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A systematic approach for identifying key stakeholders in sustainable product development—a missing step to realize decades of sustainability work

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Introduction: The manufacturing industry faces transformative challenges toward a circular economy. A key challenge in circularity is creating value for all value chain partners. In this study, the focus is on the aerospace industry and the challenge of creating resilient solutions with suppliers, given the product's long lifespan of about 30 years, a long production period of about 20 years, and a long product and technology development time of about 7 years. The overall goal of this research is to increase partners' capabilities to create and develop long-term, sustainable, resilient, and circular solutions within a value chain.

Methods: Building on a longitudinal study conducted within an aerospace company, this research applies and further develops a systematic approach for identifying key stakeholders in sustainable product development, now extended to incorporate a circularity dimension. The research methodology consisted of three methods: identifying stakeholders in the life cycle, classifying the key stakeholders using the stakeholder salience model, and conducting interviews. The stakeholder mapping was conducted using a longitudinal approach at two time points: 2015 and 2025, at the same case company. It was conducted through several workshops. Nine semi-structured interviews were conducted in 2025 with key stakeholders representing different parts of the aerospace value chain.

Results: The study indicates an increasing complexity in the company's value chain. Compared to ten years ago, the context now reflects a stronger emphasis on sustainability and circularity, requiring broader engagement and collaboration. In addition, some key factors are identified that facilitate effective collaboration among the key stakeholders in aerospace for a resilient and sustainable product development.

Discussion: The proposed stakeholder analysis method can provide a structured approach to identifying, classifying, and prioritizing key stakeholders within complex value chains, thereby supporting product design teams in developing strategic plans for circular solutions. The method helps understand which actors are most critical to collaborate with when developing sustainable and circular solutions. Furthermore, the method enables discussion of how stakeholder roles may need to evolve to support more circular and resilient value chains and identifies stakeholders that have the potential to either drive or hinder the implementation of circular solutions.

KEYWORDS
Aerospace, circular solution, resilience, stakeholder analysis, sustainable product development, value-chain

1 Introduction

Sustainability has long been recognized as a key driver shaping both current and future solutions within the aeronautics industry. More than two decades ago, the Advisory Council for Aeronautics Research in Europe (ACARE) established a Strategic Research Agenda (SRA) to guide and coordinate European research initiatives toward reducing the environmental impact of aircraft and associated systems throughout their entire lifecycle—from manufacturing and operation to maintenance and end-of-life management. Successive updates of the SRA, such as SRA2, further strengthened these ambitions by introducing the vision of an "Ultra Green Air Transport System." (ACARE, 2002; ACARE, 2004).

At a component-manufacturer level, such as at GKN Aerospace, efforts to meet ACARE's strategic goals were translated into concrete design and performance targets, including reduced weight, lower noise levels, decreased emissions, and improved reliability (Hallstedt et al., 2013). These ambitions were complemented by explorations of solutions for new fuels, optimized flight routes, and innovative design strategies to minimize fuel consumption. However, despite over two decades of technological progress, the industry continues to face major challenges in balancing environmental objectives with economic competitiveness. When full life-cycle responsibility is considered—not only from an environmental but also a social and resource perspective—the complexity increases substantially. These long-standing challenges, first identified more than ten years ago, remain unresolved and have become even more critical today as circularity and systems-level sustainability are now essential to the future resilience of the aerospace sector (ICAO, 2025).

The challenge, specifically related to circularity, is the shift toward shared system-level value creation, where new forms of collaboration and co-creation may be needed. In the aerospace industry, there is also a challenge to create resilient solutions with suppliers since the product has a long lifespan of about 30 years (Elsayed et al., 2019), a long production period of about 20 years, and a long product and technology development time of about 7 years.

In an earlier study with GKN Aerospace, risks were already identified in 2013 (Hallstedt et al., 2013) with being dependent on advanced materials in their products. The main risks highlighted at that time were: availability of alloy elements, reliable cooperation with suppliers and customers, finding the optimal ownership perspective of activities and product/services. One product design case at GKN Aerospace, which is a jet-engine component company and first-tier supplier, was studied, which focused on reducing the climate impact, resulting in the consideration of new materials. From this work, material criticality became recognized, and a new research project was initiated, which resulted in a method for how the company, in early design development, can assess alloy materials from a sustainability and availability perspective (Hallstedt and Isaksson, 2017).

Assessing materials can increase knowledge and guide design solutions in other directions, such as selecting alternative non-critical materials. Perhaps the most interesting consequence of introducing this new assessment tool was that it triggered new questions and new ways of thinking in the company. They started to consider whether there was a risk of increased material costs in the future. Considering the dependence on potential critical materials already now (2013), which need to be produced in 20–30 years, and what that would mean if the number of aircraft increased in the future. They began to consider whether they needed to investigate more radical new designs and business models, increase the degree of circularity through repair and remanufacturing, and also increase the percentage of recycled materials in components.

Six different scenarios/options of activities, flows, and ownership in the value chain with the objective to keep valuable materials in a closed-loop system were therefore discussed already in 2015, such as: which alternative(s) give fewer sustainability consequences and most value, and when in time is it most beneficial to introduce them. An introductory approach was developed to evaluate the different scenarios, and a decision-support model-based approach was proposed (Bertoni et al., 2015).

Since then, upcoming regulations and new requirements from society have pushed the industry toward a circular economy (e.g., the Critical Raw Material Act, European Commission, 2023). Therefore, there is a new incentive for the company to revisit this area and focus on developing resilient solutions by reducing dependence on critical raw materials, increasing flexibility in sourcing remanufactured parts, and improving response capabilities during supply disruptions.

One important first step is to consider who to develop and co-create new circular solutions with. To understand and identify your key stakeholders from a sustainability and life cycle perspective, a conscious and tactical decision is needed on which actors to involve creating these circular solutions. To identify the key stakeholders from a sustainable product development perspective, a proposed method was developed and applied and evaluated at GKN Aerospace and another large company within the construction industry in our previous research around 2015.

The main contribution of this research is to explore and propose (i) an adapted method for defining the core value chain actors involved in developing future sustainable and circular solutions, with a specific focus on the aerospace sector, and (ii) to explore which are some current capabilities for creating circular and sustainable solutions in the value chain and what are some future needs. Building on a longitudinal study conducted within an aerospace company, this research applies and further develops a systematic approach for identifying key stakeholders in sustainable product development, now extended to incorporate a circularity dimension. The study also aims to validate this methodology by comparing empirical findings from 2015 with contemporary results, thereby providing new insights into how stakeholder relationships and priorities have evolved. Furthermore, it proposes methodological improvements to better capture the role of circularity in stakeholder identification and engagement.

2 Literature review

2.1 Sustainable product development

The transition to a sustainable society is a complex but necessary task in which manufacturing companies have to take part in, not only to preserve the natural and social systems, but for their own long-term success.

Sustainable Product Development (SPD) was first defined in 1995 by van Weenen as "meeting the elementary demands among present and future generation through product functions and its systems, considering the resource availability and distribution" (van Weenen, 1995). Maxwell and van der Vorst (2003) further developed the concept of SPD as the process of making products which achieve a balance between environmental protection, social equity and economic prosperity. Products developed in this context need to fulfil traditional criteria as well as sustainability requirements. Sustainable product development can be applied to existing products, but ideally at the concept stage, where greater opportunities for the development of a more sustainable solution may be realized (McAloone and Bey, 2009). Nowadays, sustainable product development is generally defined as the integration of sustainability issues in the various activities associated with engineering practice (Gagnon et al., 2012), more specifically, the integration of a strategic sustainability perspective into early product innovation stages (Hallstedt, 2017). Sustainable product development is a broad term, not only covering design activities but also organizational functions such as strategy, technology or change management (Vilochani et al., 2024).

To strategically design products toward sustainability, there is a need to understand what the desired future state looks like. The Framework for Strategic Sustainable Development (FSSD) can be used in this context: it presents a definition of sustainability based on eight first-order sustainability principles. These principles can be used as boundary conditions for a long-term vision of sustainability and backcasting (Broman and Robèrt, 2017). Previous research has applied this framework in the context of sustainable product development, e.g., to define sustainability criteria and sustainability compliance index (Hallstedt, 2017), to manage sustainability risks (Schulte and Knuts, 2022) and assess product sustainability performance at early design stages (Hallstedt et al., 2023).

