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## RISK SHARING PARTNERSHIPS WITH SUPPLIERS: THE CASE OF EMBRAER

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### Abstract

Since the mid 1990s, the global aircraft industry has been creating new solutions for product development. Risk-sharing partnerships with suppliers began to be established in an attempt to reduce investments and, consequentially, the dependence on loans. The partners began not only to invest in tooling, engineering and infrastructure, but also to participate more directly in the projects, in the investments and design activities, acquiring rights to future sales income of products. This contractual modality, called risk-sharing partnership, is the focus of this study. Specifically, it analyzes the risk-sharing partnerships made by Embraer during the projects of the ERJ-170/190 family of aircrafts. It also aims to justify these partnerships, considering the current global aircraft market conditions, evaluating the critical success factors, requirements and macro-economic conditions which supported the adoption of this new policy.

**Keywords:** Innovation, technology management, partnership, projects, product development.

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## 1. INTRODUCTION

In order to address the constant changes in customers' preferences, to anticipate new product releases of rival companies and/or respond to them, to make use of technological opportunities and to increase market share, a strategic option to any firm is to invest in product development and exploit rival information for a better position in the market. This investment can be undertaken directly, through R&D, licensing of technologies or copying, for instance. However, there are other ways of developing products that involve cooperation of other firms in the process, through partnerships.

Since the mid 1990s the global aircraft industry found new solutions for product development and begun to establish risk sharing partnerships with its suppliers, in an attempt to reduce investments and, consequentially, the dependence on loans, thereby diluting the risks associated to products. In turn, these companies focused their development and manufacturing activities on specific and strategically interesting areas, that is, the concept of core competences began to be used. This concept consists of a chain of capabilities and technologies which add value to the client, differentiating competitors and strengthening the company's competencies. (Hamel and Prahalad, 1990) and (Gingrich, 2003).

At first, this trend was reflected in a less verticalized manufacture process, with an increased number of parts produced by thirds parties, not only responsible for supplying manpower but also for the material used and the manufacture process of the parts or pieces of the aircrafts. Later, partners began to take over not only investments in tools and non routine engineering and infrastructure but also to participate more directly in investments and project development, thereby acquiring rights to their future sales income. This contractual modality is called risk sharing partnership (RSP) and is the object of the current study.

Specifically, this study analyzes the risk-sharing partnerships made by Embraer during the projects of the ERJ-170/190 family of aircrafts, the so-called Embraer Regional Jets and places them in the global aircraft context, evaluating the critical success factors, requirements and macro-economic conditions which can support the adoption of a partnership policy. Embraer is frequently studied and quoted worldwide as an example of a successful Brazilian business enterprise. This analysis may be a starting point to evaluate whether the company's model of risk sharing partnerships may be applicable to companies belonging to other industrial segments in order to improve their results.

The research methodology was the case study. This methodology is suitable for exploratory research insofar as it carries out an intensive analysis of a situation and allows for an investigation of a holistic nature and of the significant characteristics of the events, objects and

phenomena under study (Yin and Campbell, 1994). In view of the objective of the current research, the use of this methodology was justified.

Data for the study were collected from various sources. Initially, non structured interviews with the Director in charge of the academic liaisons at Embraer were initially conducted followed by visits to the assembly lines. Studies of other researchers and progress reports and presentations from Embraer were then accessed. Finally, reports from companies in the aircraft sector, which were available on the internet were checked.

Section 2 of this document includes a review of literature about risk sharing partnerships, focused mainly on the aircraft sector. Section 3 presents some information on Embraer and analyses the risk sharing partnerships in the program of the ERJ-170/190 family from a global perspective. Last section exhibits the conclusions and recommendations for future studies.

## 2. FOUNDATIONS ON RISK SHARING PARTNERSHIPS.

Many explanations are found in literature to substantiate the entry of aircraft companies into risk sharing partnerships. Most research focuses on strategic alliances. The purpose of this chapter is to provide a conceptual basis for an empirical investigation of risk sharing partnerships (RSP), based upon work of other authors. Although an overview of the transaction cost theory is provided, it is not comprehensively described. There is not a single theory providing a complete basis for understanding the use of strategic alliances such as RSP, however, transaction cost theory (Williamson, 1975; 1985) offers theoretical explanations. The broader concept of strategic alliances is briefly explained, before analyzing this theory. At the end of this chapter, a description of RSP in the global aircraft market is made.

