POSITION PAPER FOR THE INDUSTRY AND POLICY MAKERS

Environmental Product Transparency in Aircraft Interiors

METHODOLOGIES TO ASSESS THE ENVIRONMENTAL IMPACT OF AIRCRAFT INTERIORS AS ENABLERS FOR EFFECTIVE INDUSTRY COLLABORATION AND ENHANCED FUTURE PRODUCT DESIGN

BDLI German Aerospace Industries Association

April 2025

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A Responsible Cabin: Transparency as a Key Enabler

Dear Reader,

The civil aviation industry continues to innovate and adapt, recognizing that sustainability is a fundamental necessity for long term resilience and growth, and we need to seek any opportunity to redefine our ecosystem and its environmental impact to that effect.

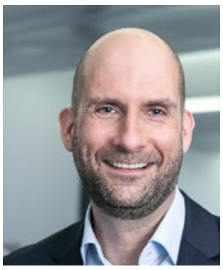
However, sustainability efforts in aviation do not exist in isolation and are highly dependent on the overall world that surrounds us, including more recent geopolitical evolutions.

Evolving regulatory frameworks, a rise in global tensions, as well as shifting economic alliances are influencing supply chains and technological cooperation. As such, it is more important than ever to stay focused on our ambitions regarding sustainable aviation.

Within the aviation industry, the cabin and its operations account for a significant share of the overall environmental impact across the life cycle of an aircraft. The cabin is replaced several times during its lifetime, and therefore it is an important contributor from a circularity point of view.

This whitepaper aims to provide a comprehensive perspective on the different methodologies to assess environmental impacts, highlighting the need to standardize and to examine any associated concepts. Furthermore, it underlines the vital role of all industrial stakeholders in shaping the path toward net-zero aviation. These include: manufacturers, regulators, researchers and policymakers.

The work presented is the result of in-depth studies carried out by the Cabin and Cargo working group of the German Aerospace Industries Association (Bundesverband der Deutschen Luft- und Raumfahrtindustrie – BDLI). I hope you find it insightful, and together with all contributors, I look forward to your thoughts and feedback.



Sincerely yours,
Dr Marc Fischer

BDLI German Aerospace Industries Association

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Summary

This whitepaper addresses the need for standardized environmental assessment methodologies in the aircraft interiors industry. In light of evolving regulatory requirements, three complementary approaches are examined – Product Carbon Footprint, Digital Product Passport, and Life Cycle Assessment – that provide progressively deeper levels of environmental transparency.

The aviation industry has established effective practices for component repair and refurbishment, yet the cabin sector faces distinctive challenges regarding material complexity and customization requirements. The analysis acknowledges the important balance between circularity objectives and carbon footprint reduction in aviation applications along all life phases, where weight considerations directly impact operational emissions.

Based on thorough analysis, seven strategic recommendations are proposed: developing industry-specific LCA standards; establishing clear guidelines for environmental data presentation and exchange; implementing appropriate validation processes; enhancing calculation tools; improving aviation-specific material databases; and promoting circularity through standardized KPIs.

These recommendations will enable aircraft interior suppliers to meet upcoming regulations efficiently, support informed customer decisions, and contribute to aviation‘s sustainability journey while maintaining operational effectiveness.

I. Evaluating Environmental Transparency: Methodologies and Assessment Approaches

The aviation industry faces mounting pressure to reduce its environmental footprint in response to climate change concerns and evolving regulatory requirements. ***Environmental impact assessment on the product level is becoming essential for all stakeholders*** *across the aviation value chain. This chapter introduces three complementary methodologies that enable varying levels of environmental transparency.*

Each of these key approaches to assessing environmental impact at the product level serves a distinct purpose and scope. Rather than being mutually exclusive, these approaches complement one another, **providing a comprehensive framework for environmental assessment.** In the near future, elements of these methods will likely become mandatory for demonstrating ESG (Environmental, Social, and Governance) compliance.

Product Carbon Footprint (PCF)

is a technique to calculate and communicate greenhouse gas emissions in CO_2-equivalents based on ISO 14067[1]. It provides a focused assessment of carbon emissions across the product‘s life-cycle stages, making it a critical tool for identifying key areas for carbon reduction.

Digital Product Passport (DPP)

creates a digital twin that accompanies the product over its life, i.e., in the form of a physical or digital tag. The information provided contains data with respect to its origin, supply chain, materials, assembly, and environmental impact. This is one means of enabling transparency for all parties involved in the handling of these products and is also intended to allow for better reuse at end-of-life.

Life Cycle Assessment (LCA)

is an advanced method for evaluating the environmental impact throughout specified stages of the life cycle of a product based on ISO 14040[2] and 14044[3] – i.e. cradle-to-gate or cradle-to-grave. It is a technique based on compiling and evaluating an inventory of energy and resource inputs and environmental releases, as well as documenting and interpreting the results. The evaluation range of impact categories can span up to 16 different criteria or may be limited to a few. LCA is a powerful tool, though it requires a rulebook and comparable databases to create similar outputs.

How These Methodologies Work Together

Each methodology serves distinct yet complementary functions within the environmental impact assessment framework:

LCA

provides the most comprehensive approach to evaluate environmental impacts across multiple categories

DPP

DPP enables processing and tracking of data for individual components and and collecting this information this information at the product or higher levels

PCF

PCF offers a focused view on carbon emissions – widely considered the most important single environmental aspect – and provides the opportunity to aggregate and digitally share this KPI across boundaries and systems

While **DPP and LCA are typically product-specific and more complex to process, PCF can serve as an entry point** for companies lacking the resources or data for a full LCA. By starting with PCF, companies can gain initial insights into their CO_2 emissions, which can later be supplemented with more comprehensive LCA data.

PCF and DPP may be considered stepping stones toward a complete LCA.

Practical Application Example: Aircraft Seat

The DPP could be used to collect and track data on the product and its related materials and processes used during seat production, facilitating efficient recovery and reuse later in the product's life cycle. Simultaneously, a PCF can serve as a first KPI, which brings insights into the environmental performance and could be requested and shared within a supply chain to facilitate multi-component product PCF. This data can then be integrated into a more comprehensive LCA to assess the overall environmental footprint of the seat to enable a deep dive into all areas of environmental performance.

