POSITION PAPER FOR INDUSTRY AND POLICYMAKERS.

The role of Cabin and Cargo for sustainable aviation.

TEAMED UP: OPPORTUNITIES AND FIELDS OF ACTION FOR THE AIRCRAFT INTERIORS COMMUNITY TO REDUCE THE ENVIRONMENTAL IMPACT OF AVIATION.

BDLI

Bundesverband der Deutschen Luft- und Raumfahrtindustrie
(BDLI – German Aerospace Industries Association)

June 2023

POSITION 1

A new understanding within the entire industry and all stakeholders is needed in the reconciliation of weight, emissions and cost efficiency.

POSITION 2

Transparency surrounding decarbonisation will be crucial for economic success. Airlines and passengers must be better supported to make the most sustainable choice.

POSITION 3

The industry needs a shared definition of circularity and a related key performance indicator system which covers the entire value chain, including end-of-use aspects.

POSITION 4

More agile funding structures are needed to reflect the shorter technology development lead times in Cabin and Cargo as well as the diversity of research opportunities.

Accelerating decarbonisation and circularity in aviation – together.

Dear Reader,

Sustainability is a top priority as we take civil aviation into the 21st century! The ability to unite people from all over the world is at the heart of our industry, and we shall continue to strive for technological excellence and innovation when it comes to protecting the environment. As such, in line with the industry's commitment from 2021[1], at last year's 41st ICAO Assembly, governments agreed to a collective long-term aspirational goal (LTAG) of net-zero carbon emissions by 2050.[2]

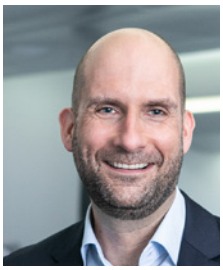
Beyond new propulsion systems and sustainable aviation fuels, many other stakeholders will have to make their contribution, including Cabin and Cargo!

During the entire life cycle of an aircraft, the cabin and its operations represent roughly 10-20% of the overall environmental impact, and provide numerous opportunities for fostering decarbonisation, recycling and circularity. The Cabin/Cargo working group of the German Aerospace Industries Association (Bundesverband der Deutschen Luft- und Raumfahrtindustrie – BDLI) decided to explore how to meet any obligations imposed by legislators, while creating at the same time a competitive advantages for all industrial stakeholders, especially the airlines.

The cabin is often described as the 'business card' of an airline, and has a major influence on the passenger's travel experience. As such, it plays an important role in how passengers perceive travel, not just from a comfort point of view, but more and more in terms of sustainability and environmental impact. By means of genuine engineering innovations the cabin and cargo community can make a true contribution towards the perception air travel has in people's minds.

I am convinced that the opportunity for low-carbon innovations and technological disruptions has never been greater than today! Let's step up to the challenges ahead of us, and by doing so also create value through jobs, knowledge and new research prospects.

The white paper in front of you is the result of an intensive process in the Cabin/Cargo working group, and I hope that you will find it stimulating. Together with all contributors, I am looking forward to receiving any thoughts or feedback you might have...



Sincerely yours, Dr Marc Fischer

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Executive Summary

Safe and affordable air transport, connecting billions of people around the world, is an incredible achievement of our society and an **indispensable part of modern life**. However, with its share accounting for 2-3% of global human-induced emissions and the passenger numbers doubling approximately every 15 years, the aviation industry has **no choice but** to substantially reduce its contribution to climate change. At the same time, the technical means to do so are further distant and more challenging when compared to many other industries.

That ist why no stone should be left unturned. That means: involve all actors, prioritise activities based on data and innovate at all levels of the aviation's value chain.

Cabin and Cargo matters. Accounting for around 10-15% [3] of an aircraft's empty weight and being replaced several times during its lifetime, the interior is responsible for a significant share of an aircraft's environmental footprint. As a result, environmental aspects are rapidly taking an increasingly prominent role in the design of new Cabin and Cargo products and services. This applies to all phases of the product life cycle, ranging from the design phase to the supply chain set-up, as well as from manufacturing and operations to ultimately the end of use.