### 2.1 Strategic Alliances

Seixas, Grave & Gimenez (2001) view a strategic alliance as a convenience game for the companies involved, which lasts as long as the parties are interested. They must have clear and well defined strategic intentions to establish trust and to bring about synergisms beneficial to the parties through joining of forces. Some examples of strategic alliances are joint-ventures, operational collaborations, licensing and supplying agreements, and RSP.

Gordon (2003) mentions that a strategic alliance can significantly improve performance of an organization through joint actions. Klotzle (2002) has a different view compared to other authors by virtue of two facts: 1) alliances serve to facilitate the access of companies to the partners' valuable resources; 2) success of a strategic

alliance relies on transfer of knowledge and capabilities during the partnership. With respect to the difficulty of knowledge transfer, Nyiri (2003) stresses that it is one of the critical factors in partnerships, which may cause differences between companies and regions. Furthermore, Oliveira (2003) discusses the fundamental role played by strategic alliances as accelerators of entrepreneurship and innovation. Liboni, Takahashi & Mauad (2004) emphasize that companies must develop mechanisms to achieve complementarity of technological competencies between two or more companies.

White (2001) affirms that strategic alliances have four possible objectives:

- Defensive – reduce the differentiations of competitors;
- Offensive / Optimizing - optimizing relationship with suppliers or partners to reduce costs. Sharing responsibilities, information and abilities.
- Cost Sharing - reduce R&D costs when investing in new technologies;
- Expand the Businesses – expand current markets and/or enter new markets.

For Liboni, Takahashi & Mauad (2004) these objectives are reduction of risk and uncertainties involved in the process; avoidance of investments for specific capabilities, new productive units, or access to new technologies and markets, as well as a search for complementarities of assets and competences. Complementarity of the alliance entails the existence of significant differences in terms of technology, product, market, qualifications and capabilities of the partner companies.

## 2.2 Transaction Cost Theory and RSP

Transaction cost theory attempts to explain why, in certain circumstances, hierarchical institutional structures may provide a more efficient means of governing economic transaction than markets. Alliances (in which RSP are included) are typically positioned as hybrid forms of organization, located somewhere between the arms' length contracts that characterize markets at one end of the spectrum and the complete equity control that characterizes "hierarchy" at the other (Jordan and Lowe, 2004). Generally speaking, the firm is said to economize on transaction costs because it internalizes transactions. Transaction cost theory focuses on the efficient choice between producing goods and services within the firm or purchasing them in the market. If the cost of purchasing goods or services is lower than the cost of internal production, the activity will be turned over to the market (Coase, 1937; Williamson, 1975, 1985).

If the transaction is a one shot enterprise, is highly certain in its terms, and does not require specific resources (an example of high specificity is a special machine or

specially trained personnel), then the integrated firm enjoys no advantage relative to a simple market transaction. Actually, the three attributes - frequency of recurrence of transactions, uncertainty to which they are subject, and the degree to which they are supported by durable and specific investments (asset specificity) - all draw the balance in favor of the integrated firm (Koenig and Thietart, 1988).

There are, however, some limitations associated with a dichotomous classification scheme. Powell (1987) noted that "...analytical concepts such as markets and hierarchies may provide us with distorted lenses through which to analyze economic change. By looking at economic organizations as a choice between markets and contractual relations on one side, and at conscious planning within a firm on the other, we fail to see the enormous variety that cooperative arrangements can take...". Gomes Casseres (1996) similarly argues that "Economists and managers now realize that the old dichotomy between firms and markets no longer applies; perhaps it never did. Alliances fill the wide gap between these two extremes. They are a unique way to govern incomplete contracts between separate parties."

Cooperative agreements, such as risk sharing partnerships, are governance structures that are intermediate to the market and the firm. This form of organization may be used when it is inappropriate for a firm to internalize an activity, but when at the same time there are high transaction costs associated with the market exchange. An explanation of the use of strategic alliances is implicit in transaction cost theory, although most of the body of theory does not specifically addresses cooperative governance structures (Kogut, 1988).

