Materiality Analysis in Aerospace Sustainable Supply Chains

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Abstract

Nowadays, following the increasing demand for air transportation, the commercial aviation sector is becoming the main driver of the global aerospace manufacturing industry. Also, sustainability has emerged as a growing concern globally and specifically for the industry. Sustainable supply chain management appears as a key factor for the aerospace industry development. Organizations and its stakeholders are increasingly incorporating sustainability with companies starting to account for sustainability issues in their reports and management.

When discussing sustainability performance, the question on the materiality of the different indicators naturally arises. The correct approach to the relevant aspects of sustainability can become critical for the organization's successful results on sustainability. Research has been done regarding the materiality on sustainability and development of frameworks for sustainability reporting. However, both the literature and the industry are lacking a uniform comprehensive approach to this subject

The present dissertation starts by contextualising the aerospace industry and the commercial aviation sector, followed by the characterisation of the problem to be studied. A comprehensive state of the art literature review is then conducted, focusing on the relevant themes to support the development of a materiality assessment methodology in the context of sustainability. Then, the proposed methodology is tested and the results discussed and compared with existing comparable data. Finally, a case study on Embraer is developed focusing on the material issues the company has identified in its sustainability strategy.

Keywords: sustainability, aerospace supply chain, key performance indicators, materiality

Resumo

Atualmente, com a procura crescente por transporte aéreo, o sector da aviação comercial está a tornar-se um dos principais motores da indústria aeroespacial. Também a sustentabilidade tem crescido como uma preocupação global e também, em particular, para esta indústria. A gestão da cadeia de valor sustentável torna-se um fator chave para o desenvolvimento da indústria aeroespacial. Organizações e *stakeholders* incorporam a sustentabilidade cada vez mais sendo que as empresas começam a incluí-la nos seus relatórios e na sua gestão.

No contexto do desempenho em sustentabilidade, surge a questão da materialidade dos diferentes indicadores. A abordagem correta aos aspetos mais relevantes na sustentabilidade pode tornar-se crítica para o sucesso de uma organização neste campo. Investigação tem sido feita sobre o tema da materialidade na sustentabilidade e no desenvolvimento de modelos para relatório de sustentabilidade. Ainda assim, tanto a literatura como a indústria ainda não têm uma abordagem uniforme e abrangente ao tema.

A presente dissertação começa com a contextualização da indústria aeroespacial e o sector da aviação comercial seguida de uma caracterização do problema a ser estudado. Segue-se uma revisão abrangente do estado da arte da literatura com foco nos temas relevantes para o desenvolvimento de uma metodologia de avaliação da materialidade no contexto da sustentabilidade. De seguida, a metodologia proposta é testada e os resultados discutidos e comparados com os dados já existentes. Finalmente, é desenvolvido um estudo de caso sobre a Embraer focado nos temas materiais que a empresa identificou no contexto da sustentabilidade.

Palavras-chave: sustentabilidade, cadeia de valor aeroespacial, indicadores de desempenho chave, materialidade

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List of Acronyms

3BL – Triple Bottom Line

3PL – Third-Party Logistics

A&D – Aerospace and Defense

BCG – The Boston Consulting Group

CDP – Carbon Disclosure Project (formerly)

CDSB – Climate Disclosure Standards Board

CEO – Chief Executive Officer

CSR – Corporate Social Responsibility

ESG – Environmental, Social and Governance

FCT – Fundação para a Ciência e Tecnologia, Foundation for Science and Technology

FEUP – Faculdade de Engenharia da Universidade do Porto

GHG - Greenhouse Gas

GRI – Global Reporting Initiative

HM – Heat Map

IAMAT – Introduction of Advanced Materials Technologies into new product development for the mobility industries

IASB – International Accounting Standards Board

ICB – Industry Classification Benchmark

IFRS – International Financial Reporting Standards

IIRC – International Integrated Reporting Council

IRI – Initiative for Responsible Investment

ISO – International Organization for Standardization

IST – Instituto Superior Técnico

IWG – Industry Working Group

KPI – Key Performance Indicator

LCA – Life Cycle Assessment

LLP – Lead Logistics Provider

LSSI – Large Scale Systems Integrator

MD&A – Management Discussion and Analysis

MIT – Massachusetts Institute of Technology

MIT SMR – MIT Sloan Management Review

NGO – Non-governmental Organisation

NPD – New Product Development

OEM – Original Equipment Manufacturer

RPK – Revenue Passenger Kilometre

RQ – Research Question

SHM – Structural Health Monitoring

SASB – Sustainability Accounting Standards Board

SC – Supply Chain

SCM – Supply Chain Management

SEC – Securities and Exchange Commission

SSC – Sustainable Supply Chain

SSCM – Sustainable Supply Chain Management

UN – United Nations

US – United States

US$ – United States dollar

UNPRI – United Nations Principles for Responsible Investment

WBCSD – World Business Council for Sustainable Development

WCED – World Commission on Environment and Development

WP – Working Package

1. Introduction

1.1 Problem contextualisation

Following the increasing demand for air transportation, the commercial aviation sector is nowadays becoming the main driver of the global aerospace manufacturing industry, with the revenues of the top 20 global commercial aircraft companies reaching almost 240 billion US$ and annual passenger enplanements rising to more than 4 billion in 2017 (Deloitte 2018). The sector is expected to continue to grow, with forecasts for new commercial aircraft until 2037 currently valuated at more than 6 trillion US$ (Boeing 2018).

However, in the last decade, the industry has been dealing with several challenges, from terrorism and natural disasters to global economic instability and record fuel prices. The financial and environmental challenges are nowadays driving fuel efficiency and cost reduction innovations, as well as trying to end monopolies through the supply chain and developing strategies to cut the industry's carbon footprint. Collaboration between stakeholders across the industry is now the vision for the future, and it is believed to be the path for sustainability (IATA 2016).

Today, sustainability is a top concern for most organizations. Managers are now required to concern about the economic, ecological and social pillars of sustainability of the business (Carter & Rogers 2008). In industrial and manufacturing businesses, the sustainability of supply chain (SC) has a major impact on the organizations' performance (Ansari & Kant 2016). The aerospace manufacturing industry is no exception, and all its complexity makes the supply chain impact in sustainability even more relevant.

When discussing sustainability performance, the question on the materiality of the different indicators naturally arises. The correct approach to the relevant aspects of sustainability can become critical for the organization's successful results on sustainability (Khan et al 2016).

Several articles and frameworks have been developed regarding the materiality on sustainability and development of frameworks for sustainability reporting. However, both the literature and the industry are lacking a uniform comprehensive approach to this subject (Lydenberg et al 2010).

This dissertation is part of a bigger project: IAMAT – Introduction of advanced materials technologies into new product development for the mobility industries. The main goal of the project is to develop an integrated framework for product development evaluation that can exploit the potential use of advanced materials, manufacturing technologies and structures in the aeronautical industry, joining together Massachusetts Institute of Technology (MIT) Portugal, Instituto Superior Técnico (IST) Lisboa, Faculdade de Engenharia da Universidade do Porto (FEUP), Universidade do Minho and the Foundation for Science and Technology (Fundação para a Ciência e Tecnologia, FCT).

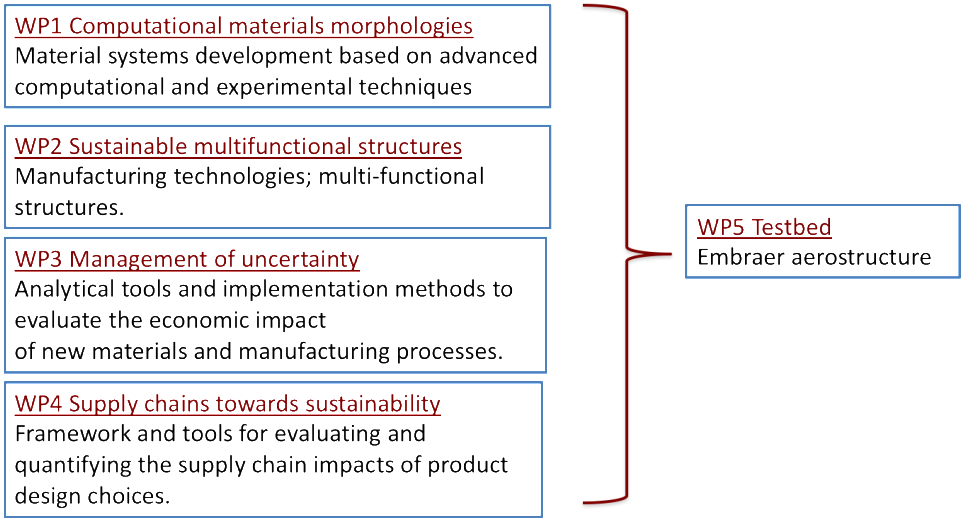

Figure 1 – IAMAT Overview

There are five working packages (WP) and this work is part of the fourth one, WP4 – Supply Chains Towards Sustainability. This WP intends to define the framework and tools to evaluate and quantify the supply chains impacts of product design choices for Embraer Évora.

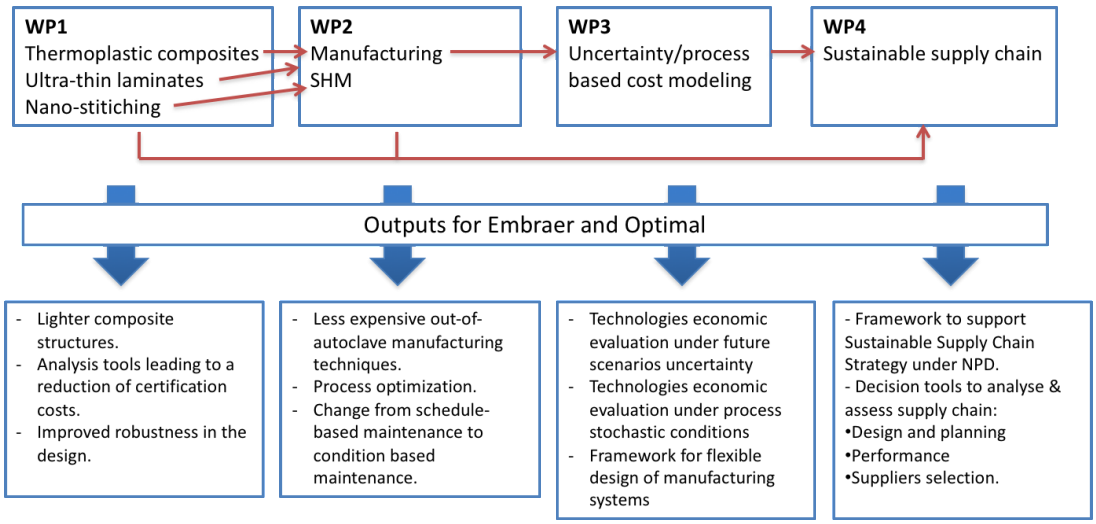

Figure 2 – IAMAT Summary

The resulting product of these working packages is intended to give significant suggestions to New Product Development (NPD), new manufacturing processes and new management models.

Starting by characterizing the aerospace industry and reviewing the state of the art on the themes above, this dissertation comes as a proposal for a comprehensive framework for defining and assessing materiality in the context of the aerospace supply chain sustainability.

1.2 Objectives

The main objective of the present dissertation in Aerospace Engineering is to conduct an analysis on materiality in the aerospace supply chain focusing on defining materiality and developing a framework for assessing it. This objective can be deconstructed into several intermediate objectives:

- Contextualise and characterise the problem:
  - Contextualisation of the aerospace manufacturing industry;
  - Characterisation and description of the problem to be studied.
- Review the state of the art on:
  - Sustainability in the aerospace supply chain;
  - Definition of Materiality;
  - Different approaches to assess materiality.
- Develop and conduct a methodology for materiality assessment;
- Compare the obtained results with the existing data for the aerospace supply chain;
- Derive conclusions and suggestions for the future.

1.3 Structure of the Dissertation

This dissertation is divided into six chapters:

- **Chapter 1** – this present chapter presents a brief context to the problem in study, as well as the methodology for the dissertation and its objectives;
- **Chapter 2** – this chapter starts with a general overview of the aerospace manufacturing industry, followed by a contextualization of the commercial aerospace sector, the airplane life cycle, the industry's supply chain and an overview of engagement towards sustainability;
- **Chapter 3** – in this chapter a literature review is presented. Concepts such as sustainability, supply chain and materiality are reviewed, presenting the state of the art regarding these themes;
- **Chapter 4** – this chapter presents the proposed methodology;
- **Chapter 5** – this chapter presents the results and discussion of the application of the methodology, including the case study of Embraer, focusing on the material aspects identified by the manufacturer;
- **Chapter 6** – in this final chapter, the major conclusions taken from the dissertation are presented, as well as suggestions for future developments.

2. Problem Contextualization

In this chapter the context for the work to be developed in this dissertation will be explained. A brief history of the aerospace manufacturing industry is presented in section 2.1. Section 2.2 gives an overview of the industry, analysing the competitive scenario, characterising the industry's typical supply chain and the aircraft life cycle. Section 2.3 comprises a brief and general overview on market engagement towards sustainability. The identification of the problem to be studied is described in section 2.4 The chapter ends with section 2.5, in which conclusions from this analysis are presented.

2.1 Brief History of the Aerospace Manufacturing Industry

Few decades after the first flight, both First World War and Second World War proven to be key events with major impact in the evolution of military aircraft and in aviation technology in general. The great technical evolution and expertise acquired especially in Second World War made airplanes capable of flying higher, faster and further, and eventually the demand for air transportation naturally increased.

In the early 1980's, the air transportation industry updated their focus and goals: safety and security were on the top of the agenda, closely followed by financial viability, product and service quality and cost and environmental-friendly standards definition. The aircraft manufacturing industry had to start finding technical solutions and bring complying products to the market. These objectives proved to be very relevant as they still have a role in the industry goals today.

The 21st century brought new and huge challenges throughout the industry, including terrorism, natural disasters, global economic disturbance and unprecedented rise in fuel prices. The previous goals were reinforced during these years, focusing on the environment and financial issues that drive fuel efficiency and cost reduction innovations. The International Air Transportation Association (IATA) lead a major initiative to reduce costs across the air transport value chain, particularly trying to end monopolies through the suppliers, as well as a long-term strategy to cut the industry's carbon emissions by half in 2050. Partnerships between regulators, airlines, manufacturers, suppliers and across the whole industry are now the vision for the years to come, and it is believed that this is the path for a profitable sustainable future (IATA 2016).

The major role of manufacturers in achieving these goals is undeniable. The following section will give an overview of the global aerospace manufacturing industry, providing a definition of its several subsectors. The economic scenario will also be explored by analyzing the last years, forecasts and the trends in the industry.

2.2 The Global Aerospace Manufacturing Industry

2.2.1 General overview

The Oxford Dictionary of English (2018) defines 'aerospace' as 'the branch of technology and industry concerned with both aviation and space flight'. Using that definition, it can be said that the aerospace manufacturing industry is engaged in research, development, production and maintenance of both aircraft and spacecraft.

While aircraft refers to vehicles designed to fly on the Earth's atmosphere, spacecraft refers to vehicles or machines designed for operation above Earth's lower atmosphere (Encyclopædia Britannica 2010). This dissertation will not consider the 'space' branch of the sector, although most top companies in the industry have businesses and participations in this area.

Regarding the classification of aircrafts, there are several approaches. Following a classification based in its purpose, aircrafts can be divided into two main categories:

1) Military aviation, which includes all combat and supporting aircraft, operated by military forces (Taylor & Guilmartin 2011);
2) Civil aviation, which represents all non-military aircraft, both commercial and private (Weiss & Amir 2014);

The classification of civil aviation activities by the International Civil Aviation Organization (ICAO 2009) shows that the segment is also divided in two main categories:

- Commercial aviation, which refers to scheduled and non-scheduled air transportation services;
- General aviation, which includes non-commercial business aviation, aerial work, instructional flying and pleasure flying aircraft.

For several years, the global aerospace and defense industry has shown a revenue expansion with a declining growth trend, mainly driven by budget cuts in the military sector. However, given the large increase in the air transportation demand and global commercial aviation revenues, the last is gaining more and more significance on the global industry numbers (Deloitte 2018).

2.2.2 Commercial Aviation Market Characterization

Commercial aviation, which is defined by passenger and/or cargo transportation (ICAO 2009), is divided in two main segments: **1)** mainline aircraft; **2)** regional aircraft, where the second is divided in turboprops and jets. These two segments have different competitors, which can be classified as mature or emerging Original Equipment Manufacturers (OEMs) (Bombardier 2015). The regional aircraft segment comprehends aircraft from 60 to 130 seats. Aircraft larger than 130 seats are considered as mainline aircraft.

For several years, mainline commercial aviation has been a duopoly shared by the United States company Boeing and the European aircraft manufacturer Airbus (Leahy 2016). In the regional aircraft market, the jet segment is dominated by Canadian Bombardier and Brazilian Embraer, while the turboprop segment is divided between Bombardier and Franco-Italian ATR.

The segment where most emerging OEMs are focused is the regional jets segment, with few developments in the mainline jets and turboprops segments. These companies are based in Russia and the Asia-Pacific region, with Chinese AVIC and Comac, Japanese Mitsubishi and Russian Irkut and Sukhoi making this group (Bombardier 2015).

The demand for air transportation is nowadays one of the main drivers of the global aerospace industry growth. Boeing (2016a) states that commercial aircraft demand is highly correlated to air transportation demand and identifies its main drivers: a) the ease-of-travel; b) the economic activity; c) local market factors.

Data presented by Deloitte (2018) shows that global airline traffic demand, measured in Revenue Passenger Kilometer (RPK), increased nearly seven times from 1981 to 2017. As seen in Figure 3, the passenger load factor (aircraft utilization) rose 27.5% during the same period and, likewise, the number of people flying per year also continued to grow, with a greater than five times increase from 1981 to 2017. Global economic and social events with major impact in the industry, like the Gulf crisis in 1990, 9/11 terrorist attacks in 2001 and the global economic crisis in 2008/2009, can be observed to have slowed or even invert the growth rate trend for a short period. Despite having to deal with multiple market shocks, air-travel industry demand is proven to be resilient to these unexpected events and always return to its historical growth trend in the long term, averaging 5 percent annual growth (Airbus 2016; Boeing 2016b; Embraer 2016).