The **advantages of focusing on Cabin and Cargo** are manifold:

→ its **impact**: even without payload, the Cabin and Cargo represent 10 to 20% [4] of the overall environmental footprint of an aircraft, mainly through its weight, energy consumption and operations (e.g. catering waste)

→ its **shorter development cycles**: many solutions can be integrated into the current aircraft models and even be retrofitted

→ the **variety of levers**: weight reduction, smart energy management and optimisation of supply systems, waste avoidance, recycled and recyclable materials, cabin layout efficiency, reuse of cabin equipment, operational efficiency gains through data analytics, new / bionic designs, and more

This position paper conveys an industry view on the key priorities and fields of action for aircraft interiors to deliver real value for the environment.

The insights in this paper underline the importance of transparency and collaboration within the industry. This paper also highlights the need for further research and clear signals from policymakers to create a reliable and agile environment for investments into relevant technologies with different time horizons.

The demand for more sustainable aviation grows.

A growing awareness of sustainability among the general population has resulted in an increasing need for flying to become more sustainable. Consumers are **calling for more conscious and responsible air travel behaviour**. On the one hand, short-haul flights are seen more and more critical, as improvements to infrastructure have made rail travel a viable alternative. Long-haul flights, on the other hand, are predominantly seen as indispensable, with expectations for technological improvements to enable low-emission travel.

In the political sphere, there are efforts to achieve a sustainable transformation of the economy. The European Union's goal is to make Europe climate-neutral by 2050. With the 'Fit for 55' package of measures, **the EU aims to reduce emissions by 55% by 2030** compared to 1990. This will require a massive transformation of all industries, including the aviation industry. As a result, airlines must implement solutions that significantly reduce emissions in this short period of time.

In December 2022, the European Union Emissions Trading System was tightened for aviation after an agreement between the EU Commission, Parliament and Council. For airlines, these higher costs either mean a cut in their profits or passing on higher prices to their customers. Therefore, reducing emissions and implementing more sustainable solutions are **becoming an increasingly decisive factor in airline competitiveness**.

Air traffic will continue to grow in the years to come. With an estimated growth of 4.0%[5] per year for the period from 2019 and 2040, annual passenger traffic is estimated to double within 20 years.

Air traffic currently accounts for approximately 2–3%[6] of global human-induced C02 emissions. Reducing emissions in the face of traffic growth requires a variety of technical innovations, including for the Cabin and Cargo sector. With other industries and the energy sector already reducing their emissions[7], it is crucial for aviation to accelerate this process. Consequently, in parallel to the development of new propulsion technologies and more sustainable fuels, industry actors are working on various fields to find **innovative and sustainable solutions to reduce the aviation's environmental impact**, which throwing light on the significant contribution Cabin and Cargo can make.

Aviation accounts for approx. 2-3% of global human-induced CO_2 emissions. Annual passenger volume is expected to double within 20 years. Given this growth, there is even **further pressure to decarbonise**. This is particularly important as emissions in other industries are about to decline at a faster rate.

Environmental efficiency starts in the cabin.

While the shift towards more sustainability in commercial aviation is **imperative, it is also highly intricate, costly and time-consuming** for industry players. The first electric aircraft are expected to come onto the market within the next decade. For now, however, most measures focus on improving the industry's environmental impact through more efficient engines and associated kerosene savings, as well as substituting kerosene with sustainable aviation fuels (SAF).

Cabin and Cargo with its related operations make up 10 to 20% of the entire environmental impact of an aircraft over its life cycle.

The cabin is well suited for implementing short-term solutions that improve sustainability. Many of its components are replaced several times during the aircraft's service life, offering **opportunities for mid-life improvements on weight and power draw**. Successful examples can be found throughout the entire aircraft interior: Seat weight was reduced by 30% despite increased requirements over the last two decades. More comfortable yet thinner backrests have freed up space – as have combined galley/lavatory monuments. This was complemented by immense weight reduction on interiors textiles and a 52% power reduction on cabin lighting. In combination, these measures have allowed 10% more passengers to be seated in the same single-aisle aircraft, thus reducing the emissions per passenger.

Beyond solutions successfully implemented in the past, there are **many more innovations in progress or planned for the future** to further reduce the cabin's carbon footprint. New material solutions like graphene-reinforced polymers, powder coating resin, aerogel insulation or bio-based resins are just a few examples. These help to improve the material thickness, which plays a significant role in weight savings as it is a huge multiplicator to large surfaces represented in a cabin. These examples demonstrate the effort required to reduce or even avoid CO_2 emissions.

