

KEY STAKEHOLDERS IN AEROSPACE FOR A SUSTAINABLE AND CIRCULAR PRODUCT DEVELOPMENT - A SYSTEMATIC APPROACH

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Abstract

Sustainability and circularity are increasingly important for the resilience of the aerospace sector, but developing circular and through-life sustainable solutions requires manufacturers to engage new stakeholders across long and complex value chains. This paper explores how a structured key stakeholder analysis method can support sustainable product development by helping project design teams identify which actors to involve.

The method combines stakeholder identification across life-cycle stages with classification based on power, legitimacy, and urgency, using the stakeholder salience framework. It is applied in a longitudinal case study at GKN Aerospace Sweden, comparing stakeholder mappings from 2015 and 2025.

The findings show that stakeholder salience changes over time, with supply chain actors and environmental regulatory agencies becoming more important. Repeated stakeholder analysis can therefore support tactical partner selection for future circular aerospace solutions.

Keywords: value chains, circularity, longitudinal study, sustainable product development, sustainable design

1. Introduction

Sustainability has long been recognized as a key driver of current and future solutions in the aeronautics industry. More than two decades ago, the Advisory Council for Aeronautics Research in Europe (ACARE) established in 2001 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. After an update in 2011, SRA-2 introduced the vision of an “Ultra Green Air Transport System” [1]. The focus was predominately on direct emissions and was used in Clean Aviation programs. The impact on climate and innovation from Clean Sky 2 (2014-2024) reported development of technologies with 20-30% potential reduction of Greenhouse gasses together with a range of innovation impact, such as more than 500 patents generated. I

For industries at the component-manufacturer level, efforts to meet ACARE’s strategic goals were early on translated into concrete design and performance targets, aiming for reduced weight, lowered noise levels, decreased emissions, and improved reliability [2]. These ambitions were complemented by explorations of solutions for new fuels, optimized flight routes, and innovative design strategies to minimize fuel consumption. During the first decades, technologies were introduced into new aircraft products, yet- as predominately the aeroengine branch of aerospace-, rely on life cycle performance, reliability and cost, the life cycle responsibility add complexity to introducing novel technologies beyond its emission performance. As the full life-cycle responsibility is considered, also a social and resource perspective need to be included and 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. This is also added into EU’s, “Fly the green deal” published in 2022 by the European Commission (https://doi.org/10.2777/732726). This strategy focused on meeting net zero targets in aerospace on the emissions side and also called for action on circular economy and societal dimensions of sustainability. EU had already released wider strategies for the manufacturing sector in the CEAP- Circular Economy Action (see for example the report in https://eur-

https://doi.org/10.71945/icas2026_0222

lex.europa.eu/resource.html?format=PDF&uri=cellar%3A9903b325-6388-11ea-b735-01aa75ed71a1.0017.02%2FDOC_1).

Already during the technology and emission focused era following SRA 1, and SRA 2, GKN Aerospace identified critical material risks linked to limited availability, geopolitical factors, and increasing competition from suppliers and customers [3]. The study highlighted the need for alternative materials, circular business models, and improved resource efficiency to reduce dependence on critical raw materials. In the aerospace industry, there is a challenge to create resilient solutions with suppliers since the product has a long lifespan of about 30 years [4], a long production period of about 20 years, and a long product and technology development time of about 7 years. Therefore, transitioning to sustainable and circular manufacturing requires co-creation between actors in the value chain that provides added value for all participating partners. Technologies that enable sustained and circular solutions, such as repair and remanufacture, increase in importance and need to be designed already early in new programs together with the product design.

A key starting point in developing circular solutions is to identify the actors with whom these solutions should be co-created. From a sustainability and life-cycle perspective, this requires a conscious and strategic decision about which stakeholders to involve. This paper proposes a methodology for identifying key stakeholders in sustainable product development. The methodology was developed, applied, and evaluated in previous research conducted around 2015 at GKN Aerospace and another large company in the construction industry.

The main contribution of this research study is to explore and propose 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.

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.

To this end, the following research questions (RQs) are addressed:

> RQ1. In what ways can a key stakeholder analysis method for sustainable product development support a project design team in 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?

2. Literature background

This section provides a brief background on the research area of Sustainable Product Development, as well as an introduction to value chain collaboration and stakeholder mapping methods. The section finishes with some details about the stakeholder mapping method selected for this study, the stakeholder salience model.