## 2.3 Risk Sharing Partnerships

In order to define RSP it is important to stress that suppliers who invest in the development of parts or systems in a project are not always risk sharing partners. A risk sharing partnership with suppliers necessarily involves a participative sharing in the project, with rights to future sales income of products. The partner relies on the commercial success of the project to receive the total or part of his share for the activities and/or products delivered. The partner of a project is subordinate to the company that wrote the contract, practicing the activities of development and manufacture according to the rules involved and acting jointly in an integrated manner with the manufacturer. As such, risk sharing partnerships are different from joint ventures, contracts of technological cooperation, mergers and mere sourcing agreements between companies.

Risk sharing partnerships can contribute to reduce the lead-times of projects. Stalk and Hout (1993) affirm that a decrease in the amount of time necessary to develop and launch new products, as well as a fast response to the client's orders, result in a competitive advantage. RSP can

reduce the duration of projects because it enables parallel work, diminishes rework, synchronizes deadlines and enhances the communication between suppliers and manufacturer. These techniques of enhancing the innovative process were pointed out by Zirger and Hartley (1996).

As stated by Bernardes (2000), the design, marketing, logistics, distribution and trading, infrastructure activities etc. are key elements of any entrepreneurial success. However, a sustainable competitive advantage is brought about not by repetitive and manual work that does not add value and may be outsourced, but by technology and knowledge related to development and manufacture processes. The recent strategy of Embraer and other companies of the sector for development and manufacture of aircraft reflects these changes. Many of these companies, although they are large size organizations with qualifications to carry out investments, faced a continuous increase in their costs for new product development, up to the point of being forced to devise a new business structure (Brown, 1998).

Difficulty in obtaining loans was another reason of this need for change. To make partnerships with the local and international suppliers was one of the approaches devised to face this situation. Constitution of international partnerships is also needed due to the lack of qualified suppliers in the country of origin. Many governments require that part of the aircraft production be made in their countries and by local companies, as a pre-requisite for the approval of contracts. China is an example of this. For Boeing to sell its 747 aircraft to the Chinese, it had to manufacture or assemble at least part of the product within this country (Pritchard, 2002). This kind of agreement has become increasingly complex, so that manufacturers such

as Boeing and Airbus started to operate in innovative, decentralized and globalized supplier networks that are not merely defined by cost criteria, quality or logistics. Many of these outsourcing relationships were formulated in response to economic development priorities by governments of other countries, who control decisions of aircraft purchase for the domestic markets (Dixon, 1999).

The new techniques which emerged in the design and manufacturing activities, such as simultaneous engineering, just in time (JIT) and the use of programs such as computer aided design (CAD) or computer aided manufacturing (CAM) increased the efficiency of the development process, cutting costs and reducing lead times (Krishnan, 2003). New network communication technologies allowed rapid exchange of data and information even between enterprises on different continents, thereby becoming a competitive factor. They also permit a degree of cooperation which had been impossible, for development as well as for manufacture of products.

### 3. RISK SHARING PARTNERSHIPS IN THE CONTEXT OF EMBRAER.

Embraer is a Brazilian open capital enterprise, a manufacturer of aircrafts, focused on the market segments of commercial, corporate and military aviation. Table 1 presents the company's products, ranked in three segments. Embraer's families of regional jets place it among the four largest aircraft manufacturers in the world, having achieved an income over BU\$3.9 in 2005. The firm backlog orders totaled US\$ 10.4 billion on March 31 of 2006.

Civil – Commercial	Corporate	Military
ERJ 140, 145, 170, 175, 190, 195	Legacy	Super Tucano/ALX, AMX-T, BEM-145 AEW&C / RS/AGS / MP/ASW (P 99)

Table 1 – Segments and Families of Aircraft

The company is prominent in the development and production of aircraft that operate in the regional aviation segment around the world, mainly with successful sales of the ERJ-145 with a capacity for about 50 seats. The segment for this model uses mostly medium size airplanes, the so-called commuters with 10 to 120 seats.