Addressing the product development level is crucial in the context of the sustainability transition, as it includes the key business functions, strategic transformations, technological advancements and social meanings of new products and services (Gaziulusoy et al., 2013). Sustainable innovations contribute to increasing competitiveness of a company; it can not only provide direct costs savings through efficiency (Maxwell and van der Vorst, 2003), but also increase companies' capability to be resilient (Chari et al., 2024) and create value for stakeholders (Li et al., 2021). These dynamics are increasingly understood by the investment sector (Schulte and Hallstedt, 2018), but there is a gap between company's ambitions to be more sustainable and actual implementation of sustainability (Schulte and Hallstedt, 2017).

2.2 Value chain collaboration in aerospace and identifying key stakeholders

Manufacturing companies increasingly consider circularity as a pathway toward sustainability, yet are faced with the challenge that extending and closing resource loops requires collaboration beyond the boundaries of their own organization and value chain. Dokter et al. (2025) point out nine key factors for the development of collaborative circular value chains, which provide a basis for understanding how collaboration can be strengthened across actors to support circular and more sustainable value chains (see Table 1).

Aerospace value chains differ from those in many other industries due to (1) a limited number of actors forming complex global networks, (2) long development cycles and low production volumes, and (3) long product lifecycles combined with strict quality and safety requirements. These characteristics create both challenges and opportunities for circularity and are essential when considering how circular value chains can be developed in this context. Vogiantzi and Tserpes (2023) highlights that the aerospace industry is characterized by a highly concentrated supplier base, creating dependency on key suppliers for the development of environmentally friendly materials. In addition, the long life cycle of aerospace products hinders the development of circular components and materials by constraining learning and feedback from material performance, reinforcing existing material choices, and increasing safety and certification risks (Franchino, 2023). A circular transition in the aerospace industry places increasing demands on traceability, which is required not only to enable the recirculation of parts and materials, but also to verify component authenticity and prevent counterfeits, which can cause safety and reliability concerns. Recent supply chain disruptions and component shortages have limited aircraft manufacturers' ability to meet rising demand for new planes due to increased travel (The Guardian, 2024).

Although collaboration is widely recognized as a key enabler for achieving circular solutions (Geissdoerfer et al., 2018), much of the literature focuses on circular initiatives within individual organizations rather than on the broader network of stakeholders needed to implement circular solutions across value chains (Dias et al., 2022). In aerospace, challenges such as maintenance, material recovery,

TABLE 1 Overview of the nine factors for development of collaborative value chains described by Dokter et al. (2025).

Factor	Description
Building trust	Certainty to partners and mitigate risks
Collaborative governance	Establish structure for collaboration
Collaborative processes	Guiding the process of collaboration
Ecosystem orchestration	Facilitate collaborative processes within the circular ecosystem
Ecosystem perspective	Foster a circular ecosystem perspective
Monitoring and evaluation	Measuring progress in collaboration toward the circular value chain
Shared vision	Develop a shared vision for a circular ecosystem
Sustainability leadership	Develop holistic leadership
Value mapping	Identifying external stakeholders and shared value

remanufacturing, recycling, and end-of-life management require the involvement of multiple actors across the lifecycle (Vogiantzi and Tserpes, 2023). However, limited research has focused on how to systematically identify the stakeholders needed to support and govern these circular activities toward the formation of circular value chains. This represents an important gap, as realizing circular value chains depends on understanding which actors are necessary for establishing and managing a circular system, and understanding respective incentives and levels of influence to better understand pathways for successful collaboration.

2.3 Stakeholder mapping methods

A broad range of stakeholder mapping methods exist, and there are different definitions on who or what constitutes as a stakeholder. According to Freeman (2015), stakeholders can be defined as "any group or individual who can affect or is affected by the achievement of the organization's objectives." As highlighted by Reed et al. (2009), understanding who has a stake in an initiative, the nature of their claims, and their interrelationships, is essential for effectively involving relevant stakeholders in environmental decision-making.

The choice of framework to identify, classify, and analyze stakeholder relationships often depends on the purpose of the stakeholder analysis, as well as the skills, resources, and technical expertise. An overview of some frameworks and models, such as the Mendelow (1981) power-interest matrix, power-influence matrix by Eden and Ackermann (1998), and the rainbow diagram (Chevalier and Buckles, 2008) is listed in Table 2. These frameworks are often used for their simplicity and visual presentation of results. Power-interest and power-influence matrices help identify which stakeholders to engage with and prioritize when addressing a particular issue, while also clearly visualizing the stakeholder positions. The rainbow diagram similarly supports clear communication of results but is dependent on how stakeholders are initially identified, which is making it useful as a pre-step before applying more analytical frameworks. A recurring challenge across these frameworks is that they typically do not account for changes over time and do not account for changes in stakeholder salience, influence, or interests. Accounting for such changes is important because stakeholder roles may evolve in response to external changes such as sustainability requirements.

2.4 The stakeholder salience model

In this research study a longitudinal approach is adopted, applying Mitchell et al. (1997) framework to analyze how stakeholder attributes and salience have shifted over the past ten years.

The stakeholder salience model by Mitchell et al. (1997) identifies and classifies stakeholders based on three attributes: power, legitimacy, and urgency, to support managers in determining when and how to respond to different types of stakeholders. It has been applied in multiple contexts, including the semiconductor supply chain (Tian et al., 2025), construction procurement (Ababio et al., 2025), and urban contexts (Esposito et al., 2023), addressing sustainability challenges. One advantage highlighted by Beck and Ferasso (2023) is the salience stakeholder model's emphasis on legitimacy, which has been shown to be a critical factor in building partnerships and fostering collaboration. Several limitations are also pointed out, for example, the attribute of power is dynamic and can shift over time and across stakeholders, which the model does not capture (Beck and Ferasso, 2023). Urgency is similarly complex, since its meaning and relevance may vary according to different stakeholders and contexts, making it difficult to assess. Additionally, the model does not capture how stakeholders may evolve in their roles, such as moving toward becoming definitive stakeholders, and does not show how the value of power, legitimacy, and urgency can change among stakeholders (Esposito et al., 2023). Therefore, there is a need for longitudinal perspectives where stakeholder roles change as new sustainability requirements emerge.

However, applications of the stakeholder salience model within aerospace to understand evolving stakeholder dynamics remain limited. This study therefore addresses the gap by providing a structured way to capture stakeholder dynamics and prioritization, which is relevant for circular economy transitions, where collaboration and stakeholder engagement across the value chain are important. Others have also highlighted that stakeholder engagement in decision-making, communication, and problem-solving is a critical mechanism by which organizations enhance resilience (Ghanbary and Karimimehr, 2026). Integrating the circularity dimension into the stakeholder salience framework enables analysis of stakeholders within the aerospace industry that are important to develop circular value chains.

2.5 Research gap and research questions

Despite the growing body of research on the role of stakeholder collaboration to create resilient, circular solutions, several limitations remain. Existing approaches provide limited support to systematically map relevant stakeholders across from a strategic, company perspective, covering the whole lifecycle of their products. Additionally, existing frameworks do not typically reflect changes over time of the role and importance of value chain stakeholders for circularity, which limits insights in a single point in time. Finally, after the stakeholder mapping is completed, companies still lack support to put actions in practice and begin to orchestrate a circular value chain.

Taken together, these gaps suggest the need for a more comprehensive investigation of capture the role of circularity in stakeholder identification and engagement. To address this need, the present study seeks to answer the following research questions (RQs):

> *RQ1*: In which way can a "key stakeholder analysis method" for sustainable product development support a project design team when creating resilient and circular solutions?
>
> *RQ2*: What are some new insights into how stakeholder relationships and priorities have evolved since a decade ago at the case company?
>
> *RQ3*: *What are gaps and capabilities* for creating long-term, sustainable, and resilient circular solutions within the value chain within the aerospace industry?