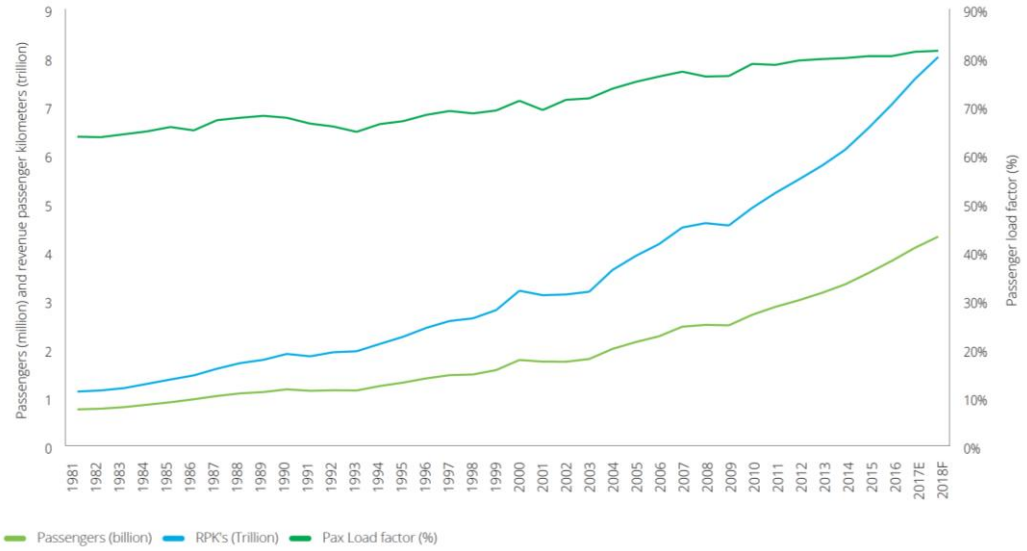

Figure 3 – Global airline traffic evolution from 1981 to 2018 (forecast). (Deloitte 2018)

Although great variability of the number of orders has been observed in the past years, demand forecasts for new commercial aircraft in the next 20 years are very optimistic. Airbus (2016) forecasted the market's need of around 33000 airplanes until 2035, valuated in US$5.2 trillion, accounting for aircraft with 100 or more seats. By doing so they are leaving most regional airplanes out of their study. Boeing (2016b) numbers are even more optimistic, going up to 39600 airplanes, valued in more than US$5.9 trillion for the same period. As opposed to the first forecast, Boeing took regional aircraft in account and, even by forecasting just about 2000 airplanes in this segment, it helped to achieve higher

numbers. On the other end, regional aircraft producers like Embraer (2016c) forecasted demand for around 6400 regional jets plus 2000 regional turboprops valuated in US$300 billion. The three forecasts agree the 130-220 seats single-aisle jets segment will be the main driver of the industry's growth, accounting to around 70% of total demand.

Other factors that influence commercial aircraft demand are:

1) economic growth cycles (Airbus 2017a);
2) the technological innovations (Airbus 2017c);
3) the availability of aircraft financing programs (Airbus 2017a);
4) national and international trade policies (Airbus 2017a; Erdbrink & Clark 2016);
5) the profitability and obsolescence of existing fleets (Boeing 2016b).

Nowadays that passengers are demanding more value for less money, the market is now seeing the emergence of the demand for better quality airplanes and more innovation, including supersonic flight (Kotoky et al. 2017; Bachman et al. 2017). That, combined with the entrance of new players in the market, is now giving a further boost to the commercial air flight business.

As the importance of commercial aviation is growing in the global industry, mostly driven by the increasing demand for air transportation, and therefore for commercial aircraft, the manufacturing supply chain needs to keep up with the demands. The following section will present the airplane life cycle as a starting point for the manufacturing supply chain, which will be presented later.

2.2.3 The Airplane Life Cycle

Airplanes are products with very long life cycles. A typical time frame for an aircraft life cycle is around 30+ years (Beelaerts van Blokland et al. 2010). Design and development are very time-consuming and costly activities, taking from several years or even decades. Production can take several months, depending on the size and complexity of the airplane. The operation is the longest part of the airplane life cycle, being usual to find airframes 25-30 years old still flying daily. During this time, maintenance, repair, retrofit and upgrade activities are performed to keep the aircraft flying safely and with technology up to date. These activities are essential to make sure the airplane can be in service for so long.

Maintenance, repair and overhaul (MRO) is an important growing segment of the aerospace value chain. The MRO supply chain is parallel to the OEMs' supply chain, which will be described in the following section, sharing with it most parts and subassemblies suppliers. Inventory across the supply chain is mandatory with the introduction of MROs, as the production times are long and MRO operations need to be agile. Most of the inventory is held by MRO entities or parts distributors, which have inventory management as one of their core capabilities. This does not mean suppliers and OEMs do not hold inventory. Nowadays, another growing source of parts for MROs is the recycling and recovery phase of the airplane life cycle. After retirement, airplanes are kept in storage and dismantling centres, often including recycling facilities, which take usable parts from old airplanes and re-introduce them through MROs. Unusable parts are sent for material reprocessing. Unrecyclable materials are disposed (Hashemi et al. 2014).

In Figure 4 the airplane life cycle is presented, as well as the position of MROs in the cycle and the spare parts flows. The introduction of recycling and recovery activities in the airplane life cycle can have a major role in reducing environmental impacts of MROs and raw material extraction.

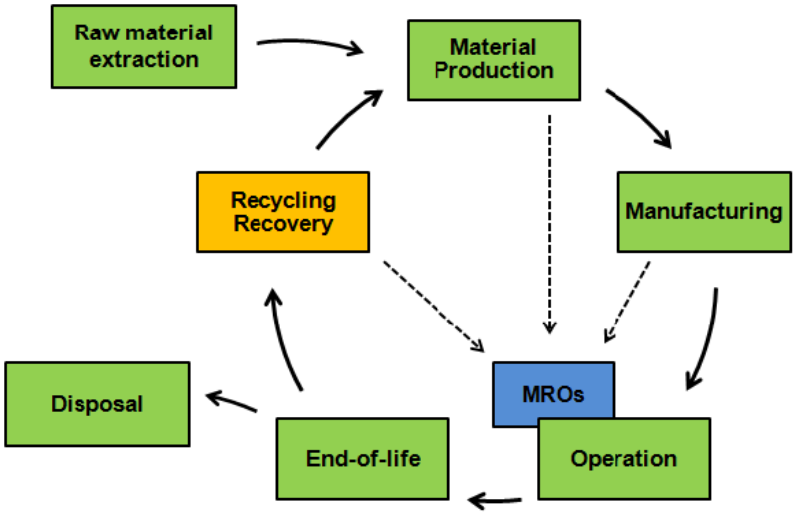

Figure 4 – The aircraft life cycle and MROs spare parts flows. (Abreu 2017)

The following section will present a model for the typical aerospace manufacturing supply chain, the major players which are part of that supply chain and the relationships that are created between them.

2.2.4 Aerospace manufacturing Supply Chain

Following the tradition across manufacturing industries, several supply chain models have been applied in aerospace manufacturing though the years. The evolution of the industry's supply chains shows the global trend to apply models based in globalisation and risk-sharing partnerships, evolving from joint ventures, stating that OEM-dominated supply chains are becoming obsolete (Rose-Anderssen et al. 2009; Petrick 2007; Kechidi 2013). Nowadays, the general aerospace manufacturing supply chain is described as having the OEM as the focal company, with 4 tiers of suppliers upstream and operator downstream, as shown in Figure 5. According to Niosi & Zhegu (2005) and Beelaerts van Blokland et al. (2010), the role of each tier for the generic aerospace supply chain could be:

- Tier-4: raw materials suppliers (extraction and processing of raw materials);
- Tiers-2 and -3: subassemblies and parts suppliers (e.g. electronic components and parts producers; engine components manufacturers);
- Tier-1: module and major assembly suppliers (e.g. airframe structures suppliers; major electric systems suppliers);
- OEMs – Original Equipment Manufacturers: aircraft/engine design and development, final assembly, sales and marketing;

Typically, material flows across the supply chain link all tiers, representing direct flows between entities in every level of the SC.

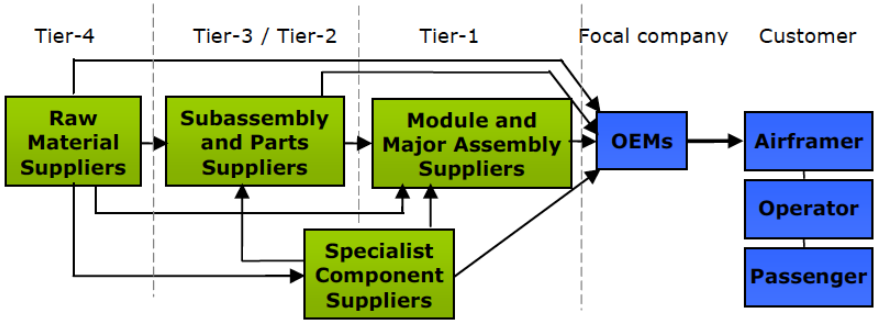

Figure 5 – General aerospace supply chain. (Beelaerts van Blokland et al. 2010)

Final assembly starts after the customer confirms the order details and the OEM is ready for final assembly. This means that the industry follows a Push-Pull integration strategy, in which raw material can be transformed into semi-finished products up to a point where the following downstream operations are triggered by customer orders and final assembly rates. The Push-Pull strategy boundary that can move upstream or downstream depending on the part/subassembly/assembly, although it is usually located between tiers-2/3 and 1. The upstream production follows a push-type production, based on forecasts and building inventory, while downstream production controlled by pull-type production (Ghrayeb et al. 2009).

Aircraft lead times are typically long: from several years for new products to a couple years in mature products. This means customers will receive their airplanes several years after putting an order. The main reason for the long lead times is the high complexity of the product with several parts which require special engineering, materials and processes which can rise lead times to several months. Therefore, the global lead time will also be very long (Berson 2015).

The most usual logistics and transportation strategy across the aeroplane manufacturing industry is to develop strategic partnerships with third-party logistics (3PLs) or leading logistics providers (LLPs). In some cases, manufacturers develop their own solutions to logistics, to better comply with their specific needs. As an example, Airbus developed a highly-modified cargo airplane, the Beluga, which can transport major assemblies from Tier-1 suppliers to OEMs final assembly facilities very quickly.

Regarding the information flows, it is hard to make a generalisation once there is not a single trend across the global industry. However, as OEM-dominated supply chains became obsolete and joint ventures and risk-sharing partnerships became the main trend, the information flows across the supply chain evolved from single supplier relationships to centralised information systems (Rose-Anderssen et al. 2009).

Here arises the question of how the information flow across the supply chain might impact the management strategies and balance of power between stakeholders. In this new era, where information is power and information is flowing at an incredible speed, the challenges it poses for the supply chain management and, particularly, for the aerospace industry.

OEMs

Following this trend, the OEMs are trying to focus on core competences of designing, assemble and market its products. This is leading these companies to become ‘large scale systems integrators’ (LSSI) (Beelaerts van Blokland et al. 2010; Petrick 2007). For Beelaerts van Blokland et al. (2010), this is now seen as a requirement for OEMs to be able to maintain a competitive advantage. By adopting the LSSI model, the OEM assumes the role of an integrator of major assemblies that are produced by tier-1 suppliers.

Tier-1

Nowadays, the trend is to increase supplier contribution on the supply chain, involving them by making use of their expertise and knowledge, decreasing global development time and sharing development costs. Following the LSSI theory by Beelaerts van Blokland et al. (2010), the tier concept was redefined, not only implying material flows, but also the functions of the entity. The industry now defines as a Tier- 1 a supplier who can design, manufacture, deliver and provide after-market service to a major assembly or system. However, the number of suppliers who can perform all these tasks is still limited and, therefore, the strongest OEMs tend to use all available capacity. Therefore, other OEMs must create their own alternatives, and vertically integrate the production of these major assemblies.

Tier-2/3

This is the tier where most suppliers are located. These suppliers receive raw materials and produce parts and sub-assemblies which will later be assembled by Tier-1 suppliers or by OEMs. Although they are located further up in the supply chain, their activities are closely controlled by OEMs as quality requirements are very high.

Raw materials suppliers

Raw materials suppliers in this industry are closely followed by OEMs. As quality requirements are very demanding, compliance with the norms and previous approval to supply from the OEM is needed, even if they are not supplying directly. The main raw materials used in the industry are aluminium, titanium and, more recently, a variety of composites.

Nowadays, as the aerospace supply chain model is evolving, collaboration and cooperation are more and more important. The OEM is abandoning its traditional role as the leader of the supply chain assuming a role of a coordination and cooperation facilitator. This is achieved through joint research and development (R&D) and through the establishment of common goals for all the stakeholders (Petrick 2007).

The aforementioned authors Petrick (2007) and Kechidi (2013) have studied the cases of both Boeing and Airbus and how they have successfully adapted to these changing roles and how their suppliers have become more and more important in the supply chain evolving from simple suppliers to ‘key collaborators’ (Petrick 2007), changing the balance of power and sharing not only the responsibilities of the production of the different parts and subassemblies but also the responsibilities of

the design of the product and R&D. New standards such as the 'modularisation' of the design (Kechidi 2013) have made this reality possible.

The following section will now focus on the sustainability engagement by different industries to set the context for the problem characterization further ahead.

2.3. Sustainability Engagement

MIT Sloan Management Review (MIT SMR) and The Boston Consulting Group (BCG) have been tracking corporate sustainability since 2009, surveying tens of thousands of managers and interviewing more than 150 executives and thought leaders, while producing eight annual reports and numerous blogs and articles, aiming to increase knowledge about business adoption of sustainable practices and to support the integration of sustainability into business strategy (Kiron et al. 2017).

Currently, 90% percent of respondents see sustainability as important, 60% have a sustainability strategy but only 25% have developed a positive business case. In this latest report, they have concluded that progress is uneven across industries, varies relative to size and between geographies (see Figure 6).

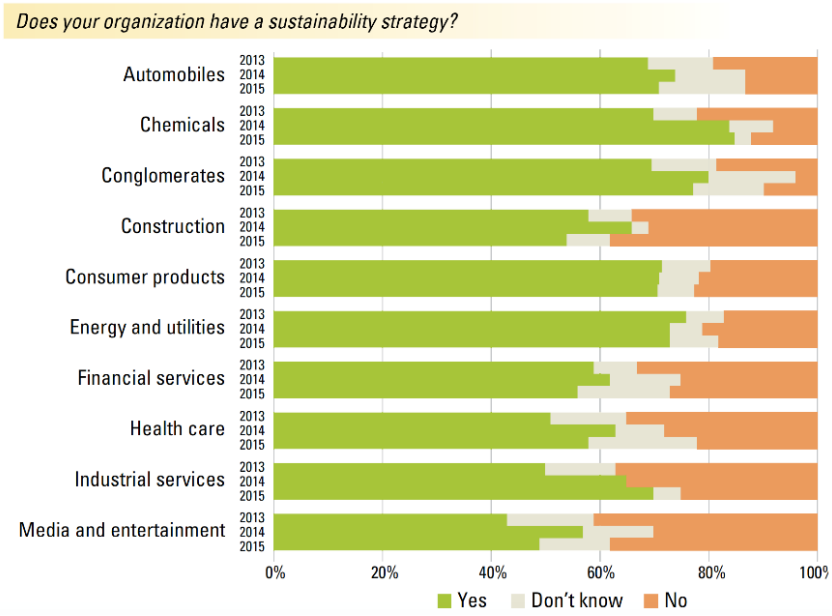

Figure 6 – Organizations with sustainability strategies by industry (Kiron et al. 2017)

Kiron et al. (2017) state that, despite significant progress, 'corporate sustainability has arrived at a crossroads. In one direction, corporate leaders in sustainability remain a minority, and are unevenly distributed across geographies and industries. In the other direction, a handful of standout companies are demonstrating that sustainability can be a driver of innovation, efficiency, and lasting business value'. Based on MIT SMR and BCG's research since 2009 on corporate sustainability, they have identified eight evidence-based factors that drive sustainable business practices, regardless of industry or region:

1. Articulate a practical sustainability vision and ambition that lays the foundation for new business practices.
2. Identify and prioritize material issues to focus resources.
3. Embed sustainability organizationally through cross-functional teams, clear targets, and key performance indicators (KPIs).
4. Innovate on multiple dimensions of your business model.
5. Develop a clear business case.
6. Get the board of directors on board.
7. Communicate a sustainability value-creation story to your shareholders.
8. Collaborate with a variety of stakeholders to drive strategic change.

Materiality, as defined by the Oxford Dictionary of English (2018), is 'the quality of being relevant or significant'. When it comes to materiality, on their 2013 report, "Sustainability's Next Frontier", MIT SMR and BCG offer evidence that 52% of companies that mostly or completely address their material sustainability issues also profit from their sustainability strategies. In contrast, only 16% of companies that pay little or no attention to material issues report that they profit from sustainability (Kiron et al. 2017). Although some sustainability concerns are common within a given industry, material sustainability issues vary by industry.

Other authors have come to similar conclusions. Khan et al (2016) reported results that indicate that firms with strong ratings on material sustainability topics outperform firms with poor ratings on these topics. In contrast, firms with strong ratings on immaterial sustainability topics do not outperform firms with poor ratings on the same topics.

Also, regarding the investors side, they have stated that an increasing number of investors have committed to integrating sustainability issues in their asset allocation decisions. As of 2014, the United Nations Principles for Responsible Investment (UNPRI) had 1,260 signatories with $45 trillion in assets under management who had committed to six principles 'recognizing the materiality of environmental, social, and governance (ESG) issues.' At the same, time an increasing number of companies have been disclosing sustainability information, growing from less than 30 in the early 1990s to more than 7,000 in 2014 (Khan et al 2016).

Given this backdrop, understanding the value implications of sustainability issues has been of interest to a wide audience.

2.4 Problem Characterization

As seen in the previous sections, the aerospace supply chain has changed over the past decades and sustainability has become a fundamental issue. Nowadays, organizations seek to define and implement a sustainability strategy and the question of what the material aspects are arises naturally. The following research questions result from discussing these subjects:

- **RQ1**: Which methodology can be used to assess materiality in the sustainability strategy in the aerospace supply chain?
- **RQ2**: What are the material aspects in the sustainability strategy in the aerospace supply chain?

This dissertation aims to organize a comprehensive state of the art followed by the development of a materiality definition in the context of sustainability and a methodology to assess it, the gathering of the results achieved so far by the WP4 of the IAMAT project on stakeholders' analysis and measurement of stakeholder engagement, followed by the application of the proposed methodology and comparison of the obtained results with existing comparable data. This work will end with a case study on Embraer focusing on the material issues the company has identified in its sustainability strategy.

2.5 Chapter Conclusions

Nowadays, following the increasing demand for air transportation, the commercial aviation sector is becoming the main driver of the global aerospace manufacturing industry. The typical aerospace supply chain currently follows a systems integrator model, where OEMs design, develop, assemble and sell aircraft. Tier-1 suppliers are now expected to design, develop and manufacture major modules and assemblies. However, as capable suppliers are yet not commonly available, the biggest players in the industry tend to use all available capacity. The supply chain is also characterized by high OEM control through the whole chain, and by increasing collaboration.

Sustainable supply chain management appears as a key factor for the aerospace development. Sustainability has become a growing concern for companies and stakeholders with companies starting to account for sustainability issues in their reports and management. When it comes to materiality in sustainability, evidence shows that companies that focus on their material sustainability issues outperform those that do not. In contrast, firms with strong ratings on immaterial sustainability topics do not outperform firms with poor ratings on the same topics.