2.1 Sustainable Product Development and Value chain collaboration in aerospace

The transition to a sustainable society is 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 is generally defined as the integration of sustainability issues in the various activities associated with engineering practice [5], more specifically the integration of a strategic sustainability perspective into early product innovation stages [6]. Sustainable product development is a broad term, not only covering design activities but also organisational functions such as strategy, technology or change management [7].

To strategically design products towards 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 [8]. Previous research has applied this framework in the context of sustainable product development, e.g. to define sustainability criteria and sustainability compliance index [6], to manage sustainability risks [9] and assess product sustainability performance at early design stages [10].

Manufacturing companies increasingly consider circularity as a pathway towards 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) [11] 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).

Table 1. Overview of the nine factors for development of collaborative value chains [11]

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 towards 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

Aerospace value chains differ from many other industries as they are shaped by few actors, forming complex global networks. Products are developed over a long time, produced in low volumes and have long lifecycles, all under strict quality and safety requirements [12]. These characteristics create both challenges and opportunities for circularity and are essential when considering how circular value chains can be developed in this context.

Several studies highlight barriers to circularity related to aerospace value chains. The aerospace industry is characterized by a limited supply chain, creating dependency on suppliers for the development of environmentally friendly materials [20]. In addition, the long life cycle of aerospace products hinder the development of components and materials that support circular solutions, as long service lives constrain learning and feedback from material performance, lock in existing material choices, and increase safety and certification risks. Traceability further complicates a circular transition in the aerospace industry, as it is required not only to advance circularity, but also to protect the authenticity of components and avoid counterfeit components which can cause safety and reliability concerns. Recent supply chain issues and component shortages have limited the ability of aircraft manufacturers to meet the rising demand for new planes due to increasing travel.

Although collaboration is widely recognized in the literature as a key enabler for achieving circular solutions, most studies address collaboration implicitly rather than providing guidance on how it should be developed across value chains. Many papers choose to focus on internal circularity without addressing the need to increase value chain collaboration [13]. For example, Vogiantzi and Tserpes [14] point out that aerospace needs to find solutions to recycle materials and maintain end-of-life aircraft. To date, there is still limited practical guidance for manufacturers on how collaboration can be supported across value chains, despite some prescriptive frameworks focused on circular innovation presented in [15].

Lastly, before any resilient and circular solution in the aerospace value chain can be developed, a crucial step is to firstly identify and analyze the requires stakeholders to establish and manage a circular system, and understand the respective motives and levels of influence, to better understand the pathways for successful collaboration throughout the value chain.

2.2 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 [16], 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, Graves [17], 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. Many stakeholder analysis methods exist, such as the Mendelow [18] power-interest matrix, power-influence matrix [19], and the rainbow diagram [20]. 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.

2.3 The stakeholder salience model

In this research study a longitudinal approach is adopted, applying Mitchell, Agle [21] framework to analyze how stakeholder attributes and salience have shifted over the past ten years.

The stakeholder salience model by Mitchell, Agle [21] identifies and classifies stakeholders based on three attributes: power, legitimacy, and urgency, to support managers determine when and how to respond to different types of stakeholders. It has been applied in multiple contexts, for instance in the semiconductor supply chain [22], construction procurement [23], and urban contexts [24], addressing sustainability challenges. One advantage highlighted by Beck and Ferasso [25] 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 [25]. 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 [24]. Therefore, there is a need for longitudinal perspectives where stakeholder roles change as new sustainability requirements emerge.

However, applications reported within the aerospace industry 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 across the value chain is important. Integrating the circularity dimension into the stakeholder salience framework enables analysis of stakeholders within the aerospace industry that are important to develop circular value chain.

3. Methodology

This research employs a single case study approach where an organization's value chain was explored in depth. The case company, GKN Aerospace Sweden AB, is a Tier 1 aerospace components designer and manufacturer. It is characterized by long product lifecycles, long development cycles, few actors in the value chain and low production volumes. Since 2023, the group focuses solely on the aerospace business and has about 16 000 employees. GKN Aerospace Sweden AB is today the headquarters of the group's Engines division and counts.

Figure 1 provides an overview of the research approach of the study, which consists in a literature review, the development of a key stakeholder analysis method for sustainable product development, and validation of the method at the case company.