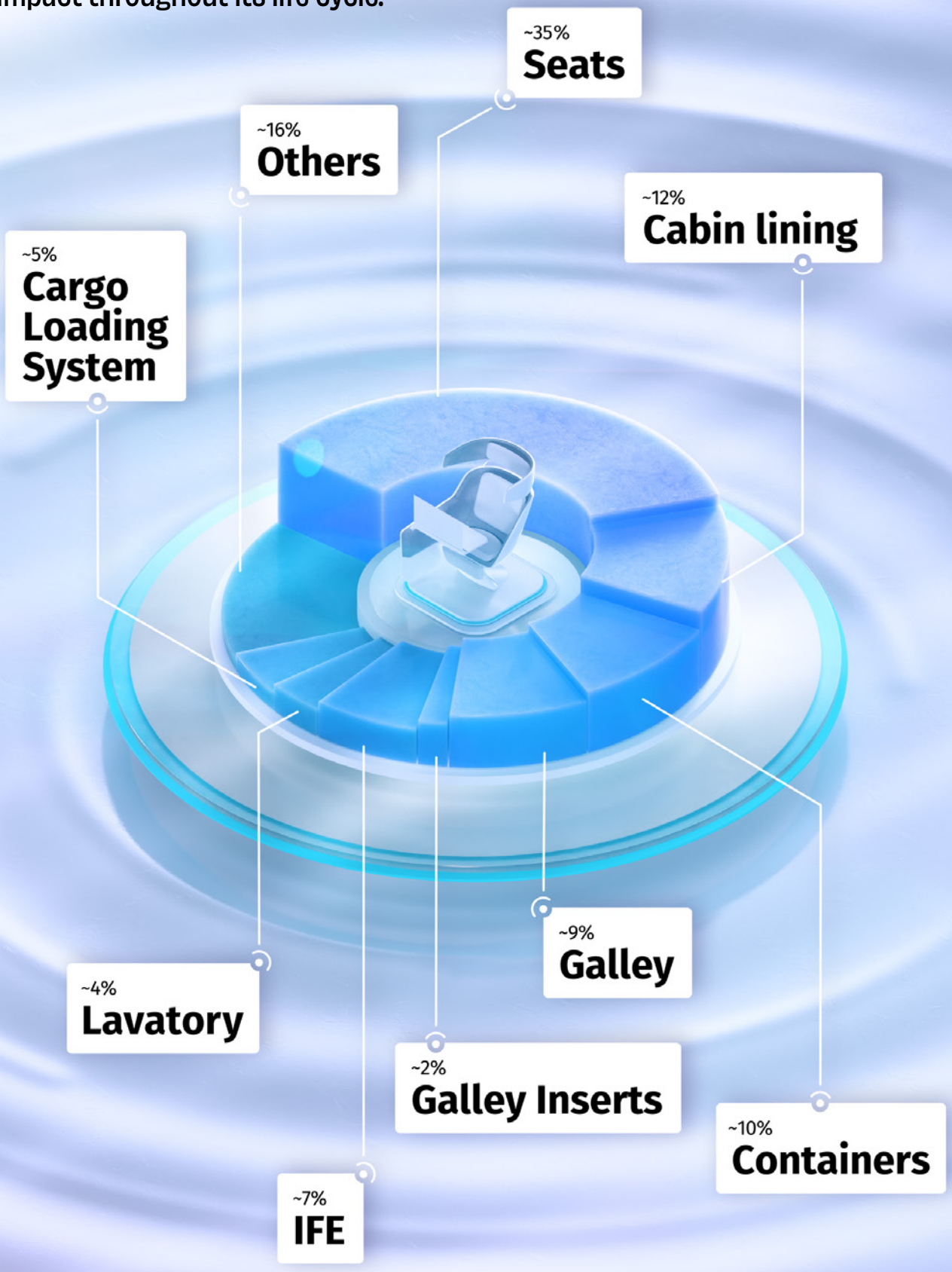
Technical developments aside, the aircraft cabin also has a signicifant human impact. As the 'business card' of an airline, it is the **most visible and recognisable interface of the industry that the passenger encounters.** Addressing the evolving needs of airline customers and end users will be of the utmost importance in the near future. Raising awareness of new solutions and their lower environmental impact will **enable customers to make more sustainability-driven decisions**.