Two research questions were derived, regarding materiality in the aerospace supply chain sustainability: (RQ1) "Which methodology can be used to assess materiality in the sustainability strategy in the aerospace supply chain?"; (RQ2) "What are the material aspects in the sustainability strategy in the aerospace supply chain?" This will be the focus of this dissertation and of the literature review which will be conducted next.

3. State of the Art

This chapter presents a literature review about the theoretical concepts related to this dissertation. A brief literature review about supply chain is presented in section 3.1. Section 3.2 presents a review on sustainability: its different concepts and definitions and the Triple Bottom Line approach. In section 3.3 a brief overview of Sustainable Supply Chain Management is presented. Section 3.4 presents a literature review on the concept of materiality and its use in the sustainability field. A literature review of several frameworks related to this concept is also presented in this section. The chapter ends with section 3.5 presenting the conclusions drawn from the previous sections.

3.1 Supply Chain

There are various definitions for Supply Chain (SC). One can define it as being the flow of products and services amongst raw materials manufacturer, intermediate products manufacturers, end product manufacturers, wholesalers, distributors and retailers, connected by transportation and storage activities and integrated through information, planning and integration activities (Póvoa 2015).

Póvoa (2015) also presents other two formal definitions of 'supply chain': *the design and management of seamless, value-added process across organizational boundaries to meet the real needs of the end costumer* (by the Institute for Supply Management) and *managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, and delivery to the customer* (by The Supply Chain Council).

There is not a universal definition of the concept making it hard sometimes to define the scope. In the 1980's the concepts of Supply Chain and Supply Chain Management (SCM) started to emerge and they have been evolving over the past decades as the markets and consumers' requirements changed. The extended literature available on SC and SCM fails to provide a universal definition of these two concepts (Croom et al., 2000). The supply chain concept takes the perspective beyond the individual firm and focuses on the coordination of something larger: a chain, network, and all the other crucial aspects and functions essential to the chain integration. It is the end customer who has the final power to appraise the success or failure of supply chains (Christopher and Towill, 2001). Therefore, the competitive advantages of the companies do not rely only on their own internal strengths, but also on their ability to achieve value added integration throughout the SC with customers and suppliers.

A traditional supply chain is composed by two distinct business processes. One relates to the production planning and inventory control process which encompasses the inbound logistics, the manufacturing activities and the storage issues. The other one relates with the physical distribution and logistics processes, i.e., customer service and transportation activities aiming at managing the transportation services and delivery process (Beamon, 1998; Carvalho and Ramos, 2009; Min and Zhou, 2002; Tsiakis et al., 2001). A traditional supply chain may be defined as a set of companies operating individually where a forward flow of materials and products is created and a backward flow of information, orders and cash, is generated (see Figure 8) (Disney et al., 2003; Tsiakis et al., 2001; Vidal and Goetschalckx, 1997).

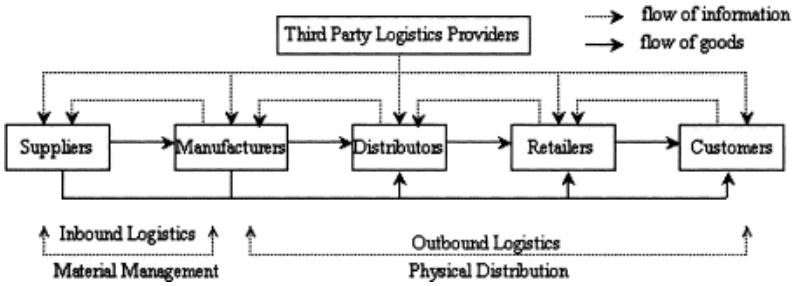

Figure 7 – The traditional supply chain (Min and Zhou, 2002)

Supply Chain Management is concerned with the efficient integration of suppliers, factories, warehouses and stores so that merchandise is produced and distributed in the right quantities, to the right locations and at the right time in order to minimize total system cost and satisfy customer service requirements (Póvoa 2015). As it happens to the 'supply chain' concept, there is not also a universal definition for 'supply chain management'

3.2 Sustainability

3.2.1 Concepts and Definitions

The year of 2017 marked the 30th anniversary of the publication of "Our Common Future", the report from the United Nations World Commission on Environment and Development (also known as the Bruntland report) that launched the idea of "sustainable development" (Kiron et al. 2017). The report envisioned a future where current economic prosperity did not come at the expense of future generations. Its definition of sustainability as "development that meets the needs of present generations without compromising the ability of future generations to meet their own needs" (WCED, 1987, p.15) is one of the most cited definitions of Sustainable Development (Azapagic, 2003; Seuring and Müller, 2008a; Winkler, 2010).

Employees, suppliers, community groups, governments, agencies and NGOs started to impose pressure forcing organizations to adopt new strategies in order to achieve sustainability both in the internal and external operations (Ciliberti *et al*., 2008; Halldórsson *et al*., 2009; Sarkis *et al.*, 2012; Seuring and Müller, 2008a, 2008b).

Sustainability is a very broad notion and still lacks clarity, leading to a lack of success in translating the theory into practice. This is mainly due to the fact that sustainability and sustainable development concepts are not clearly standardised and defined, there is a lack of standardisation on what to measure and how to measure sustainability in supply chains, there are conflicting points of view and interests imposing trade-offs between stakeholders, there are different values, ethical and cultural backgrounds, and different core activities and impacts (Azapagic and Perdan, 2000; Carter and Rogers, 2008; Clift, 2003; Hutchins and Sutherland, 2008; Mota and Soares, 2013; Vachon and Mao, 2008).

The scientific community is deeply committed to investigate sustainability and sustainable development issues due to the growing importance of these matters in business practices and the lack of consensus on what is the best approach to apply (Ageron *et al.*, 2012; Dobers, 2009; Hassini *et al.*, 2012). Companies have also become more interested in sustainable practices since they are a possible

source of value creation for customers, reputation building and revenue increase. Companies started to engage effective policies to ensure business sustainability and for that reason the World Business Council for Sustainable Development (WBCSD) was founded. WBCSD aims to “galvanize the global business community to create a sustainable future for business, society and the environment” (WBCSD, 2012). These three elements were effectively attached and linked together to form the most generalised model of sustainable development (Azapagic and Perdan, 2000): The Triple Bottom Line.

3.2.2 The Triple Bottom Line (3BL)

John Elkington introduced The Triple Bottom Line (3BL) concept in 1994 (Elkington, 2004): *“Triple Bottom Line accounting attempts to describe the social and environmental impact of an organization’s activities, in a measurable way, to its economic performance in order to show improvement or to make evaluation more in-depth”* (Elkington, 1998). In 1995 Elkington attempted to clarify the pillars’ meaning by naming them in a novel way: Profit; Planet; People (Elkington, 2004).

The major difference from the past models is that all three dimensions are evaluated in an equal way so it quickly became a popular way to consider economic, environmental and social aspects in decision making (see Figure 8) (Beske, 2012). The biggest gain of the 3BL was its successful understanding and adoption by several global companies in the quest to demonstrate to their stakeholders the progresses over efficiency and sustainability in the long-term (Closs et al., 2010; Hassini et al., 2012).

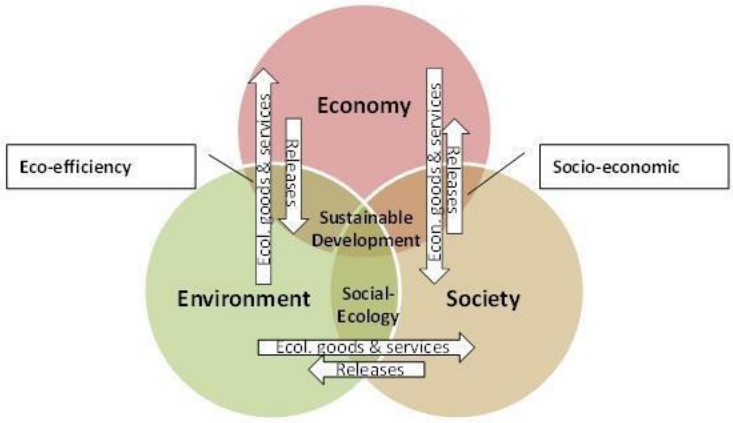

Figure 8 – The Triple Bottom Line (Ruiz-Mercado et al. 2012)

“The economic dimension of sustainability concerns the organisation’s impacts on the economic conditions of its stakeholders and on the economic systems at local, national, and global levels” (Global Reporting Initiative, 2011). Edum-Fotwe and Price (2009) state that traditionally only the economic dimension of sustainability is covered. Stamford and Azapagic (2011) argued that “in a competitive market, financial viability is a prerequisite”. Summarizing, the organisations’ survival relies on the ability to manage the “economic sustainability which can be interpreted as how companies stay in business” (Doane and MacGillivray, 2001).

"The environmental dimension of sustainability concerns an organization's impacts on living and non-living natural systems, including ecosystems, land, air, and water" (Global Reporting Initiative, 2011). There is a growing awareness of the significant impacts of the products on the environment, therefore stakeholders and government pressures forced businesses to rethink their environmental practices across their entire supply chains (Beske, 2012; Seuring, 2012; Winkler, 2010).

*"Social sustainability is a quality of societies. It signifies the nature-society relationships, mediated by work, as well as relationships within the society. Social sustainability is given, if work within a society and the related institutional arrangements: 1) satisfy an extended set of human needs; 2) are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled" (*Littig and Griessler, 2005). This pillar considers a wide variety of subjects like education, potable water, food, equity, employment, business ethics, wealth, human rights, safety, stakeholder relationship, labour standards and social responsibility (Azapagic, 2003; Closs et al., 2010; Klassen and Vereecke, 2012; Sverdrup and Svensson, 2004; Vachon and Mao, 2008; Vallance et al., 2011).

In theory the 3BL should be applicable having into consideration the three pillars and many authors have argued in favour of the equal treatment of the three dimensions in order to achieve what Sverdrup and Svensson (2004) called *Integrated Sustainability* (Ashby et al., 2012; Halldórsson et al., 2009; Kleine and Hauff, 2009; Spangenberg and Omann, 2006; Wittstruck and Teuteberg, 2012).

In reality the 3BL in not applicable as a whole since companies and communities face four recurring problems:

1) lack of theory such as protocols, tools, indicators;

2) metrics to assess the pillars;

3) the methodologies and guidelines are not universally accepted (Clift, 2003; Meehan *et al.*, 2006);

4) existence of trade-offs between the pillars and the stakeholder groups add to the problem (Heemskerk et al., 2002; Kruse et al., 2008; Stonebraker et al., 2009; You et al., 2012).

In general, environmental issues have recently dominated the discussion and there is little research on integrating the three systems altogether (Ashby et al., 2012; Seuring and Müller, 2008a). Economic and environmental systems were frequently optimised together, leaving the social pillar in the background (Edum-Fotwe and Price, 2009; Hutchins and Sutherland, 2008). Some companies have the tendency to only run a sustainability analysis on one of the three systems, effectively showing a lack of ability and/or awareness to integrate and inter-relate all of them (Edum-Fotwe and Price, 2009; Kruse *et al.*, 2008). As a matter of fact, some of the previous concepts of sustainability did not recognise the crucial importance of the interdependencies among the systems, thus presenting theoretical models with isolated pillars (Kleine and Hauff, 2009; Wittstruck and Teuteberg, 2012). This type of analysis is no longer satisfactory for the stakeholders, and organisations must make a serious effort to measure all the Bottom Lines.

3.3 Sustainable Supply Chain Management

Nowadays, increasing globalisation, challenging markets and economic competitiveness allied to the dwindling natural resources is seriously threatening business organisations to sustain their existent supply chains (Gopalakrishnan et al. 2012; Ansari & Kant 2016). According to Ansari & Kant (2016), focusing on internal efficiencies and processes of supply chain is no longer enough to gain a competitive advantage. Today, for companies to achieve a competitive position, it is essential to integrate sustainability concepts and practices in the supply chain. In other words, the sustainable supply chain management (SSCM) is a requirement to the success of business organisations.

Based on the concept of the Triple Bottom Line, Carter & Rogers (2008) defined SSCM as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains."

Research on SSCM applied to the aerospace industry, conducted by Gopalakrishnan et al. (2012), identified ten essential elements for deploying sustainability in supply chains, from which we highlight: i) supplier management and integration of supply chain; ii) carbon management across supply chain; iii) review sourcing of raw materials ensuring sustainable procurement; iv) government legislations and external support factors; v) organisational culture and employee involvement.

These elements are in accordance with the findings in Khalid et al. (2015), which established technological integration, long-term relationship development, partner development, joint development, enhanced communication, stakeholder management and innovation as the core SSCM practices. This is also in line with the findings in Chapter 2 stating that joint research and development are key and common goals for all the stakeholders should be aligned. The stakeholders' engagement relevance in SSCM is therefore undeniable.

Meckenstock et al. (2015) have studied the complexity of SSCM and the issues of operationalizing sustainability throughout the supply chain. They have approached the problem using the 'wicked problem' framework by dividing it into three categories: social, cognitive and temporal complexities.

Taking all these challenges into account and building on the findings explained earlier, one issue that arises is the correct approach to sustainability, namely, focusing on the material issues. In the context of this WP of the IAMAT project, Abreu (2017) has defined a series of economic, social and environmental indicators regarding sustainability. So the problem comes in a simple but challenging way: what are the material issues on sustainability that companies and institution need to engage? That is, as explained earlier, the subject of this dissertation. In the following sections, we will better define materiality and review the different approaches to this important aspect.

3.4 Materiality

The Oxford Dictionary of English (2018) defines 'materiality' as 'the quality of being relevant or significant'. This is a concept that is usually associated with financial reporting of companies. It

recognizes that some information is important to investors in making investment decisions (SASB 2018a).

Materiality is a general and pervasive concept and is nowadays widely used in both financial and non-financial reporting and for many other business purposes. Materiality is frequently a legal concept as well because some countries, by either statute, case law or regulation, have established a definition of materiality they require to be applied in their jurisdiction. As an obvious consequence, it is not possible to establish a 'one size fits all' quantified definition of materiality (Corporate Reporting Dialogue 2016).

In financial reporting, materiality is commonly thought of as a threshold for influencing the economic decisions of those using an organization's financial statements, investors in particular. A similar concept is also important in sustainability reporting. The Global Reporting Initiative (GRI) defines materiality as a principle for a company's reporting to 'cover topics that reflect the organization's significant economic, environmental and social impacts or substantively influence the assessments and decisions of stakeholders' (GRI 2016).

The International Integrated Reporting Council (IIRC), in its International <IR> Framework (2013), defines materiality as a principle guiding an organization's reporting so that 'an integrated report should disclose information about matters that substantively affect the organization's ability to create value over the short, medium and long term'.

The Sustainability Accounting Standards Board (SASB) uses the definition by the United States laws regarding companies' reporting saying that 'materiality recognizes that some information is important to investors in making investment and voting decisions, while other information is not' (SASB 2017). SASB uses this definition to guide their process on assessing the environmental, social and governance topics that are reasonably likely to have material impacts on the financial condition or operating performance of companies in a given industry.

3.4.2 The International Integrated Reporting Council framework

The International Integrated Reporting Council (IIRC) is a global coalition of regulators, investors, companies, standard setters, the accounting profession and NGOs. This coalition communicates the view that communication about value creation should be the next step in the evolution of corporate reporting. The International <IR> Framework has been developed to meet this need and provide a foundation for the future (IIRC 2013).

One of the guiding principles of this framework is materiality, with the framework clearly stating, as mentioned earlier, that 'an integrated report should disclose information about matters that substantively affect the organization's ability to create value over the short, medium and long term'.

According to this framework, the materiality determination process for the purpose of preparing and presenting an integrated report involves:

- Identifying relevant matters based on their ability to affect value creation;
- Evaluating the importance of relevant matters in terms of their known or potential effect on value creation;
- Prioritizing the matters based on their relative importance;

- Determining the information to disclose about material matters.

These steps clearly explained in the Standards and no more detail will be explored at this stage. However, it is important to underline that this process must apply to both positive and negative matters, including risks and opportunities and favourable and unfavourable performance or prospects, both financial and other information.

One aspect considered “key” to the IIRC framework is the reporting boundary, which is quite important to the subject of this dissertation. Determining the boundary for an integrated report has two aspects:

- The financial reporting entity (i.e., the boundary used for financial reporting purposes);
- Risks, opportunities and outcomes attributable to, or associated with, other entities/stakeholders beyond the financial reporting entity that have a significant effect on the ability of the financial reporting entity to create value.

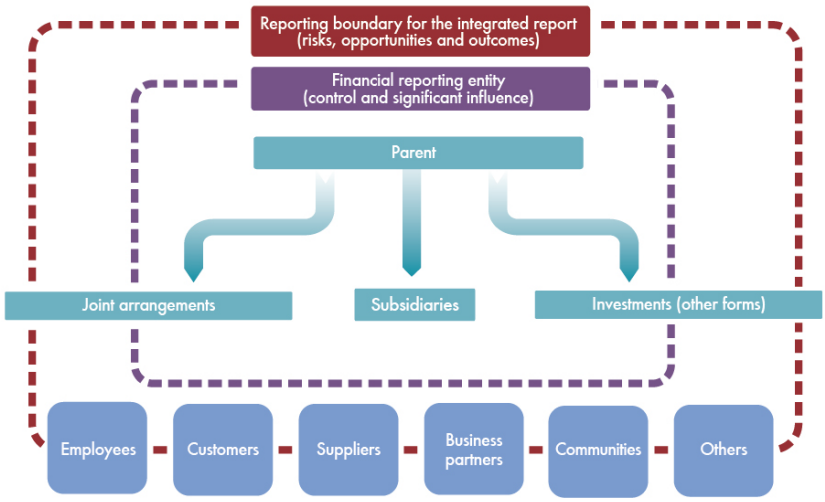

Figure 9 – Entities/stakeholders considered in determining the reporting boundary (IIRC 2013)

No more details will be explored on how to assess the reporting boundary not only because it is well explained in the framework but also because, in this dissertation, previous results gathered in the IAMAT project will be used.

This framework presents an approach to assess materiality in general reporting processes providing a “materiality test” that can help organization in their assessment processes.

3.4.3 The Global Reporting Initiative framework

The Global Reporting Initiative (GRI) is an independent international organization that has worked on sustainability reporting since 1997. GRI helps businesses and governments worldwide understand and communicate their impact on critical sustainability issues such as climate change, human rights, governance and social well-being, enabling real action to create social, environmental and economic benefits for everyone. The GRI Sustainability Reporting Standards are developed with true multi-stakeholder contributions and rooted in the public interest (GRI 2018).