Purpose of Life Cycle Assessments in the Cabin and Cargo Industry

Life Cycle Assessments (LCAs) are considered a foundational element for the continuous improvement of products and processes within the aviation industry. They can also enhance environmental transparency and support informed product choices on the customer side.

Companies can use LCAs to collect and analyse detailed data on the environmental impact of their products and services. This data enables them to identify potentials for improvement (e.g. in design, material selection, production processes, etc.) and introduce targeted measures to reduce emissions, energy consumption and waste, to enhance the product's environmental performance. A prioritization of products and components based on the LCA can be made to improve the products' environmental impact-related properties, sustainability and ability to be recycled early in the design phase.

Stricter regulations such as the Green Claims Directive[4] require companies to back up their environmental claims with verified data. LCA will play a central role in this context as it provides a scientifically sound method for assessing, comparing and communicating the environmental impact of products and services. Airlines can use LCA results to provide credible and transparent environmental information in their external communication. The Green Claims Directive also includes third-party verification to ensure that the sustainability claims made are accurate and trustworthy.

In the longer term, regulatory requirements such as the Ecodesign for Sustainable Products Regulation (ESPR),[5] which already applies to the consumer goods sector, are expected to be extended to all industries, including aviation. Although the exact timeframe is still unclear, LCA will likely play a crucial role in ensuring compliance with these regulations. The ESPR consists of performance and information requirements for products, the combined use of LCA and DPP will help to prove compliance.

The aviation industry must prepare to conduct comprehensive environmental assessments in oder to foster the reduction of environmental impact of its products in accordance with future regulatory requirements and the long term decarbonization target. This will not only affect product development, but also the entire value chain and operational strategies of companies in the industry.

However, there are some challenges for the Cabin and Cargo industry with regard to LCA. Experts and software solutions are required for the LCA generation, which increases the effort and costs of LCA preparation. In addition, much of the data on escpecially aviation specific materials and their related processes is not directly available and results-creation and interpretation may vary from case to case.

Topic	Medium term / Step I	
Standards	Development of PCF-Rulebook	Development of LCA-Rulebook
	Development of guidelines for Light LCA (e.g. LCA during product development)	
	Development of simple guidelines in addition to ISO standard	Use of simple guidelines in addition to ISO standard
Result presentation	Development of a recommendation for prioritization of impact categories	
	Development of a recommendation for result representation	
3rd party validation	Development of guidelines for validation of LCAs	
	Validation as required (recommendation: external validation upon publication)	
Calculation tools		
Databases	Integration of datasets for aviation materials according to ISO	
Circularity KPI	Development and definition of circularity KPIs	Application of KPIs
Data exchange	Manual PCF exchange on request	Manual LCA exchange on request
	Development of Digital Product Passport (DPP) (standardized exchange format and specification of content [circularity])	Adaption for LCA / PCF
		Development of (semi-)automatic tools for data exchange
Priority product list	Data collection of prioritized product groups (on product group level not at part number level)	

- *Foundation for continuous product improvement*
- *Marketing purposes and Green Claims Directive compliance*
- *Tool for identifying design and material improvements*

Topic	Long term / Step 2
Standards	Use of rulebook Evaluation and continuous improvement of the rulebooks
Result presentation	
3rd party validation	Validation in accordance with the provisions of the rulebook (validation of the LCA creation process)
Calculation tools	Development of guidelines for validation of LCAs Validation as required (recommendation: external validation upon publication)
Databases	Integration of datasets for aviation materials according to rulebook Whitelisting of datasets according to rulebook Improve compatibility of databases / tools Options for integrating own datasets
Circularity KPI	Standardization and industry-wide application
Data exchange	Adaption of the DPP Development of (semi-)automatic tools for data exchange Use of DPP Automatic data exchange on request
Priority product list	Expansion of the prioritized product groups

- *Adaptation to expanded ESPR regulations*
- *Comprehensive environmental assessment requirements*
- *Integration into entire value chain and operational strategies*

2. Circularity and Carbon Footprint

Basics of Circularity

As part of the initiative to enhance transparency within the Cabin and Cargo domain, the concept of circular economy – also commonly referred to as circularity – is examined. The analysis begins with fundamental definitions and widely accepted terminology, followed by an exploration of potential Key Performance Indicators and their calculation methods, with the aim of aligning these with established Life Cycle Assessment practices. ***The main focus is on pragmatic ways and enablers for a transition from linear to circular business processes and opportunities, respecting the needs of aviation and honouring the already existing circular practices.***

The standard ISO 59004 provides the following definition of circular economy:

"Economic sytem that uses systemic approach to maintain a circular flow of resources, by recovering, retaining or adding their value, while contributing to sustainable development."[6]

Current State in Aviation

The aviation industry is already very advanced with regard to repair and refurbishment. *Components are engineered for an extended and safe operational life. The substantial MRO services sector plays a crucial role in maximizing aircraft service life. Markets for reusable products continue to develop and expand, especially for turbines and system components.*

When examining Cabin and Cargo specifically, we encounter distinct challenges. The requirement for highly customizable cabin elements with complex material compositions currently restricts reuse and recycling opportunities. Seats offer potential for reuse, though this necessitates additional processes like replacing cushions and covers. Maintaining certification compliance during parts exchange is vital for successful integration into the reuse market. **Stringent certification requirements like fire properties often necessitate the addition of chemicals/flame retardants to many material types, and the market for recycling these highly engineered materials is very limited.** Additionally, the market volume is still too small to generate sufficient interest from recycling enterprises.

Based on current assessments, **the main products used in aircraft cabin and cargo areas are not recyclable, only partially reusable. However, repairability and refurbishment options for many items exist and are applied in daily operations.**

Paths to Greater Circularity

Rethinking Design

Accelerating the transition toward a more circular business model starts with rethinking the design of a product. Circular requirements and opportunities need to be integrated into every new development process. The primary obstacle for parts reuse is often customer-specific design. Each airline requires its unique aesthetic, as this creates the first impression recognizable by their customers – the passengers – and will remain a key customer requirement for the aircraft interiors industry. **Hence, a design must satisfy branding needs while enabling reuse.**

Logistics and Economic Considerations

A sophisticated logistics system can further support parts reuse, with easy interchangeability being crucial as time equals cost. As long as purchasing new parts remains more economical than refurbishing existing ones, market interest in reusable parts will remain limited. Therefore, we also require an effective indication system for valuable components to support harvesting lists for both MRO businesses and disassembly activites. Moreover, custom or waste regulation needs further investigation and/or changes to enable pragmatic reverse logistics options. **The industry needs to better understand this ecosystem and build partnerships.**

Paths to Greater Circularity

Enhancing Product Transparency

Additionally, product transparency is beneficial. This includes indicating critical substances and preferably end-of-life/end-of-use options while also demonstrating their circularity status. Currently, disconnected information chains create costs for MRO/dismantler operations. Without knowledge of a product‘s composition, identifying the appropriate alternative to landfill disposal becomes challenging. This consideration becomes increasingly important as landfill costs rise, potentially becoming unavailable in certain global regions.