It's crucial to **complement macro-level efforts, such as fuel and propulsion**, whose full impact is further down in the future. Cabin and Cargo's contributions to the short- and medium-term development of more sustainable solutions and their pivotal role for passengers are therefore key strategic elements that need to be exploited to an even greater degree.

10 - 20%

of the aircraft's overall environmental impact is related to Cabin and Cargo and its operations during the entire life cycle.

10-20% – Share of Cabin and Cargo's environmental impact throughout its life cycle.



Weight breakdown depends on configuration and customer layout. % values based on a typical A350 configuraton. [8]

Decarbonisation. Circularity. Transparency. Key enablers for progress.

Given the environmental challenges, it is all the more important to initiate the right measures throughout the entire life cycle of the aircraft. The responses from the aircraft interiors industry are broad and manifold. The key enablers for more sustainable Cabin and Cargo in the future can be categorized into three axes: **decarbonisation**, **circularity** *and* **transparency**.

DECARBONISATION:

Reducing Cabin and Cargo's weight and resource consumption.

The **most pressing and obvious target of the aerospace industry is decarbonisation**, which also covers aircraft interiors. It must be a primary focus throughout the entire product life cycle, always under consideration of each product's impact. As a result, lowering the Cabin and Cargo's weight and energy consumption has to take centre stage to reduce its impact on operations and therefore fuel burn.

A320 @ 2800 flight hours per year:

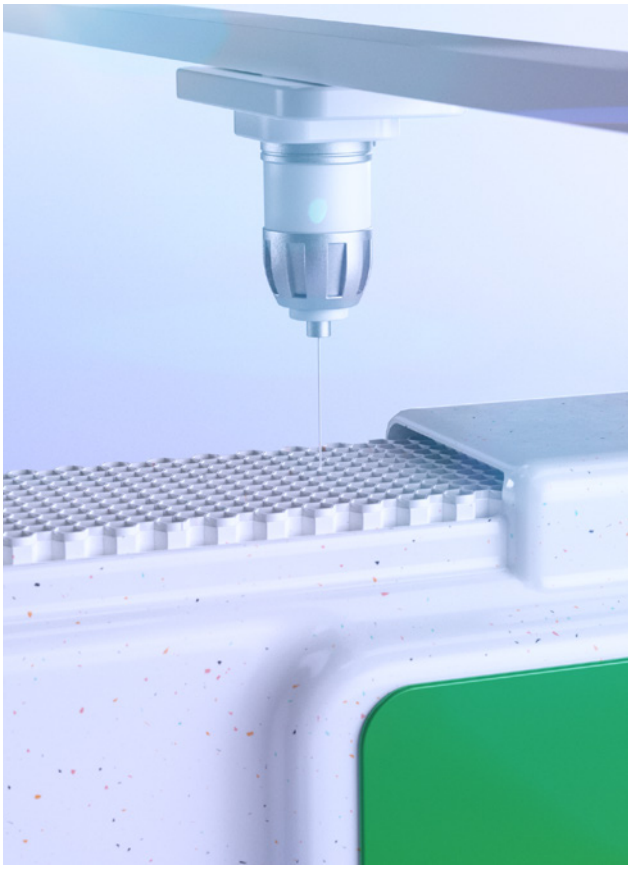
1 kg weight saving

= ca. **~100** kg kerosene saving / year

= ca. **~350** kg CO_2 saving / year

According to current Life-Cycle Analyses (LCA) for new and existing products within the industry, cabin weight is, and for a long time will remain, the key enabler for a more sustainable travel. Therefore, there must be a balance between measures taken to reduce the weight and energy consumption and activities that enable a circular economy, such as using recycled and recyclable new materials, bio-based materials, new designs that use production methods with a lower environmental impact as well as end of use.

The application of bio-based composite materials is a topic that is seeing speedy development in research departments. The compensation of the mechanical disadvantage of natural fibres after longterm usage is part of further investigations in the aircraft industry.