3 Methodology

This research employs a single-case study approach in which an organization's value chain is explored in depth. The case company, GKN Aerospace Sweden AB, is a Tier 1 aerospace components designer and manufacturer. Since 2023, the group has focused solely on the aerospace business and has about 16,000 employees. GKN

TABLE 2 Examples of stakeholder frameworks found in literature, expanded and based on Reed et al. (2009).

Framework/Tool	Purpose and application	Strengths	Limitations
Stakeholder Salience Model (Mitchell et al., 1997)	To rank stakeholders according to their importance to the organization based on three attributes: power, legitimacy, and urgency	Explains stakeholder salience and dynamism systematically. Systematic sorting of stakeholder relationships.	Stakeholders change in salience, and levels of attributes can vary from issue to issue and time to time. Each attribute is treated as" present or absent."
Power-Interest Matrix (Bryson, 2004; Mendelow, 1981; Reed et al., 2009)	Help determine which stakeholders' interests and power must be taken into account when addressing a problem	Simple, good for prioritization, visualizable	Subjective, does not show changes over time
Power-Influence Matrix (Eden and Ackermann, 1998; Reed et al., 2009)	Help determine which stakeholders to involve and engage with based on four categories: key players, context setters, subjects, and crowd	Help to specify how stakeholders might be engaged, how much interest vs. influence the stakeholders have	Interest and influence typically change over time
Stakeholder Typology (Freeman, 2015)	Categorizes primary and secondary stakeholders, applies when deciding what stakeholders to prioritize, or as a pre-step for other frameworks	Classic overview of the most central stakeholders, easy to use	Secondary stakeholders can also be important, does not show changes over time or different contexts
Rainbow diagram (Chevalier and Buckles, 2008; Reed et al., 2009)	Classifying stakeholders according to the degree they can affect or be affected by a problem or action, can be used as a pre-step for other frameworks or used to easier communicate results	Can be used together with other frameworks, visualisable	Who is included may depend on the method used for identifying stakeholders, does not show which stakeholders are most important
Q methodology (Barry and Proops, 1999; Reed et al., 2009)	Used to group individuals into social discourses based on shared perceptions and commonalities, can be used in, e.g., environmental policy research	Different social discourses surrounding an issue can be identified	Large number of stakeholders, difficult to engage with all of them
Strategic Perspectives Analysis (Dale and Lane, 1994; Reed et al., 2009)	Identifies and compares the goals of different groups, and the perceived opportunities and constraints they have to reach their goals	Stakeholder who share similar goals can be identified, collected information may also be useful for negotiation between conflicting groups (useful to negotiations between groups)	
Actor-linkage matrices (Biggs and Matsaert, 1999)	Describing stakeholder interrelations, creating a grid by using keywords such as if the relationships are of conflict, complementary, or cooperation. Can be applied when investigating stakeholder relationships	Simple, flexible, require few resources, particular valuable in development	Can become confusing and difficult to use if many linkages are described
Social Network Analysis (SNA) (Wasserman and Faust, 1994)	Matrices to organize data on the relational ties linking stakeholders together, with numbers to represent the presence/absence of a tie and the strength of it. Each matrix represents a unique relation, for example communication, conflict, trust, etc. Can be applied when investigating stakeholder relationships	Captures different kinds of relations and strength of those relational ties, can be used to select stakeholders to work together who are likely to trust one another	Individuals sharing weak ties may lack trust and understanding that is needed for dialog over environmental issues (Maybe not limitation with the framework itself)
Knowledge mapping (Reed et al., 2009)	Captures knowledge of different stakeholders by identifying flows of knowledge, knowledge bottlenecks, and areas of latent knowledge, and locating and explaining knowledge gaps	Fostering effective collaboration, social learning, and innovation	Novel method within stakeholder analysis, knowledge needs may still not be met due to differences in the types of knowledge held and needed by different stakeholders

The table shows the different frameworks, their purposes and applications, as well as the limitations of the result from applying each method.

Aerospace Sweden AB is today the headquarters of the group's Engines division.

The company operates within a highly connected industrial network involving a variety of stakeholders, e.g., OEMs, material providers, airliners, recycling partners, and regulators. The aerospace industry is a particularly demanding context for circularity due to high safety and quality requirements, few long-established actors, long product lifecycles, long development cycles, and low production volumes. These characteristics limit the pace and scope of change, creating lock-ins for decades, and it is therefore essential to coordinate among established actors to drive circularity forward. Studying how circular change emerges in such a setting can provide insights into mechanisms that may also support sustainability transitions in other mature industrial sectors.

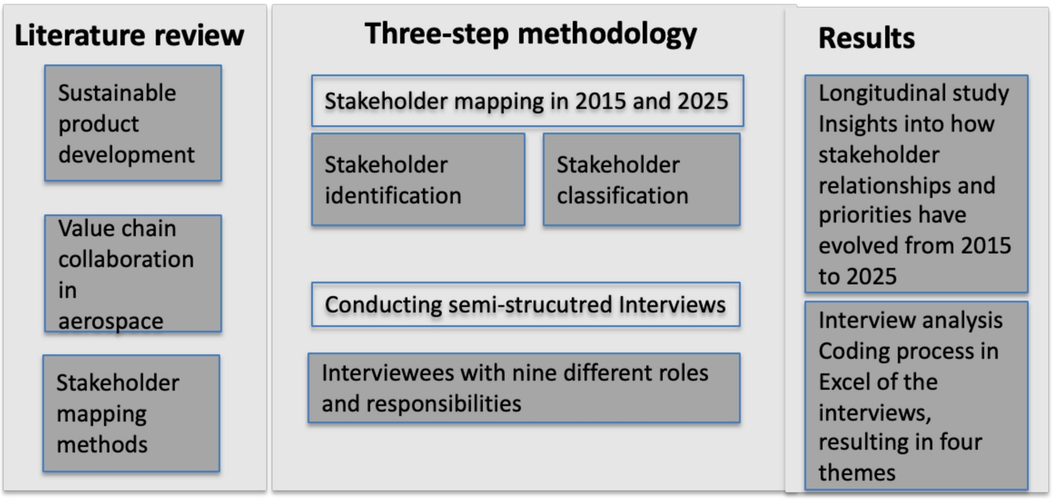

FIGURE 1
Overview of the research approach of this study.

The methodology consisted of three steps: identifying stakeholders in the life cycle, classifying the key stakeholders using the stakeholder salience model, and conducting interviews. Figure 1 provides an overview of the process.

The stakeholder mapping was conducted using a longitudinal approach at two time points: 2015 and 2025, at the same case company. It was conducted through several workshops, of which participants are listed in Table 3. Each mapping was conducted in two main steps, namely (i) identification and (ii) classification. After completion of the second mapping, participants set 2 in Table 3, did an additional workshop to compare results and discuss the path forward.

The two studies included similar roles in relation to sustainability but differed in relation to expertise on engineering design. The numbers of participants were fewer in the 2015 study, as there were fewer dedicated sustainability roles at the company at that time.

TABLE 3 List of participants for the stakeholder mapping workshops.

Participants set 1 (2015 workshop)	Participants set 2 (2025 workshop)
Design engineer (2)	Sustainability specialists (4)
Environmental manager (1)	Business strategists (1)
Sustainability specialist (1)	Director strategic analytics & sustainability (1)
	Data & analytics project leader (1)
	Life cycle assessment engineer (1)
	Global graduate engineer (1)

This approach ensured a broad stakeholder representation across both stakeholder categories and lifecycle stages.

3.1 Stakeholder identification

The first step involved identifying key stakeholders based on the four stakeholder categories adjusted from O'Hare et al. (2014):

Professional interest: Stakeholders whose professional activities may bring them into contact with the focus company or have an impact on the company.

Supply chain: Stakeholders that provide goods or services to the company.

Personal interest: Stakeholders who do not have a professional interest in the company, but may have a personal interest in the company, or the company has an impact on them in some way.

Customers: Stakeholders to whom the company sells goods and services.

Stakeholder identification was conducted from the perspective of GKN Aerospace's Swedish site to leverage the contextual knowledge of participants while maintaining a manageable scope for the assessment. To capture stakeholders across the entire product lifecycle, participants were asked to identify relevant actors at each lifecycle stage: raw materials extraction, manufacturing, distribution, usage and end-of-life. Participants used a whiteboard and sticky notes during a facilitated session and discussed until reaching consensus (see Figure 2).

