Dinâmicas de inovação na indústria aeronáutica: impacto na manutenção

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Abstract

This dissertation aims to study the innovation dynamics in the aeronautic maintenance sector, using Portugal as a case study and integrating it in the international context. This is strategic sector, where innovation plays an important role, that needs to be understood at technological, commercial and industrial level, given the impulse that innovation to have in the aeronautic industry, producing high technology products with a wide and varied field of application. Although a high tech industry, the aeronautics industry does not introduce new technologies as quickly as it once did. Nevertheless, there is a need for advancement and improvement due to current trends in aircraft development with minimal environmental impact, leading to new technological processes. The study will focus on Portugal, which can be characterized as a follower in the adoption of new technologies, and where the aeronautics sector is mainly based on maintenance. To develop this study, a mixed methodology will be used, using quantitative data analysis, and qualitative information – through interviews with relevant maintenance or supplier companies. Analysing the data, we conclude that that the priority will be to add value and build strong relations of cooperation between the various groups present in this sector, focusing on partnerships and developing proposals through European programs. The development and projection of the Portuguese offer in the aviation sector should be focused on the formation of consortia, in order to achieve and enhance the innovative capability and competitive advantage. In addition, this study concluded that changes or adjustments that had the greatest impact on maintenance are related mainly to the introduction of new materials (composite structures), new test methods, philosophies (modular) and the will to change the existing paradigms ('curative' maintenance for preventive maintenance) and focus attention on different concepts that until now had not been thought of or created. Concepts such as the redesign of the entire value chain of an MRO (Maintenance, Repair and Operations) or focus around the passenger will probably be lead technology introduction in the future. Along with the ideals already set to decrease the environmental impact, noise, pollution, these new concepts will lead the development and possibly the creation and implementation of radical concepts, based on biomimetic structures with the assistance of technologies such as manufacturing additive, which may lead to a new technological cycle and the establishment of a new dominant design.

Keywords: Dynamics of innovation, Aeronautic industry, Maintenance, Development and Innovation, Technological adaptation.

1. Introduction

The aeronautic industry is very important to the economy and is considered of great strategic interest due to the development of security systems and socioeconomic development it provides. Also from the point of view of technological development and the generation of qualified jobs, the aeronautical sector is considered strategic and is influenced by the internationalization of production and technological development, with priority in public policies for industrial development and technological innovation (INTELI, 2005; Oliveira & Paulino, 2008).

The development of new products in this type of industry is characterized by long periods of research and development (R&D) and may even reach a decade. These medium/ long-term strategies have long cycles from initial investment to the financial return. There is a need to react in order to reduce costs through efficiency improvements or pressing on suppliers to reduce prices charged and acceptance of new contractual terms.

As other sectors, the aviation industry feels the effects of globalization, new competitors, new markets and the need to innovate. Thus, research and innovation become critical to maintaining the capacity and competitiveness, being necessary to look more and more to this sector with a long-term vision.

The aircraft maintenance is a part of the sector where there is interest in analysing regarding the integration and adaptation of technological change, due to the fact that the aircraft maintenance activities form an essential part of the capacity of an aircraft performing a safe flight. Since science and technology are key factors for the evolution and growth of Portugal to overcome new challenges, the economic development achieved by these factors translates into benefits in terms of new scientific and technological knowledge with the use of new technologies in the modernization of traditional industries and sectors that show growth prospects (INTELI, 2005).

It is from the innovation dynamics in this sector that the main challenges arise, particularly in small countries like Portugal, where the attempt to establish a competitive aviation industry has financial and development risks, and the main difficulty is focused on return on invested capital (Flightpath 2050, 2011).

The main objective of this dissertation is to study the innovation dynamics in the aeronautical industry by analysing the maintenance sector (after market) using the case study of Portugal as a country with a poorly developed aviation industry. In a context of adaptation to technological development, but integrated in an international context, it is expected therefore, that this study may generate results with impact in countries with a similar structure (Santos, 2013).

Through this evolution in the innovation dynamics in this sector, we analyse the maintenance sector behaviour in order to study how it fits and what impact resulting therefrom.