Once again, one of the fundamental aspects of the framework is materiality. In its most recent version of the standards – GRI Standards, which are an evolution of the previous G4 principles – this organization defines material topics as those which 'reflect the reporting organization's significant economic, environmental and social impacts or substantively influence the assessments and decisions of stakeholders', as seen earlier. It starts by referring to the traditional meaning of materiality, used in financing reporting, which is commonly thought of as a threshold for influencing the economic decisions of those using an organization's financial statements, investors in particular.

When it comes to sustainability, a broader definition is used considering two dimensions – a wider range of impacts (environmental, social and economic) and stakeholders – stating that materiality is the principle that determines which relevant topics are sufficiently important that it is essential to report on them, with the relative importance amongst them defined. It is of paramount importance that the organization can explain the process by which it determined the priority of topics – confirming the previously explained topic in the IIRC framework.

The GRI Standards propose a matrix (example in the figure below) to prioritize the topics, showing the two dimensions for assessing whether a topic is material or not: 'influence on stakeholder assessments and decisions' and 'significance of economic, environmental and social impacts'.

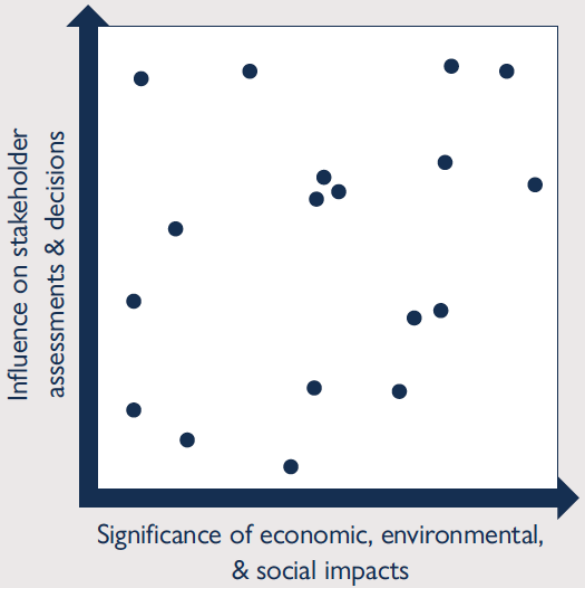

Figure 10 – Visual representation of prioritization of topics (GRI 2016)

In defining material topics, the reporting organization should take into account:

- Reasonably estimable economic, environmental, and/or social impacts (such as climate change or poverty) identified through sound investigation by people with recognized expertise, or by expert bodies with recognized credentials;
- The interests and expectations of stakeholders specifically invested in the organization, such as employees and shareholders;

- Broader economic, social, and/or environmental interests and topics raised by stakeholders such as workers who are not employees, suppliers, local communities, vulnerable groups, and civil society;
- The main topics and future challenges for a sector, as identified by peers and competitors;
- Laws, regulations, international agreements, or voluntary agreements of strategic significance to the organization and its stakeholders;
- Key organizational values, policies, strategies, operational management systems, goals, and targets;
- The core capabilities of the organization and the manner in which they can contribute to sustainable development;
- Consequences for the organization which are related to its impacts on the economy, the environment, and/or society (for example, risks to its business model or reputation);
- Material topics are appropriately prioritized in the report.

Once again, the GRI standard itself does not provide the material aspects that companies should report on, but it does propose this methodology for companies to work with and also an extensive database with multiple possible indicators.

3.4.4 Materiality on Sustainability

When it comes to sustainability, as seen earlier, there are many definitions of supply chain, sustainability, SCM, SSCM, etc. There are more than seventy listed sustainability definitions, besides a profuse quantity of frameworks, indicator sets, indexes and methodologies that exist in the literature meaning no systematic consistent approach or framework has been adopted yet (Chee Tahir and Darton, 2010; Gallego Carrera and Mack, 2010; Krajnc and Glavič, 2005; Roca and Searcy, 2012).

On their paper out of Harvard Business School, Khan et al. (2016) make the first significant study to differentiate between those sustainability factors that are likely to have material impacts and those that are not (SASB 2017). The number of sustainability issues firms can potentially invest in is very large. For example, KLD, a leading data provider, ranks firms' performance on more than fifty distinct sustainability issues. In addition, an increasing number of investors recognize that a given sustainability issue is unlikely to be equally material for firms in distinct industries. For example, managing climate change risk can be strategically important for some firms, while employee health and safety issues are more likely to be strategically important for other firms. As such, exploiting variation in the materiality of sustainability issues across firms in testing the future performance implications of sustainability investments has the potential 'to increase the signal to noise ratio in the investment-performance relation and reduce the dimensionality of investment signals considered by institutional investors in the asset allocation decisions'. As such, the efforts of many organizations providing guidance on reporting of Environmental, Social and Governance (ESG) issues are now concentrated on discriminating between material and immaterial issues (Khan et al. 2016).

Lydenberg et al. (2010), in the context of the Initiative for Responsible Investment (IRI) at Harvard University, underlined the importance of a materiality analysis on sustainability aspects. This paper focuses on the importance of reporting sustainability issues and proposes a method for identifying key performance indicators (KPIs) on the sustainability impacts of corporations in specific industries. They also report on the growth of voluntary sustainability reporting (as opposed to the mandatory filings) and the convergence with financial reporting. They argue that sustainability disclosure tracks, and allows for improvement on, those issues most tied to a corporation's environmental and social impact and most material to a company's financial performance. One of the conclusions from Abreu (2017) – in the context of the IAMAT project – is precisely the need for standard practices in the sustainability reporting.

This method proposed by Lydenberg et al. (2010) for developing KPIs for sustainability relies on three principles – simplicity, materiality, and transparency. Building on a broad disclosure framework such as that of the GRI, it suggests how those sustainability KPIs most material to all stakeholders can be identified (Lydenberg et al. 2010). It consists of a six-step approach for identifying specific indicators by Industry Sector, meeting the dual challenges of comparability and practicability:

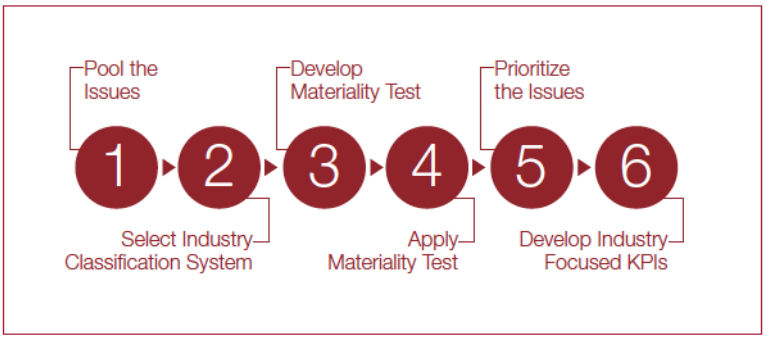

Figure 11 – Six-Step method for developing industry specific KPIs (Lydenberg et al. 2010)

1) Assemble a broad universe of sustainability risks or opportunities that could apply to all industries;
2) Select an industry classification system;
3) Establish a definition of materiality to address non-financial issues;
4) Apply the materiality test to the sustainability issues potentially applicable to each industry sector;
5) Rank the materiality of these issues within each industry and establish a threshold that defines those issues that are key;
6) Create a tailored set of KPIs for the most material issues for each sector.

According to the layout of the six-step process, materiality is critical for successful implementation of a minimum ESG reporting scheme, according to the authors. The six steps comprising this methodology will be further analysed.

Step 1 – Pool the issues

The existing body of work on enhanced corporate reporting, such as those of the IIRC and GRI (detailed in the previous sections), offers an excellent pool of issues from which to work. In their paper, the authors use mostly the GRI database, organizing the issues under the headings of community, customer, employees, supply chain, environment and governance (see figure below). The authors state that the advantages of starting with GRI's universe of sustainability issues are many, the main one being that they have emerged from a 'continuing multi-stakeholder engagement that looks beyond any single group's view' and that GRI has incorporated review processes with organizational stakeholders that allow for the evolution of issues.

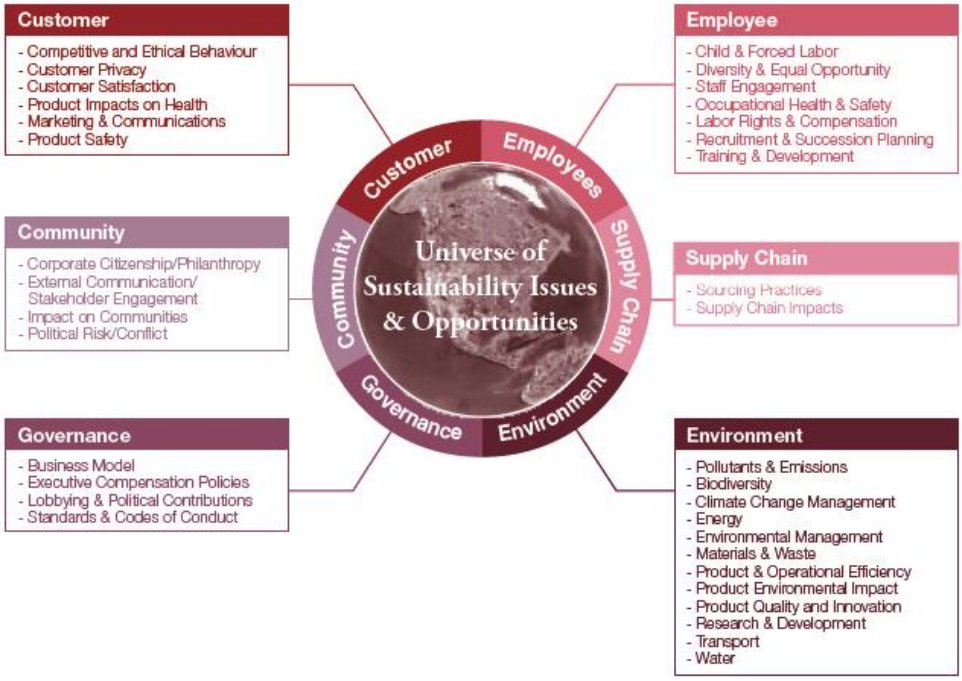

Figure 12 – Universe of ESG issues and opportunities (Lydenberg et al. 2010)

Step 2 – Select Industry Classification System

To facilitate comparative assessments of KPIs, the authors have selected a classification method – the sector classification system known as the Industry Classification Benchmark (ICB) – to identify distinct industry groups of corporations engaged in similar activities and facing comparable ESG challenges and opportunities.

Step 3 – Develop Materiality Test

The working definition of materiality used by the authors is a modified version of the materiality test advocated by the GRI, which was also explained earlier in this dissertation. Like explained earlier, this definition is broader in scope than the definitions of materiality historically used by financial regulatory parties but by no means excludes definitions of financial materiality – the sustainability approach incorporates the three pillars of the Triple Bottom Line. The authors underline that this process

results in a minimum set of material issues and should not replace corporate managers' responsibility to report on all financially material issues.

The materiality test envisioned by the authors includes five categories of impact to be evaluated at a sector (or sub-sector) level (see Figure 13). It includes, among other facts, opportunities for ESG innovation, stakeholder concerns – which is very important for the context of this dissertation and the IAMAT project – and societal trends.

Figure 13 – Materiality Test by Lydenberg et al (2010)

The five categories can be summarized as follows:

1. Financial impacts/risks: Issues that may have a financial impact or may pose a risk to the sector in the short-, medium-, or long-term (e.g., product safety).
2. Legal/regulatory/policy drivers: Sectoral issues that are being shaped by emerging or evolving government policy and regulation (e.g., carbon emissions regulation).
3. Peer-based norms: Sustainability issues that companies in the sector tend to report on and recognize as important drivers in their line of business (e.g., safety in the airline industry).
4. Stakeholder concerns and societal trends: Issues that are of high importance to stakeholders, including communities, NGOs and the general public, and/or reflect social and consumer trends (e.g., consumer push against genetically modified ingredients).
5. Opportunity for innovation: Areas where the potential exists to explore innovative solutions that benefit the environment, customers and other stakeholders, demonstrate sector leadership and create competitive advantage.

Step 4 – Apply Materiality Test

The authors start by constructing a hypothetical score for each issue on a four-point (0-3) Likert scale using each of the five materiality categories they have chosen: Financial impacts/risks, Legal Regulatory Policy Drivers, Business Peer-based Norms, Stakeholder Concerns/Social Trends and Opportunity for Innovation. These were reviewed in the previous section. These scores are then added together to give each issue an overall score of 0-15, with the higher scoring issues understood to be more material to the particular subsector.

Before testing the materiality of sustainability issues at a subsector level, it is important to translate these issues into meaningful ones for the subsector. This means identifying how each issue from the pool would apply to or manifest itself within the subsector, given the particular nature and context of the subsector. For instances, Product Safety for the airlines industry refers to accidents/safety, whereas it could refer to product recalls for the food products industry. Results of the hypothetical exercises that the authors conduct in six different industries demonstrate that there are issues common in all of them and other particular for each sector.

The authors advocate that this exercise makes it possible to rank issues in terms of their materiality, helping stakeholders identify key issues and allowing corporations to efficiently allocate resources to those issues most relevant to their sustainability performance.

Step 5 – Prioritize the Issues

After the materiality test has been performed, a line must be drawn to establish which are the material issues – until now, the process has just granted a scoring to all the possible issues. The authors suggest many different approaches – for instances, establishing a “cut-off point” for the obtained scorings or selecting only the top quartile. The determination envisioned by Lydenberg et al. (2010) as to where to draw the line in establishing material issues is underpinned by the need of judgment but also consistency in logic across sectors. Their focus is on obtaining a consistent approach to all industries so that a defined number of material topics is reported by all companies in the sector and all the other on a “case-by-case” analysis.

The authors have outlined several approaches to define the cut-off point:

- Take a particular score as the cut-off point – all issues that scored some number or higher on the ranking system;
- A set number of issues for all industry sectors;
- Select as key the top quartile (25%) scoring issues for any subsector.

The authors state that the ‘greatest challenge (…) is to assure that in the end the number of key indicators strikes an appropriate balance between manageability, comprehensiveness and materiality in assessing a sector’s ESG impacts’. The authors advocate that the identification is manageable, and it all comes down to the judgment of the organization.

Step 6 – Develop Industry Focused KPIs

This is the step considered to be the most challenging one by the authors, reflecting the need to translate the general sustainability issues into sector specific KPIs. For the hypothetical exercise undertaken by the authors, they chose to define two different types of KPIs – the Impact Indicators and the Innovation Indicators – and two methods of disclosure for each type – Performance Based and Management Based. In the figure below, the resulting framework and respective definitions are presented.

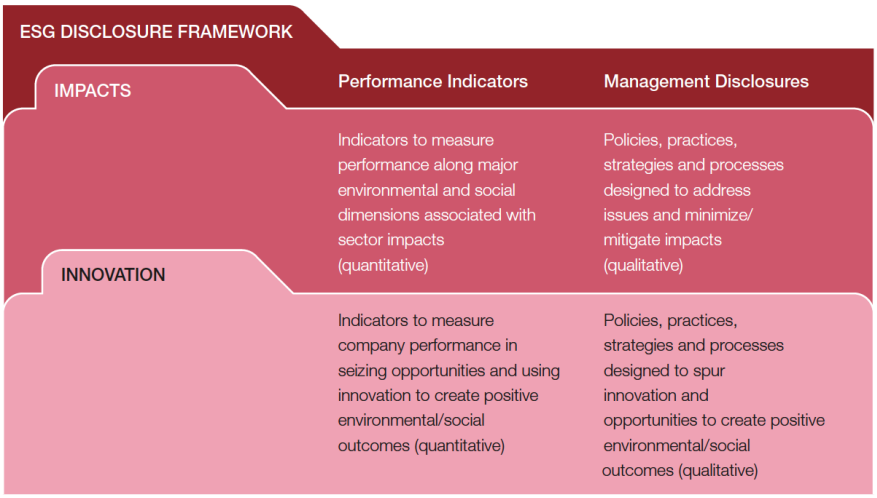

Figure 14 – Framework for ESG key performance indicators and managements disclosures (Lydenberg et al. 2010)

Throughout the paper, the authors stress the important idea that their intention is not to provide a definitive list of KPIs for industries. Rather it suggests a method by which such KPI indicators can be established in a transparent and flexible manner (Lydenberg et al. 2010). In their conclusions and recommendations, the authors also state that sustainability reporting should become mandatory and that a common framework should be developed by the interested parties.

3.4.5 The Sustainability Accounting Standards Board framework

One of the major initiatives working on these subjects is the Sustainability Accounting Standards Board (SASB), which has done extensive research on finding out what the material issues are for a company when it comes to sustainability, in an industry-based approach. SASB intends to be a "standards setter" (SASB 2017) when it comes to setting and reporting sustainability issues.

Established in 2011, the Sustainability Accounting Standards Board (SASB) is an independent, private-sector standards setting organization based in San Francisco, California dedicated to enhancing the efficiency of the capital markets by fostering high-quality disclosure of material sustainability information that meets investor needs.

The SASB develops and maintains sustainability accounting standards – for 79 industries in 11 sectors – that help public corporations disclose financially material information to investors in a cost-

effective and decision-useful format. The SASB's transparent, inclusive, and rigorous standards-setting process is materiality focused, evidence-based and market informed. (SASB 2018c)

Contrary to the other frameworks, SASB proposes, based on an extensive evidence-based approach from multiple stakeholders, specific indicators and metrics that are considered material to the sustainability strategies. For that, they have created a tool, the SASB Materiality Map™, which is often referred as a tool to help companies identify relevant material issues common to their respective industries (Kiron et al. 2017).

The idea of the Materiality Map was first introduced in the white paper from Lydenberg et al. (2010), which was studied in depth in the previous section. Today's Map is adapted from the evidence-based methods piloted in that study and is an interactive tool that identifies and compares disclosure topics across different industries and sectors (SASB 2018b). SASB's Materiality Map identifies likely material sustainability issues on an industry-by-industry basis and intends not only an investor use (analysing portfolio exposure to specific sustainability risks and opportunities represented by each issue) but also a corporate use (focus sustainability strategies on the most important issues and understand the metrics that underpin each disclosure topic).

The definition process that SASB uses is very well explained in SASB (2017). The list of sustainability factors presented in Table 1 is filtered down through a series of steps which are designed to identify only those issues reasonably likely to have material impacts on companies in an industry.