3.2 Stakeholder classification

The second step included the classification of stakeholders using the stakeholder salience model by Mitchell et al. (1997). In addition to updating the stakeholder classification conducted in 2015, the stakeholders identified in the first step were classified according to the three salience attributes of power, legitimacy, and urgency using the following dichotomous questions:

- *Power*: Does this stakeholder have the ability to influence the organization or project despite resistance? Power can be: coercive (e.g., through force or threat), utilitarian (e.g., through financial means) or normative (e.g., through symbolic influence or values).
- *Legitimacy*: Is this stakeholder's current involvement perceived as appropriate or rightful? It can be based on legal standing, moral claims, social norms, and whether the stakeholder's exercise of influence is perceived as supporting rather than undermining ecosystem collaboration, e.g., a company that treats partners unfairly or prioritises control over collaboration.
- *Urgency*: Can this stakeholder make claims that call for immediate attention? It depends on time sensitivity and criticality of the

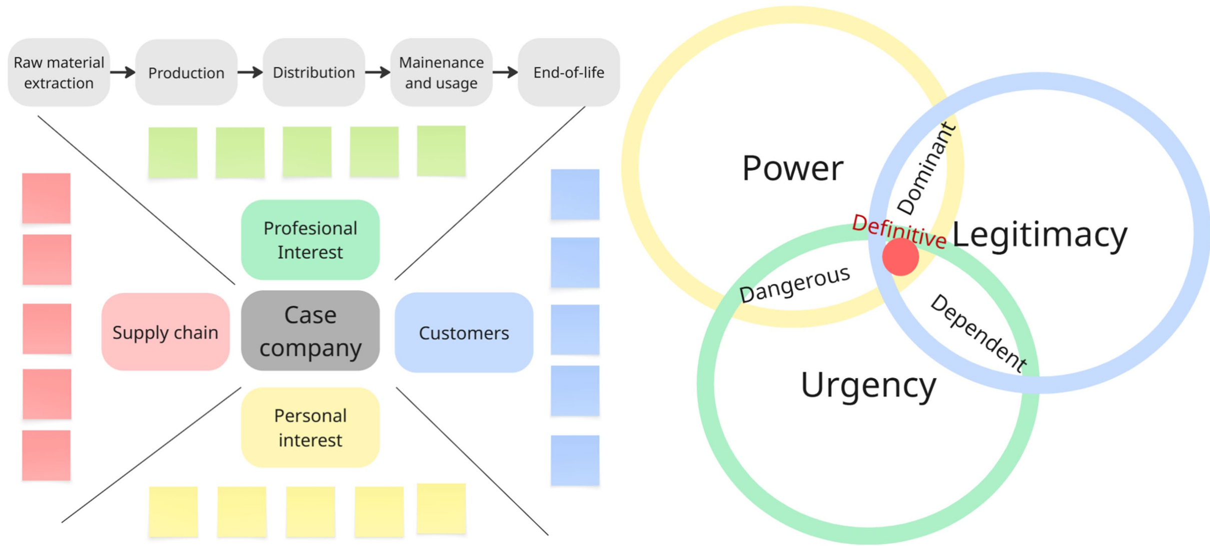

FIGURE 2
Templates for stakeholder identification (left) and classification (right). The participants were invited to write down stakeholder names on digital notes before classifying them.

issue, e.g., a regulatory issuing a deadline for compliance with new environmental policies, or a supplier threatening to stop deliveries.

The classification was based on consensus among workshop participants. Based on the presence of these attributes, stakeholders were categorized into the corresponding salience classes, including dominant, dangerous, and definitive stakeholders. The classification template used in the workshop is presented in Figure 2.

Following the stakeholder classification, a reflection session was conducted to explore the future roles of stakeholders in supporting circular value propositions. Participants were asked: "*What roles should the various actors have in a sustainable value chain for an innovative and circular value proposition?*" The discussion generated insights regarding stakeholder relationships, the potential emergence of new stakeholders, possible shifts in stakeholder salience, including which actors may become increasingly important in enabling circular value chains.

3.3 Interviews

Nine semi-structured interviews were conducted in 2025 with roles and responsibilities representing different parts of the aerospace value chain. Participants were selected through purposeful sampling to identify individuals directly involved in sustainability and circular economy activities, aiming to cover all product lifecycle stages. As the number of individuals occupying these specialist roles was limited, the study focused on interviewing key informants rather than maximizing the total number of interviews.

The interviews were conducted either face-to-face or online, recorded with the consent of the participants, and transcribed using Microsoft Teams. The aim of the interviews was to understand current capabilities and challenges for creating long-term, sustainable, and resilient circular solutions across the value chain. The interview guide included questions covering five main topics: (1) current approaches to collaboration for addressing sustainability challenges, (2) the identification and prioritization of sustainability and circularity criteria, (3) data management and exchange between value chain actors, (4) the perceived potential of various circular solutions, and (5) the roles of stakeholders in enabling sustainable and circular value propositions. The interview participants are outlined in Table 4.

Interview transcripts were analyzed through a thematic coding process conducted in Excel. The coding was conducted by a single researcher, and formal intercoder validation was therefore not undertaken. Instead, analytical rigor was supported through iterative coding, and coding decisions, emerging themes, and interpretations were discussed among the authors throughout the analysis process. The coding resulted in the following eight initial themes: requirements, collaboration approaches, sustainability criteria, circularity, waste, recycling, data sharing and traceability, and value chain roles. The eight themes were then aggregated in four broader themes presented in the results of this article to facilitate scientific communication.

4 Results

4.1 Stakeholder identification in the past and today

Stakeholders were identified from the perspective of GKN Aerospace's site in Sweden, aiming to cover the whole lifecycle of the company's products and gathering professional interest, supply chain, personal interest and customers. An overview of the results is shown in Figure 3. The figure shows stakeholders identified in 2015 and 2025, respectively, arranged by stakeholder type, and those deemed no longer relevant in 2025.

In 2015, stakeholders within the supply chain consisted of casting producers, capital equipment providers, smelters, producers of chemicals, mining companies, technology providers, and suppliers of billets and forged goods. Customers such as cargo carriers, logistics companies, aerospace components manufacturing, and space agency were

TABLE 4 List of interview participants and their role at the company.

Participant ID	Interview participant's role	Product lifecycle stage expertise	Experience
SPD specialist A	Sustainable product development specialist	Whole lifecycle	5–10 years
SPD specialist B	Sustainable product development specialist	Whole lifecycle	10–20 years
SPD specialist C	Sustainable product development specialist	Whole lifecycle	20 + years
Environmental manager	Environmental manager	Production, distribution	2–5 years
Procurement A	Procurement sustainability and compliance manager	Raw materials	10–20 years
Procurement B	Procurement, raw material strategic sourcing manager	Raw materials	10–20 years
Sustainability manager	Sustainability manager	Whole lifecycle	2–5 years
Customer manager	Customer strategy manager	Use phase	10–20 years
Facility director	Facilities and operation support, Director facilities & environment	Production	10–20 years

mapped as well. Within the category of professional interest, stakeholders such as aerospace, environmental, and airport regulatory agencies were identified, along with airports, and NGOs. Lastly, stakeholders connected to personal interests included organizations and non-profits working on climate change, shareholders, unions, ground personal at airports, and communities located near airports or affected by mining activities.

Between 2015 and 2025, several new stakeholders were identified, as shown in Table 5. Only three stakeholders were removed between 2015 and 2025 as they were no longer considered part of the value chain or product offering due to strategic changes or were redundant with other stakeholder categories. Auditors, environmentalists, and industrial associations have gained a place on the stakeholder mapping due to evolving sustainability requirements and expectations. Metal foundries have also appeared on the map as the case company has become more aware of other actors beyond the contractor responsible for material waste. Organizational changes have also caused new stakeholders to emerge in the mapping, such as rating agencies and owners. Finally, many other stakeholders were newly mapped in 2025, but the participants did not judge them to have particularly changed in salience. This result is most likely due to the different set of participants in the two mapping workshops, as the set of participants in 2025 covered more broadly the value chain with their expertise. Compared to ten years ago, the context now reflects a stronger emphasis on sustainability and circularity, requiring broader engagement and collaboration.