For Cassiolato (2002) the main thrust of Embraer's technological strategy was not the import of technology packages known as "black boxes", to be "opened" and taken apart, optimized and adapted to local conditions,

according to the principle of reverse engineering. Much to the contrary, investments and efforts were directed towards acquiring competence by solid qualification in basic and applied research and for continued training of human resources, apt to develop and design specific technological solutions.

In the mid 1990s Embraer started to pay closer attention to strategic project activities such as development, systems engineering, materials and integration. The company adopted the strategy to look for partners to

manufacture parts and subsystems that correspond to the assembly of systems and kits, that is to say, to the off-load strategy. Thereby, investments in the sectors of machining and stamping were limited to partial modernization of existing equipment, in accordance with production requirements and also when suppliers were not available (Mendonça, 1997).

Currently, Embraer has an extremely modernized product development structure. In 1998 with the beginning of the development of a new family of regional jets ERJ-170/190, the company strived to act in the market of commuters, with a capacity of 70 to 118 seats. Development of the new program of the ERJ-170/190 family, that took about four years, and required around US\$ 900 million of the company's own investments. Pre-launching took place seven years after starting production of the ERJ-145. It is important to note that the ERJ-145, although a lesser complex project also took four years, showing an improved company efficiency in the development of product families.

To meet its targets, the ERJ-170/190 program included modern management techniques of commercial aircraft development. The company has oriented its activities towards the generation of value, acting as a system integrator, mastering various technical phases and details of aircraft subsystems without, however, manufacturing them, maintaining the capability to combine and adapt according to project requirements. Therefore, Embraer sought to combine the complex technological issues associated to the demand, with a vision always oriented towards low costs, increase of income and solid return on investment. As an aircraft is comprised of more than 28 thousand parts, the capability to project and specify the product and harmoniously integrate components in various subsystems is a complex and difficult task. This activity is the core of Embraer's strategy. Linked with the marketing and technical services activities, it forms the core element of the company's competencies. It is this that permits Embraer to control its network of partners and its global supply chain, strengthening its commercial performance and competitive advantage, Cassiolato (2002).

Embraer established a well defined hierarchy regarding its suppliers. The firm coordinates a network structured on three levels in a decreasing order of importance. On the first level are the risk sharing partners, those that take on financial risks in the projects, or better, multinationals that participate jointly in the design project and add technological value. The second level consists of suppliers that provide the systems, parts, components and services ordered by the company. The majority of these suppliers (98%) are companies from other countries. The companies at this level supply their equipment, avionics, components, etc., according to the specifications given by Embraer. An intense exchange of knowledge and technologies takes place between suppliers and the

contracting company, however with less intensity than that taking place on the first level. This group may be subdivided. Some do not have rights to future sales income, just being paid for the supplied products and services. Others make significant investments in development such as: non-routine engineering, tooling and infrastructure. They also participate in the last part of the Joint Definition Phase and are therefore called risk suppliers. Different from risk sharing partners, this last group is responsible for less complex and expensive components. On the third level are the outsourced suppliers, the companies and individuals that receive the raw material and the design from Embraer and sell their manpower services. Services outsourced by Embraer include project and system engineering services, machining and chemical treatments, as well as finishing and production services. Many of these companies are located near the plant (headquarters) in São José dos Campos and are directly subordinated to Embraer.

### 3.1 Risk Sharing Partnerships in the ERJ-170/190 Aircraft Family.

This section highlights major differences in the framework of partnerships when compared to those made during development of the ERJ-145, Embraer's first family of Regional Jets. Investment in the ERJ-170/190 program was a risky decision for the company, that sought to participate in a market segment closer to that in which Boeing and Airbus operate, that of airplanes for about 100 passengers. The development of the family of ERJ-170 and ERJ-190 jets, with 70 to 118 seats respectively, had an extensive participation of risk sharing partners – a total of 16 - which include enterprises such as General Electric, supplier of the turbines, Honeywell manufacturer of the avionic systems, Gamesa, responsible for the empennage and rear fuselage units and the Hamilton Sundstrand, supplier of the tail cone, among various others, see Figure 1.