2. Problem Definition

The aeronautic industry is facing some factors and challenges that somehow characterize this industry. It is necessary to understand the barriers which are present and take into account the importance of technological advancement, which is considered one of the factors to improve competitiveness. The innovation in this type of industry is expensive and is associated with an intense R&D, with a long period of time and high technological and financial risks. The high technological level of current aircraft configurations and its underlying technology implies that a slight technological improvement is obtained through a lot of effort, increasing the final cost of the aircraft. Thus, there is a very high risk for a wrong position in the technological matrix and can lead to financial instability without any economic or technological return (ECORY, 2009).

The aviation industry represents a factor in the economic development of countries and associated with defence policy, benefits from incentives that allow it to develop and assume as a leading industry in the technology sector. Since this is a high value-added industry is seen as a vector of innovation that encourages and values the investment in innovation and development[1]. Through high rules, aeronautical sectors are standardized and regulated for safety and for the environment, taking these areas as those of greater significance and focus. As regulation can act as an incentive, it can also be a barrier to innovation, as governments regulate markets and are often themselves a major customer in the market, thereby playing a central role in the development of the sector, and supporting the industry through a wide range of innovation support tools (Yazan, 2013).

The aircraft maintenance is an industry where never was a rapid growth of

[1] *Diário da República, 1ª série - Nº 198 - 12 Outubro de 2010*

technological point of view, and its evolution is not constant or gradual. With the development of commercial aviation, have added new challenges to maintain, requiring the development of prevention methods and a greater focus on safety of people and property. The planning and control of maintenance started to have a more important role ensuring that resources are applied correctly and at the right time, ensuring the availability of equipment and increased security on flights.

This dissertation discusses the evolution in the dynamics of innovation in the aviation sector, studying how the area of maintenance corresponds and adapts and what the resulting impact. It is necessary to realize if innovation occurs more in contexts of organizational failures and management, communication processes, decision-making, implementation and evaluation, or ineffective monitoring systems and inefficient regulation (McDonald, Corrigan, Daily, & Cromie, 2000). Or innovation happens more in companies in which maintenance is a support activity to the main and core competence of the organization (Prahalad & Hamel, 1990); or is it a strategic role to support the business (Pintelon, Kumar, & Vereecke, 2006); or, if innovation is more or less linked to scheduled or unscheduled maintenance.

3. Methodology

The preparation of the interview requires some caution in its planning, in the availability of the respondent to provide the interview and in the organization of the issues. Since this is a step that requires some time and have a high degree of importance in the research, was carried out carefully in order to gather all favourable conditions (Lakatos & Marconi, 1996). There was a care in the formulation and preparation of the issues, avoiding arbitrary, ambiguous, out of context or tendentious questions and there were a continuity with a logical direction for the conduct of the interview (Boni & Quaresma, 2005).

It was applied a semi-structured interview protocol. This type of interview seeks to detail the issues so as to obtain a more precise formulation of related concepts, combining open and closed questions, with the possibility of developing better each theme. Thus, there is a degree of freedom by the interviewed, managing to explore the issue more broadly and thereby an informal discussion be generated where the interviewer should take a listener posture often avoiding interfering the respondent. This technique is used when attempting get more information on a particular topic through the vision of who is interviewed, and also to get more detail the issue in question (Boni & Quaresma, 2005; Minayo, 1993).

Through interviews with experts, it was necessary to seek to collect qualitative information, providing a better view and understanding of the reality of this sector in Portugal (Duarte, 2004).

For this study were interviewed 11 experts (see Appendix A) of 7 different companies/ organizations belonging to three distinct areas: MROs, suppliers and aeronautics association. Within the suppliers there was the interest to look for different areas of operation, covering different intervention areas in the aircraft provided more specific work such as coatings or sensors, to more global areas such as components and even areas that establish the link between industry and user, such as design.

Although they were collected 11 interviews from 7 companies / different organizations in total were contacted 23 companies/ organizations. This difference lies in the unavailability in terms of time by some interviewees and companies and also due to lack of response and/ or lack of interest in collaboration.

Snowball Sampling method was applied due to its purpose of being an 'informal' method to reach a target population. There are practical advantages when the goal of a study is essentially exploratory, qualitative and descriptive, and often used to conduct qualitative research, mainly through interviews (Hendricks, Blanken, & Adriaans, 1992). This sampling method can be seen in Appendix B, wherein is shown the chain of interactions during the development of this study.