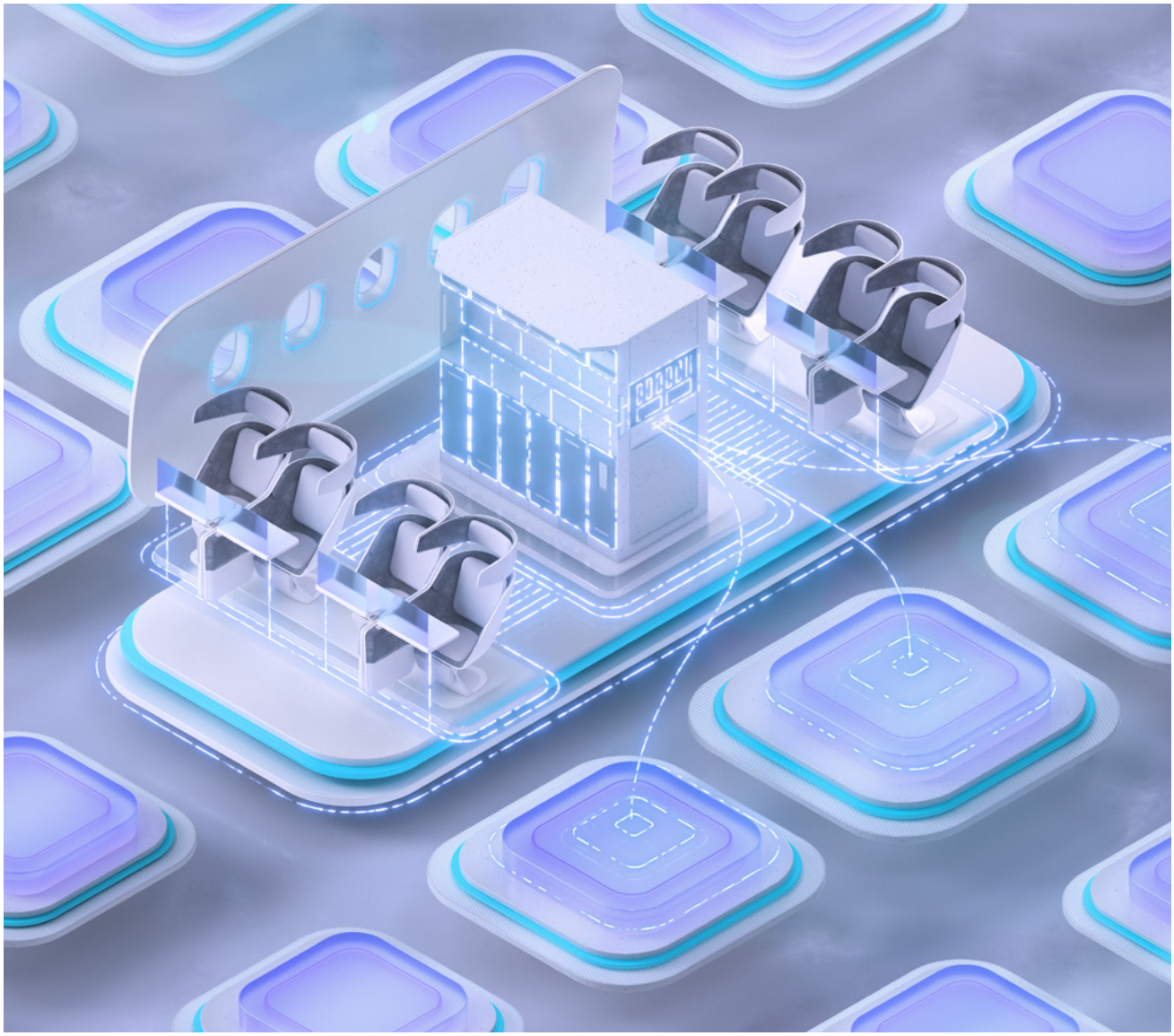
Curtain header printed by 3D technology

The general trend in the aircraft industry is towards more sustainability, but bio-based materials are not automatically used if they are heavier than existing solutions. The key driver must be to **identify high-performance light weight materials that also enable recoverability at the end of use**.

To further reduce weight and improve sustainability, the industry is increasingly adopting generative manufacturing methods. For example, the curtain header for the A350 cabin was generated using 3D printing, which enabled the production of complex parts without specific tools. This project showed that **generative manufacturing supports the decarbonisation target of production facilities and provides ecological benefits**.