4.2 Stakeholder classification in the past and today

The identified key stakeholders were classified according to the stakeholder salience model to assess their salience and explore how it evolved between 2015 and 2025, potentially driven by sustainability and future circular demands. It is important to not only understand the influence that the company has on other stakeholders, but also the influence that stakeholders have on GKN's business. Addition and removal of stakeholders therefore affected the overall influence.

Table 6 provides an overview of the stakeholders who have been assigned different salience levels between 2015 and 2025. In addition to "new" stakeholders identified (see Table 5), some stakeholders have gained new salience attributes. The environmental regulatory agencies and the European Union have both gained urgency, which classifies them now as dominant stakeholders.

On the other hand, some stakeholders have lost attributes. Both the EU and the space agency changed from dominant to definitive, and unions were similarly reclassified. The municipality, however, was moved from a definitive to a stakeholder with legitimacy only. There were also internal discussions regarding employees and whether they can be considered to have urgent claims, which would determine whether they are classified as dominant or definitive stakeholders. It was concluded that this depends on their role within the company. Certain specialists were considered definitive, as they combine power, legitimacy, and urgency, while employees in general were seen as having power and legitimacy. Interestingly, senior management employees were assumed to have less legitimacy. Large casting suppliers were classified as lacking legitimacy due to their control and lack of collaboration with the value chain.

The stakeholder classification results for 2015 and the results including stakeholders added in 2025 are presented in Figure 4, and Figure 5 focuses on the definitive stakeholders classified in 2015 and 2025.

In Figure 4, a shift in stakeholder salience between 2015 and 2025 is illustrated. In 2015, dominant stakeholders were primarily characterized by professional interest, including research funding agencies, governmental actors, aerospace and environmental regulators, and the European Union. By 2025, the dominant category had expanded to include stakeholders across multiple categories, such as employees (personal interest), landlords (supply chain), space agencies and land turbine manufacturers (customers), and metal smelters. This shift suggests a change in influence across the value chain and increased recognition of stakeholders beyond traditional regulatory stakeholders. In particular, the European Union moved from dominant to definitive category, indicating strengthened urgency and power in relation to sustainability and circularity.

The dependent category also evolved, expanding from only supply chain actors in 2015 to include stakeholders driven by personal interest in 2025. Furthermore, one stakeholder, a producer of large

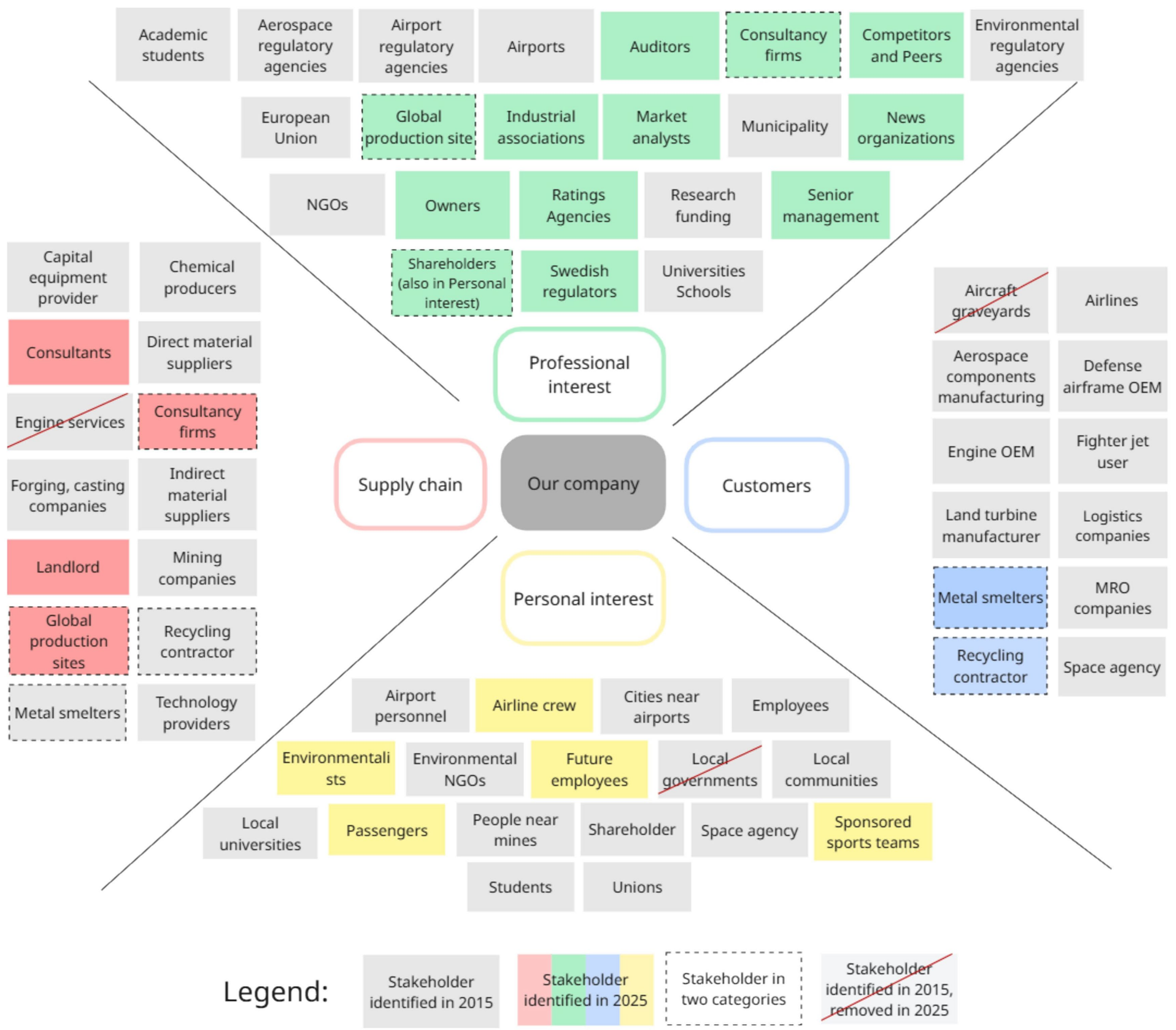

FIGURE 3
Stakeholder identification comparison between 2015 and 2025. Stakeholders were mapped throughout the product lifecycle and for each category, namely supply chain, professional interest, personal interest, and customers.

castings, was classified as dangerous in 2025, suggesting that it has power and urgency without corresponding to legitimacy. This can potentially be linked to risks, material criticality, or dependency within the value chain.

Figure 5 shows the change in mapping the *definitive* stakeholders in greater detail. This reflects an evolution in the company's strategy, with less focus on industrial gas turbines and the space segment. More stakeholders with professional interests are *definitive* in 2025 due to increased regulatory pressure and due to the company becoming publicly listed. New types of suppliers also appear in the *definitive* category, reflecting supply challenges faced by the aerospace sector in 2025.

4.3 Capabilities and gaps based on interviews

The results of the interviews present several key capabilities and gaps for enabling long-term, sustainable, and resilient value chains. Figure 6 illustrates the capabilities and gaps identified in the interviews for enabling circular value chains.

4.3.1 Requirements and collaboration approaches

This capability reflects the ability of stakeholders to align sustainability efforts through the use of requirements and collaboration approaches within the value chain. While requirements were seen as actionable, collaboration introduces opportunities for shared responsibility across the value chain actors.

Customer demands typically shape company actions and are often prioritized over internal sustainability requirements, though internal standards and tools also inform company decision-making. The interviews indicate a need to balance strict requirements with softer expectations to support and ensure supplier engagement, particularly regarding sustainability. Looking forward, requirements are expected to become more stringent, and stakeholders are encouraged to take a more proactive role by engaging directly with customers as described by SPD specialist A: "*I think actors in the value chain should take a more proactive role and not just wait for requirements to come down, but go to the customer and propose something.*"

In addition, participants expressed differing views on whether setting requirements counts as collaboration, with some seeing it as coordination and others as a top-down approach with limited

TABLE 5 Stakeholders identified in 2025, but not in 2015.