Another important consideration is the number of suppliers involved, which in comparison to the ERJ-145, was reduced from 400 to 40. The decrease was a strategic decision to better manage them, minimize costs and improve product quality through collaboration with the best companies in the sector. The ERJ-170/190 program was developed according to a new philosophy – strategic partnerships. This philosophy brought about new dynamics for product development, aiming at commercial success so all could benefit from the results. This philosophy also mirrors the new competitive reality in the aircraft market – a new standard of “integrated organization” through networks of knowledge, development and technological innovation with participants that provide resources for project funding, as well as share the risks and uncertainties.

With implementation of the ERJ-170/190 program some changes in the partnership process were introduced. In addition to reduction in the number of suppliers, new forms of relationship evolved. For Cassiolato (2000), the American companies are losing their share as Embraer's suppliers, retaining 57%. The Japanese now have 8%, the Europeans 27% and the remaining countries 8%. As for supplier participation in the manufacture of aircraft components, risk sharing partners have 36% of the total

shown below, international suppliers have 57% and Brazilians have a participation of 7%:

- 60% of equipments (engines, avionics, air conditioning systems);
- 34% of the metal structures (wings and carenage);
- 4% of the electrical components (cables, wires and systems) and mechanical systems (brakes, wheels); and
- 2% of the basic components (aluminum, titanium, Kevlar, carbon fibers).

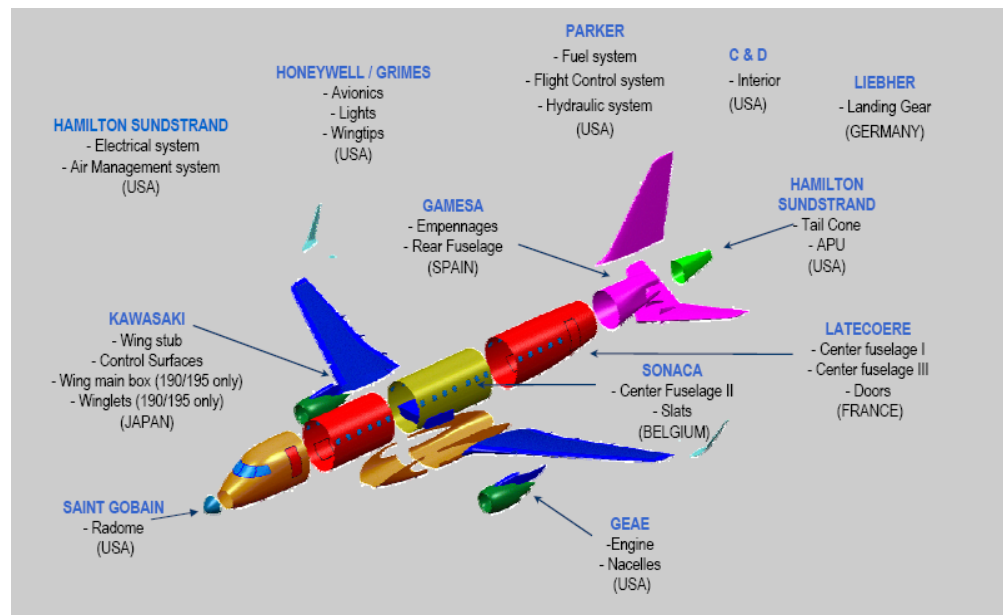


Figure 1. Risk Sharing Partnerships of the ERJ – 170/190 Program

Source: Embraer Company

### 3.2 Product Development Phases at Embraer

The phases are in agreement with Embraer's Product Development System, based upon knowledge and organized on line with its risk sharing partners for the development of the ERJ -170/190 aircraft family. Each of the project phases and the interactions with the risk sharing partners are described below.