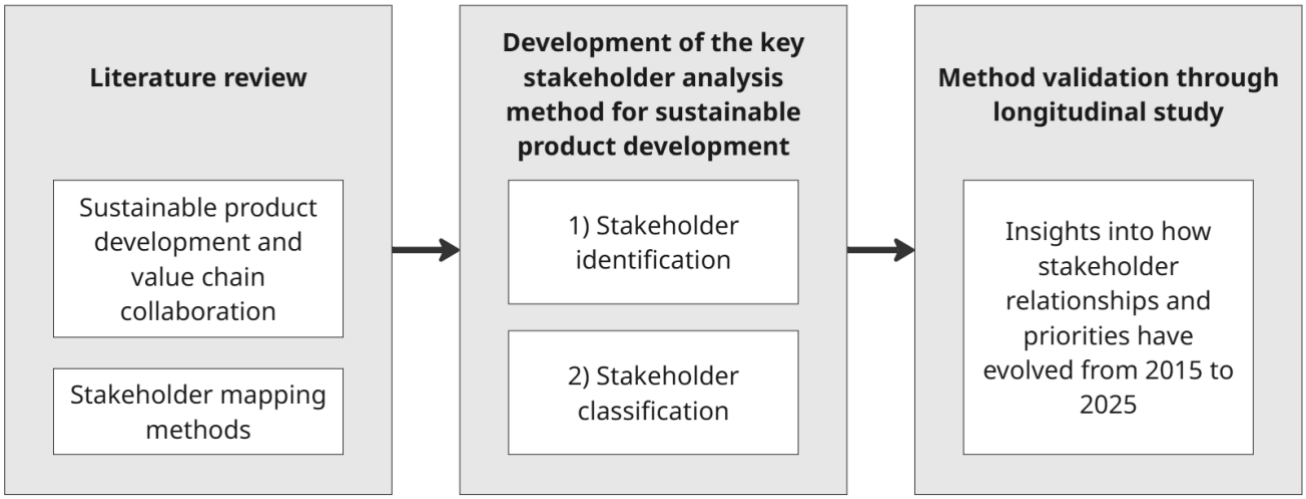


Figure 1. Overview of the research approach of this study.

The stakeholder mapping was conducted with a longitudinal approach at two points in time: in 2015 and in 2025 at the same case company. It was conducted through a number of 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 did an additional workshop to compare results and discuss path forward.

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 (3)
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)

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

3.1 Stakeholder identification

The first step was to identify key stakeholders belonging to four categories of actors as defined by O'Hare, McAloone [26]:

- Professional interest: have professional activities that may have an impact on the company
- Supply chain: provide goods and services to the company
- Personal interest: may take a personal interest because in the company, or the company has an impact on them in some way.
- Customers: are purchasing the goods and services from the company.

Stakeholders were identified from the perspective of GKN Aerospace's site in Sweden to best utilize participant's knowledge and limit the complexity of the assessment. Additionally, participants were asked to identify stakeholders at each product life stage: raw materials extraction, manufacturing, distribution, usage and end-of-life. This approach ensures a broad stakeholder representation, both across different types and throughout the value chain. Figure 2 shows the template used for stakeholder identification.

3.2 Stakeholder classification

The second step was to classify the stakeholders by using the stakeholder salience model by Mitchell, Agle [21]. The previous stakeholder classification from 2015 was also updated and the stakeholders identified from the first step were classified depending on if they have power, legitimacy, or urgency:

- Power: This refers to a stakeholder's ability to influence the organization or project despite resistance. Power can be enforced (e.g., through force or threat) utilitarian (e.g., through financial means) or normative (e.g., through symbolic influence or values).
- Legitimacy: This is about whether a stakeholder's involvement is perceived as appropriate or rightful. It can be based on legal standing, moral claims or social norms.
- Urgency: The degree to which stakeholder claims call for immediate attention. It depends on time sensitivity and criticality of the issue.

They were also classified as dominant, dependent, dangerous, or definitive, depending on if they had two or three attributes. Figure 2 shows the template used for stakeholder classification. After the application of the method, a reflection session took place discussing the desired future state by asking the question: *What roles should the various actors have in a sustainable value chain for an innovative and circular value proposition?* From that, some insights were defined such as stakeholder relationships and new potential stakeholders, and how stakeholder salience might evolve, including which actors should gain greater importance in enabling circular value chains.