Material Flow and Recycling Challenges

For recycling, certain materials and substances necessary for safe and lightweight design impede access to existing recycling channels. Consequently, the industry must investigate and promote the streamlining of material flows and develop suitable recycling alternatives. **In the future, end-of-life requirements have to be considered in product development and material selection, as this will facilitate integration into appropriate recycling pathways independent of industry-specific constraints.** Indicating product characteristics such as recycled content and recyclability can also increase customer interest in certain product categories.

Addressing Obsolescence

Due to the longevity of aircraft and many aircraft parts, obsolescence may become a significant driver for salvaging components before classifying them as waste. As a reminder, the oldest commercial aircraft still in operation celebrated its 50th anniversary in 2024! Parts no longer in production but available in well-organized warehouses support the circular ambition of maximizing product utilization.

Future Market Development

As mentioned, the market for parts reuse is expanding, though currently without substantial focus on cabin components. The reasons for this gap must be assessed and levers identified to generate greater interest in this area for appropriate product development, strategic product positioning, and effective value extraction at end-of-life/end-of-use.

KPI Recommendations for Circularity

Some existing KPIs (Key Performance Indicators) and calculation methodologies are rather academically oriented, requiring extensive data points and ultimately producing “only“ a numerical value without necessarily indicating the underlying reasons. Only practitioners can identify the drivers, and must then communicate them effectively. **The business environment requires simplified and standardized approaches, preferably utilizing the same data points as for LCA/PCF.**

We therefore recommend four Key Performance Indicators:

1

The mass percentage of recycled material within a product. This is straightforward to calculate and aggregates throughout the supply chain. It is also easily comprehensible for customers and can be expressed as a percentage.

2

The mass percentage of reused material within a product. This indicator calculates the percentage of reused or repurposed material, thereby determining the amount of primary raw material.

3

The mass perentage of bio-based material within a product. Correspondingly, the quantity of fossil-based material is known. Regarding bio-based material utilization, an industry-wide discussion is recommended to evaluate all potential negative effects.

4

The recyclability of a product. In the absence of a clear definition of this term for our industry, guidance for baselines and KPIs are required at an international level as well as from political entities. With a clear definition, comprehensive guidance and new requirements for future products can be established.

3. Technical Requirements for Effective LCA Implementation

3.1. Paving the Way: Standardized Approaches for LCA Creation

Challenges of Life Cycle Assessment Implementation

When conducting a Life Cycle Assessment, various tools and databases are available as outlined in the basics section. However, several significant challenges can be encountered with the calculation and practical application of LCA data.

The current standards leave room for interpretation and individual definition when executing the calculation. While this flexibility accommodates the needs of diverse industries, it means that utilizing results in subsequent LCAs and their interpretation can only be accomplished by thoroughly examining all underlying assumptions. Furthermore, the exchange of all relevant details becomes necessary. These details must describe, for example, the scope used, cut-off rules, calculation databases, and other parameters. Such information is typically found in comprehensive reports when an LCA is externally verified, leading to considerable time consumption in further data processing.

The data validity can be dependent on the scope employed. Results may no longer be applicable for subsequent usage. Due to the costs associated with the preparation of LCAs, common industry-wide use should be a high priority in order to limit the number of LCAs required. Unclear industry-specific procedures lead to unnecessary expenses.

Since every LCA incorporates its own assumptions during calculation execution, the results cannot be reliably compared with outcomes from other LCAs. Comparisons can only be made between LCAs where identical assumptions, databases, and standards have been applied.

A further critical consideration is data quality and the proportion of primary data utilized, or the amount of data with sufficient similarity. **LCAs for specific materials are not widely available and depend to a high degree on the energy consumed at the production facility and additional local factors such as water usage.** Consequently, primary data is essential for drawing accurate conclusions.