#### 3.2.1 Preliminary Studies

At this phase the target market is perceived and defined. For this purpose are set the terms and costs for carrying out the preliminary studies, the business plan as well as definition of macro requisites and the basic design of the aircraft and also the general planning (Bernardes, 2000). Part of this phase is risk analysis in which are foreseen the items that generate an impact on costs and

terms. Basically, studies that analyze the advantage of purchase or manufacture of parts and subsystems are carried out (make-or-buy decision). Therefore, the possible risk sharing partners and suppliers are defined. During this phase, the company needs to evaluate the advantages and disadvantages of making a partnership or joint venture or even keep the manufacture and development activities in house in a verticalized manner.

#### 3.2.2. Contact and Selection of Partners

Through requests for proposals it was possible to establish which partners could qualify to meet the technical and commercial requisites and guarantee the quality standards. The strategy for selection of the international partner companies had, as guideline, three high level prerequisites, to guarantee added value to the program, that

is to say make it meet the issues of a) technical qualification; b) supply and integration of “technological packages” and c) financial and investment structure. In thesis, risk sharing partners acted as first line suppliers, responsible for a significant part of the R&D and for the aggregation of a set of subsystems and components of the aircraft project to be supplied and integrated by Embraer, Oliveira & Bernardes (2002).

The of risk sharing partners of the ERJ- 170/190 family of jets was selected from a group of 85 companies with a potential. In a first selection 58 companies were pre-qualified and later only 16 were chosen from 7 countries located on four continents. For future projects it is hoped that the supplier and partner selection will be even more rigorous, because Embraer is achieving a stronger position to impose conditions on the network participants. Bernardes (2000) reports that for the assessment of the management of suppliers and partners, specific aspects were considered. For this purpose Embraer keeps a program of supplier follow-up supporting its activities. Some of these suppliers already adopted the JIT and Kanban philosophy for replacement of parts to reduce delivery and storage times, optimizing costs.

The capability to manage risks globally is a critical factor to keep alliances healthy. The criterion for choice of partners is one of the ingredients of Embraer’s success. In its nationalization program Embraer hopes to produce 50% of the components in Brazil. In this context, risk sharing partners view Brazil as a strategic place for investment, because of the country’s tradition in this segment and the high level of education and knowledge in the area. Other appeals for investment in the country are low wages, political stability and industrial capability. Some of the risk sharing partners have already invested in Brazil especially in the cluster of São José dos Campos, near Embraer. Among them are noteworthy the Kawasaki Heavy Industries (Japan), C&D Interiors (USA), Sonaca (Belgium) and the Pilkington Optronics (England).

### 3.2.3 Joint Definition Phase

In this phase more than 650 engineers, technicians and Embraer specialists and partners participated without having yet a breakdown of the project. Partnership contracts, that were signed prior to the Joint Definition Phase (JDP), defined the parts of the aircraft that would be manufactured and the investments needed in general terms only, nevertheless in a rigid manner. Outcome of the JDP was the production of complete electronic mock-up system of the aircraft or in other words, the mock up of all the structural, manufacturing, systemic and quality aspects of the project. Figure 1 shows how the multidisciplinary and multicultural teams worked in the development of the ERJ program.

During the JDP, the activities were performed in the Embraer facilities. The performance requirements of each of the aircraft systems were specified as well as the requirements of functional and physical integration of the aircraft components. Partners’ investments were made in development of parts and purchase of equipment.

For integrated and simultaneous product development, using multidisciplinary project teams, Embraer adopted the methodology called Integrated Product Development. As such, the project team was physically organized during JDP in the shape of an airplane – See Figure 1, in the Embraer facilities. The objective was to maximize interaction between the program’s partner teams and allow all professionals to communicate better and understand the dynamics and goals of each group, carrying out activities in parallel and simultaneously. This organization is in agreement with the suggestion by Stalk and Hout (1993) who stressed the importance of a physical layout suited to reduce development time and improve product quality. According to the authors this layout must be flexible and organized by product and the teams responsible for one component must be kept as close together as possible.

Information Technology was mandatory for JDP success. Embraer supplied electronic equipment and exchange of information to make the work of the development team possible. The Virtual Reality Center (VRC) was of fundamental importance for this phase of the project, helping to integrate various aircraft subsystems, in addition to contributing towards customizing of products according to client requirements. Furthermore, simulations that permitted follow-up of the development were made available to future buyers of the aircraft. VRC also contributed to better marketing of the company/product because some of the sales were driven by presentation in virtual reality. Cassiolato (2002) stresses the importance of the VRC for the efficiency of decision making, identification of errors, problems in the design, etc. Embraer is noteworthy for investment in technologies that support the development process. Without Embraer’s core competence in design, product specification and integration of components, JDP would not have been successful.