Table 1 – SASB Universe of Sustainability Issues (SASB 2017)

Sustainability Dimension	General Topic
Environment	GHG Emissions Air Quality Energy Management Water and Wastewater Management Waste and Hazardous Materials Management Ecological Impacts Climate Impacts
Social Capital	Community Relations Human Rights Data Privacy and Security Access and Affordability Customer Welfare Selling Practices and Product Labeling
Human Capital	Labor Relations Labor Practices and Compensation Employee Health, Safety and Wellbeing Employee Recruitment, Engagement and Diversity
Business Model & Innovation	Product Design and Lifecycle Management Product Quality and Safety Product Packaging and Distribution Supply Chain Management Materials Sourcing Financing Risks Rate Structure and Pricing Business Model Resilience
Leadership & Governance	Business Ethics Competitive Behavior

	Management of Legal & Regulatory Environment Critical Incident Risk Management Systemic Risk Management

The process that SASB undertakes has 6 different steps: 1) Surfacing issues; 2) Materiality Assessment; 3) Characterizing the Nature of Financial Impact; 4) Vetting; 5) Verification and 6) Validation. The first three can be categorized as 'assessing materiality' and the last three as ´testing the reasonableness of the materiality assessment'. SASB standard-setting process is evidence-based, market-informed and validated through research and quantitative analysis, as can be checked in the below that describes the process:

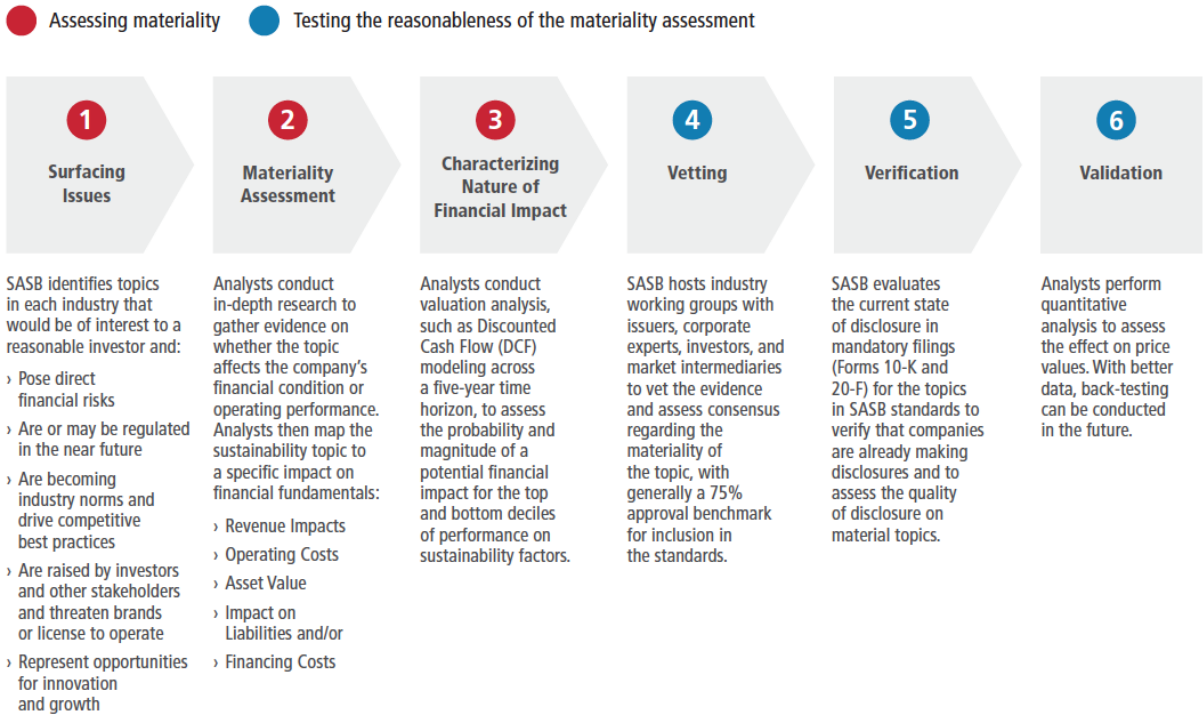

Figure 15 – SASB Research Methodology (SASB 2017)

It is interesting to note the similarities between the approach on step 1 and the categories included in the Materiality Test envisioned by Lydenberg et al. 2010.

For each step, SASB analysts consider 'key questions' that guide their analysis:

- **Assessing materiality**

1) Surfacing issues
    i. Is the issue important to the "total mix" of information?
    ii. Would it likely be of interest to the "reasonable investor"?
2) Materiality assessment

i. How strong is the evidence to support a conclusion that this topic relates to a known trend or uncertainty that is reasonably likely to occur? If the evidence is strong, what is the likelihood that this will have a material effect on companies in the industry?
ii. What are the specific financial impacts that can be identified and what are the drivers of these impacts?

3) Characterizing nature of financial impact
   i. What is the probability of an impact occurring to a typical industry firm? If an impact were to occur, what would be its likely magnitude? Would the nature of the financial impact more likely be acute or chronic?
   ii. What type of risk factor might the issue present? Is it likely to be a market risk (e.g., due to regulations affecting the entire industry) or a specific one (e.g., due to management of operational safety)?

- **Testing the reasonableness of the materiality assessment**

4) Vetting
   i. Does market feedback indicate that performance on the sustainability topic is reasonably likely to have a material impact on companies in the industry?
   ii. Is there a consensus that the proposed topics or changes to the standards are reasonably likely to have material impacts?
5) Verification
   i. Are companies reporting on SASB disclosure topics in their Form 10-K or 20-F filings?
   ii. What is the quality of disclosure on these topics?
6) Validation
   i. Can risk/return impacts be seen at the company level in terms of a correlation to market price, fundamental performance, or both?
   ii. Can risk/return impacts be discerned at the portfolio level in terms of the contribution to industry common factors?

Each of SASB's industry-specific topics goes through every step of the process outlined above. SASB analysts are engaged in deep consultation with issuers, investors, employees, technical resource groups and sector advisory groups. SASB also uses industry performance data (or reasonable assumptions) on the issues and build models to assess the probability and magnitude of impacts of a specific issue in a company's performance. If this evidence-based research and market feedback indicate the topic warrants a standardized disclosure topic and, therefore, inclusion in the industry's sustainability accounting standard, SASB will issue it for public comment.

SASB's analysis of 2015 filings (Forms 10-K and 20-F) shows that 69 percent of the companies reported on at least three-quarters of the sustainability topics included in their industry's SASB provisional standard, and 38 percent provided disclosure on every SASB topic. (SASB 2017)

One of the outputs that SASB provides is an interactive map that summarizes the current information gathered by the board. That map is available online:

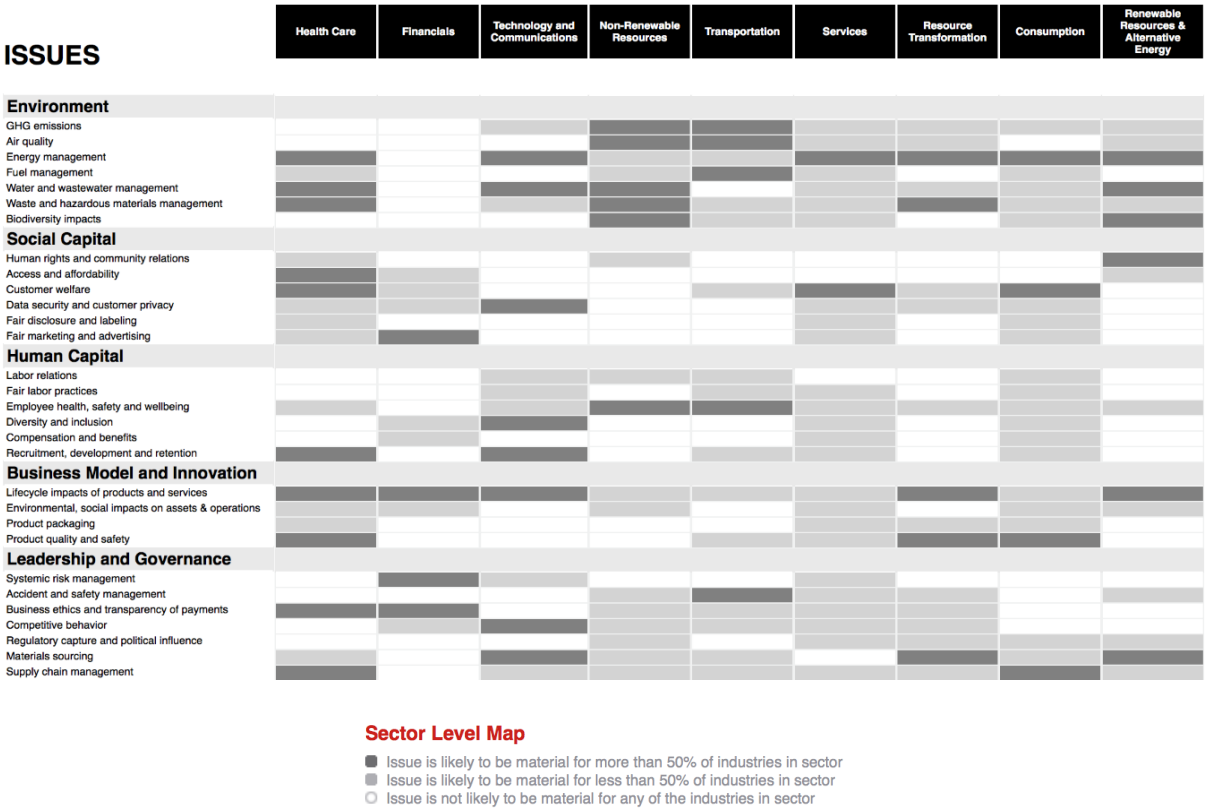

Figure 16 – Overview of the SASB Materiality Map™ [https://materiality.sasb.org accessed March 10, 2018]

For each specific topic, there is a variety of information regarding the assessment on materiality and the accounting metrics proposed for the desired industry. In the two figures below, an example is shown with the explanations of each disclosure:

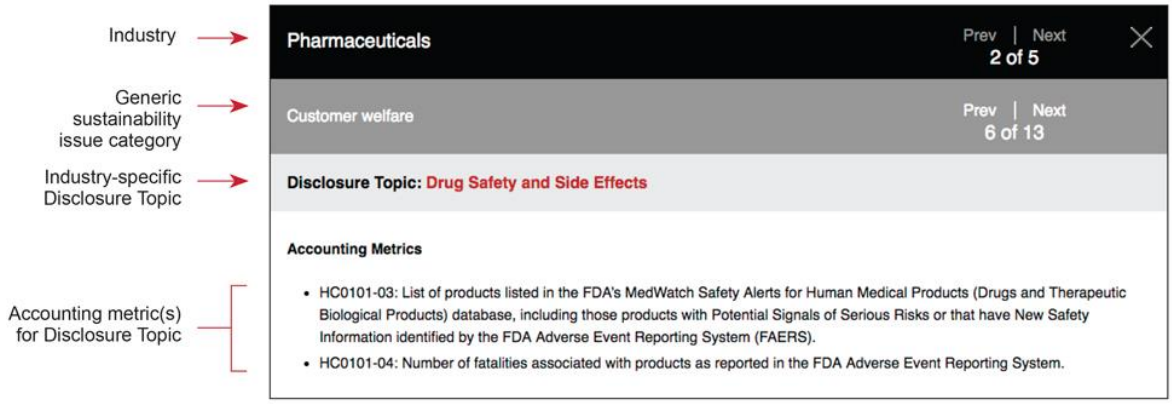

Figure 17 – SASB Materiality Map example 1 (SASB 2018b) [https://materiality.sasb.org accessed March 10, 2018]

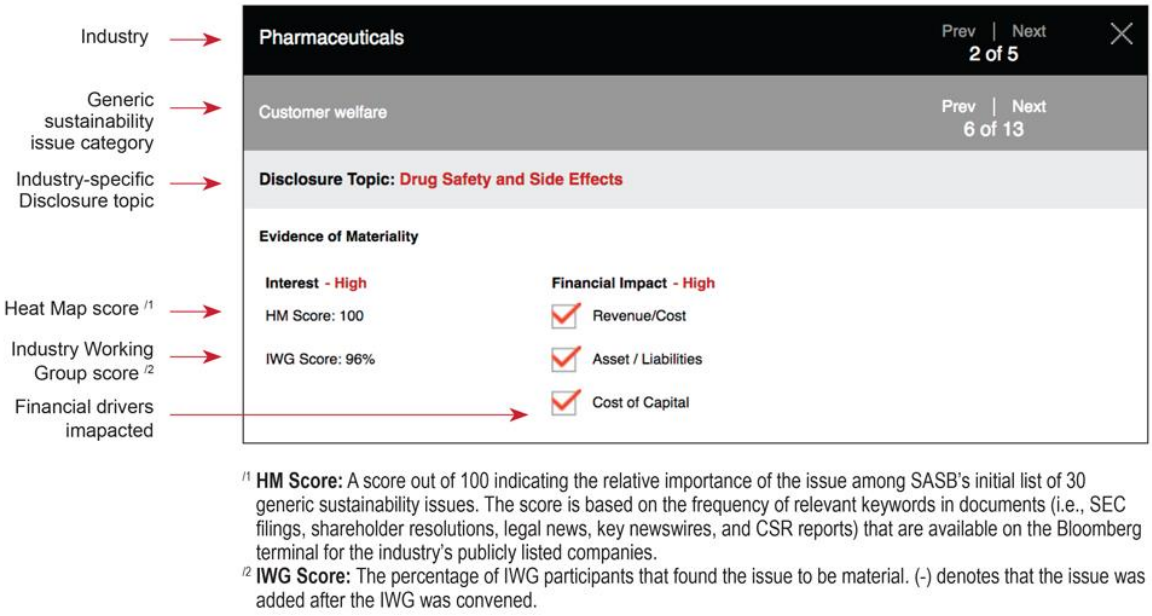

Figure 18 – SASB Materiality Map example 2 with advanced information (SASB 2018b) [https://materiality.sasb.org accessed March 10, 2018]

For the aerospace industry, SASB has already collect data for the airlines (sector "Transportation"). That information can be easily accessed in the Materiality Map and will be discussed in depth in Chapter 5.

3.4.6 Different Concepts of Materiality

As concluded from the previous sections, different organisations have different approaches to materiality on sustainability.

Park (2015) underlines that there are different concepts of materiality. His focus is on companies' reporting and accounts for the legal implications, so he compares the definitions from these three major players: SASB, the Global Reporting Initiative (GRI) and the International Integrated Reporting Council (IIRC). In Table 2, Park (2015) summarizes the main differences on the approach of SASB, GRI and IIRC.

Table 2 – Different concepts of materiality (adapted from Park 2015)

	SASB	GRI	IIRC
Subject	Non-financial	Non-financial	Both financial and non-financial
Definion of materiality	US Supreme Court	Proprietary	Proprietary
Target audience	Investors	All stakeholders	Investors
Target disclousure	Mandatory filing	Voluntary report	Voluntary report
Decisions affected	Investment decisions	Broad range	Investment decisions

The US Supreme Court defines material information as presenting 'a substantial likelihood that the disclousure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the 'total mix' of information made available' (SASB 2017).

While the SASB definition is a more restrict one – because it focuses on the mandatory filing that the companies must comply with –, the GRI and IIRC definitions are broader and targeted not only to the investors but to all stakeholders.

Statement of Common Principles of Materiality

As concluded from the above sections, there are several approaches and different concepts of materiality. Even the organizations that deal specifically with sustainability reporting (and, therefore, materiality) have different views. Lydenberg et al. (2010), in the paper reviewed in section 3.4.4, also recommend the cooperation in the development of a "full-blown method and governance structure for identifying and providing guidance to corporations reporting KPIs". That is a view that these and other major players have identified and taken steps to deal with, creating the Corporate Reporting Dialogue initiative.

The Corporate Reporting Dialogue is designed to respond to market calls for greater coherence, consistency and comparability between corporate reporting frameworks, standards and related requirements. The initiative aims to:

- Communicate about the direction, content and ongoing development of reporting frameworks, standards and related requirements;
- Identify practical means by which respective frameworks, standards and related requirements can be aligned and rationalized;
- Share information and express a common voice on areas of mutual interest, where possible, to engage key regulators.

The Corporate Reporting Dialogue includes the eight principal organizations chartered with establishing standards and guidance for reporting to investors, creditors and other stakeholders: CDP

(formerly the Carbon Disclosure Project), Climate Disclosure Standards Board (CDSB), GRI, International Accounting Standards Board (which defines the International Financial Reporting Standards (IFRS)), IIRC, International Organization for Standardization (ISO) and SASB. Regardless of their individual missions, participants share a mutual interest in clarifying reporting concepts based on market demand. *The Statement of Common Principles of Materiality* (which is included in Appendix I) is one response to this demand.

Figure 19 – Organizations that are part of the Corporate Reporting Dialogue initiative

3.5 Chapter conclusions

In this chapter, the fundamentals on supply chain, sustainability, sustainable supply chain management and materiality in the context of sustainability were reviewed. The issues of defining the concept and boundaries of Supply Chain and Supply Chain Management were identified, with special focus on Sustainable Supply Chain Management. The 3BL approach to sustainability was presented and the three pillars that compose it were described.

A state-of-the-art revision was conducted on materiality on sustainability issues, arguing for its significance, and multiple approaches to assess materiality were presented, according to the most recent market practices. There are several frameworks already developed, most of them leaving for the organizations the decision process on materiality assessment. While the IIRC gives a broader view on the materiality subject, the GRI and SASB frameworks are more focused on sustainability. They all underline the importance of gathering information from the different stakeholders that have a relationship to the reporting organization and also the importance of prioritizing topics.

Some of them have already gathered information from different stakeholders, in different industries, creating databases on the material issues facing sustainability strategies. The SASB's Materiality Map™ is one of them and is the one the currently offers more insight.

4. Methodology

In this chapter a methodology for assessing the materiality of the different sustainability indicators will be proposed based on the conclusions reached so far and building on the results already achieved in the IAMAT project.

4.1 Proposed methodology

The methodology followed in this work is based on Lydenberg et al. (2010) and is presented on Figure 20 below.

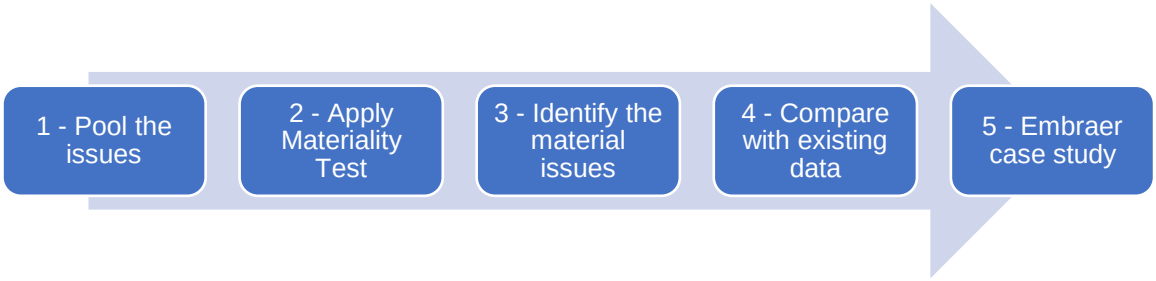

Figure 20 – Proposed methodology

The steps of the methodology are described as follows:

Step 1 – Pool the issues

In this step the pool of issues needs to be defined. The pool of issues represents a broad universe of sustainability risks or opportunities that could apply to the industry. For instances, Lydenberg et al. (2010) choose GRI's database as their pool of issues, since they have emerged from a continuing engagement with stakeholders across the specific industries and that GRI has incorporated review processes with organizational stakeholders that allow for the evolution of issues.