As a semi-structured interview protocol was applied, sought to adapt the script depending on the company and interviewee's work area. In order to obtain a more precise formulation of related concepts, it was necessary on some issues enter into further detail, combining between open and closed questions and giving the possibility of developing better each topic, so that the qualitative information collected from the experts, provides a better view and

understanding of the reality of this sector in Portugal.

4. Results and Discussion

The main objective of this research is the analysis of the innovation dynamics in the aerospace industry, specifically in the maintenance sector. Along with national organizations and entities linked to the aeronautical sector, we tried to understand the evolution of the innovation dynamics in this sector, since it has an activity based on maintenance and a follower in adapting to new technologies.

The issues and topics addressed were structured according to four categories: Industry, Maintenance, Innovation and Future. Each of these categories can be found inserted into the former category, looking initially to get an overview, and then delve into each topic, focusing on the critical area of study.

4.1. Industry

This industry is heavily regulated through certifications and regulations issued by the manufacturers of the aircraft, creating barriers and requiring a fairly large effort to companies that try to enter and compete in this market.

From the side of a supplier to enter the market of this industry is a long and difficult process that can take many years to be financial return.

One way is to enter the market through partnerships with large companies that are already fully integrated into the market, particularly through R & D projects co-financed. Through this way there is a possibility for companies to gradually integrate into the industry, ensuring continuous learning and progressive growth, avoiding mistakes that can be fatal for a company in an insertion position or statement in the aircraft market (Entrevistado FS2).

On the other hand, you can choose to a different path through participation in fairs and aeronautical events. While it will require a large initial investment, in economic terms, traveling time, participation and development efforts, in the end due to face recognition in the displayed events there is return and it's possible to get contacts and invitations to participate in projects and partnerships (Entrevistado FS1; Entrevistado FS2).

The absence of an aeronautical culture, i.e., the lack of a strong aviation tradition, along with the lack of national and international recognition, are two of the barriers that prevent Portugal to participate in the supply chain (Entrevistado AA).

Most industrial assets operating in the aviation industry have a low share within its core business, where maintenance performs a support activity to the main and core competence of the organization (Prahalad & Hamel, 1990).

Through the formation of a consortium with small entities but with very specific skills, when working directly with a large company, there are advantages such as greater asymmetry present in development projects.

In research, development and innovation projects, niche skills are much more visible and Portugal can take advantage that national companies have to have knowledge and flexibility to develop new products or products that can be integrated into a value chain that already exists (Entrevistado AA; Entrevistado CM2.3).

4.2. Maintenance

The aeronautical sector in Portugal concentrates mainly around companies that develop maintenance activities and tend to follow the inherent needs of the primary level of air operators. The maintenance activity turns out to be a need, i.e., an inevitable consequence, one of the regulated areas of the world (Entrevistado CM2.1).

4.2.1. Relationship with the manufacturer

Once the maintenance centers are conditioned by the manufacturer we sought to understand how maintenance it is organized, with special attention to the relationship and the weight that the manufacturer has in this activity.

Through certifications, it is the manufacturer who decides which components and aircrafts that maintenance centers are authorized to repair, limiting all the efforts of

the maintenance centers in this type of activity. The manufacturer is the one who has the knowledge and who authorizes and sends the documents to the maintenance centers perform the steps of the repair procedure.

The maintenance organizations are guided by the manuals provided by the manufacturer so that the aircraft be airworthy.

The manuals are more and more simple and directed to the use of new tools and equipment developed by the manufacturer. Therefore the maintenance centers may be caught off guard, and from a certain point of view, are 'forced' to hire the services from the manufacturer, thus increasing the power and influence that it has in carrying out the maintenance activity.

The manufacturer seeks to work together with the maintenance centers throughout the development of an aircraft in order to collect knowledge, ideas and experience that these centers can provide. In Portugal, and in the whole industry in general, there is a long tradition of maintenance centers participate in projects and innovative initiatives by manufacturers. There is a need for an end user to carry out tests and, in the case of Portugal or a country with the size and capacity of Portugal, the companies are small and operate in a very demanding airspace in terms of aviation - Europe - being crucial exist good relations of cooperation with the manufacturers.

