"Strategic Methodology for the creation and administration of a Collaborative Network of SMEs for the Aerospace Industry in México"

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TO GOD
For filling my entire life with blessings, giving me the strength in times of weakness and the necessary humbleness in times of joy.

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Executive Summary

The Aerospace Industry represents almost US $500bn around the world and for some countries like the U.S., more than 15% of their economy is related to this Industry. Mexico is trying to become a new player, despite supplying just US $600m to the U.S.-based Industry, it has been showing several signs of growth and consolidation. Mexico supply just 0.9% of U.S. aerospace imports. Mexico needs to innovate its traditional way of doing business if it wants to succeed in the Aerospace Industry. Mexico needs to become highly competitive in a market in which we are incumbents and in which our traditional core competencies (cheap labor, closeness to the U.S. and strategic position in the global economy) are not that great differentiators. The Mexican Federal Government has defined the Aerospace Industry as one of the key strategic sectors for Mexico in the 21st century, but the HOW of this has not been approached by anyone yet. This opportunity for the Mexican economy cannot be overlooked. Therefore an entity in charge of looking for the overall good of the Industry needs to be proposed and implemented.

Collaborative Networks (CN) can be the solution to the issues presented to the Mexican Aerospace Industry. The development of such Collaborative Networks that includes Mexican Small and Medium Sized Enterprises (SMEs) will improve the overall competitiveness of the Industry, ultimately creating a world-class aerospace cluster in Mexico. The author proposed an Aerospace Industry Collaborative Network (AICON) as an innovative business concept that works with the objective of developing and improving the performance of the Aerospace Supplier Cluster in Mexico.

The AICON concept proposed includes the creation of a nation-wide Aerospace Virtual Cluster formed by a set of several regional or OEM-driven sub-networks or clusters. A set of particular functions done as a network for the companies and overall well is proposed. This set of functions include tools to improve the sourcing process, logistic aspects, competence creation and many others that are particularly needed in the Aerospace competitive environment. Besides these particular functionality designed specifically for the Mexican Aerospace Industry, an evaluation of a group of functions proposed by ECOLEAD through its Collaborative Network Reference Model (ARCON) is evaluated and prioritized to ensure the general correct implementation of any given CN.

In order to validate some of the special functionality designed for the Aerospace Industry, a Case Study was done with an Aerospace OEM and its network of suppliers in order to create one of the OEM-driven sub-networks proposed in this Thesis. This sub-networks is the basis of the future creation of the nation-wide AICON.
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Chapter 1. Introduction

1.1 Background

With the rise of Capitalism as the world’s leading economic policy, international competition and globalization had become one of the most important issues for companies around the world. Companies are selling products overseas, buying raw materials from developing countries and integrating suppliers around the world more than ever. The importance of globalization is breathtaking: there are a whole range of activities that can only be understood in global terms, from finance capital and corporate behavior to cultural, environmental, and labor practices.

Aerospace Industry

According to the US Department of Commerce (2007), aerospace imports from Mexico to the U.S. have risen from US $77m in 1997 to over US $600m in 2006. Mexico is now the U.S’s 10th supplier after being the 17th not too long ago. With over 130 aerospace related companies employing 12,000+ people in 11 States, the Mexican Aerospace Industry is gaining momentum and world reconnaissance. These figures are expected to increase fourfold with exports forecast in the region of US $2bn by 2010. In order to understand the importance of this Industry for the Mexican economy of the following years, we should revise the case of the U.S. economy, according to the Commission on the Future of the U.S. Aerospace Industry (2002), the aerospace industry accounts for about 15% of the U.S. GDP, summing US $170bn in sales during 2005. With more than US $49bn in positive trade balance with the rest of the world, the Aerospace Industry is one of the major bets of North America for keeping the pace with the rest of the world. Furthermore, there is still much room for growth, the global market is expected to grow more than 6% annually for the next years according to the World Aerospace Database (2006) and the strength of the U.S. based companies is now better than ever.

There are currently more than 130 aerospace related companies operating in Mexico with main clusters located in the northern States of Sonora, Baja California, Nuevo Leon, Chihuahua, and in the central State of Queretaro. As an emerging player that it is, the Mexican Aerospace Industry has had different approaches for developing. United Technologies, Honeywell, GE Aircraft Engines, Textron and Snecma all have International Procurement Offices in Mexico (Responsible for developing suppliers in Latin America). Some other companies like Bombardier, Goodrich, National Aviation, Lockheed Martin and Smith West have set manufacturing facilities. And a
third smaller group of Mexican companies is migrating from its core business model (mostly automotive) to serve the Aerospace Industry as a 2nd or 3rd Tier suppliers.

As it happens in other Industries, Mexican Aerospace Industry (AI) has been competing in low manufacturing cost and closeness to the U.S. market. But because the volumes that are moved in the Industry are so low, more competitiveness is needed besides labor savings. Some of the reasons that have been slowing down its growth are lead time, logistic costs and lack of economy of scale’s advantages. The experience and success in the development of the automotive, metal-mechanical and electrical-electronic sectors should help in the development and integration of Mexican Aerospace Suppliers to this Industry.

**Supply Chain Integration**

Globalization and intensive international commerce have forced technological improvements in different industry sectors in order to keep their competitiveness with the increasing pressure from emerging players in the rest of the world. Initially those improvements were focused on the implementation of lean production, quality systems and other techniques that became popular, now companies need more than that. In the other hand, strategic planning, collaborative networking and scheduling of logistic operations are important supply chain practices that can do a great improvement (Chopra and Meindl, 2001).