Stakeholders added in 2025	Rationale
Auditors	Increased sustainability-related audits in 2025.
Environmentalists	Increased pressure on company.
Future employees	Company growth incentivises to recruit skilled workforce
Global production site	Company has more exchanges with other company sites.
Industrial associations	Create new norms, guidelines and methods on sustainability.
Metal smelters, recycling contractor	No longer seen as "just" a supplier, they are now also customers as they purchase metal chips from the company.
Market and financial analysts, Owners, Ratings agencies	Important since company became publicly listed.
Competitors and peers, Consultancy firms, Landlords, Material suppliers, News organizations, Suppliers of small castings, Senior management, Suppliers (large size, misc.), Suppliers (small size, misc.), Swedish regulators	Indicates the stakeholder existed previously with similar salience, but was not part of 2015 mapping.

Several stakeholders identified in 2025 were not included in the 2015 stakeholder mapping. Their emergence reflects changes in the business context, including the company becoming publicly listed and increasing societal and regulatory expectations related to sustainability.

TABLE 6 Stakeholders' salience attributes (P = Power, L = Legitimacy, U = Urgency), focusing on new stakeholders and stakeholders with different attributes between 2015 and 2025.

Stakeholders with different attributes between 2015 and 2025	2015			2025		
	P	L	U	P	L	U
Auditors					X	
Environmental regulatory agencies	X	X		X	X	X
Environmentalists					X	
European Union	X	X		X	X	X
Future employees				X	X	
Global production site				X	X	X
Industrial associations					X	
Market and financial analysts					X	
Metal foundry				X	X	
Municipality	X	X	X		X	
Owners				X	X	X
Ratings agencies					X	
Space agency	X	X	X	X	X	
Supplier of large castings	X	X	X	X		X
Unions	X	X	X	X	X	

Cells highlighted in grey indicate changes in salience attributes between 2015 and 2025.

mutual engagement. True collaboration was instead defined as developing goals or expectations together with stakeholders: "*Requirements are very strict and expectations are more soft "(…), you can not only do the hard requirements, you also have to work with them so they are on board and they want to do it themselves*" (Environmental manager).

Collaboration is generally project-based rather than systematic, often depending on the technical maturity of the product. At present, collaboration methods are generally limited and include temporary partnerships in research or technology development, involving suppliers, customers, and sometimes academia, with sustainability embedded in externally funded projects. Internally, collaboration occurs through working groups and shared goals on site. Looking forward, participants highlighted the need for more joint development of industry standards, guidelines, and sustainability goals. The environmental manager highlights that collaboration with suppliers and customers could create a multiplier effect by aligning requirements and expectations across the supply chain, ensuring resilience and progress toward shared sustainability goals.

4.3.2 Strategies for value chain sustainability and circularity

This capability reflects actors' ability to implement sustainability within the value chain through assessment criteria, circularity strategies, and material management practices, highlighting current approaches, gaps, and opportunities for improvement in integrating circularity into decision-making processes.

In the aerospace industry, sustainability is typically assessed at the company level using common indicators and frameworks, such as science-based targets. SPD specialist A and B point out that key performance indicators are needed to guide concept choice, evaluating sustainability, costs, technical requirements, manufacturing, quality, safety, and line-up strategy. The Sustainability manager and SPD Specialist C mention tools, such as a compliance tool that applies predefined requirements and is supported by documentation, while sustainability and Health- Safety- Environment goals are set at the department level in collaboration with specialists. Despite these approaches participants highlighted that processes are not completely standardized and remain at an early stage of maturity. The Environmental manager points out that effective implementation requires showing how sustainability measures also affect other, highly prioritized areas: "*The most effective way would be if we could show how things would not just affect the sustainability or circularity metrics, but also showing that you can improve on production, delivery time, costs, quality and all that.*"

Although the company has defined sustainability criteria, these do not always address circular solutions. There is potential in expanding indicators to include material use and circularity performance, and a need for improved data availability and traceability to support decision-making. Existing circular strategies, such as recycling, repair, remanufacturing, and the use of additive manufacturing, are not prioritized across all areas and hold potential for becoming more circular. Key challenges include material waste, regulatory constraints, and limited availability of circular materials, with closer collaboration suggested as a way forward.

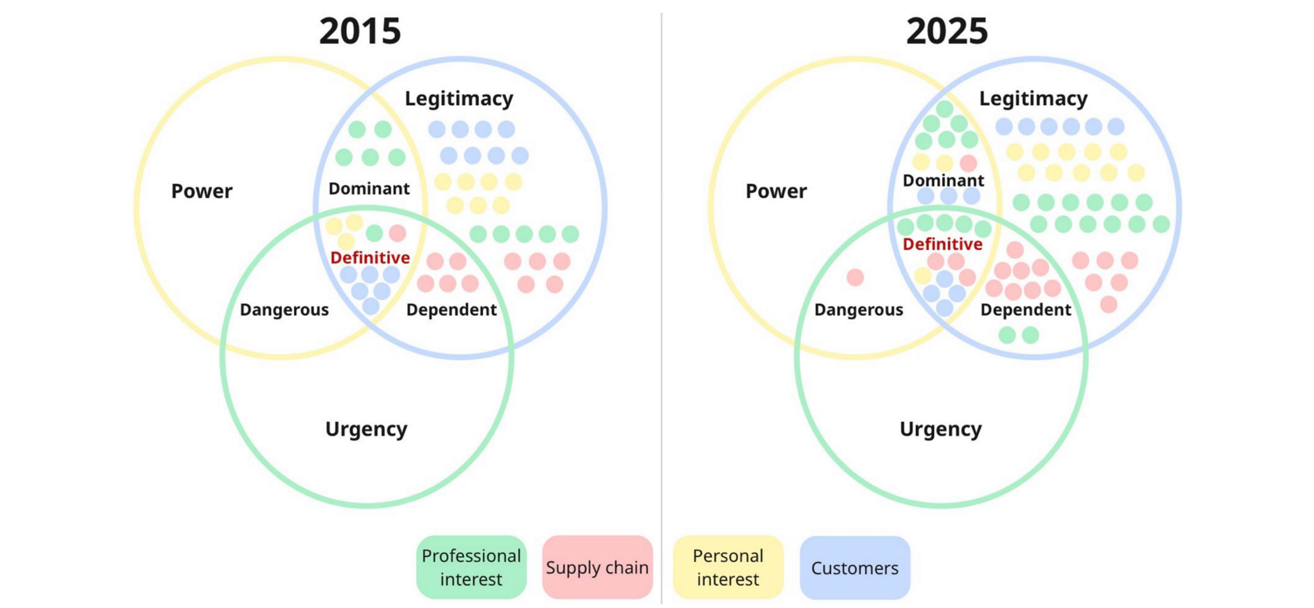

FIGURE 4
Overview of stakeholder classification in 2015 and 2025. The total number of stakeholders identified has increased, both due to a more comprehensive mapping, both due to increased complexity in the value chain with new regulatory pressure and greater influence of investors. The mapping shows an increase in power of supply chain actors.