4.2.2. Repair vs Discard

Over the years, repair manuals have increasingly limited restrictions. Due to new types of design as well as the search for the optimization of parts and components, there is a greater accuracy which consequently requires less repairs limits, causing a part or component to be more easily discarded (Entrevistado CM2.3).

In addition to this greater rigor in repair specifications, through new manufacturing processes, sometimes there are pieces that have a cost of repair higher than the cost of acquisition of a new part. Once the repair of this piece is not economically feasible, despite being within the repair limits, this piece is discarded and marked as junk (Entrevistado CM2.3).

Although there are no data to support the statement of the interviewee about the increasing percentage of scrap from the maintenance centers, the aircraft manufacturers are concerned about the increase number of aircrafts for scrap, and they are joining efforts to reduce the number of aircrafts for dismantling and trying to increase the rate of recycling.

4.2.3. Impact and effort in adapting to new technologies

As creativity in this sector is limited, the need to understand the effort in adapting to technological development and the impact caused by the innovation dynamics in the area of maintenance of the aircraft industry it's very important. For this purpose was collected information from interviewees about changes and adaptations, effort and impact of innovation on maintenance. They were only collected opinions of interviewees who working in MRO, with the attention that the working area of the interviewees were the most varied possible to cover different maintenance activities.

The main changes were new testing methods the use of new materials, and therefore new repair techniques. There were also more conceptual changes such as the adaptation of new philosophies (modular), the paradigm shift in maintenance (curative maintenance to preventive maintenance) and the reshaping of the value chain of an MRO.

As for the impact of these changes, it was possible to carry out new techniques and repair methods, the maintenance became easier and more efficient, and there was a growth and improvement about technological developments through new knowledge and skills.

However, for these changes occur an effort is needed in adaptation and understanding of these changes. In addition to the financial effort on investment in training, equipment and tools, it is also necessary to overcome some barriers in the implementation of innovations, trying to put together different areas in order to reap the rewards of each.

The aircraft maintenance is an industry that does not progress very fast from the technological point of view. It is in a state where the appearance of small incremental

improvements are such that all maintenance is influenced, making it better quality, more efficient, faster and more economically feasible (Lombardo, 2008). It is through incorporation of different configurations technologies, materials and processes that all the maintenance improves (Entrevistado CM2.2). On the one hand can ease the rapid replacement through modular concepts, but also on the other hand, may require a greater effort in repair due to the requirement to know how to handle and work with these new components (Entrevistado FS1).

4.2.4. Training

Taking into account the level of technological requirement of the sector, training is a central aspect of the analysis, leading to the need to understand the integration and difficulties in training of qualified personnel for maintenance (Yazan, 2013).

The training given by the manufacturer is usually given to qualified engineers who subsequently will give the training to employees. There are different advantages and disadvantages in the decision to invest in training, however it will always depend on the present workload (Entrevistado CM2.1).

The training happens to be a challenge in the future, not only due to the introduction of new technologies and regulations in the sector as the difficulty of skilled labour allocation (Cheung, Ip, & Lu, 2005)

4.3. Industry

Over time, in addition to a significant reduction in cost and fuel performance few measures have changed. This apparent lack of innovation in the aviation industry may suggest that this industry is in a high maturity level. However, the recent lack of innovation can also be considered as a source of interest and as a booster to meet the challenges created by an industry of this type (Walker, 2002).

In order to study and analyse these assumptions, we tried to understand innovation in a peculiar type of industry such as aeronautics, and especially to understand how innovation is integrated in the maintenance sector. In addition to trying to understand how the maintenance deals with the development of new products, we tried to also identify innovations that have had origin in maintaining and understand how these are associated and follow the evolution and technological development.

4.3.1. Development of new products

The great innovative dynamism of the aeronautic industry is evidenced by the growing level of demand from the commercial and military market, which is increasingly seeking safe, economic and efficient aircrafts (Ferreira, 2009). Given the high level of security required on the aircrafts, the aeronautic industry has a rather conservative nature, requiring high levels of quality, proven by time-consuming and costly tests, certifications and qualifications that restrict the level of creativity in innovative enterprises in this sector (Entrevistado CM1). These high costs and risks associated with the development of a new technology, as mentioned above, may be one of the causes of the apparent stagnation of the aeronautic industry (Kroo, 2004).

