✓ Reuse, repair and remanufacturing of products and components up to generally accepted industry standards;
  - ✓ Repurposing and refurbishment of abandoned buildings and redundant assets up to generally accepted industry standards;
  - ✓ Decontamination and redevelopment of abandoned brownfield sites;
  - ✓ Extension of use/life of assets/products through product-as-service, sharing, leasing/subscription business models incorporating circular economy principles;
- **Circular value recovery** - Application of recycle/recover strategies in after-use phase:
  - ✓ Recovery of materials and chemicals from waste, residues and by-products;
  - ✓ Recovery of bioresources, chemicals and nutrients from bio-waste, bioresidues and wastewater sludge;

- ✓ Recovery of energy from residual biomass, bio-waste, bioresidues and organic sludge;
- ✓ Recovery of waste heat;
- ✓ Reuse of treated wastewater;

➢ **Circular support** - Support and facilitation of all circular strategies in all lifecycle phases:

- ✓ Development/deployment of key enabling ICT technologies and services supporting/ facilitating circular business models and value chains.

Further to falling under one of these categories, CE projects or project components should be “intentional“ in the sense of having a clearly communicated intention, goal or design brief to contribute to the CE goals and objectives, and generate a positive impact on society and the environment, similar to impact investing. The due diligence must consider the long-term thinking and broader conception of value common in many CE projects where upfront investments generate: (i) returns (or reduce risks further in the future than conventional projects); and (ii) multiple values (ecological, social and financial).

6. Conclusions

Several previous mainly demonstrative experiences in the adoption of Circular Economy principles in the Aviation sector have shown an increase in the recycling rates, a decrease in the landfill needs and have fostered a market for reuse of components. Although many recent Circular Economy policies and regulations have been adopted by the European Commission, the specific Aviation sector is still not regulated and legislative instruments can be used to set the lowest common denominator for ensuring minimum requirements towards a more Circular Economy oriented industry. Despite the achievements, the aircraft industry still has challenges defining a new more sustainable value chain and single businesses involved.

In this respect, the document aims at representing a baseline to starting thinking in a “Circular Economy” perspective both at individual business level as well as at value chain level. The recent modifications in the main value chain of the addressed sector with higher involvement and risk taking of lower level suppliers can contribute towards a more cooperative work for a more sustainable Aviation sector.

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