Energy-efficient Cabin and Cargo modules are the next step in the supply chain. **Digitalisation enables energy savings during flight operations and aircraft preparation**. For example, smart galleys will optimise their energy demand and also be equipped with a self-ordering management system that correlates with the flight profile. Smarter inventory management can then help avoid overcatering resulting in lower catering weight, less packaging and food waste as well as less equipment for storage and preparation of meals.

Energy-efficient galley module optimised by digitalisation



CIRCULARITY:

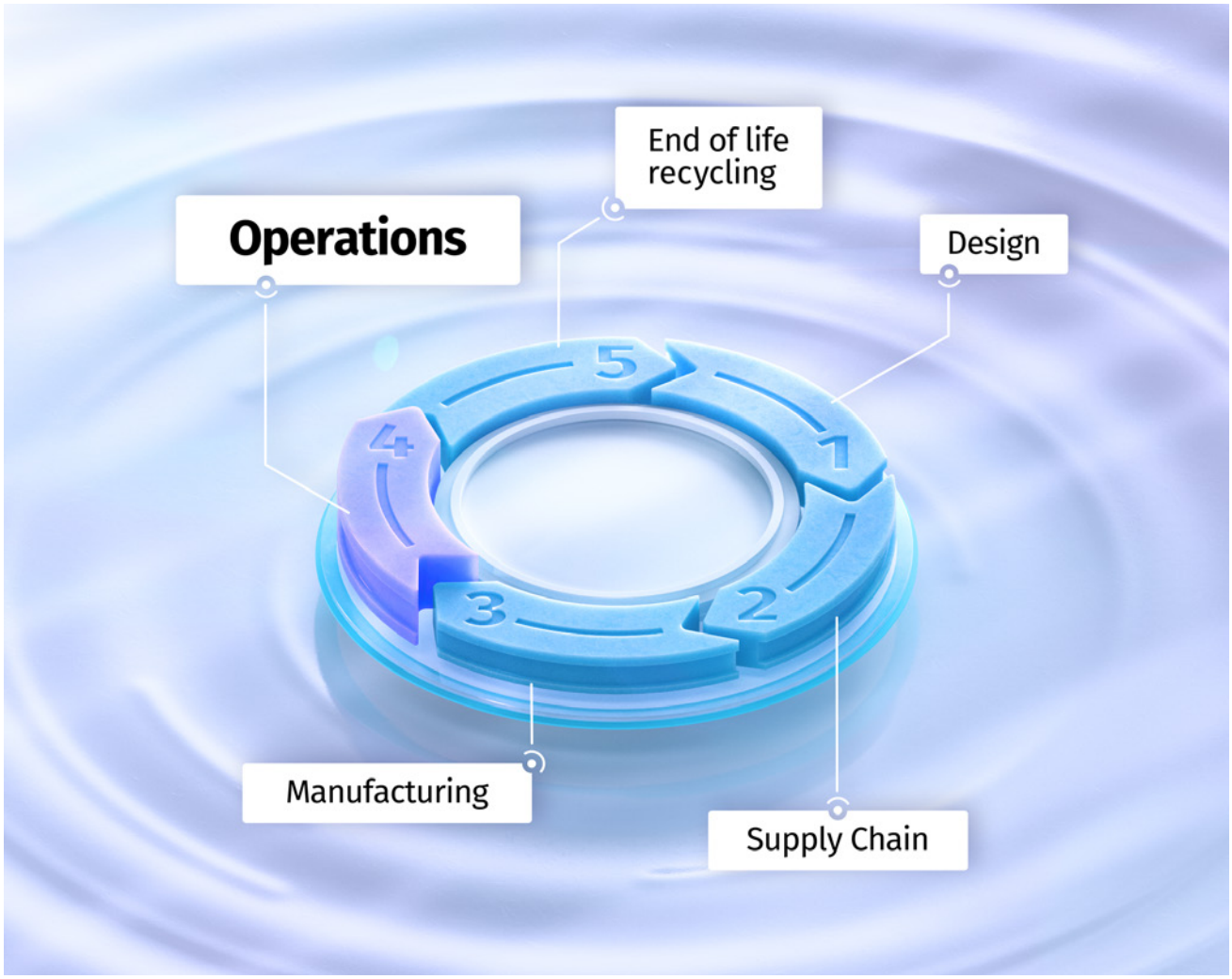
Preserving natural resources along the entire life cycle of the aircraft.