Since it is difficult to escape certain parameters, it is the manufacturer who makes and develops all kinds of innovation, seeking partnerships with other entities such as universities (inspection techniques) or MROs (special manufacturing processes such as electrochemical treatment , thermal coatings or welds) (Entrevistado CM1).

One of the most important partnerships in the development of a new product is cooperation between the MRO and the manufacturer (Entrevistado CM1). As aircraft manufacturers have increasingly less time to innovate contact the MRO to assist with its experience and knowledge in the development process. In addition to the MROs, there is also the demand to include operators and other entities working in the field of development and innovation (Entrevistado CM2.2).

The maintenance area has a key role in this process. The manufacturer not only absorb knowledge and information for the development of the product, as it will receive, by the maintenance inputs on whether certain tools and repair techniques may cause problems or have implications for the future. Sometimes the tools or techniques that the manufacturer thought to be the indicated may not be the best suited to a

given maintenance activity or in certain operating conditions (Entrevistado CM2.2).

Innovation despite being risky in this type of industry is necessary and can inspire the creation of alternatives and different concepts (Kroo, 2004). These changes may be associated with requirements and environmental standards at the level of reduction of noise and emissions (Entrevistado FS1).

The main difficulty in developing a product is the certification barrier. Typically, initially applies in military aviation and subsequently in civil aviation, since the military certify their own systems. As previously mentioned, an important feature in the innovation dynamics of military aviation is the high asymmetry in the incorporation of existing technologies in the same generation of aircrafts (Ferreira, 2009).

4.3.2. Innovation in MROs

In a country with the capacity and size of Portugal, the MROs receive the manufacturer's manual and perform the procedures that are described just like if they were an automatic machine. However, as discussed earlier, the latest manuals reveal sometimes lack of rigor and, perhaps due to economic pressure, there is a lack of monitoring and verification by the aeronautical authorities (Entrevistado CM1).

In Portugal, there is integration and adaptation of new technologies, allowing production management systems become more efficient and effective. In addition to monitoring of technological systems related to planning and workforce optimization is achieved by reducing time and minimize cost through minor changes (Entrevistado CM2.1).

Despite the innovation and development of new products from the manufacturer, the MROs start to realize that many of these initiatives could be developed through European funding programs (Entrevistado CM2.5). The ingenuity that MROs had along the collaboration with manufacturers has been changing. (*Ibid.*). There is the need for MROs have more visible compensations through the participation in these projects because in the end the manufacturer reaches its goal and the MRO have to pay to the manufacturer what had helped test (*Ibid.*).

4.3.3. Technology integration

The implementation of a technology, either the modification of an existing aircraft or a feature of a new aircraft, will have repercussions for both the manufacturer and the operator. For example, new production technologies can help reduce manufacturer's costs, or the new design of a wing can reduce the cost of fuel operator (Entrevistado CM2.2).

However, on the other hand, implementation of a technology will result in additional costs, such as investment costs for the manufacturer (new tools, equipment, etc.), as for the operator (maintenance costs and spare parts, for example) (Henke, 2012). Some technologies can benefit from its implementation since it can save weight and reduce the use of raw materials, however there may be some technologies that will only compensate in the future through rates, fuel prices, labour-work etc. (Entrevistado CM2.2).

Any implementation of a new technology requires careful assessment in order to analyse the repercussions caused by the introduction of this technology (Entrevistado FS2). Should be analysed in comparison with an aircraft without this technology, and the effects calculated taking into account all the benefits and losses that may occur during the lifetime of the aircraft, as well as all costs (current and non-current) that are associated. Having made the calculation under a certain set of assumptions, the result will allow reaching the decision to proceed or not with the development and application of this technology (Henke, 2012).

4.3.4. Challenges

Innovation in maintenance at this time, has as its main challenge the difficulty of developing as the products also are developed. If maintenance not adapt, cannot keep up this development, whether in terms of training, techniques or tools (Entrevistado CM2.2).