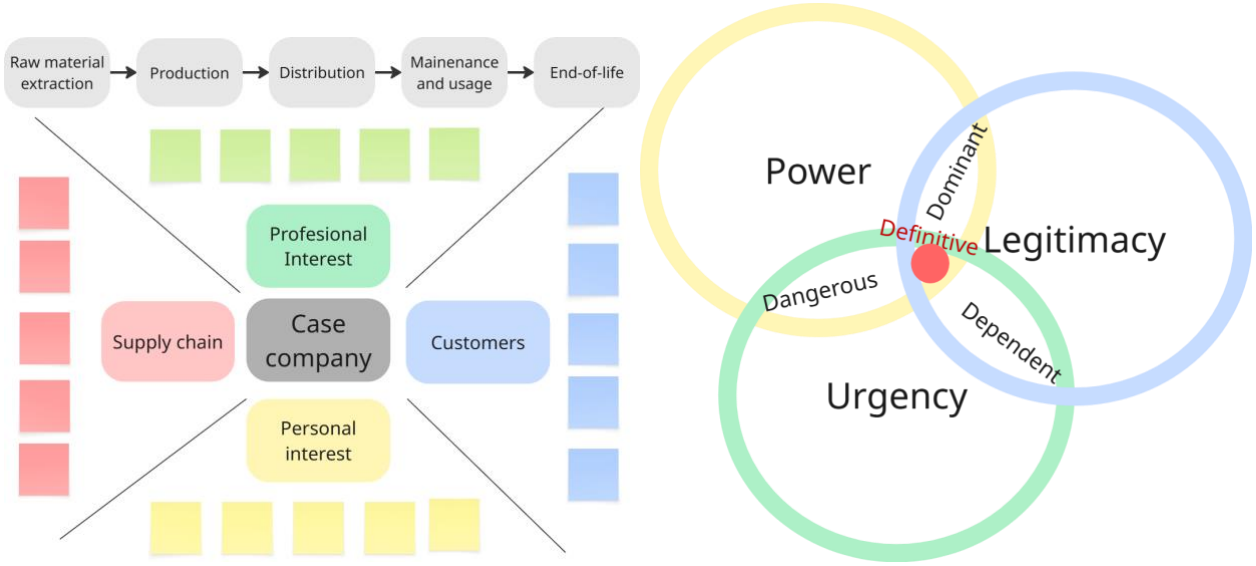


Figure 2. Templates for stakeholder identification (left) and classification (right). The participants were invited to write down stakeholder names on digital notes before classifying them.

4. Results

This section presents the results from the study in the following order: identifying stakeholders in the life cycle, and classifying the key stakeholders using the stakeholder salience model.

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.

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 added 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 in the professional category, rating agencies, consulting agencies, shareholders were added to the mapping. Among the newly identified stakeholders in 2025 within the supply chain were other sites, consultants, local companies, international corporations of various sizes, bankers, analysts, and landlords. On the costumer side, organisations such as metal foundries, Maintenance, Repair and Overhaul (MRO) shops and value

chain actors in the field of Industrial gas turbine. In essence, more business areas are added as the company has grown and created new partnerships over the last 10 years.

These additions indicate 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. This perspective formed the basis for the stakeholder classification using [21] framework.

Several stakeholders were removed between 2015 and 2025 for three main reasons: i) they were no longer considered as external stakeholder due to company reorganisation, ii) they are not part of the case company (GKN Aerospace) value chain, iii) were redundant with other stakeholder categories.