In the context of this dissertation, the issues identified in Abreu (2017) – classified using the GRI-G4 standards – will be used as the pool of issues because Abreu (2017) has conducted a survey for many aerospace industry stakeholders. Abreu (2017) was able to first identify the relevant stakeholders and then review their engagement towards sustainability. Having done so, Abreu (2017) identified the most relevant sustainability issues in the aerospace industry and those are the ones we will use in our methodology. This pool of issues is also adequate to this dissertation since it is already categorized according to the three pillars of the 3BL approach to sustainability. The pool of issues is presented in the Table 3.

Table 3 – Pool of issues: Sustainability indicators by Abreu (2017)

Aspects	Management Board of the OEMs				Reg	Gov.	Customers			Sci Com
	Airbus	Boeing*	Bombardier*	Embraer	EASA*	City of Chicago	Finnair	Lufthansa Group	TAP Group	Uni. Minho
Economic										
Economic Performance	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Market Presence		▲		▲				▲	▲	▲
Indirect Economic Impacts		▲	▲	▲		▲	▲		▲	▲
Procurement Practices		▲	▲		▲		▲		▲	▲
Environmental										
Materials									▲	▲
Energy	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Water	▲	▲	▲	▲		▲		▲	▲	▲
Biodiversity		▲				▲	▲	▲		
Emissions	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Effluents and Waste	▲	▲	▲	▲		▲	▲		▲	▲
Products and Services				▲				▲		
Compliance		▲					▲			
Transport						▲				
Overall						▲			▲	
Supplier Environmental Assessment				▲				▲		
Environmental Grievance Mechanisms				▲					▲	
Social: Labour Practices and Decent Work Aspect										
Employment	▲	▲	▲	▲	▲		▲	▲	▲	▲
Labour/Management Relations							▲	▲	▲	
Occupational Health and Safety	▲	▲	▲	▲			▲	▲	▲	▲
Training and Education	▲			▲	▲		▲	▲	▲	▲
Diversity and Equal Opportunity	▲	▲	▲				▲	▲	▲	▲
Equal Remuneration for Women and Men			▲				▲	▲	▲	▲
Supplier Assessment for Labour Practices				▲				▲		
Labour Practices Grievance Mechanisms				▲						▲

▲ Reported; *non-GRI reporting – equivalent aspects reported

Aspects	Management Board of the OEMs				Reg	Gov	Customers			Sci Com
	Airbus	Boeing*	Bombardier*	Embraer	EASA*	City of Chicago	Finnair	Lufthansa Group	TAP Group	Uni. Minho
Social: Human Rights										
Investment				▲				▲		▲
Non-discrimination		▲		▲				▲		▲
Freedom of Association and Collective Bargaining		▲	▲	▲				▲	▲	
Child Labour		▲		▲					▲	
Forced or Compulsory Labour		▲	▲	▲					▲	
Security Practices			▲						▲	
Indigenous Rights										
Assessment							▲	▲		
Supplier Human Rights Assessment				▲			▲	▲		
Human Rights Grievance Mechanisms				▲				▲		
Social: Society										
Local Communities	▲	▲		▲						▲
Anti-corruption	▲		▲	▲		▲	▲	▲	▲	▲
Public Policy						▲	▲			
Anti-competitive Behaviour			▲				▲			
Compliance							▲			
Supplier Assessment for Impacts on Society				▲				▲		
Grievance Mechanisms for Impacts on Society				▲						
Social: Product Responsibility										
Customer Health and Safety							▲	▲		
Product and Service Labelling	▲			▲			▲	▲		
Marketing Communications							▲			
Customer Privacy							▲	▲		
Compliance							▲			

▲ Reported; *non-GRI reporting – equivalent aspects reported

Step 2 – Apply Materiality Test

An adapted version of the Materiality Test envisioned by Lydenberg et al. (2010) will be employed. A score for each issue will be given on a four-point (0-3) Likert scale using each of the same five materiality categories used by the authors: Financial impacts/risks, Legal Regulatory Policy Drivers, Business Peer-based Norms, Stakeholder Concerns/Social Trends and Opportunity for Innovation. The issue will be scored in each of these five categories and then the scores are added together to give an overall score of 0-15, with the higher scoring issues understood to be more material.

This method relies on subjective judgments for each category of analysis and it is important to note that the numbers generated through this process rely on judgment. To have a robust assessment, the approach in this dissertation to apply the materiality test was to set up a Focus Group of specialists.

A focus group (or group interview) is characterized as a qualitative research method where a facilitator guides a group of pre-selected participants in a group interview, with the objective of understanding a wide range of perspectives (Wilson 2014; Lazar et al. 2017). Participants in a focus group are chosen based on the premise they share characteristics relevant for the topic to be discussed (Wilson 2014).

Although it usually comes with expenses, like renting a room for the meeting, food and drink, or high-quality facilitation, this method is considered to be cost-effective as results are typically rapid to obtain. It is also considered to be particularly effective when addressing complex issues that require discussion for knowledge development (Reed et al. 2009). However, depending on the dynamics of individuals or of the group, execution and analysis of the meeting results can become complicated (Lazar et al. 2017).

Step 3 – Identify the material issues

The pool of issues will be ranked to identify the materiality according to the results obtained from the Focus Group. Once the materiality tests have been applied to the broad set of sustainability issues and those issues ranked by their relative importance within a particular industry, a determination needs to be made as to where to draw the line in establishing material issues according to the results obtained from the Materiality Test.

Lydenberg et al. (2010) suggest several approaches. Some options will be explored and a set of ranked top issues will be defined. In this dissertation, the data will be analysed and rearranged from the most score to the least and conclusions will be derived. A cut-off point will be defined according to the dispersion of the scores.

Step 4 – Compare with existing comparable data

The obtained results from the previous steps will be compared with existing data previously identified in this dissertation. The goal is to understand if the proposed methodology yields similar results, validating its robustness and applicability.

Step 5 – Embraer case study

The materiality issues will be compared to Embraer's sustainability strategy, serving as a case study to highlight the practical applicability of this work. Embraer has been selected as case study because it is part of the IAMAT project and is a good example of a manufacturing company in the sector that has already established their key sustainability issues to tackle. The generic material issues identified in step 3 will be compared with the material issues identified by Embraer. This will allow to conclude if the results are aligned and if the proposed methodology is robust.

This entire exercise will present a framework to make it possible to rank issues (from a broad pool of possible ones) in terms of their materiality, help stakeholders identify key issues and allow organizations to efficiently allocate resources to those issues most relevant to their sustainability performance.

4.2 Chapter conclusions

In this chapter a proposed methodology to assess the materiality of the different sustainability indicators was outlined based on the conclusions reached so far.

In section 4.1 the different steps that will take place were described, clearly stating the proposed actions for each of them. The proposed methodology is based in the one presented by Lydenberg et al. (2010) with some restrictions to better reach the specific goals of this dissertation. The pool of issues that will be the starting point of the analysis is identified as well as the focus group that was set up to undertake the Materiality Test.

In the next two chapters, the results will be outlined, analysed and conclusions will be derived to assess the robustness of the proposed methodology.

5. Results and Discussion

This chapter presents the data obtained with the application of the proposed methodology for the development of the dissertation. Additionally, the discussion of the results will be performed in this chapter. Section 5.1 presents the results for applying the proposed materiality test with the focus group and the identification of the material issues and section 5.2 presents the comparison of the obtained results with existing comparable data and section 5.3 presents the case study of Embraer. In section 5.4, the chapter conclusions are presented.

5.1 Results of the materiality test

As discussed earlier, the focus group was conducted as step 2 of the proposed methodology. The group gathered to go through all the 45 topics of the pool of issues (already identified in chapter 4) and give a score to each one of them for each of the 5 categories.

The focus group applied for this dissertation was conducted on October 11th, 2018. The participants were:

- The author of this dissertation as the facilitator,
- A specialist on the aerospace industry,
- A specialist on the aerospace supply chain and
- Two specialists on both sustainability and supply chain.

The focus group was led by the author of the present dissertation. The guidelines that were delivered to the Focus Group can be found in Appendix II of this dissertation.

The focus group met for three hours. For each of the topics and each of the 5 categories to be scored, the approach was to get unanimity in the value. In most of the cases the consensus was easily reached and in other cases some discussion had to be undertaken. Every time that the topic was not fully understood, the group consulted the GRI-G4 documents to clear all doubts about the topic. Even so, the group experienced difficulties in reaching an agreement since the interpretation of the indicators was not consensual. For instances, for the indicator “Procurement”, since there are not many available suppliers, it was not consensual how that reality would be reflected in the score given to each category for this particular aspect.

The first topics were more difficult to conclude as the group needed time to adjust to the process and to get familiar with the five categories. As things moved forward and the group went through the table, the classification of the issues started to be speedier.

Because the subject of analysis was the aerospace supply chain, one of the difficulties in obtaining the score for each topic in each category was the perceived differences inside the industry i.e., the score could differ for each party inside the supply chain. For instances, the indicator “Customer Health and Safety” can be differently scored dependent on the specific company in the supply chain that is being analysed.

After concluding the focus group, the experience confirms what the literature says about this being a cost-effective way to reach results in a rapid fashion. In a three-hour session the group could

find the scores for the different aspects despite the struggles. The dynamics of the group worked well as the participants engaged in the discussion in order to reach the best consensual score.

From the classification proposed by the group the most material aspects can be identified. The results obtained in the focus group are presented in the following table, already rearranged with the aspects ranked by overall score. As noted earlier, the overall score for each aspect is the sum of the score in each of the five categories.

Table 4 – Results from the focus group rearranged

Aspect	Pillar	Financial	Legal/Regulatory/ Policy	Industry	Stakeholders	Innovation	SUM
Emissions	Environmental	3	3	3	3	3	**15**
Products and Services	Environmental	3	3	3	3	3	**15**
Training and Education	Social	3	3	3	3	3	**15**
Materials	Environmental	3	3	3	2	3	**14**
Energy	Environmental	3	2	3	3	3	**14**
Occupational Health and Safety	Social	3	3	3	3	2	**14**
Security Practices	Social	3	3	3	3	2	**14**
Anti-corruption	Social	3	3	3	3	2	**14**
Procurement Practices	Economic	3	3	3	1	3	**13**
Employment	Social	3	3	3	3	1	**13**
Compliance	Social	2	3	3	3	2	**13**
Customer Health and Safety	Social	3	3	3	2	2	**13**
Compliance	Social	2	3	3	3	2	**13**
Economic Performance	Economic	3	2	3	1	3	**12**
Indirect Economic Impacts	Economic	2	3	3	3	1	**12**
Product and Service Labelling	Social	3	1	3	3	2	**12**
Effluents and Waste	Environmental	2	2	2	2	3	**11**
Environmental Grievance Mechanisms	Environmental	2	3	2	3	1	**11**
Freedom of Association and Collective Barganing	Social	3	3	1	3	1	**11**
Local Communities	Social	2	1	3	3	2	**11**

Biodiversity	Environmental	2	3	1	3	1	**10**
Compliance	Environmental	3	3	3	1	0	**10**
Market Presence	Economic	3	1	2	0	3	**9**
Supplier Environmental Assessment	Environmental	1	1	2	2	3	**9**
Labour/Management Relations	Social	3	3	0	2	1	**9**
Supplier Assessment for Labour Practices	Social	1	1	2	3	2	**9**
Labour Practices Grievance Mechanisms	Social	2	3	1	2	1	**9**
Public Policy	Social	3	1	1	2	2	**9**
Customer Privacy	Social	2	3	1	2	1	**9**
Investment	Social	1	1	3	1	2	**8**
Human Rights Grievance Mechanisms	Social	1	3	1	2	1	**8**
Grievance Mechanisms for Impacts on Society	Social	1	3	1	2	1	**8**
Diversity and Equal Opportunity	Social	0	0	2	3	2	**7**
Anti-competitive Behaviour	Social	1	2	1	2	1	**7**
Non-discrimination	Social	0	3	2	1	0	**6**
Child Labour	Social	0	3	2	1	0	**6**
Forced or Compulsory Labour	Social	0	3	2	1	0	**6**
Indigenous Rights	Social	0	3	2	1	0	**6**
Water	Environmental	1	1	1	1	1	**5**
Transport	Environmental	1	2	0	1	1	**5**
Equal Remuneration for Women and Men	Social	0	0	1	2	2	**5**
Assessment	Social	1	2	0	1	1	**5**
Supplier Human Rights Assessment	Social	1	2	0	1	1	**5**
Supplier Assessment	Social	1	2	0	1	1	**5**

for Impacts on Society							
Marketing Communications	Social	1	1	0	2	1	**5**

Higher total scores indicate higher materiality relative to other issues. From the original pool of issues and the obtained results rearranged by overall score, it is interesting to note that there is a predominance in the number of the social aspects in the top positions and, as it is expected, the Environmental aspect is predominant. After defining the cut-off, a more comprehensive analysis will be done.

The cut-off point

An appropriate cut-off point can be established based on the materiality score to determine the minimum issues to be included. This analysis has a high degree of variability, since it depends on the judgment of who is doing the analysis. These results are not definitive, but rather illustrative of the transparency of the method. Any interested party can see and comment on the relative significance of an issue with respect to other issues in the sector.

From the obtained results described in Table 4 it is possible to conclude that:

- there are three aspects tied with the same highest score 15 (the maximum possible) and
- that the lowest score presented is 5.

In order to have a better understanding of the data dispersion, some statistics calculations were made about the data in hands (minimum, maximum, mean, median, standard deviation, coefficient of variation and first and third quartiles):

Table 5 – Data dispersion

Minimum	First Quartile	Median	Third Quartile	Mean	Mode	Standard Deviation	Coefficient of variation
5	7	9	13	9,78	9	3,34	0,341

Looking at the table above, some conclusions can be derived:

- The mode is equal to the median and the mean is relatively close (but higher) to the median;
- If we consider that the minimum score is zero and the maximum is fifteen, any score equal or greater than 8 has a “positive” grade. From the first quartile we can conclude that almost 75% of our aspects have a “positive” grade and are considered relevant according to the scale;
- Therefore, it is possible to conclude from the data dispersion that the scores are high for most of them. The mean is higher than the median and the median is higher than 8 (which we have established as the “positive” grade)

As seen for the Lydenberg et al. (2010) approach, on which the proposed methodology is based, there are several ways to approach the selection of a minimum threshold or cut-off point to establish the

most relevant issues for sustainability. Here are the proposed criteria for the obtained results in this dissertation:

- To eliminate all the aspects that scored lower than 8;
- If only the 10 first aspects (arbitrary number for ease of reference) are selected, aspects that have scored the same (13) are eliminated.
- If the 3rd quartile (score 13) is chosen as the cut-off, aspects with the same score will not be eliminated. Following this criterion, 13 material issues are identified.

Lydenberg et al. (2010) state that in their exercise reviewing six industry examples that it was 'fairly' clear to differentiate between those issues that score highly within a sector on the materiality test and those that do not. In this dissertation a different conclusion is reached since that differentiation is not clear. There are many aspects scoring very high on the ranking and many with a tied score. The proposed methodology relies heavily on the judgment of the appraiser. They advocate that the identification of the most material issues is manageable, and it all comes down to the judgment of the organization. The criteria for the cut-off point depend a lot on the party that is establishing them and the intended target audience. For the purposes of this dissertation, the 3rd quartile will be used as it defines a cut-off point based on the dispersion of the data and it allows for the inclusion of a relevant number (13) of aspects to be considered in the next sections. At this stage, a conclusion is reached that the cut-off point should also have been included in the Focus Group to benefit from the expertise of the participants.

In conclusion, applying the proposed criteria, from the analysis the following 13 material aspects can be derived:

1. **Emissions** (Environmental);
2. **Products and Services** (Environmental);
3. **Training and Education** (Social: Labour Practices and Decent Work Aspect);
4. **Materials** (Environmental);
5. **Energy** (Environmental);
6. **Occupational Health and Safety** (Social: Labour Practices and Decent Work Aspect);
7. **Security practices** (Social: Human Rights);
8. **Anti-corruption** (Social: Society);
9. **Procurement practices** (Economic);
10. **Employmen**t (Social: Labour Practices and Decent Work Aspect);
11. **Compliance** (Social: Society);
12. **Customer Health and Safety** (Social: Product Responsability);
13. **Compliance** (Social: Product Responsibility).

The ranking of the aspects is also not definitive as there are many issues that are tied with the same score and a more detailed analysis was not done to further refine the scores. An equal weight is

being given to all the five categories and some further analysis – perhaps using the multi-criteria analysis.

As to the obtained results, in the first five material aspects, four of them have to do with the Environmental pillar and one belongs to the Social pillar, specifically Training and Education. Emissions are on the top, which is coherent with the analysis done to the sector in Chapter 2, as well as the Materials and Energy aspects. The second identified material Aspect (Products and Services) has to do with the extent of impact mitigation of environmental impacts of products and services.

It is also interesting that of the other eight aspects, seven are from the social pillar and one is economic. In Chapter 2, the confusion around the Social pillar had been mentioned and it is interesting to find that the Social pillar has such prominence on the identified material issues. The pool of issues of Abreu (2017) has many indicators from this pillar, confirming the broad spectrum of applicable topics. From the Social aspects, three have to do with labour and decent work, two have to do with product responsibility, two have to do with society and finally one has to do with human rights. It is interesting to note that in the Social pillar the concern is concentrated on good labour practices. The Society sub-Category of the Social pillar concerns impacts that an organization has on society and local communities. The related Compliance aspect that was identified as material is related to the monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations. Social indicators included in the top positions are related to Labour practices.

The identified Economic material aspect presented relates to stakeholders, confirming the importance that the supply chain has on the Sustainability strategy for the sector.

5.2 Comparison with existing comparable data

This section corresponds to step 4 of the proposed methodology. The obtained results are going to be compared to the results from existing comparable data. The goal is to understand if the results match i.e. if the indicators that resulted from the proposed methodology are in line with the indicators included in the existing data. After analysing the exercise conducted by Lydenberg et al. (2010) to the Airlines subsector it was decided not to include that set in this dissertation since the authors did it as a simple illustrative example to their proposed methodology not explaining how the results were obtained and the expertise used. Hence only the SASB Materiality Map will be used.

5.2.1 SASB Materiality Map

In the SASB Materiality Map, there is no order for the presented indicators. The Map presents a set of indicators with a white, light-grey or dark-grey colour as to identify the relevance of the indicator according to:

Sector Level Map

- White colour: Issue is not likely to be material for any of the industries in sector;
- Light grey: Issue is likely to be material for fewer than 50% of industries in sector;
- Dark grey: Issue is likely to be material for more than 50% of industries in sector.