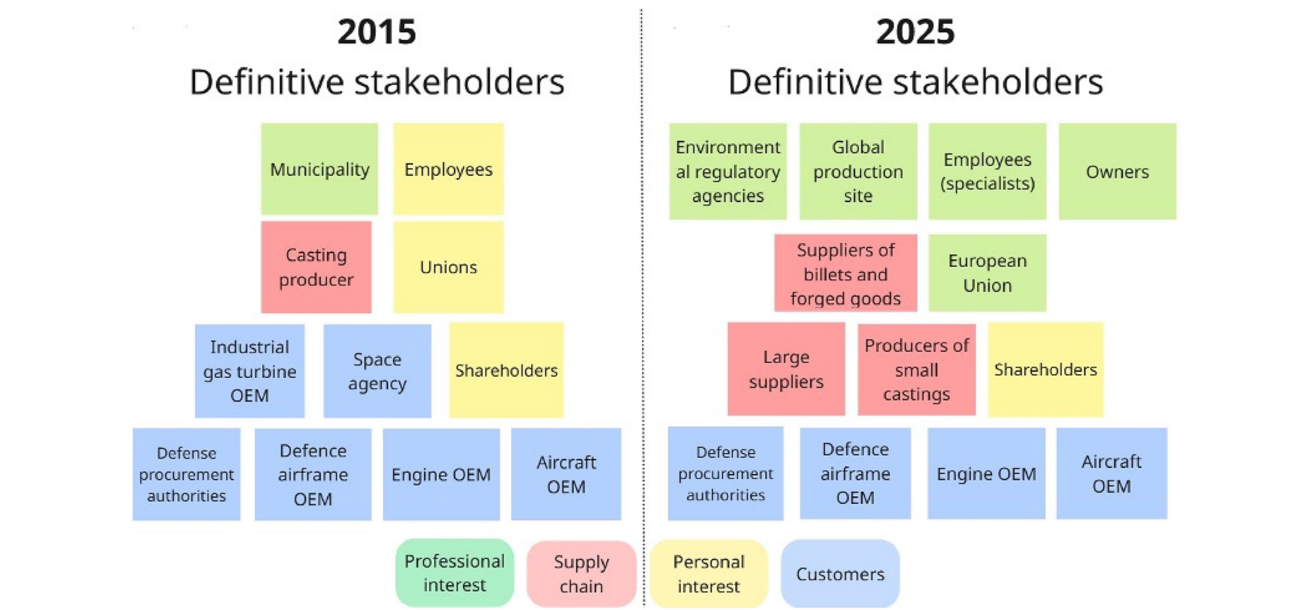

FIGURE 5
Comparison of "definitive" stakeholders identified in 2015 (on the left) and in 2025 (on the right). Strategic and organizational changes, increased regulatory pressure, and greater attention to supplier mapping have changed who the definitive stakeholders are.

During the interviews, the role of business models was discussed to further enhance circularity: "*Looking at our business models and how circular they are, I think in our industry, this is something where we are already going in the right direction because we have agreements that we call PBH and RRSP. I think that is in general already more circular thinking in our business model.*" (SPD specialist B). For a company such as GKN Aerospace, such business models ensure a partnership with OEMs from design to the end-of-life of the aero-engine. Such business models also encourage the OEMs to extend the life of their products through durable design, repair, and even upgrades of systems and components.

The company has set sustainability targets to reduce waste, water, and energy use and collaborates with an external partner on waste management. Material recycling was frequently discussed, yet definitions and traceability of recycled materials vary. There is also a lack of clear corporate-level standards for circular economy solutions. Significant quantities of valuable materials are purchased but later machined away, resulting in substantial waste. SPD specialist A questioned whether recycling can be further improved given the high value already placed on materials.

While some of this waste is recycled, it typically passes through multiple actors, making traceability and closing the loop challenging.

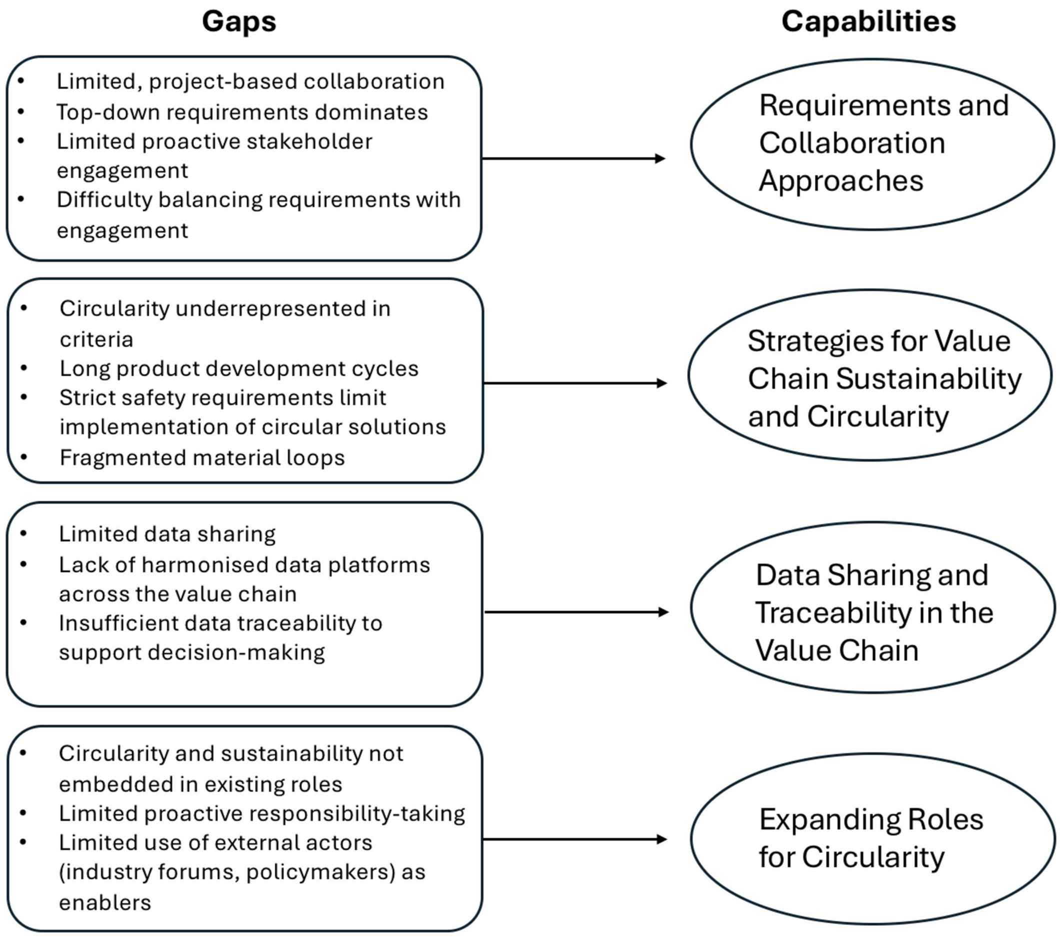

FIGURE 6
Overview of capabilities and associated gaps for enabling circular value chains. The gaps identified from the interviews are organized within four areas of capabilities.

"*A great potential solution would be to reduce the number of actors in the recycling chain so we know where our waste is going and how we get it back, and I think it will also help keep more value and get feedback*" (SPD Specialist A). Suggested solutions included reusing parts from older engines and returning waste to suppliers, although such initiatives are not frequent.

SPD specialist B mentioned that although suppliers were initially unwilling to share data, transparency has improved as recycled content is increasingly valued as a positive sustainability aspect. Production generates valuable alloy waste that is recycled, but the involvement of multiple actors makes it challenging to track and close loops.

4.3.3 Data sharing and traceability in the value chain

Data management and sharing across the value chain emerged as a significant challenge. This capability refers to stakeholders' ability to manage, share, and use sustainability-related data to support decision-making and the integration of circularity. The environmental manager highlights that sensitive technical information is protected and usually not shared beyond formal collaborations, and the lack of harmonized platforms contributes to fragmentation. Procurement A points out that the company has developed a supplier platform to collect information, such as sustainability-related performance, but participation is voluntary, and data quality varies. Gaps in data availability, particularly in the supply chain and use phase, limit informed decision-making and hinder progress toward circularity. These gaps point to a need for improved traceability, harmonization, and supplier engagement to support circularity integration: "*We need to improve the data availability, the ease of collecting data and the ease of using the data and analyzing it and tracing it, so we can make more data-driven decisions and build our knowledge and expertise there*" (Environmental manager).

4.3.4 Expanding roles for circularity

The need for the capability to expand roles for circularity refers to stakeholders' ability in the value chain to integrate circularity and sustainability responsibilities. Circular solutions require expanded responsibilities within existing roles rather than entirely new positions. For example, SPD specialist B points out: "*I do not really think that roles need to change, but I do think that roles need to take greater responsibility for sustainability issues. The company should take the lead in enabling recycling efforts, while suppliers carry them out, and commercial roles should integrate circularity in supplier relations. Opportunities exist to develop roles around material waste*".