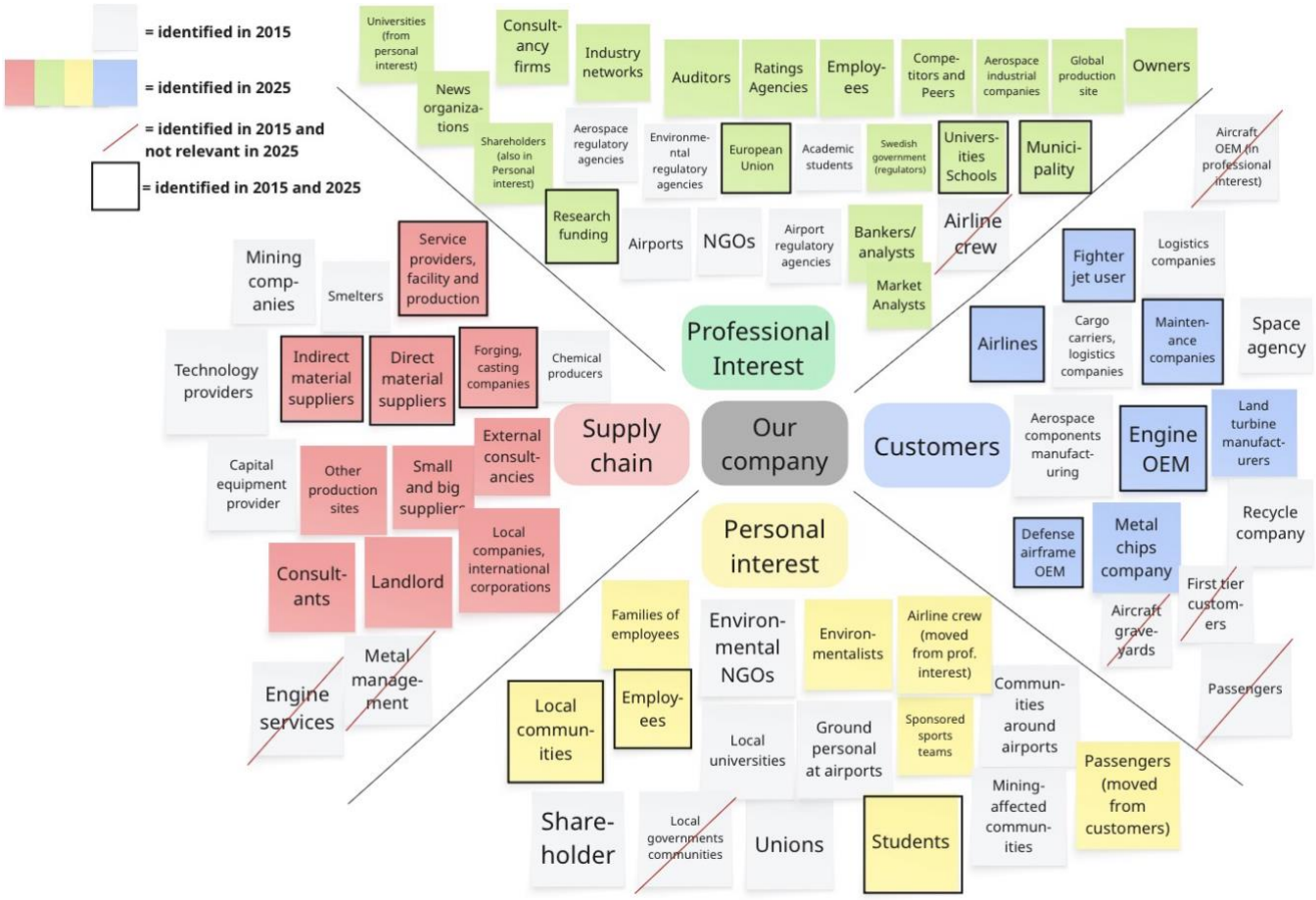


Figure 3: Stakeholder identification comparison between 2015 and 2025.

4.2 Stakeholder classification in the past and today

The identified key stakeholders were classified according to the stakeholder salience model by Mitchell et al. (1997) [21] to investigate their salience and explore how their salience have evolved between 2015 and 2025, potentially driven by sustainability and future circular demands. 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.

The longitudinal study reveals an evolution in the case company customer focus: the European space agency, and industrial gas turbine OEM, classified as definitive in 2015 shifted to dominant in 2025. At the same time, significant changes can be observed in relation to suppliers. Suppliers of billets and forged goods shifted from the dependent category to being classified as definitive stakeholders in 2025. Only one supply chain actor was found in the definitive category in 2015, expanding to three in 2025. Finally, one supplier appeared in the dangerous category in 2025, reflecting increased supply constrained experienced by the aerospace industry in the recent years. 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.

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.

Applying the salience framework [21] helps to illustrate how the salience of stakeholders has changed over time. These changes in stakeholder salience indicate a gradual shift in the value chain, where sustainability and circular solutions might become more important.