Industry Level Map

- White colour: Not likely a material issue for companies in the industry;
- Dark grey: Likely a material issue for companies in the industry.

For the comparison of the material sustainability issues resulting from the proposed methodology and the ones identified by SASB, the following industries will be analysed:

- Aerospace & Defense (Resource Transformation sector);
- Airlines (Transportation sector);
- Air Freight & Logistics (Transportation sector).

For ease of analysis and comparison, the topics from the Materiality Map for the three above identified industries are included in Table 6 below alongside the results from this work. It is important to remember that the topics from the SASB Materiality Map are not presented in a ranking and the relative order is not relevant. They are only the topics that are 'likely material' for companies in the industry.

Table 6 – Comparative analysis of the found issues and SASB's Materiality Map

SASB A&D	SASB Airlines	SASB Air Freight & Logistics	Proposed methodology
Energy Management	GHG Emissions	GHG Emissions	Emissions
Waste & Hazardous Materials Management	Labour Practices	Air Quality	Products and Services
Data Security	Competitive behaviour	Labour Practices	Training and Education
Product Quality & Safety	Critical Incident Risk Management	Employee Health & Safety	Materials
Product Design & Lifecycle Management		Supply Chain Management	Energy
Materials Sourcing & Efficiency		Critical Incident Risk Management	Occupational Health and Safety
Business Ethics			Security practices
			Anti-corruption
			Procurement practices
			Employment
			Compliance (Social pillar: Society)
			Customer Health and Safety

			Compliance (Social pillar: Product Responsibility)

When comparing the 4 sets of date, the first conclusion that can be drawn is that, for each of the sectors, SASB only highlights a small number of issues. Since our proposed methodology is more comprehensive (the scope is larger), in a first approach it can be concluded that a bigger number of issues is required. But the difficulty in establishing the cut-off point and the tied scores could also explain the high number of topics. For future work a more focused analysis (e.g. on the different subsectors of the aerospace industry) is recommended.

It is also interesting to note that, looking only to the three sets from SASB, there are differences in the reported topics. For the Aerospace & Defense sector there seems to be a prominence of topics related to the manufacturing process and is the only sector where Business Ethics appears – once again, that does not happen in the other two sectors. That can also explain the difficulty found in the proposed methodology since the subject was too wide and not targeted to a specific part of the supply chain.

It is also interesting to note that the Labour practices are also highlighted by SASB for the Airlines and Air Freight and Logistics. Also 'Employee Health & Safety' is highlighted for the Air Freight and Logistics subsector, confirming the results obtained in the proposed methodology.

5.3. Case Study – Embraer

In this section a case study on Embraer, one of the subjects of the IAMAT project, will be developed as foreseen is set 5 of the proposed methodology. A comparison between the data on sustainability reporting of the company and the results achieved in the last chapter will be drawn and conclusions will be derived. Section 5.3.1 gives a brief overview of the company and its history. In Section 5.3.2 the sustainability strategy and materiality matrix of Embraer are presented and in section 5.3.3 a comparative analysis is performed with the obtained results so far.

5.3.1 The company

Embraer S.A. is a Brazilian company with a global footprint, with business in the segments of Commercial Aviation, Executive Aviation, Defense & Security, Services & Support and Agricultural Aviation. The company is headquartered in São José dos Campos (São Paulo, Brazil), it maintains a workforce that totalled more than 18,000 employees by the end of 2018, distributed in operations in 28 cities in Brazil and abroad. It is a world leader in the commercial jets segment of up to 150 seats and the largest exporter of high value-added goods in the country.

Throughout fifty years of history, Embraer has delivered more than 8 thousand aircraft that translate a strategy oriented to the combination of cutting-edge technology, design and creative engineering. According to the company (as of the end of 2018), in total 145 million passengers are transported yearly in airplanes manufactured by the company.

By the end of 2018, business results included net revenues of US$ 5.839 billion and US$ 16.3 billion in firm orders – reflecting a strategy driven towards profitability and business continuity. According to the most recent filings, in 2019 the net revenue was R$ 21.8 billion, from which 41% are attributable to commercial aviation and 26% to executive aviation. By year's end the company reported firm orders of US$ 16.8 billion, a total of 18.734 employees (from which 15,901 in Brazil and 2,833 abroad)

In its corporate documents, Embraer sets as its mission the further consolidation of its position as one of the leading forces in the global aerospace and defence and security industries, keeping as a market leader in the segments in which it operates and commanding a reputation for excellence. As its values, the company sets ethics, integrity, its employees, serving the customers with excellence, boldness, innovation, sustainability and a global presence.

The company's annual report complies with key indicators and information based on the methodology of the Global Reporting Initiative (GRI).

5.3.2 Sustainability strategy and Materiality Matrix

Embraer states Sustainable management as one of its 'strategic objectives', recognizing that it is fundamental for the continuity of any business and to align economic goals with socio-environmental awareness – this can be seen as a practical application of the Triple Bottom Line, the reference for sustainability throughout this dissertation. The company has established a Sustainability Committee that works with stakeholders and company leaders to develop strategies of sustainability, using as guide the Sustainable Development Objectives as defined by the UN as well as sustainability questionnaires outlining good practices. Following on from this work, the company defines indicators and targets, which are integrated into their sustainability plan (Embraer 2019). Embraer's 'Sustainability Plan 2020' will be outlined further ahead.

Embraer already includes stakeholders in their sustainability approach, carrying out three-year consultations with them. This process was last held in 2016/2017, covering shareholders, leadership, customers, specialists, suppliers and representatives of professional associations, civil society and regulatory agencies. In total, 46 internal and external stakeholders were consulted, as well as the vice presidents and the Chief Executive Officer (CEO) of Embraer. The intersection of internal and external perceptions was the base to the creation of Materiality Matrix (see Figure 21 below), which was also submitted to a validation by the Sustainability Committee, the Board of Directors and the CEO (Embraer 2019).

The eight material subjects are presented in the image in Figure 21, with an indication of their criticality (measured by score) for the Embraer strategy and the stakeholders.

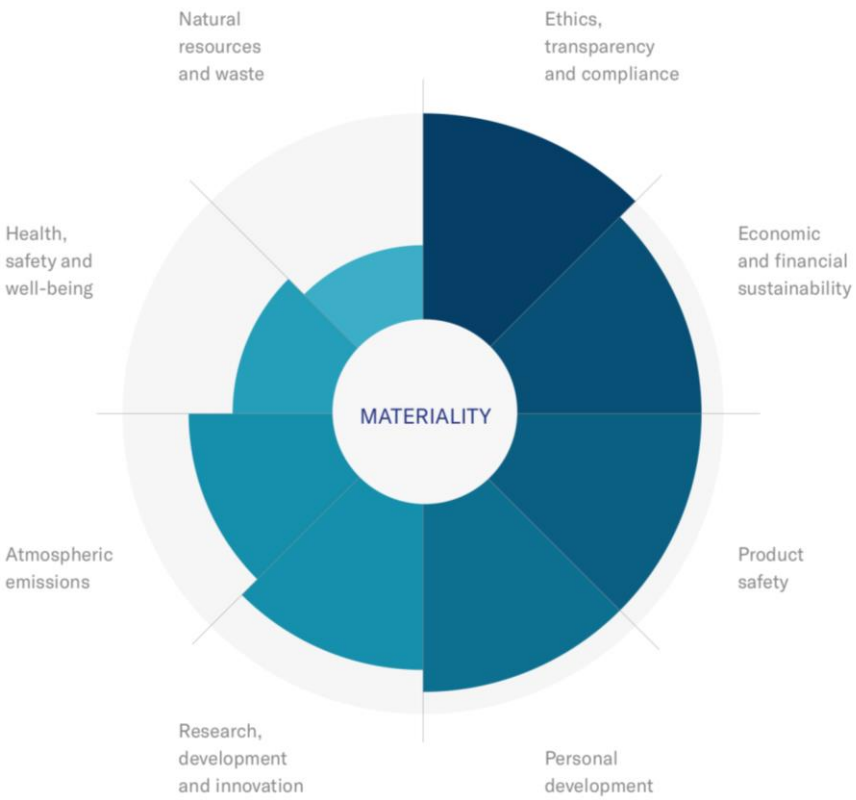

Figure 21 – Embraer Materiality Matrix – Annual Report 2018 (Embraer 2019)

This Materiality Matrix has eight broad categories: Ethics, transparency and compliance; Economic and financial sustainability; Product safety; Personal development; Research, development and innovation; Atmospheric emissions; Health, safety and well-being; Natural resources and waste. To help identify more specific implications of these eight categories, the targets for each one will be presented in Table 7 further ahead. Analysing previous annual reports, it is found that Embraer's Materiality Matrix has changed its form with the one from 2016 closer to the typical expected form by GRI, as analyzed in Chapter 3 and depicted in Figure 10. As seen in Chapter 3, the typical two dimensions for assessing whether a topic is material or not are 'influence on stakeholder assessments and decisions' and 'significance of economic, environmental and social impacts'. The two dimensions identified in the previous Materiality Matrix from Embraer (as shown in Figure 22 below) are 'importance for interested parties' and 'influence for business strategy'. It is reasonable to conclude that they are very similar and the implications should be the same.

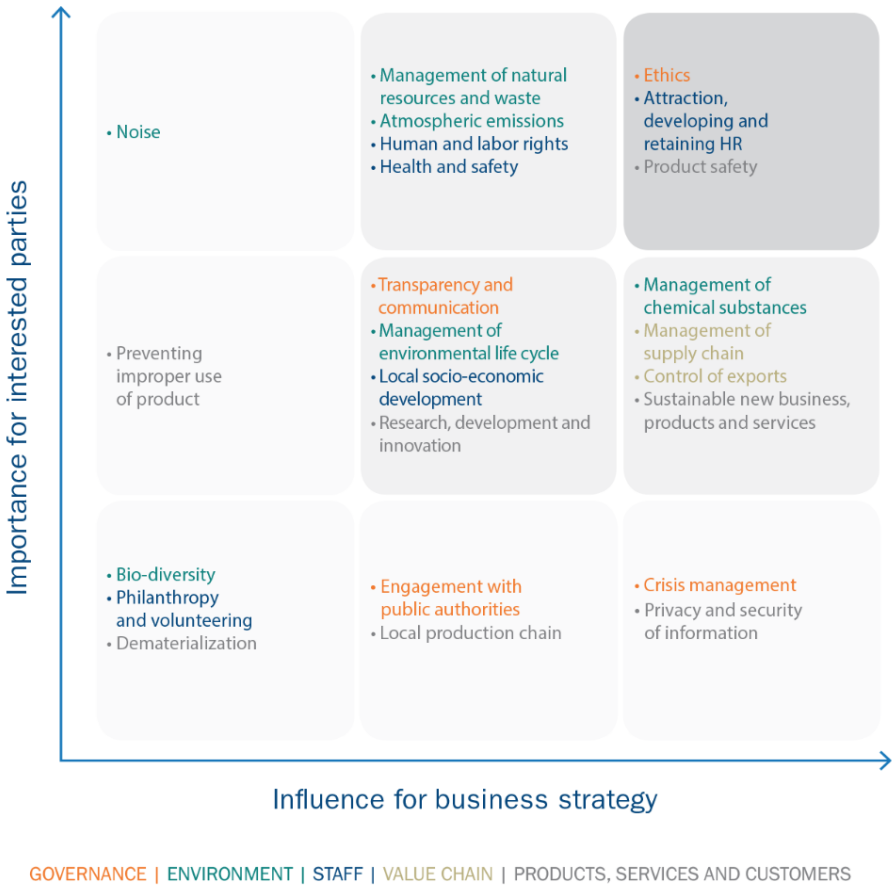

Figure 22 – Embraer Materiality Matrix (2014 – 2016) (Embraer 2017)

A closer look to Embraer's reports helps clarify that, besides the eight material subjects in the current Materiality Matrix, the company also intends to address other subjects: Biofuels, biodiversity, development of local communities and suppliers, dematerialization, human and labor rights, diversity and inclusion, availability of raw materials, product life cycle, risk and crisis management, chemicals, noise and information security (Embraer 2019). It can be concluded that Embraer has evolved from a broader inclusion of topics in their Materiality Matrix (as seen in Figure 22) to a more focused approach in the current Materiality Matrix, leaving other indicators in a second tier of focus.

It is also interesting to note that, as seen throughout this dissertation, one of the main vectors of a sustainability strategy is the relationship with stakeholders. As seen above, Embraer already includes stakeholders in their sustainability approach, carrying out three-year consultations with them. In its dedicated corporate website for Sustainability, Embraer also introduces the 'Corporate Procedure of Stakeholders Engagement'. This document is a product of Embraer's strategy for stakeholder's engagement – Embraer defines 'stakeholders engagement' as a process of a broader, more inclusive and continuous relationship between a company and those who are potentially impacted, encompassing the efforts of an organization to understand and involve the concerns of the interested parties in its actions and decision-making processes. The company has established relationships with the representatives of each one of its stakeholders, by identifying and understanding their requirements, needs, expectations, and by incorporating that information in the decision-making processes. This document is intended to help in this relationship by defining procedures, responsibilities and scope, in

order to ensure the correct identification and interaction with stakeholders, and guidance regarding methods of communication for the engagement.

According to Embraer's approach to sustainability, the subjects presented in the Materiality Matrix give rise to the Sustainability Plan, a tool with corporate goals that supports projects and priorities of the company during its validity. To help further clarify what each category of Embraer's current Materiality Matrix implies, their "Sustainability Plan 2020" can be consulted. Embraer has set many goals that detail the targets to achieve in each area and they are outlined in Table 7 below.

Table 7 – Embraer's sustainability targets for 2020 (Annual Report 2018)

Pillar	Target	2018 Status
Natural resources and waste	100% certification of manufacturing plants and service centers with more than 100 people (including outsourced employees)	62.50%
	Item: Water — Indicator - base year 2016: 172 m²/U$ MM — Target (%): -2 Item: Energy (electricity) — Indicator - base year 2016: 28.5 MWh/U$ MM — Target (%): -5 Item: Hazardous waste — Indicator - base year 2016: 0.81 t/U$ MM — Target (%): -3 Item: Non-hazardous waste — Indicator - base year 2016: 3.36 t/U$ MM — Target (%): -2	Water 181.7 m³/ million USD (+5.6%) Energy (electricity) 33.99 MWh/million USD (+24.96%) Hazardous waste 1.152 t/million USD (+14.22%) Non-hazardous waste 3.916 t/million USD (+16.5%)
Health, safety and well-being	Lost Time Injury Frequency Rate (LTIFR) for employees and third parties less than or equal to 1	2,01
	100% certification of manufacturing plants and service centers with more than 100 people (including outsourced employees)	62.50%
Atmospheric emissions	3% reduction in emissions measured in tCO2e (Scope 1)/ Net revenue* * It does not consider fuel consumption for development flights and certification of new products.	4.03
Research, development and innovation	Invest 1% of annual revenue in pre-competitive investment in research and technological development	0.90%
	Invest 5% of annual net revenue in research, development and innovation	6.20%
People development	Increase the presence of women and blacks in the company by 2% (base year 2017, 16% of women and 8% of black people)	Women = 16.09% Black employees = 3.08%
	Increase volunteer positions to 12% of total employees (base year 2017, 4%)	1497 (~8%)
Product safety	100% risk analysis applied to products	100%
Economic and financial sustainability	Return on equity (ROE) > Cost of capital, by relation between ROE and adjusted net income / shareholders' equity	ROE -1.3%
Ethics, transparency and compliance	90% of employees responding to Ethics Survey (base year 2017, 70%)	No survey done in 2018

This is the first time that specific metrics and target values for the respective metrics are presented. This can set an example for future analysis in the sense that it results from a comprehensive internal process that included a materiality analysis of the company's sustainability strategy. This table will help to better understand the broad 8 categories of Embraer's sustainability strategy but no further

detail is needed. Also, the specific metrics and targets are out of the scope of this dissertation. Embraer has a dedicated page to sustainability indicators within its corporate website for Sustainability reporting the target values for 2020 and the evolution of the indicators (when available) since the definition of the goals in 2018.

5.3.3 Comparative analysis

As part of step 5 of the proposed methodology, the obtained results will be compared with the eight identified goals from Embraer. In Table 8 a side-by-side summary of both is presented to help drawing conclusions:

Table 8 – Comparative analysis of the found issues and Embraer's sustainability goals

Embraer	Our proposed methodology
Ethics, transparency and compliance	Emissions
Economic and financial sustainability	Products and Services
Product safety	Training and Education
Personal development	Materials
Research, development and innovation	Energy
Atmospheric emissions	Occupational Health and Safety
Health, safety and wellbeing	Security practices
Natural resources and waste	Anti-corruption
	Procurement practices
	Employment
	Compliance (Social pillar: Society)
	Customer Health and Safety
	Compliance (Social pillar: Product Responsibility)

The first conclusion that can be drawn is, once again, that there are only eight topics covered by Embraer and thirteen out of forty-five have been identified with the proposed methodology. In the case of Embraer, the issues identified are more generic and each one encompasses a wide variety of targets as seen in their Sustainability Plan for 2020. For instances, the 'Natural resources and waste' topic covers five concrete goals encompassing certification for the factories and targets for water, energy (electricity), hazardous waste and non-hazardous waste. In this regards, Embraer's strategy seems to be more developed.

The atmospheric emissions issue confirms, once again, that this is a major topic for the commercial aviation sector and is transversely referred throughout this dissertation. Also the topic of

energy is a constant as can be seen in both the results from the proposed methodology and the target indicator for the 'Natural resources and waste' pillar in Embraer's strategy.

Overall, a suggestion to Embraer could be made to include a bigger focus on Training and Education for its employees. Although they have already established a goal for people development, it is currently only focused on diversity and inclusion. The aspect 'Training and Education' from the GRI-G4 standards encompasses three indicators: average hours of training per year per employee by gender and by employee category, programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings and percentage of employees receiving regular performance and career development reviews, by gender and by employee category. This is something that feeds back into the objectives of continued sustainability engagement and also the need for innovation required by the industry, as seen in previous chapters and confirmed by Embraer's pillar of 'Research, development and innovation'.

There is the case of the 'Ethics, transparency and compliance' pillar that only includes a target regarding employees responding to an ethics survey. Since this is the subject with the highest score for Embraer, some more work should be developed into this. The Compliance aspects identified in the thirteen material topics (both in the Social pillar – the first related to Society and the second related to Product Responsibility) can be included in Embraer's strategy. The Society compliance aspect is defined by the GRI-G4 standards as the monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations and the Product Responsibility compliance and the Product Responsibility compliance relates to the monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services. Both these aspects can strengthen Embraer's standing on compliance and also transparency. It can also help to steer the company into more focus complying with the regulations, which is also something that can be valued by all stakeholders.