The environmental manager emphasizes that externally, industry forums and governments can support common standards, while customers have an important role by setting clear sustainability requirements. Additionally, Procurement A states that: "*When it comes to industry forums, I think they play an important role in developing the right types of standards and guidelines and expectations so that everybody work towards the same goal*."

Despite these expectations, there is a gap in proactive responsibility-taking across the value chains, indicating that circularity is not yet fully embedded in existing roles. SPD specialist A states that across the value chain, actors need to take more proactive responsibility for sustainability and build resilience capacities to quickly adapt and recover from changes.

5 Concluding discussion

This research explored how a structured stakeholder analysis method can support sustainable product development and the development of resilient and circular solutions within the aerospace industry. By applying the stakeholder salience framework in combination with a longitudinal comparison and interviews, this research provides an adapted method for identifying key stakeholders to be involved in developing circular solutions, and explores current capabilities for creating circular solutions in the value chain, as well as future needs.

This study shows that the proposed stakeholder analysis method can provide a structured approach to identify, classify, and prioritize key stakeholders within complex value chains. This means that management and product design teams can make strategic plans for long-term solutions, build a resilient supplier network, and collaborate with value-chain actors for circular solutions. In addition to the framework by Mitchell et al. (1997), analyzing stakeholder attributes such as power, legitimacy and urgency, stakeholders are identified through the perspectives of a product life cycle in relation to supply chain, customers, professional interest, and personal interest. In this way, this method helps understand which actors are most critical to collaborate with when developing sustainable and circular solutions. Furthermore, the method enables a discussion of how stakeholder roles may need to evolve to support more circular and resilient value chains and to identify stakeholders that have the potential to either drive or hinder the implementation of circular solutions.

The longitudinal study showed an increase in the number of stakeholders identified in the 2025 mapping, and that certain stakeholders have gained or lost salience over time. For example, the environmental regulatory agencies are now considered a key stakeholder, and three types of suppliers have moved from the *dependent* to the *definitive* category. One possible reason for these changes is the growing focus on circular solutions and the need for collaboration across the industry value chain. There are indications of a slow but a clear path toward a circular thinking in this industry sector (Paletti et al., 2025; Pellegrino et al., 2026). Even if there were insights ten years ago into potential dependencies on critical materials and the need to create a resilient system, no strategic long-term plans or key stakeholders are involved in the co-creation of circular solutions today at the case company. However, with this research presenting a systematic approach to identify key partners in the value chain for circular and resilient solutions toward sustainability, effective and efficient solutions can be expected. We argue that identifying the key partners for long-term solutions is a missing piece in accelerating a sustainability transformation. Once these key partners are identified, resilient and sustainability maturity assessments and support for a common solution that adds value to all partners, with a co-creation focus, can take place.

Another reason for a change of stakeholders in 2025 compared to 2015 is the growing emphasis on sustainability, which may have led to the emergence of new stakeholders or to changes in their importance as key partners in future solutions. Also, several employees at the case company now have sustainability roles compared to ten years ago. An increased level of competence within the team applying the method may also be a reason for identifying new key stakeholders. When interpreted through the stakeholder salience framework, this could lead to shifts in attributes, particularly among stakeholders associated with environmental and regulatory concerns. Also highlighted in Ghanbary and Karimimehr (2026), stakeholder salience evolves due to both internal organizational changes and external pressures, and it is important to conduct continuous stakeholder analyses, particularly in companies undergoing sustainability transitions, where new relationships and priorities may emerge over time.

This research contributes to stakeholder theory by extending the application of the stakeholder salience framework (Mitchell et al., 1997) to the context of circular transformation in the aerospace industry, where its use has been largely unexplored. By integrating a circularity dimension and adopting a longitudinal perspective, this research demonstrates how the stakeholder salience framework can be applied to address sustainability challenges in complex value chains. The observed changes between 2015 and 2025 highlight the importance of considering the dynamic nature of stakeholder salience and accounting for temporal aspects in stakeholder analyses, particularly in industries characterized by long product life cycles.

In this research, we extended the application of the stakeholder salience framework by incorporating a lifecycle perspective into the stakeholder identification process, thereby broadening the scope beyond traditional internal and external stakeholders to encompass the wider ecosystem required for circularity. This broader perspective is essential because circular business models depend on interactions across multiple lifecycle stages and organizational boundaries. While the underlying stakeholder salience framework itself was not substantially modified, this study demonstrates its application within the specific context of circular transformation, where stakeholder identification and engagement become considerably more complex. Unlike linear business models, circular strategies often require OEMs and Tier-1 suppliers to engage actors beyond their established value chains, including customers, recyclers, service providers, policymakers, and, in some cases, even competitors, to enable system-wide circularity. Such interactions introduce challenges related to power dynamics, competition, confidentiality, transparency, and trust. Our findings suggest that the extended stakeholder salience framework, including a life cycle perspective, provides a valuable lens for systematically identifying, prioritizing, and examining these evolving stakeholder relationships and the associated complexities throughout the circular ecosystem.

Another theoretical contribution of this research is that it provides clarity to two of the nine key factors previously presented by Dokter et al. (2025), namely value mapping and the ecosystem perspective, for developing collaborative value chains. Collaborative value chains are a prerequisite for circular economy strategies and, according to Acerbi et al. (2026), these strategies enhance operational flexibility, resource availability, effective risk management, and economic performance. For example, a shared commitment among the key stakeholders to circular economy principles fosters resilience by enabling partners to collectively address challenges and leverage opportunities for sustainable growth. Furthermore, resource sharing and localized, agile supply chains strengthen collaboration, increase adaptability, and enhance resilience across the supply chain. By supporting systematic stakeholder identification and engagement, this research contributes to an important preparatory step toward developing successful collaborative circular economy strategies that strengthen organizations' ability to navigate uncertainty and build resilience across value chains.

From a practical perspective, this research provides a practical framework for organizations that aim to increase circularity and collaborate with stakeholders, and support a project management and design team when creating resilient and circular solutions. A key managerial implication is that manufacturers should formalize stakeholder mapping as an integral part of their circular transformation efforts rather than treating it as a one-off activity. The proposed stakeholder method can support not only the early identification and prioritization of stakeholders during the development of circular initiatives but also serve as a structured tool throughout pilot projects and implementation to monitor how stakeholder relationships evolve and to identify emerging challenges related to power, legitimacy, urgency, trust, transparency, competition, and confidentiality. At the same time, the value of such stakeholder mapping depends on the breadth and quality of the perspectives represented. Because the assessment is inherently shaped by participants' knowledge and experience, organizations should engage cross-functional teams—including representatives from engineering, sustainability, procurement, aftermarket, business development, and legal functions—to ensure a more comprehensive understanding of stakeholder dynamics and to support more robust and informed stakeholder engagement decisions throughout the circular transformation process. To explore the method's future potential, it should be applied in other organizational and industrial contexts to evaluate its relevance and usefulness.

This research has several limitations that should be acknowledged. It is based on a single-case company, which limits its generalizability. The results should therefore be interpreted as an indication rather than as representing the aerospace. Additionally, the stakeholder mappings were conducted through workshops at two time points. Differences in expertise and roles, such as higher presence of product designers in 2015 and sustainability specialists in 2025, may have influenced the results. It is therefore important to consider multiple perspectives when analyzing stakeholders. This method also represents two time points rather than continuous assessment of stakeholder analysis, and future research could benefit from longitudinal approaches that track changes systematically.

It should also be noted that the proposed approach was evaluated and tested by potential users within the company. The purpose of this evaluation was to assess its usefulness, usability, and adaptability, rather than to support strategic decision-making or evaluate changes in strategic priorities. Consequently, this study cannot provide empirical examples of stakeholder identification influencing strategic priorities. Furthermore, to the authors' knowledge, no formal stakeholder-analysis approach was in use within the company at the time of the study, making comparisons with alternative approaches impossible. Future action research should therefore focus on applying and validating the approach in real industrial circular transformation projects to investigate how it influences stakeholder-related decisions and strategic priorities in practice.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing. PL: Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. MA: Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. GD: Supervision, Writing – original draft, Writing – review & editing, Methodology.

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Conflict of interest

PL was employed by GKN Aerospace.

The remaining author(s) declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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