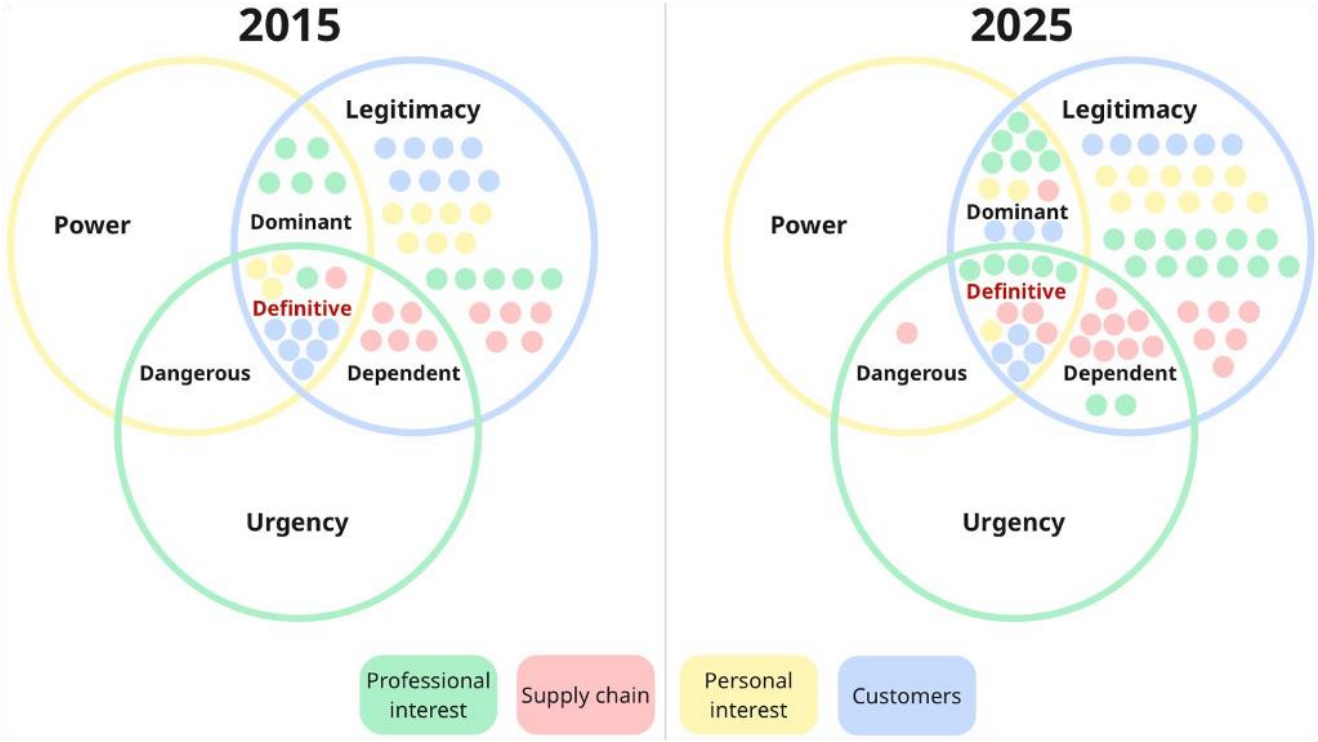


Figure 4. Overview of stakeholder classification in 2015 and 2025.