Since decarbonisation alone will be not enough to tackle the environmental challenges, the aircraft interiors industry also needs to focus on another important field of action: Achieving circularity. The circular economy aims to tackle biodiversity loss, waste and pollution by decoupling economic activity from the consumption of finite resources. It is based on three principles: elimination of waste and pollution, circulation of products and materials (at their highest value), and the regeneration of nature. [9]

In aviation, the goal is to establish circularity throughout the entire life cycle of aircraft. This involves responsibly managing all resources used, from the raw materials to ecodesign, manufacturing, operational phase and end of use. It is about progressively creating closed loops, preserving value and using renewable energy sources wherever possible.

The **new Circular Economy Action Plan (CEAP)** is one of the main building blocks of the European Green Deal. [10] It's **crucial to support this plan by developing closed-loop solutions wherever possible**. One way to achieve this is through conducting the design process with a **life-cycle analysis**. It provides transparent results that airlines can use to choose designs with the lowest environmental impact.

Life-cycle analysis process



Recycable particle foams in the cabin air distribution system

Historically, the materials had been chosen to combine the best specific solution for the highest performance during operations. This resulted in a design that was not optimised for valuable raw material disintegration. In the future, the challenge will be achieving **lower component weight while also enabling the separation of different materials after their service life**.

The goal now is to **think in closed-loop solutions without any weight increase**, meaning it should be possible to extract high-performance materials from Cabin and Cargo components and keep them at their property level. The low amount of recyclable high-performance materials will only enable a business case for the recycled material, if the properties will not get lost. In addition, the components have to be made of technical materials for which a closed loop solution already exists. Design solutions with particle foams are one example of innovation in the cabin air distribution system.

The Cabin and Cargo industry has to also work on a **common solution for a take-back process**. This could be an identification system for each part combined with a related lifetime file which facilitates the handling and recycling at the end of the component's life. Here, it's essential to think beyond just the next few years and have the next generation in mind, as the lifetime of an aircraft ranges between 20 and 30 years.

TRANSPARENCY:

Providing clarity and direction to improve ecological activities.

Establishing **transparency, both inside each contributing organisation and along the value chain**, including suppliers, customers and all other stakeholders, is the **foundation for efficiency in the transformation towards more sustainability**. This involves creating a comprehensive view of the current environmental impact of all activities and identifying measurable indicators to improve this picture in the future.

Transparency is the key requirement to achieve progress. This starts with the internal transparency in all companies along the value chain: communicate, inform, give guidance, explain the different impacts, set objectives, establish relevant KPIs, build awareness among all employees and offer education. Equally, it's about transparency with external stakeholders by providing information and data (e.g. on scope 1, 2, 3) and committing to accepted metrics and standards. It's about **creating a clear position for each company with regard to its values and objectives and demonstrating the steps to get there**.

For example, one key task for the future is to increase transparency on materials. The goal is to provide dismantlers with alle the relevant information in order to make optimum use of materials and parts at the end of the operational life.

Nearly all industrial companies in the aviation industry are already **certified according to ISO 14001**.[11] This means they are committed to preserve nature and achieving climate goals, which obligates them to continually improve their systems and approaches to environmental concerns. This requires organisations to consider all environmental issues relevant to their operations, such as air pollution, water and sewage issues, waste management, soil contamination, climate change mitigation and resource use and efficiency. On this basis, the aviation industry is prepared for the required lifecycle assessment which has to be performed along the whole industrial development and production chain. Other management system standards are able to adopt the data out of this ISO 14001 standard. The aviation industry now needs to contribute towards **closing the gap to ensure there is a transparent supply chain for Cabin and Cargo parts**.

In addition to internal transparency, it is equally important to be transparent with customers. It allows them to assess and understand the environmental impact of the products and services they are procuring. The industry needs to offer options where possible and **involve them in innovation activities by collecting feedback from airlines, crew and passengers at an early stage for new developments**.

The pathway to low-emission Cabin and Cargo: Joint forces needed.