### 3.2.4 Development

In this phase of the program the detailed design of the airplane is accomplished. Conjoint work at the Embraer plant is concluded and the final definition of the aircraft is made. Engineers and technicians of the partners return to their home countries to finalize the project.

To facilitate communication, the management model adopted by Embraer is organized in a network on line with its risk sharing partners, an imperative fact for the successful development of the aircraft. Prior to the start of the project, few of the partner companies held a



technological capability enabling them to use the powerful software for direct connection in a harmonious and standardized form, in the creation and transmission of industrial design files for aircraft pieces and parts.

Technological advances applied to the program provide for substantial economies of time and for quality in the aircraft development. According to Cassiolato (2000), approximately 18 months were gained. The prime responsible for this reduction of time between finishing of the design and certification is the VCR. It also contributed to a 50% reduction of the time to market by permitting a better evaluation of the aircraft by the certifying authorities. Utilization of an electronic mock-up system, instead of the traditional wood model, further contributed to process efficacy. Some other Information Technologies utilized in the project were the flight simulator, electronic data interchange and the CAD software in 3D - Catia®. This software eliminated the need for slow and expensive prototype constructions, virtually reproducing all functionalities, carrying out simulations and tests and detecting problems that the product might present, thereby minimizing the project risks.

#### 4. CONCLUSIONS

The main objective of this study was to analyze the risk sharing partnerships established by Embraer in the ERJ-170/190 aircraft family project. Some prerequisites and macro-economical conditions which privileged adoption of a policy of risk sharing partnerships were presented. This analysis may be used in various ways, particularly by the academic and entrepreneurial milieu. Scholars of productive systems may better understand the process of development and manufacture of products through risk sharing partnerships and compare the solutions found by Embraer with those of other companies in this industry. The critical factors for success of the risk sharing partnerships of Embraer may also help to resolve if this contractual modality may be used in other industrial or technology sectors or even serve as an example for other aircraft companies.

One of the factors of success was the clear identification of the market needs, especially in regional aviation and in taking over the technological capabilities, having focused its actions on delivering products of high technology at competitive prices for its clients. Today, Embraer is a point of reference of competence and success for emerging high technology companies. The reasons that led the company to take this strategic decision of making risk sharing partnerships are several:

- Concentration of the activities in core competencies;
- Need to reduce development time of its aircraft through shorter R&D cycles;

- Difficulty to find government financing after the company's-privatization;
- Market opportunities achieved by means of having partners in different countries.

As such, with its excellence in design, integration capability and high aircraft technology, Embraer was able to attract partners on the global market who would take a stake in and invest in its projects. As for risk sharing partners, technology transfer by means of participation in the project represented a major advantage. Nevertheless, in the future, these partners may become indirect competitors of Embraer in areas where they acquired know-how.

Risk sharing partnerships emerged as a crucial factor for Embraer's survival in the competitive market where it acts. Survival conditions in the aircraft industry may be tougher if companies are isolated or not very creative and flexible in terms of associations and alliances, or even modernization of its criteria and production methods. Based upon this study, some factors critical for the success of risk sharing partnerships may be identified.

##### 1. Capability for Integration

Physical and simultaneous integration of various multidisciplinary and multicultural teams was decisive in some phases of the project, especially in the Joint Definition Phase. Embraer was able to coordinate the development process and establish a sequence of activities to save project time. Many of these complex development activities were performed in parallel. Usage of modern Information Technology tools such as extranet communication, computer aided design and manufacturing (CAD-CAM), Virtual Reality Center and electronic mock-up were crucial to assure integration of the project teams.

##### 2. Mastering of key technologies

The fact that Embraer was able to establish the project's basic technical prerequisites permitted its autonomy as leader and enabled the choice of eventual partners. Concentration in core competences of design, materials engineering, system integration, project management and supply of technical support to clients ensures independence of the company's decisions and results in a sustainable competitive advantage.