It is difficult to understand the innovation peaks, and technological changes present in this industry that, in a way, change the vision and give a new direction to technological developments in this sector. These changes do not happen in a constant or gradually over time, mainly depend on external factors

linked to technological innovation in this type of industry (Balaguer, 2008).

The allocation of technicians according to their training is one of the main challenges present in maintenance, especially because of the weight that must exist in the mobilization of employees. Another challenge is the identification of critical paths, due to the possibility to compromise crucial components such as motors or the structure of the aircraft. Such challenges affects mainly the planning and can create delays that hinder and influence the entire operation and maintenance activity (Entrevistado CM2.2).

There is a contradictory concept in the aviation industry that turns out to be a challenge in understanding and overcoming future challenges. On the one hand, the aviation culture traditionally encourages collaboration between companies, there is a long tradition of cooperation in this industry (Entrevistado CM2.5). The aviation industry is so complex that only with collaboration it is possible to develop an aircraft or an aircraft operating procedures that are standard throughout the world, for example. However, currently, the industry has entered a phase in which the own aircraft manufacturers are now competing against airlines companies, particularly in the area of aircraft maintenance (*Ibid.*). This change has meant that the spirit of innovation, which was propitiator of innovation, were to be called into question, causing airlines began to retract more and more. An industry that has a great tradition of cooperation now takes on a defensive behaviour (*Ibid.*). In Portugal, although there was an attempt to change this paradigm (Entrevistado CM2.4) and try to be the companies to look for manufacturers and partners, there is a closed culture that acts as a barrier to the development of innovations (Entrevistado CM2.5).

5. Future

5.1. Development of the aviation industry in Portugal

All the technological evolution that has seen is beneficial for a country like Portugal. The possibility of entities linked to areas that have aroused an increasingly strong interest in the aviation industry, as the area of sensors for example, provides opportunities for Portuguese companies (Entrevistado FS4). Such areas do not require a high monitoring, nor is it necessary to be a large company with a large structure. The areas that operate with such software, make it possible for Portugal have companies capable of competing with any other company globally (Entrevistado AA).

Although the mind-set is changing, Portugal does not have a mind-set of making innovation and create something of value (Entrevistado AA). We must continue to change this mind-set and start having capacity for innovation. Perhaps as a matter of culture or mentality, Portugal is a country averse to risk. We create little to the capacity that we have (*Ibid.*).

Besides the connection to the manufacturer, Portugal also has to pay attention to the type of client that exists. One area in which Portugal can specialize and which is growing gradually, is the executive aviation. The business aviation has a more limited supply, and the existing opportunities for renewal of interiors have a turnover of just two years (*Ibid.*).

It is from this attention to the client that is expected a change in the airline industry. Up to today, this industry has always been much focused on the operator and very little in the passenger. However, it is expected a change in this subject. The passenger will be the focus, and the aim will be improve the comfort and flight experience (Entrevistado CM2.5). The new aircraft will start to be always thought with the idea to improve the passenger experience in terms of cabin and noise, thereby forcing some changes particularly in engines, cabin, used materials, structure and design (*Ibid.*).

In addition to this change, also the different initiatives that are in Europe about the optimization of European airspace have to be viewed from an integrated perspective as it will involve all sectors of the industry - those who build the plane, those who operate, who manages air traffic, maintenance , etc. (Entrevistado CM2.5). The use of new composite structures (Entrevistado CM2.3), requires that the minutia requirements for this type of technology and knowledge required be huge, creating many difficulties in maintenance (Entrevistado AA).

Concepts such as the redesign of the entire value chain of an MRO or focus around the passenger (Entrevistado CM2.5), along with the ideals already set to decrease the

environmental impact, noise, pollution, etc., will lead the development and possibly the creation and implementation of radicals concepts, possibly based on biomimetic structures with the aid of technologies such as additive manufacturing, that can lead to a new dominant design (Sander, 2015).

6. Conclusions

Although Portugal does not have an aeronautical culture or have international recognition, positioning the national aviation industry should be based on competitive factors and entrepreneurship. These factors must be well established in innovation so they can be added to the final product. Being aeronautical engineering in a maturation phase, there may be opportunities for innovation by introducing increments of product technology (to improve productivity and product quality), technological processes and innovations in order to create substitute products of superior quality.