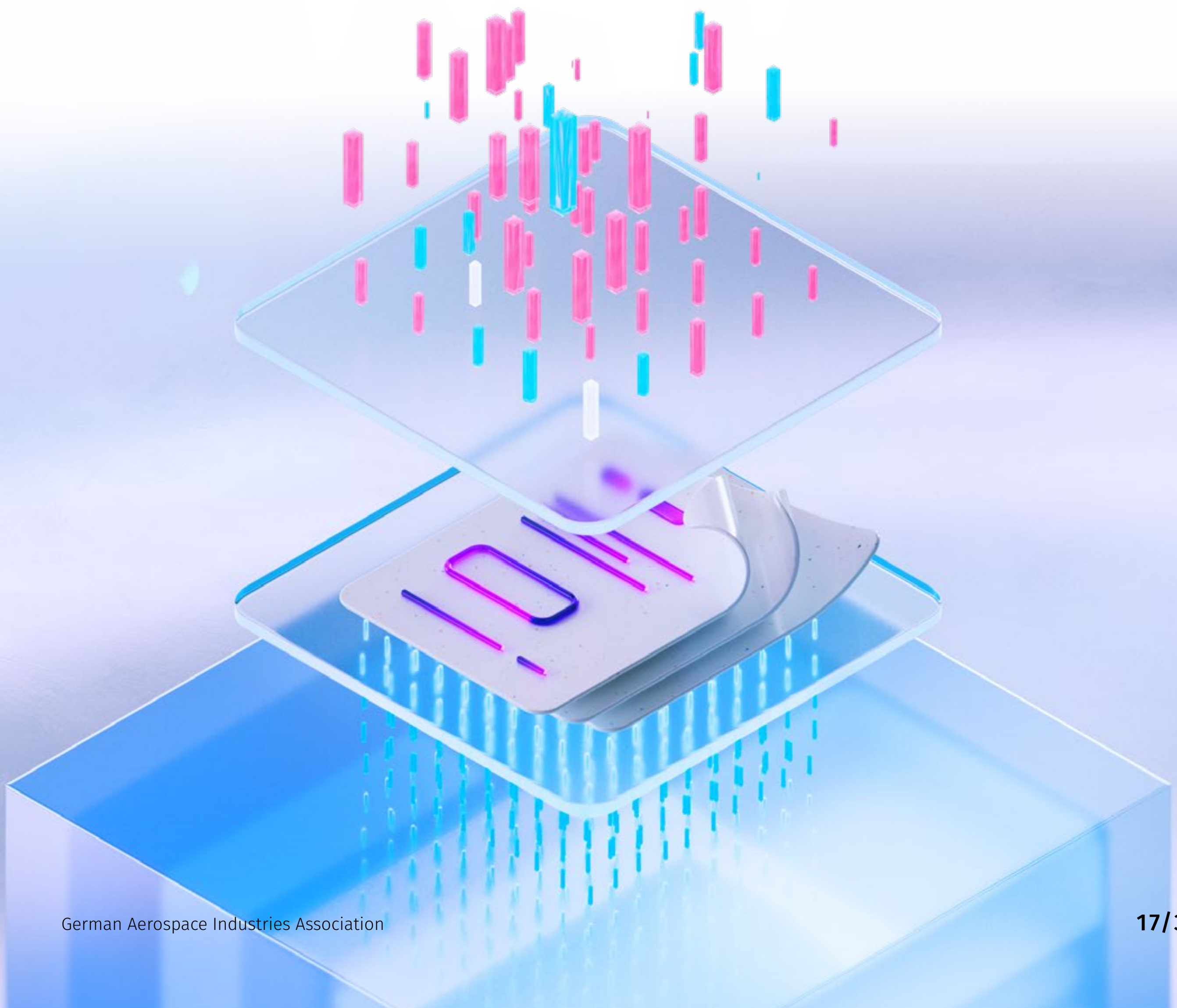
Another challenge involves the availability of highly scientific tools and different databases with limited interconnectivity. Progress towards better integration and more user-friendly software is necessary, which should reflect further developed industry-specific standards.

The Solution: Industry-Specific Rulebook

To address these challenges, ***a solution is recommended that has already been successfully implemented in other industries: the development of an industry-specific rulebook.*** *This rulebook would serve as a supplement to the established ISO norms and would close the gap in assumptions. It would further clarify aviation industry-specific requirements and establish a new standard that could serve as the foundation for external validation. LCAs based on this rulebook would be easily and efficiently usable for subsequent calculations throughout the supply chain.*

The rulebook should include the following information as examples of the most critical aspects:

- The required scope for inter-industry exchange and communication purposes
- Typical product lifetimes, as these significantly impact CO_2 emissions during in-service aircraft operation
- Standardized aircraft mission profiles
- Usage profiles for electrical onboard systems such as IFE (In-Flight Entertainment) or galley components
- Incorporation of standards such as DIN EN 4855-x (GAINs) and prEN 4912 / prEN 4727 (seats) or the European ECO efficiency index
- Guidelines from IAEG (International Aerospace Environmental Group)
- Clarification regarding the end-of-life phase and maintenance aspects
- Clarification on production processes and respective system boundaries



Realization: A Two-Step Approach

As the need for LCA standards is already high today and the development of a dedicated rulebook requires phrasing ***it is recommended to apply a two-step approach.*** *This gives a realistic expectation of the future of LCA analysis.*

MEDIUM TERM

From a medium-term perspective, existing standards such as ISO 14040/14044 or the EU's Product Environmental Footprint provide fundamental guidance and should be applied accordingly. In addition, further guidance shall be developed for the time until a rulebook supports the LCA creation process, as many aspects are already available or self-evident. Within the next two years, the development of a rulebook by the Aerospace-X community is expected. This shall be deployed within the whole industry and can be further used for product carbon footprint calculations.

LONG TERM

In the long-term, the rulebook shall be further refined and widely implemented and the amount of standardized LCAs has to be further increased.

3.2. The Foundation of Analysis: Databases and Tools for LCA Calculations

A state-of-the-art software with connections to one or more databases is essential for LCA calculations. To date, the market offers a limited selection of adequate scientific tools. Some software enables the creation of numerous LCAs through AI implementation. However, such software typically involves substantial implementation and licensing costs. Also, the use of these tools usually requires specific expertise. Therefore, a rapid implementation without comprehensive training and low-effort "quick LCA calculations" is not realistic.

All these factors make it difficult especially for small and medium enterprises (SME) to afford LCA creation. SMEs have a significant share in the aviation supply chains. Therefore, it is important that they receive support in preparing LCAs. This can be achieved either through discounted licenses from a shared pool or through assistance in commissioning service providers.

Currently, the exchange of LCA data between different tools is only possible to a very limited extent. It is important to maintain freedom of competition, allowing aviation industry companies to determine which tool is most suitable for their needs. Tool providers should therefore work on developing standardized interfaces and a standardized exchange format.

Where only individual calculations are required to evaluate technologies and their impacts regarding comprehensive Life Cycle Assessments, the available LCA software solutions appear to be sufficient. Product Carbon Footprints (PCFs) require different approaches. **User-friendly tools are required that can generate**

initial indications of high-impact areas. This approach would lower the threshold for entering the field of environmental product transparency with a data-driven methodology.

For the longer term, we anticipate the need to adapt tools toward greater accessibility and alignment with further standards to reduce calculation time and complexity. Since the most time-consuming aspect of the calculation process is identifying correct datasets, tools could be improved by implementing enhanced features for searching and incorporating datasets.

As current tools are predominantly calculating single LCA analyses, comparing a few similar products, the market lacks comprehensive solutions that analyse the environmental impact across an entire aircraft. A tool integrating environmental impact data at the layout level would support airlines in decision-making and manufacturers in prioritizing the development of sustainable solutions by assessing the overall impact.