There is a large variety of concepts for aircraft cabins that have an improved environmental performance. However, a lot of these approaches have yet to reach a stage of development that meets airworthiness standards or an industrial level. Many of them are still in the early research stage.

To best exploit this potential, the industry requires **clear political framework conditions, room for agility and closer collaboration between government and industry** to assess whether investments are worthwhile. The BDLI is committed to achieving these aims by implementing following positions together with the respective stakeholders.

#1

A new understanding within the entire industry and all stakeholders is needed in the reconciliation of weight, emissions and cost efficiency.

In order to achieve a consistent reduction of the global warming potential (GWP), there is a need for a paradigm shift within the entire industry that involves all stakeholders, such as airlines, policymakers and authorities. The main focus must shift from primarily cost and weight towards a more holistic approach that considers sustainability and the United Nation's Sustainable Development Goals (SDGs) as a whole. Following this perspective, the environment becomes a precondition for social justice and economic development. [12]

#2

Transparency surrounding decarbonisation will be crucial for economic success. Airlines and passengers must be better supported to make the most sustainable choice.

Customers and passengers need to understand the impacts of their choices. It is our responsibility to provide them with what they need to know to help them make more informed and sustainable decisions. This way, we will be in a better position to reshape the industry and the competition, establishing sustainability as THE differentiating factor in the market.

#3

The industry needs a shared definition of circularity and a related key performance indicator system which covers the entire value chain, including end-of-use aspects.

The way towards a more sustainable aircraft economy has to evaluate the circularity of all materials, components and resources that are used in Cabin and Cargo products throughout their entire life cycle. To help customers and operators make informed choices a reporting system needs to be established that communicates a meaningful measure on a level playing field. The desired outcome is a circularity index that includes recycling rates, similar to the one in the consumer market for beverage containers. The recycling rate would need to be combined with recycling quality as in up- or downcycling, put into context with an overall impact. The diversity of products that makes up an aircraft cabin requires a circularity assessment that accounts for those diversities and establishes a level playing field that produces realistic and credible indicators.

#4

More agile funding structures are needed to reflect the shorter technology development lead times in Cabin and Cargo as well as the diversity of research opportunities.

The budget for research and technology support, especially for the aircraft cabin, must be available and expanded through more agile funding processes. This includes shorter cycles in funding programmes, more flexible application and easier access to funding. Today, existing funding instruments are not yet sufficiently designed for the shorter development and implementation cycles in Cabin and Cargo. Advanced planning of research projects, which is typically established in the research departments of the aviation industry, takes a period of five years – which is too long in view of the needed short-term solutions, such as for improving efficiency and the ability to adapt to new aircraft architectures.

In addition, existing potential for decarbonisation could be better utilised and easily increased by broadening the funding spectrum accordingly. To achieve that, main Cabin and Cargo activities must be adequately addressed, such as in the Luftfahrtforschungsprogramm (LuFo – Federal Aviation Research Programme). It is also important to take into account the technology roadmap and the strategy of the BDLI.

Sources

[1]: Our Commitment to Fly Net Zero by 2050, IATA. 2021

[2]: States adopt net-zero 2050 global aspirational goal for international flight operations, ICAO. 2022

[3]: Weight Contribution C&C, Airbus. 2023

Disclaimer and Assumptions:
· Estimation based on typical C&C layout; C&C weight vs A/C (empty)
· Range depends on A/C program, C&C configuration and layout

[4]: Environmental Contribution C&C, Airbus. 2023

Disclaimer and Assumptions:
· Estimated range based on Airbus LCA studies with internal assumptions.
· LCA performed in line with ISO 14040/44
· Range depends on A/C program, C&C layout, cabin operational profile and mission mix
· Cabin & Cargo equipment considered incl. cabin operations impact (such as catering, cleaning, inflight cabin waste, power consumption and weight of catering and potable water) without payload (PAX, luggage, Cargo Load)

[5]: Boeing Commercial Market Outlook 2021-2040, Boeing. 2021

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[8]: Weight breakdown C&C equipment, Airbus. 2023

Disclaimer and Assumptions:
· Estimation based on typical C&C layout; C&C weight vs A/C (empty)
· Range depends on A/C program, C&C configuration and layout

[9]: Definition of Circular Economy, Ellen MacArthur Foundation. 2023

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