To put the Portuguese companies in the technological vanguard sector is necessary to anticipate business opportunities. Since entering the market in an industry such as aeronautics is a long and difficult process for suppliers, must continue to be a support and an encouragement to the aeronautical sector, so that the Portuguese presence in international R & D projects increase, promoting their skills and inserting themselves in the global supply network of the aeronautical industry. This type of opportunities allows to gradually integrate the industry, avoiding possible errors that could be fatal for their growth and affirmation on the market. The development and projection of the Portuguese offer in the aviation sector should be focused on the formation of consortia, in order to achieve and strengthen the innovative capacity and competitive advantage. The priority will be to add value and build strong relations of cooperation between the various groups present in this sector, focusing on partnerships and developing proposals through European programs.

Since the room for creativity in this sector is limited it was concluded that changes or adjustments which had a higher impact on maintenance are associated especially with the introduction of new materials, concepts or philosophies. For materials, the change of metal structures for composite structures required the use of new inspection and repair methods, and investment in terms of training and purchase of tools and equipment. In its turn, the implementation of a new concept or philosophy, requires a more abrupt change to the operating level. Demands a reformulation in the modus operandi that can be difficult to implement. However it will bring new approaches and more efficient working methods, as well as benefits especially in terms of time savings in performing maintenance tasks.

Therefore, since the incorporation of new materials and inspection techniques it is possible to have access to a huge range aircraft data in flight. Thus the entire structure and of the aeronautical industry operating mode may change. Portugal should look into this technological evolution as an opportunity to enter and prosper in a market as demanding as aeronautics. And in an industry like this, knowledge becomes crucial to gain an advantage, because the goal becomes to be in front of the development of future trends.

Throughout this study, very different opinions were collected. On the one hand, there is a clear concern about the inability to cultural and technological level to evolve and gain scale in the industry, since there is a tendency to Portugal consider creating synergies and joint efforts as a cost rather than an investment that can bring benefits in the future. On the other hand, there are opinions that believe that Portugal, by creating synergies and formulating a goal where there is a clear focus and something to strive, can gain a competitive advantage that allows to create products with value, create links and gain ground on the network.

6.1. Future studies

Due to the increasingly limited restrictions present in repair manuals, there is an increase in the quantity of discarded parts sent for scrap. Being the manufacturer indirectly responsible for this increase, there is a contradiction when there is by the same manufacturer an effort in recycling aircrafts and reducing scrap. It would be interesting to carry out a careful analysis of the scrap rates of discarded parts in maintenance tasks and to relate the effort along with increased opportunities in the area of dismantling and recycling of aircrafts. If recycling of aircraft is expected to be profitable in the coming years, may not

recycling of certain parts and components also become profitable?

In addition to this by manufacturer's contradictory behaviour, this defensive behaviour in the airline industry may also be the subject of future study object. In order to understand the reason behind this change, it would be interesting to analyse the different paradigms that dominate this industry. The rivalry that increases between operators and manufacturers can create problems in their relationship, particularly in organizations with a more closed culture, stagnating and creating barriers in the development of innovation and cooperation between entities in projects and partnerships.

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7. Appendix

7.1. Appendix A

List of interviewees.
Source: elaborated by the author.

Abreviatura	Área de Trabalho da Empresa	Área de Trabalho do Entrevistado
CM1	Centro de Manutenção	Manutenção de Motores
CM2.1	Centro de Manutenção	Manutenção de Motores
CM2.2	Centro de Manutenção	Manutenção de Cabines/ Estruturas
CM2.3	Centro de Manutenção	Reparação e Manutenção
CM2.4	Centro de Manutenção	Melhoria Contínua
CM2.5	Centro de Manutenção	Gestão de Inovação
FS1	Fornecedor de Serviços - Design	Design
FS2	Fornecedor de Serviços - Componentes	Direção Geral
FS3	Fornecedor de Serviços - Revestimentos	Direção Geral
FS4	Fornecedor de Serviços - Sensores	Direção Geral
AA	Associação Aeronáutica	Direção Geral

7.2. Appendix B

Demonstration of interactions chain conducted in this study through Snowball sampling.
Source: elaborated by the author.