The Importance of High-Quality Datasets

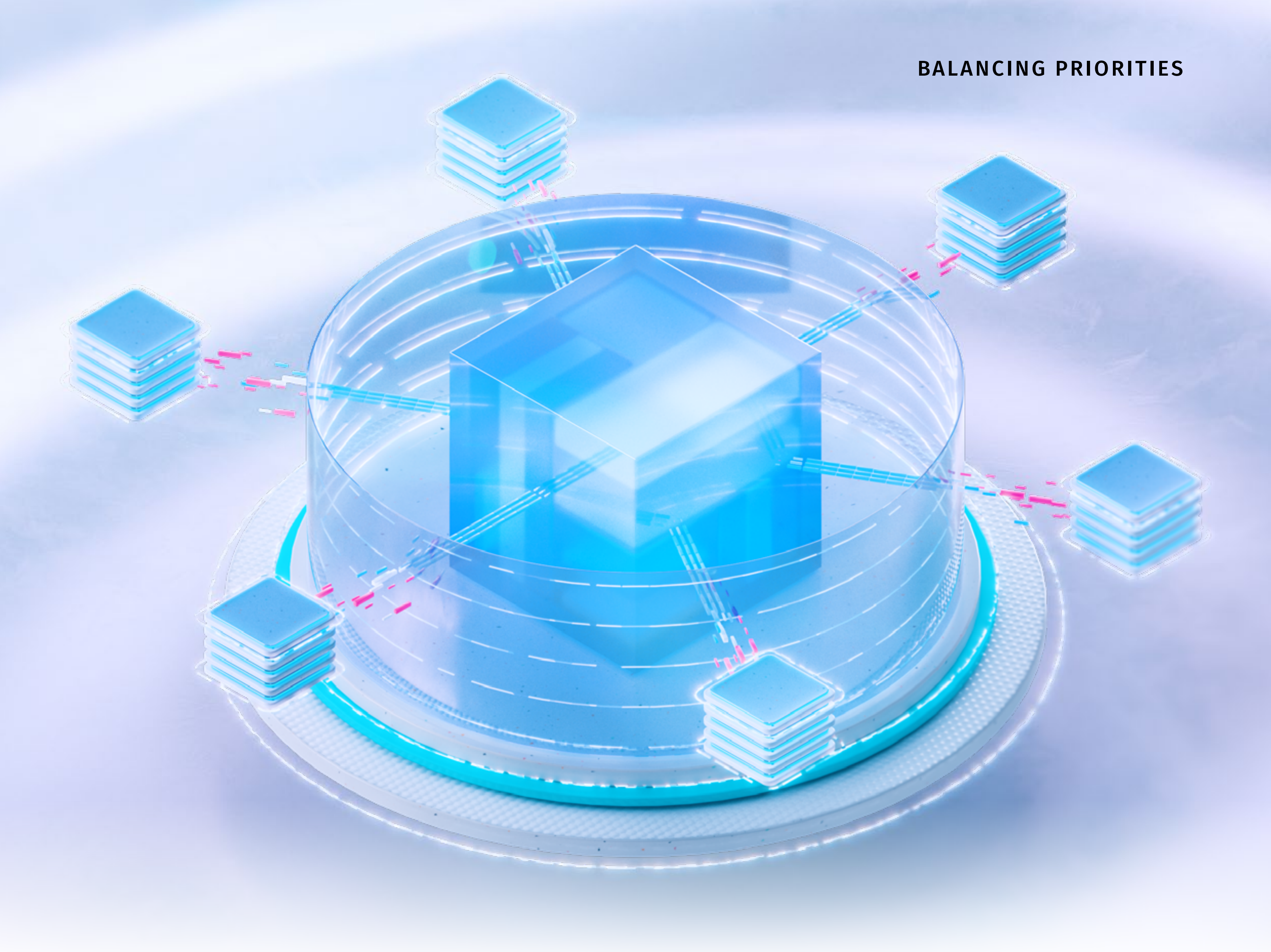
A critical component of LCA calculation is the availability of interconnected datasets within comprehensive databases. Several important aspects must be considered in this regard.

A well-designed database facilitates efficient searching and rapid data retrieval. It also ensures information is stored in a consistent format. **The sheer volume of aircraft interior parts can only be managed and queried with a logical collection of data.** Since dataset selection is influenced by numerous factors, these databases must offer easily accessible and searchable parameters. Moreover, the values must be reliably validated as described in the external validation chapter.

The incomplete and missing entries for aviation materials pose a major challenge. Addressing these gaps comes with substantial effort, necessitating careful prioritization. Another significant weakness involves the compatibility between datasets and calculation tools, as most tools cannot accommodate all databases. The exchange and utilization of data independent of the database presents difficulties, as datasets cannot be easily imported. Therefore, enhanced capability to integrate proprietary datasets represents another essential requirement for these tools. This functionality is frequently needed, as many datasets remain confidential due to non-disclosure agreements and stringent standards for inclusion in public databases.

The databases must satisfy the requirements established for aviation LCAs in terms of standards such as ISO norms or custom rulebook standards. **A high-quality database can readily indicate dataset quality through searchable attributes.** Furthermore, the input and output processes for datasets within a database should be governed by specific security protocols. The database architecture should be adaptable to accommodate aviation materials.

Guidelines should be developed for substitute materials when data for specific materials is unavailable. **The use of different databases can significantly reduce comparability between results.** For use in aviation, tools should also progressively be able to integrate environmental impact data at the layout level.



Recommendations for Database Improvement

MEDIUM TERM

For the medium term it is therefore recommended to improve the databases to achieve a possible future whitelisting due to higher transparency of information. Whitelisting is intended to mark LCA datasets that meet the quality requirements of the rulebook. To accomplish this, evaluation criteria for databases including datasets need to be developed. An overview list of the most commonly used industry-wide datasets can reduce the time-consuming search process within databases.

In parallel, evaluation criteria for database selection should be established. Additionally, a whitelisting system for databases used in aviation LCAs should be implemented during this period. Requirements for tool-to-database interfaces should also be clearly defined at this stage.

LONG TERM

In the longer term, means shall be created to expand LCA data sets for materials and manufacturing processes used in aviation.