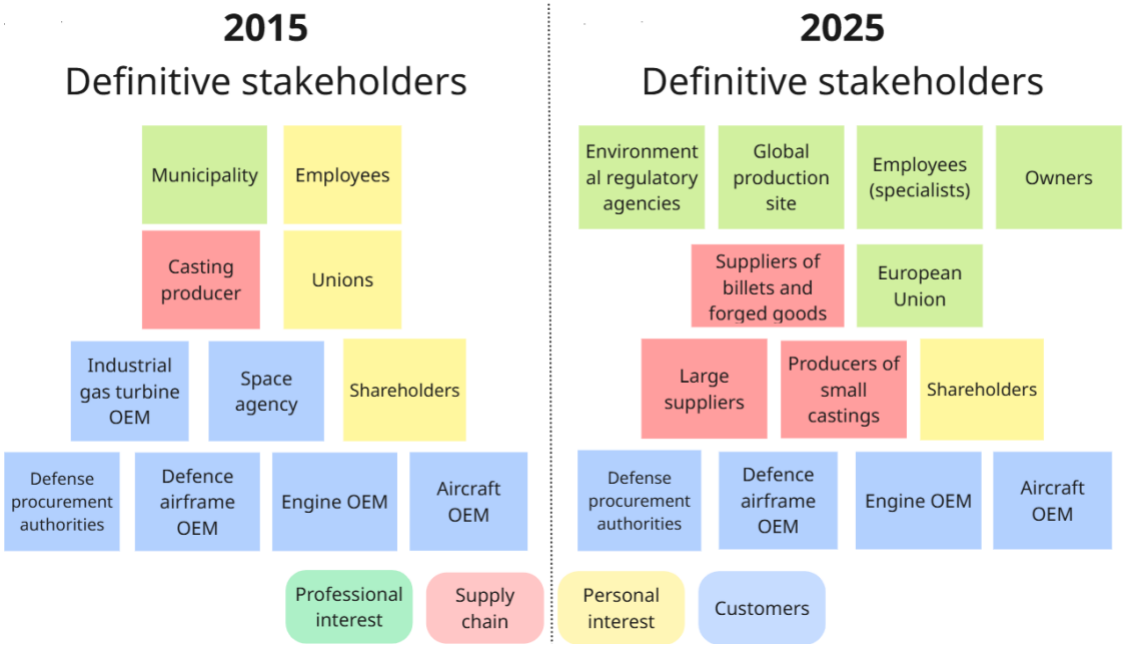


Figure 5. Comparison of stakeholder classification in 2015 (on the left) and 2025 (on the right), with a focus on "definitive" stakeholders.

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 defining core value chain actors involved in developing circular solutions and explores current capabilities for creating circular solutions in the value chain as well as future needs. It raises important questions as who will need to be included in next generation aircraft development and how.

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, and thereby support product design teams making strategic plans for circular solutions. In addition to the framework by Mitchell et al. (1997) [21], analyzing stakeholder attributes such as power, legitimacy and urgency, stakeholders are identified through the perspectives of supply chain, customers, professional interest, and personal interest. In this way, the method helps understanding which actors that 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 identify stakeholders that have the potential to either drive or hinder the implementation of circular solutions.

The longitudinal comparison between the stakeholder mappings conducted in 2015 and 2025 indicated shifts in stakeholder identification and salience. This was somewhat unexpected considering the long product development processes and life cycles typically associated with the aerospace industry.

The longitudinal study showed that it was an increased number of stakeholders identified in the 2025 mapping and 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 increasing focus on circular solutions and the need for collaboration in the value chain within the industry. Another possible reason for the differences of the identified key stakeholders may be the composition of the roles applying the method. In the study of 2025 there were five participants with sustainability roles in the team applying the method, compared to one of the four participant in 2015. These differences may have most certainly shaped both the identification and classification of stakeholders, indicating the importance of a diverse set of competencies for these types of tasks in a company.

On the other hand, growing emphasis on sustainability may have led to the emergence of new stakeholders or changed their importance to becoming a key partner of future solutions. When interpreted through the stakeholder salience framework, this could result in shifts in attributes particularly for stakeholders associated with environmental and regulatory concerns. Therefore, stakeholder salience evolves both due to internal organizational changes and external pressures, and it is important with continuous stakeholder analyses particularly in companies undergoing sustainability transitions, where new relationships and priorities may evolve over time.

This research contributes to theory by extending stakeholder analysis into a relatively unexplored context. Applications of the stakeholder salience framework by [21] within the aerospace industry, particularly in relation to circular transitions, remain limited. By integrating a circularity dimension and adopting a longitudinal perspective, this research shows how stakeholder analysis can be used to address sustainability challenges in complex value chains. In addition, the literature shows that the stakeholder salience framework does not capture temporal change and that salience is dynamic. The observed changes from 2015 and 2025 in this context highlight the importance of considering temporal aspects in stakeholder analyses, particularly in industries characterized by life cycles.

From a practical perspective, this research provides a practical framework for organizations that aim to increase circularity and collaborate with stakeholders, and may support a project design team when creating resilient and circular solutions. The method may provide tactical decision-making support on which partners to involve to create long-term future circular solution. To explore its future potential the proposed method should be applied in other organizational/industrial contexts to evaluate its relevance and usefulness. Given that the strategic aerospace agendas in Europe clearly goes beyond the important area of emissions to include wider circular economy and sustainability aspects, the

ability to identify, understand and bring in key stakeholders, normally less active in new product development closer into co-development roles.

This research has several limitations that should be acknowledged. It is based on a single case company which limits the generalizability. The results should therefore be interpreted as an indication rather than representing the aerospace as a whole. 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.

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