##### 3. Capability as a negotiator

The company was successful in making partnership contracts beneficial for both parties, in terms of participation in the projects, investments, budgets for the activities of each partner, clauses related to terms to be met, quality and adjustment requirements to the technical

specifications, and assignment of responsibilities in case of failures in design or manufacture.

#### 4. Post-sale partnership services

Embraer's partners also participate in client services, in the supply of replacement parts and services and even in training offered to clients. In a verticalized production process, this type of activity may be offered only by the manufacturer, however in a shared design and manufacture process it is important that partner companies be available, as they master specific technologies that the manufacturer does not.

For Embraer the most significant learning during the ERJ-145 project was management of contracts between companies, not advantages related to technologies it did not have. Another thing learned was how to achieve cost reduction of the subcontracted production processes. With the deverticalization process of production and balancing of its production plants, Embraer created conditions to reduce the price of its products. The strategy that oriented the partnership program definitely is focused on costs and financial engineering.

All this learning process led to an even more intense focus on the ERJ-170/190 program. Strategic partnerships were more integrated and complex. The project was carried out in co-design with partner companies. Another significant aspect that must be taken into account, the technical requisites of the new partners were determined prior to beginning of the aircraft project, something that did not happen with the ERJ-145 project. Partnerships were made with large multinational companies, which made the aggregation of markets and distribution of development costs easier, thereby minimizing capital investments, enabling acquisition of business know-how and commercial and logistics infrastructure. To summarize, the major acquisitions in knowledge were:

- Development process integrated with information systems and networks interconnecting clients, suppliers and partners;
- Ability to integrate project teams from various countries in a shared physical environment and later, in a separate environment;
- Faster development of complex products, with shorter cycles;
- Experience in the offering of post-sales services together with other partners;
- Ability to negotiate strategic partnership contracts with other companies in the market;
- Integration and products sales and services on global level, increasing the opportunity to internationalize business/markets.

Examples of recent and punctual risk sharing partnerships that were signed by other aircraft companies substantiate Embraer's position as a front line company in the local and international market. This type of contractual modality is a relatively new trend in the aircraft industry, which began to be part of projects, mainly after the mid 1990s. It was precisely during this time period that the company began to develop the ERJ-145 family and carried out the changes in its production system and in R&D that included the constitution of partnerships. Some companies of the sector such as Boeing are more conservative and resist adoption of partnerships in these same way as Embraer; however, considering its current success, it seems that they will become standard in the future.

An interesting subject for analysis, which may serve for future studies, is the comparison of two distinct, seemingly opposing tendencies: a) that of concentration of companies through mergers; b) cooperation between companies through risk sharing partnerships. During the Cold War, the great impact of government actions kept the aircraft sector in an artificial situation, with too many companies in activity. With the end of this policy, the sector became globalized and showed a tendency for concentration. The reduced number of large commercial aircraft manufacturing companies in the international market seems to signal that the process of mergers and acquisitions like that of Airbus in 2001 has reached a stabilizing stage and that the companies now have begun to follow a strategy of verticalization and cooperation.

Another research possibility would be to assess the cost/benefit of using risk sharing partnerships in other industrial and technological sectors. Besides assessing if these companies meet the critical factors previously cited, such analysis should also consider aspects such as scale, regional influences, investments, project complexity, macro-economical and political contexts, as well as the level of dependence on the partners.

It is questionable if the model adopted by Embraer can serve as benchmark and inspiration for other Brazilian companies. The company distinguishes itself by a strategic and innovative insight and by its system of developing personnel. With regard to the latter, in the building of its technological capabilities, excellence of human resources has been one of the decisive factors. Brazilian companies wishing to follow Embraer's model will have to invest in these managerial systems. The making of risk sharing partnerships demands a whole set of managerial abilities. Should the companies lack them, they might be better off seeking foreign partners for the signing of joint-ventures. On the other hand, complexity of the projects is another important factor. It may not be interesting to establish partnerships in industries with low or medium complexity products, where there are not high risks involved and the projects do not require high investments.

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