3.3. Breaking Silos: Data Exchange Across Supply Chains

The exchange of data across multiple tiers of the supply chain presents a substantial challenge for comprehensive Life Cycle Assessments. *Creating full transparency requires collecting and sharing data from diverse suppliers throughout the value chain. This becomes particularly complex when dealing with information protected by intellectual property (IP) rights, which significantly complicates transfer and exchange processes. Currently, there are no clear guidelines that specify when and how frequently this data should be exchanged, as well as which specific types of data should be provided.* ***One practical solution is to require, at minimum, the cradle-to-gate results for any produced component, while the final integrator would then complete the full cradle-to-grave analyses. This requires a standardized data interface format that includes environmental indicators tailored to the specific data requirements of the customers.***

Key Challenges in Data Exchange

Ensuring transparency across the entire supply chain represents one of the most significant challenges. This necessitates that all participating parties have access to essential data to guarantee complete traceability. The development of standardized interfaces becomes critical to facilitate automated data exchange and ensure data availability in consistent formats.

Managing intellectual property rights creates additional complexity, as IP protection can impede effective data exchange. Addressing this requires clarification of the legal framework and precise definition of which LCA data falls under IP protection. A thorough legal assessment is needed to determine appropriate methods for exchanging LCA datasets.

Data quality and verification play equally crucial roles. Establishing data quality requirements and verification processes ensures that exchanged LCA data remains reliable and accurate. This can be accomplished through certification bodies and robust internal quality control systems. Implementing strong data security measures is also essential to protect sensitive information during exchanges, including encryption, controlled access protocols, and secure communication channels.

Exchange Framework

When considering LCA data exchange, a fundamental question emerges regarding whether to exchange raw data or processed LCA datasets. **Exchanging LCA datasets according to well-defined rules is generally preferable as it minimizes research efforts.** While primary data exchange should remain exceptional, third-party providers may facilitate such exchanges in the future, e.g. by using block chain technologies. The timing and frequency of exchanges should align with product group prioritization and internal company requirements, particularly for new developments.

Implementation Approaches

The depth and breadth of data exchange varies based on specific needs. **In the near term, verified absolute values should support B2B communication, while delta values for reference components can serve public communication purposes.** Looking ahead, advanced software tools enabling automated LCA data exchange –

similar to applications and solutions from Manufacturing-X projects – represent promising solutions.

The absence of unified data exchange standards currently complicates the implementation of consistent interfaces. However, existing software solutions like those mentioned above offer valuable models for developing such standards. These tools enable automated and standardized data exchange, ensuring traceability and facilitating correction of inaccurate information.

By embracing these technologies, organizations can manage and share LCA data more efficiently, enhancing transparency and traceability throughout their supply chains. Addressing data exchange challenges in LCA contexts requires a combination of clear regulations and sophisticated technological solutions. Developing standardized interfaces and leveraging advanced software tools represent crucial steps toward increased supply chain transparency and efficiency. By implementing these measures, companies can not only satisfy emerging regulatory requirements but also gain competitive advantages through more sustainable and transparent operational processes.

3.4. Beyond Numbers: Meaningful Presentation of Results

The LCA is generating a dataset on the ecological, health, and resource aspects for each product, categorized into 16 critical information points on important criteria such as carbon emissions that drive other decisions.

To maintain transparency while focusing on the most significant impact criteria, standardization of LCA outputs within the industry becomes essential. A promising approach would involve categorizing impact priorities according to their accuracy and confidence levels. This methodology would preserve critical insights while making results more accessible and actionable for decision-makers.

Reporting Approaches

LCA reporting could start with a delta representation to a baseline LCA, in which the differences or improvments of the new product are shown. **The BDLI Working Group recommends four alternative reporting approaches:**

1. Presentation of every impact category
2. Single score and climate change
3. Single score and selection of midpoint indicators
4. Selection of midpoint indicators

Prioritization of Impact Categories

A Life Cycle Assessment (LCA) offers a comprehensive methodology for evaluating environmental impacts within the aviation industry. It is essential to recognize, however, that aviation activities have varying degrees of influence across different impact categories. For instance, categories such as ionizing radiation are minimally affected by aviation operations.

Excluding specific categories based on perceived limited relevance introduces the risk of overlooking potentially significant issues. Furthermore, such omissions would preclude the possibility of developing consolidated evaluations, such as single-score assessments.

Therefore, it is recommended to include all impact categories and prioritize them by differentiating between their accuracy requirements. This approach ensures a thorough and balanced analysis without neglecting any potentially significant environmental aspects, while acknowledging the varying relevance of different categories to aviation-specific activities.

3.5. Ensuring Credibility: The Role of Independent Validation

As described above, there is a clear need for a standardized approach to performing Life Cycle Assessments in order to ensure consistent and comparable results that align with existing high-level standards and regulations. ***This is of specific importance in a global industrial ecosystem like Cabin and Cargo with a high variety of suppliers and products and shorter life cycles and related cabin upgrades.***

If LCA results are intended to be used for publication or any other external use cases, it is recommended that the method applied in the LCA study as well as the data and life cycle inventory being used undergo an independent 3rd party validation. This validation process involves an independent organization assessing the accuracy and completeness of the study. Such validation can ensure that the applied methods and tools comply with existing ISO 14040 and 14044 standards, as well as with future industry-specific rulebooks. Additionally, it confirms that the data used and defined boundaries are appropriate for the specified scope and objectives of the study.

Life Cycle Assessments also play an increasingly significant role in the regulatory context. To ensure the credibility of these assessments, verification by an independent body becomes essential, especially when aggregating data across different stakeholders into an integrated product evaluation.

The assessment by a third party also examines how results are used, interpreted, and presented, ensuring that the final report maintains coherence and transparency throughout.