5.4 Chapter conclusions

In this chapter the data obtained with the application of the proposed methodology is presented and the results discussed. The chapter starts with the results of the focus group. The results were analysed in further detail and a cut-off point was defined for selecting the most relevant aspects. For this particular case, the cut-off point was not clear as it would be expected from the literature. The focus group should have included the cut-off point definition. It is also not possible to rely on the ranking of the issues as many have tied scores. Further analysis – perhaps using multiple-criteria analysis – can be taken as future work.

The complete analysis resulted in the identification of thirteen most material sustainability aspects in the context of the aerospace industry: (1) Emissions, (2) Products and Services, (3) Training and Education, (4) Materials, (5) Energy, (6) Occupational Health and Safety, (7) Security practices, (8) Anti-corruption, (9) Procurement practices, (10) Employment, (11) Compliance (Social pillar: Society), (12) Customer Health and Safety and (13) Compliance (Social pillar: Product Responsibility). The expected prominence of Environmental issues was confirmed and there were interesting results with the Social pillar. Only one economic topic reached the thirteen aspects.

In section 5.3 a comparison with the existing data is undertaken. For the robustness of the comparison, only the results from the SASB Materiality Map were analysed. The application of the proposed methodology confirmed first-hand, as derived from Chapter 3 and the last sections, that there are different approaches and results when it comes to determine the indicators and material issues. This confirms the need to have a more uniform approach to Sustainability. The SASB Materiality Map does not rank the issues and only reports a small number for each of the three identified industries (Aerospace & Defense, Airlines and Air Freight & Logistics). The Emissions aspect and Labour and Employee safety matters are also highlighted by SASB.

Finally, the case study of Embraer was also studied. First, a brief history of Embraer and its present operation was presented with focus on Embraer's commitment and strategy on sustainability and their approach to materiality. It was found that Embraer not only has already a fully established reporting framework based on the Global Reporting Initiative (GRI) framework but also a firm commitment to create value for its stakeholders through sustainability. The Materiality Matrix of Embraer's Sustainability Strategy was analysed and the results compared with those from the proposed methodology. Some suggestions following the conclusions were presented.

6. Conclusions and Future Work

Nowadays, following the increasing demand for air transportation, the commercial aviation sector is becoming the main driver of the global aerospace manufacturing industry. Also, sustainability has emerged as a growing concern globally and specifically for the industry. Sustainable supply chain management appears as a key factor for the aerospace industry development. Sustainability has become a growing concern for companies and stakeholders with companies starting to account for sustainability issues in their reports and management.

In the beginning of this dissertation, having set the context for the problem to be solved, two research questions were derived regarding materiality in the aerospace supply chain sustainability:

- **RQ1**: Which methodology can be used to assess materiality in the sustainability strategy in the aerospace supply chain?
- **RQ2**: What are the material aspects in the sustainability strategy in the aerospace supply chain?

Afterwards, the state of the art on the relevant themes was presented, therefore achieving the objective of performing a literature review defining materiality in the context of sustainability and several approaches to assess it. A conclusion was derived that there are several frameworks already developed, most of them leaving for the organizations the decision process on materiality assessment. While the IIRC gives a broader view on the materiality subject, the GRI and SASB frameworks are more focused on sustainability. They all underline the importance of gathering information from the different stakeholders that have a relationship to the reporting organization and the importance of prioritizing topics. It was also found that some of them have already gathered information from different stakeholders, in different industries, creating a database on the material issues facing sustainability strategies. The research has proven that the stakeholders are a key part to approach sustainability confirming the focus that has been given to the overall supply chain in the IAMAT project.

As a result, a proposed methodology was outlined to assess the materiality of the different sustainability indicators. The proposed methodology has been applied with the execution of a focus group with the goal to come up with a set of issues considered material for the sustainability strategies in the aerospace industry. The complete analysis resulted in the identification of thirteen most material sustainability aspects in the context of the aerospace industry: (1) Emissions, (2) Products and Services, (3) Training and Education, (4) Materials, (5) Energy, (6) Occupational Health and Safety, (7) Security practices, (8) Anti-corruption, (9) Procurement practices, (10) Employment, (11) Compliance (Social pillar: Society), (12) Customer Health and Safety and (13) Compliance (Social pillar: Product Responsibility). The matter of the cut-off point was of great importance and the difficulties in establishing it indicate that more focus in needed. The cut-off point discussion could have been included in the Focus Group to obtain a more sustained result with the expertise of the participants in the Focus Group.

Next, the obtained results were compared with the existing comparable data and the case of Embraer was reviewed. The results confirm the importance of the Environmental pillar but also the emergence of issues related to the Social pillar. Having had compared the results, a conclusion is reached that a more focused approach should be applied: not only the subject cannot be so

comprehensive and should focus on a particular subsector but also the number of topics highlighted must be optimized. It will ultimately depend on the analyst, the target audience and the proposed goals.

In the end, as expected from the literature review, the set of found topics cannot be seen as a final and definitive to be applied transversely to all the industry. The scope of the analysis can vary a lot, starting with the very concept of materiality and the assessment made by the analyst/group that is undertaking the assessment. The scope of the analysis is also very important.

As to the objectives of this dissertation, summarized in the two research questions, the proposed methodology offers a good framework depending ultimately on judgement. The methodology presents a good option for its transparency and applicability provided that the criteria are well defined and the scope is more developed. As to the second research question, it is concluded that it is not possible to give a definitive answer on the material sustainability indicators in the aerospace supply chain as a whole as the literature and results demonstrate. Some topics (as Emissions) are a constant but it is hard to clearly state a number of issues deemed material for a sustainability strategy for all the supply chain.

As future work, a definition of materiality in the context of sustainability should be determined and adopted throughout the industry and a common general framework for assessing it should be defined. From that moment onwards, each organization should have the power to define its topics, even if there is a common basis for its industry. Initiatives such as *The Statement of Common Principles of Materiality* by The Corporate Reporting Dialogue are a good step in that direction and confirm this urgency. Also, the recent merger between IIRC and SASB into the Value Reporting Foundation is a good indicator of how the industry is unifying.

It is also recommended to test the proposed methodology with a more detailed focus on particular segments of the aerospace industry in general or the commercial aviation sector in specific. It would also be interesting to test this proposed methodology for materiality assessment in the context of sustainability to other industries to prove the effectiveness of the model. The next step should be defining the relevant key performance indicators for each sustainability topics so that there is a reference/benchmark. Above all, the future work done in this field should be focused on developing a standardized approach to sustainability, combining efforts among all the relevant stakeholders so that a unified approach to sustainability can be reached.

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Appendix I – The Statement of Common Principles of Materiality

Common Principles of Materiality

Introduction

- The concept of materiality is pervasive throughout the business, financial, legal and regulatory communities of the world and accordingly there are many definitions and measures of materiality. While each serves different purposes and operates in different contexts, all are definitionally aligned in that material information is any information which is capable of making a difference to the evaluation and analysis at hand.
- Materiality is both a general and a legal concept. For purposes of this Statement of Common Principles of Materiality, its focus is on the materiality principles underlying the Corporate Reporting Dialogue participants' standards setting activities and on the reporting by business enterprises in compliance with those standards. Legal authorities such as regulators may require or enforce different definitions, which may be more or less restrictive.

Concepts

- The definition of materiality focuses on the material information needs of the primary stakeholders for the report being issued. Further, the focus of reporting should be on primary stakeholders as a group and not on a single or atypical stakeholder or one who is behaving unreasonably or irrationally. Lastly, when preparing reports to and for the benefit of the primary stakeholders of that report, management is entitled to assume that the stakeholder has a reasonable knowledge of business activities and will diligently study the information presented.
- Since the definition of materiality indicates that material information is that which is reasonably capable of making a difference to the proper evaluation of the issue at hand, it follows then that immaterial information cannot and does not make such a difference.
- Business reporting to stakeholders of necessity requires the aggregation of large amounts of detailed transaction and other information into a manageable reporting format. When Corporate Reporting Dialogue participants do not specify required elements or disclosures, judgment is necessary to determine the appropriate level of aggregation or disaggregation of detailed information.
- The Corporate Reporting Dialogue recognizes that a reporting entity may disclose immaterial information in a report, but believes the inclusion of immaterial information in a report must not obscure that information which is material and, consequently, make the report less understandable.
- Materiality must be evaluated and applied in context; what is material information in one context may be immaterial in another.
- When developing new standards of reporting and disclosures, Corporate Reporting Dialogue participants should always note that their detailed promulgated requirements need not be applied if an item is not material to the reporting entity when viewed from the perspective of its primary stakeholders.

Application

- Assessment of what is or is not material is primarily qualitative and therefore judgement is both critical and necessary. Quantitative materiality thresholds have a role in this process but generally are not dispositive by themselves. If an applicable legal authority has a more restrictive materiality requirement or definition than those included by the Corporate Reporting Dialogue members in their respective standards, the legal definition or requirement supersedes any guidance issued by Corporate Reporting Dialogue member organizations. In fact, deliberate failure to comply with the applicable legal requirements may, by itself, be a material event.
- Business management is ultimately responsible for determining which information is material, i.e. relevant, to the purposes of its primary stakeholders (such as investors), for being reported. This assessment is made from the perspective of stakeholders and not the perspective of management and should reflect management's best interpretation of stakeholder expectations as of the reporting date.
- Business reporting often includes multiple periods of comparable information. Information is typically most material in the year in which the underlying transaction or event occurs and may diminish in relative importance over time. Consequently, it may not always be necessary to repeat the same level of detailed information in subsequent periods.
- It is frequently necessary to make estimates when preparing reportable information. When estimates of, or about, material information are necessary, such estimates should be free from bias, objectively consider all reliable and available inputs and other evidence and consider the material information needs of relevant stakeholders.
- Consequently, when applying the concept of materiality, the Corporate Reporting Dialogue does not expect reporting entities to report or disclose information more precisely than such information is inherently capable of being reasonably measured.

Misstatements and Errors

- Material misstatements of reported information can occur in several ways: Omissions (i.e. excluding relevant information); Errors (e.g. the incorrect use of available information), Irregularities and other causes such as presenting or describing information obscurely or ambiguously. When material misstatements occur, they must be corrected if the report in which they are included is still relevant to its primary stakeholders. Different Corporate Reporting Dialogue participants and related regulators typically have established the required reporting and disclosure standards, which should be referred to for guidance.
- When a misstatement is deliberate and made primarily or solely for achieving a particular reporting result, it should always be considered a material error because it is assumed to have been made with the intention to deceive.

Appendix II – Focus Group Guidelines

Materiality Analysis in Aerospace Sustainable Supply Chains

Focus Group: Material Sustainability Indicators in the Aerospace Industry

GUIDELINES

Context

This focus group was created to test the methodology developed under the master thesis "Materiality in Aerospace Supply Chain". The aim of this work is to provide a definition and possible reference frameworks to assess materiality in the context of sustainability in the aerospace supply chain. This dissertation is part of a bigger project: IAMAT – Introduction of advanced materials technologies into new product development for the mobility industries. The main goal of the project is to develop an integrated framework for product development evaluation that can exploit the potential use of advanced materials, manufacturing technologies and structures in the aeronautical industry. Inside this project, the dissertation is under the Working Package (WP) 4 – Supply Chains Towards Sustainability. This WP intends to define the framework and tools to evaluate and quantify the supply chains impacts of product design choices for Embraer Évora.

Goal

The goal of this focus group is to undergo the proposed methodology and come up with a set of indicators considered material for the sustainability strategies in the aerospace industry.

Materiality definition

There are various definitions of materiality. We will use the Global Reporting Initiative (GRI). This organization defines material topics as those which 'reflect the reporting organization's significant economic, environmental and social impacts or substantively influence the assessments and decisions of stakeholders'. It starts with the traditional meaning of materiality, used in financing reporting, which is commonly thought of as a threshold for influencing the economic decisions of those using an organization's financial statements, investors in particular.

When it comes to sustainability, a broader definition is used considering two dimensions – a wider range of impacts (environmental, social and economic) and stakeholders – stating that materiality is the principle that determines which relevant topics are sufficiently important that it is essential to report on them, with the relative importance amongst them defined. It is of paramount importance that the organization can explain the process by which it determined the priority of topics.

Methodology

The chosen methodology for this focus group is the proposed methodology in the dissertation (Chapter 4), which is based on the article by Lydenberg et al. (2010). Our methodology consists of a five-step approach for identifying specific indicators:

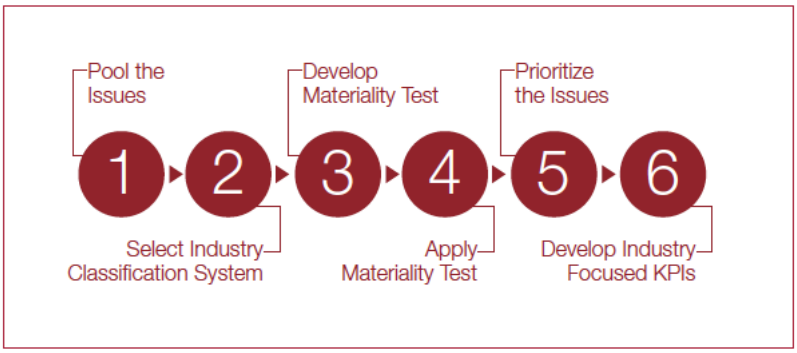

Figure A – Six-Step method for developing industry specific KPIs by Lydenberg et al. (2010)

1) Assemble a broad universe of sustainability risks or opportunities that could apply to all industries;
2) Select an industry classification system;
3) Establish a definition of materiality to address non-financial issues;
4) Apply the materiality test to the sustainability issues potentially applicable to each industry sector;
5) Rank the materiality of these issues within each industry and establish a threshold that defines those issues that are key;

We will not use the 6th step proposed by the authors as we want to focus at this time on the indicators and not specific metrics.

Step 1 – Pool the issues

We will use the already identified issues by Abreu (2017), which can be found in Table A (at the end of this document).

Step 2 – Select Industry Classification System

We will take a comprehensive approach and use as reference the aerospace supply chain as a whole.

Step 3 – Develop Materiality Test

The materiality test envisioned by the authors – the one we will use – includes five categories of impact to be evaluated at a sector (or sub-sector) level (see Figure B). It includes, among other facts, opportunities for ESG innovation, stakeholder concerns – which is very important for the context of this dissertation and the IAMAT project – and societal trends.

Figure B – Materiality Test by Lydenberg et al (2010)

The five categories can be summarized as follows:

1. Financial impacts/risks: Issues that may have a financial impact or may pose a risk to the sector in the short-, medium-, or long-term (e.g., product safety).
2. Legal/regulatory/policy drivers: Sectoral issues that are being shaped by emerging or evolving government policy and regulation (e.g., carbon emissions regulation).
3. Peer-based norms: Sustainability issues that companies in the sector tend to report on and recognize as important drivers in their line of business (e.g., safety in the airline industry).
4. Stakeholder concerns and societal trends: Issues that are of high importance to stakeholders, including communities, NGOs and the general public, and/or reflect social and consumer trends (e.g., consumer push against genetically modified ingredients).
5. Opportunity for innovation: Areas where the potential exists to explore innovative solutions that benefit the environment, customers and other stakeholders, demonstrate sector leadership and create competitive advantage.

Step 4 – Apply Materiality Test

We will use the same method as the authors: start by constructing a hypothetical score for each issue on a four-point (0-3) Likert scale using each of the five materiality categories they have chosen: Financial impacts/risks, Legal Regulatory Policy Drivers, Business Peer-based Norms, Stakeholder Concerns/Social Trends and Opportunity for Innovation. We have reviewed them just earlier. These scores are then added together to give each issue an overall score of 0-15, with the higher scoring issues understood to be more material to the the industry.

Step 5 – Prioritize the Issues

After the materiality test has been performed, a line has to be drawn to establish which are the material issues – until now, the process has just granted a scoring to all of the possible issues. The authors suggest many different approaches – for instances, establishing a "cut-off point" for the obtained scorings or selecting only the top quartile. The authors advocate that the identification is manageable and it all comes down to the judgment of the organization – in this case, the focus group

Table A – Pool of issues: Sustainability indicator by Abreu (2017)

Aspects	Management Board of the OEMs				Reg	Gov.	Customers			Sci Com
	Airbus	Boeing*	Bombardier*	Embraer	EASA*	City of Chicago	Finnair	Lufthansa Group	TAP Group	Uni. Minho
Economic										
Economic Performance	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Market Presence		▲		▲				▲	▲	▲
Indirect Economic Impacts		▲	▲	▲		▲	▲		▲	▲
Procurement Practices		▲	▲		▲		▲		▲	▲
Environmental										
Materials									▲	▲
Energy	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Water	▲	▲	▲	▲		▲		▲	▲	▲
Biodiversity		▲				▲	▲	▲		
Emissions	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Effluents and Waste	▲	▲	▲	▲		▲	▲		▲	▲
Products and Services				▲				▲		
Compliance		▲					▲			
Transport						▲				
Overall						▲			▲	
Supplier Environmental Assessment				▲				▲		
Environmental Grievance Mechanisms				▲					▲	
Social: Labour Practices and Decent Work Aspect										
Employment	▲	▲	▲	▲	▲		▲	▲	▲	▲
Labour/Management Relations							▲	▲	▲	
Occupational Health and Safety	▲	▲	▲	▲			▲	▲	▲	▲
Training and Education	▲			▲	▲		▲	▲	▲	▲
Diversity and Equal Opportunity	▲	▲	▲				▲	▲	▲	▲
Equal Remuneration for Women and Men			▲				▲	▲	▲	▲
Supplier Assessment for Labour Practices				▲				▲		
Labour Practices Grievance Mechanisms				▲						▲

▲ Reported; *non-GRI reporting – equivalent aspects reported

Aspects	Management Board of the OEMs				Reg	Gov	Customers			Sci Com
	Airbus	Boeing*	Bombardier*	Embraer	EASA*	City of Chicago	Finnair	Lufthansa Group	TAP Group	Uni. Minho
Social: Human Rights										
Investment				▲				▲		▲
Non-discrimination		▲		▲				▲		▲
Freedom of Association and Collective Bargaining		▲	▲	▲				▲	▲	
Child Labour		▲		▲					▲	
Forced or Compulsory Labour		▲	▲	▲					▲	
Security Practices			▲						▲	
Indigenous Rights										
Assessment							▲	▲		
Supplier Human Rights Assessment				▲			▲	▲		
Human Rights Grievance Mechanisms				▲				▲		
Social: Society										
Local Communities	▲	▲		▲						▲
Anti-corruption	▲		▲	▲		▲	▲	▲	▲	▲
Public Policy						▲	▲			
Anti-competitive Behaviour			▲				▲			
Compliance							▲			
Supplier Assessment for Impacts on Society				▲				▲		
Grievance Mechanisms for Impacts on Society				▲						
Social: Product Responsibility										
Customer Health and Safety							▲	▲		
Product and Service Labelling	▲			▲			▲	▲		
Marketing Communications							▲			
Customer Privacy							▲	▲		
Compliance							▲			

▲ Reported; *non-GRI reporting – equivalent aspects reported