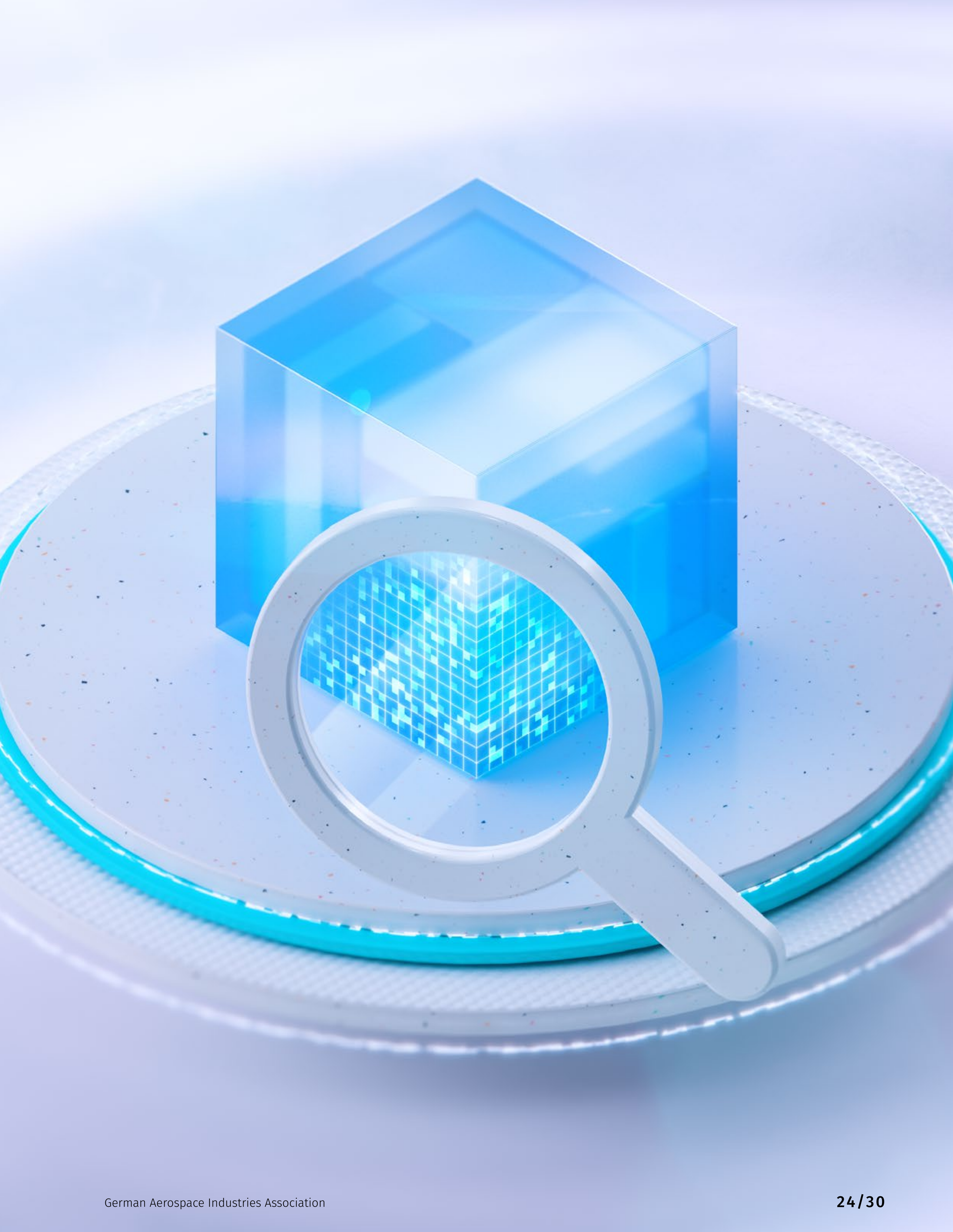
Another aspect is the avoidance of greenwashing, for which the involvement of independent 3rd party validation is an important prerequisite. This external verification helps establish trust in environmental claims and helps prevent misleading communication about sustainability performance.

Validation Approaches

In principle there are two possibilities for a 3rd party validation:

1. **3rd Party Validation of each individual LCA.** That would require significant effort, time and costs.
2. **3rd party validation of the overall process** (e.g. as part of a industry specific rulebook). Each LCA has to be in line with the process definition in the rulebook.

For simplified environmental assessments created during the product development phase, third-party validation is not mandatory. Any assumptions made during these preliminary assessments should be documented and shared using a standardized template. These initial assessments can be replaced with a comprehensive Life Cycle Assessment once the product development is finalized. **For the final LCA, a 3rd party validation is required.**



3.6. Setting Priorities: Creating a Product List for Cabin and Cargo

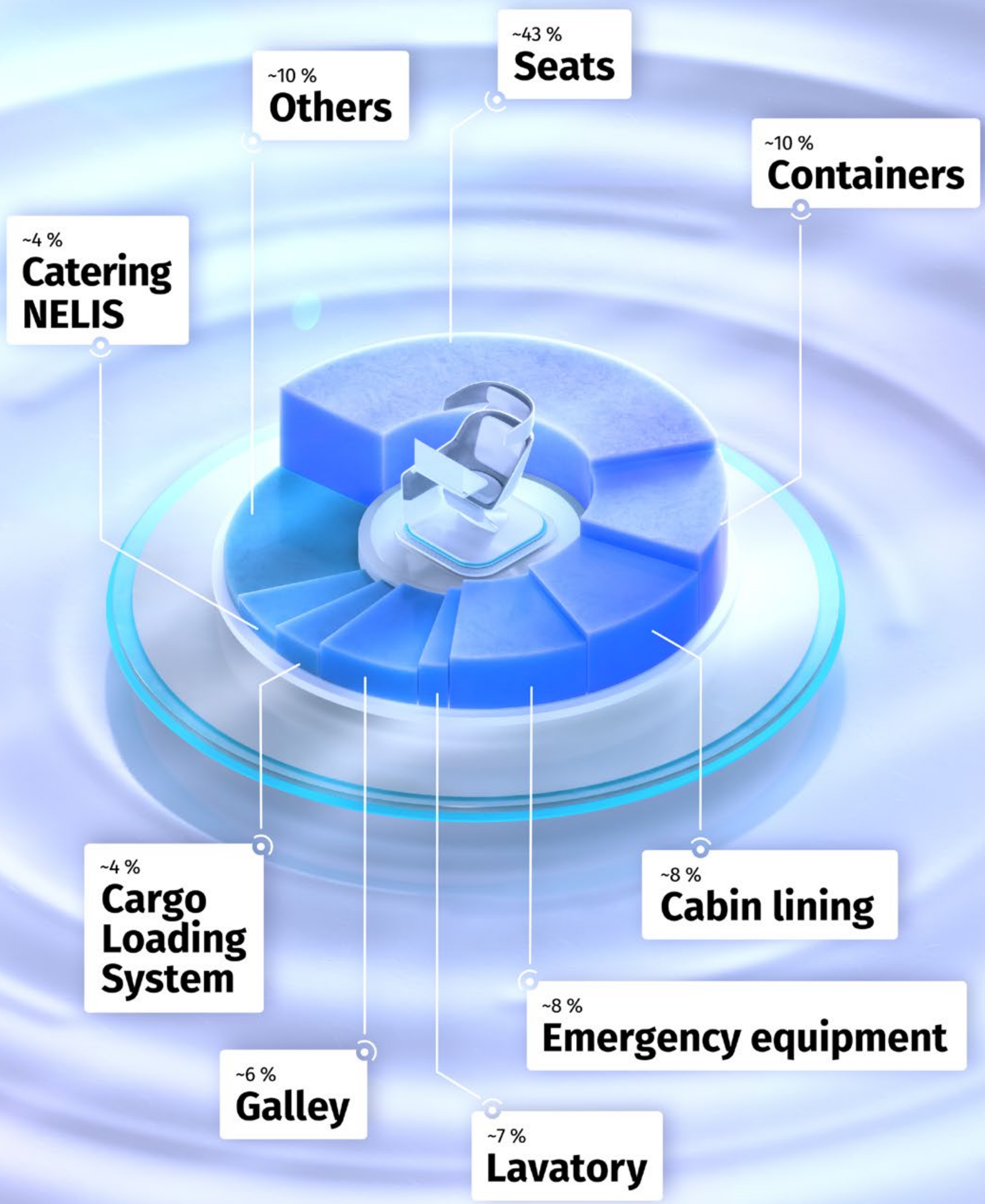
*When implementing transparency measures, a fundamental question emerges: which products should be addressed first? **A carefully compiled product group list with reference LCAs is crucial to achieving a comprehensive overview of the environmental impact of different products in the cabin.** This strategic approach provides a structured framework for identifying environmental hotspots and establishing clear priorities among specific product groups.*

Initially, prioritization can be primarily done based on weight, as weight is usually the main contributor to the products' environmental impact. The weight share per product group can be determined by analysing light, medium and heavy single-aisle cabin layouts. **Product groups with a high contribution to the cabin weight could be addressed first.**

Product prioritization could also focus on cabin components with fully or partly-known recycling and environmental data to perform initial LCAs on low-complexity products and supply chains. This approach enables a systematic scaling of LCA efforts from simpler assessments to more complex environmental impact evaluations.

Additional evaluation criteria include energy consumption, product service life, and supplier diversity. Supplier diversity was selected as a rating category because customers have significant choice in this area. Consequently, more comprehensive environmental data should be collected in these cases to enable customers to select the products with the best environmental performance.

Percentage weight distribution based on an average single-aisle cabin layout



4. Strategic Recommendations for Standardized Environmental Assessment in Aviation

Comprehensive Action Plan for Industry Implementation

To improve environmental assessments in the aviation industry, the gradual development of standards is recommended. *Initially, efforts should concentrate on developing a Product Carbon Footprint (PCF) standard, which can later be expanded to encompass more comprehensive LCA standards. Until these formalized standards are established, simple guidelines should define key assumptions and be applied alongside existing ISO standards. Additionally, guidelines for a simplified LCA approach (Light LCA) should be developed specifically for application during the early stages of product development.*

Key Recommendations:

#1: Industry-wide Collaboration

Close industry-wide collaboration and alignment with existing working groups (such as IAEG WG 12 or Aerospace-X) is recommended to identify synergies, strengthen partnerships among stakeholders, and foster the implementation of environmental assessments in product development. In this context, the BDLI working group can play a key role in identifying the specific needs of Cabin and Cargo and in developing the necessary standards and rulebooks.

#2: Standardize LCA Approaches

It is recommended to develop an industry-specific rulebook that supplements existing ISO standards and provides clear guidelines for aviation-specific LCA creation, ensuring comparability and efficient resource use.

#3: Optimize Result Presentation

All relevant environmental impacts should be calculated, with different accuracy requirements for certain categories being prioritized in a set of rules. The aim is to develop a clear recommendation for the presentation of results that is also defined in the rulebook and that is understandable and adaptable for different areas of application. A harmonized data interface format (incl. boundary conditions, functional units, metrics) should be established to ensure seamless data integration between stakeholders.

#4: Ensure Result Credibility

The rulebook should define how the validation of LCA results should be carried out. **It should be specified when validation by third parties is required in order to ensure the transparency and credibility of the results.** The recommendation is that LCAs are externally validated in case of publication; internal validation would be sufficient for exchanges between companies.

#5: Improve Calculation Tools

The development of more user-friendly LCA calculation tools is recommended, for example by improving the search functions and better integration of own datasets. Tool flexibility is essential to maintain market competition. Compatibility between different tools should therefore be improved. Small and medium-sized enterprises (SMEs) can quickly become overwhelmed by high license costs and technical requirements for users. Further support is therefore recommended, e.g. in the form of discounted/shared licenses from a common pool. In addition, tools should be developed that enable environmental assessment at the layout level in order to support well-founded sustainability decisions at an early stage.

#6: Enhance Database Quality

For the aviation industry, specific datasets on materials should be integrated to enable a more accurate LCA. **It is recommended to whitelist datasets that meet the quality requirements of the rulebook and improve compatibility between different databases and tools.** The possibility to integrate own datasets into the tools should also be enabled.

#7: Promote Circularity Measures

Thanks to its short product life cycles, the Cabin and Cargo industry has the opportunity to implement new innovations quickly. The transition to a more circular economy should be accelerated. Transparency and measurability are crucial here, which is why the following KPIs are recommended:

- Recyclate content
- Proportion of reused components
- Proportion of materials made from renewable resources (each by mass percentage)
- Recyclability

The definition of recyclability has not yet been established. A standardized definition should be developed.

Sources

[1]: ISO 14067:2018 — Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification

[2]: ISO 14040:2006 — Environmental management — Life cycle assessment — Principles and framework

[3]: ISO 14044:2006 — Environmental management — Life cycle assessment — Requirements and guidelines

[4]: Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on substantiation and communication of explicit environmental claims (Green Claims Directive), 2023, European Commission, Directorate-General for Environment

[5]: Ecodesign for Sustainable Products Regulation, 2024, European Commission, Directorate-General for Environment

[6]: ISO 59004:2024 Circular economy — Vocabulary, principles and guidance for implementation

[7]: The role of Cabin and Cargo for sustainable aviation, 2023, Bundesverband der Deutschen Luft- und Raumfahrtindustrie (BDLI – German Aerospace Industries Association)

Bundesverband der Deutschen Luft- und Raumfahrtindustrie
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