As stated by Lambert and Cooper (2000) “The supply chain looks less like a pipeline or chain than an uprooted tree”, the complex relationships involved have lead to the realization that “Successful SCM requires a change from managing individual functions to integrating activities into key supply chain processes”. Globalization has been creating global supply chains around the world, and the performance of the individuals rests more in its supply chain partners then ever before (Skjott-Larsen, 2006).

The improvements achieved by large companies like Wal-Mart, Dell, Zara among others it is well documented and proved when applying supply chain management practices. Those companies have saved millions of dollars in costs and decreased inventories by integrating the SCM concept in their business strategy. The potential benefits of SCM include product and delivery process quality such as shorter delivery times, more reliable delivery promises, fewer schedule disruptions, cost savings and risk reductions (Christopher, 1998; Busk and Juga, 2001). When trying to implement SC practices in the Small and Medium-sized Enterprise (SME) to spread those benefits, a question always pops up; Can Supply Chain Management work for the small

The growth of small businesses and their importance on the entire economy is becoming clear according to Chapman and Etkin (2000). Whether the SME is intrinsically integrated in a broader supply chain or if it is leading its own when competing against larger companies, it should deal with logistic inefficiency that affects its competitiveness (Lewis, 2005). If the SME wants to get involved in a broader chain, traditional SCM could be a way of obtaining some vertical integration benefits without its formal ownership costs (Arend and Wisner, 2003). If SMEs want to partner in strategic alliances to scale-up their competences, they have different options to do so. The concept of horizontal integration through collaborative networks (even among rival firms) stands out as one of the best ways to form alliances. And in the mid-term it can even be the foundation of an industrial cluster with all the competitive advantages that this could represent (Porter, 1992).

**Aerospace Industry Supply Chain Integration through Virtual Collaboration Networks**

Given the huge business opportunity that the Aerospace Industry represents for Small and Medium Sized Enterprises already working in analog industries, an easy approach for them to integrate to Aerospace Industry Supply Chains is urgently needed.

The concept of virtual collaboration could be an interesting approach for the SME when trying to integrate to the Aerospace Industry. Some special conditions of this Industry make it even more attractive, for example the low volume and high variability of parts combined with the great amount of different processes required. With collaborative networked organizations, legally independent SMEs could join temporarily to form virtual organizations to satisfy this aerospace products demand. Now it is difficult for one single company to incorporate many of the process alone. That is why Aerospace Industry Original Equipment Manufacturers (OEMs) establish procurement offices to outsource their processes.

Some research has been done in the development of Collaborative Networked Organizations (CNOs) by the European Collaboration Networked Organizations Leadership Initiative (ECOLEAD). They have settled the theoretical fundamentals for the creation of collaborative networks seeking competitiveness, world-excellence and agility in turbulent market conditions. Some of the concepts proposed by ECOLEAD and other authors focusing on the Supply Chain Integration of the SME are a very attractive option for the Aerospace Industry in Mexico.
The Aerospace Industry Supply Chain Integration process in Mexico has been slowed down for different reasons. Companies are struggling when looking for suppliers in Mexico; logistic costs and lead time are slowing the development of new ones, economies of scale’s advantages are not available for existing suppliers due to aerospace industry main characteristics (parts’ low volume and high mixture). Lack of information about aerospace industry special requirements and certifications is another big barrier for the development of this industry for Mexico.

Mexico’s economy needs the catalytic energy that the Aerospace Industry can provide to it. There are few historic opportunities a country can face in order to change the curse of its economic faith. Mexico is now facing one of these opportunities and needs the knowledge base to take the most advantage from it possible. The aerospace Industry can increase the average income of the population and the development of the SMEs around it can balance the distribution of wealth in the country.
1.2 Problem Statement

1. What has been done so far in the literature in the areas of Supply Chain Management and Collaborative Networks for Small and Medium-Sized Enterprises and for Cluster Development?

2. In which way should an Aerospace Industry Collaborative Network in Mexico be implemented in order to increase the amount of SMEs willing to collaborate?

3. Which characteristics should an Aerospace Industry Collaborative Network in Mexico have in order to guarantee its success among SMEs and the effectiveness needed to tackle the most important issues the Industry faces?

It is important to first understand what has been done in the literature in the topics of Supply Chain Integration for SMEs, in the Aerospace Industry and in the process of creating different kind of Clusters. This previous research should be able to validate the necessity to use Collaborative Networks to integrate Mexican SMEs to this Industry. After this decision we should answer the questions of How, Who and What needs to be proposed to implement this integration process. In Figure 1.2 we can appreciate graphically the linkage needed between the Aerospace Industry and the Mexican SMEs that needs to be defined.
1.3 Justification

This research should explain the positive relationship that the implementation of a (virtual) collaboration network can have in the supply chain integration process for SMEs that are supplying or are interested in becoming suppliers for the Aerospace Industry’s main programs (See Appendix A). Even if we could integrate the SMEs into some sort of networked organization, the network creation and companies’ integration processes should be studied carefully. SMEs in Mexico have to deal with difficult situations everyday, leaving them without the opportunity to do some strategic planning. If a collaborative network could lead the efforts of developing strategic competences, promotion and improve the competitiveness of it and its members, it would eventually become a world class industrial cluster.

Promoting cluster formation, especially those based upon technological innovation like the Aerospace one, is increasingly viewed as the new basis for competitive advantage and economic development of countries in a global economy. The understanding of the factors that motivate cluster formation as well as amplify the regional economic impact of cluster economies will certainly continue to be a public as well as academic priority for regions and governments.

By setting the basis for the use of a virtual collaborative network in the creation of aerospace industry clusters, the eventual members of this network will benefit and improve its overall efficiency. Some very specific issues that Mexican Aerospace suppliers are facing now and that put a break in the development of the Industry in Mexico are the following:

1. Lack of information about the competences and capabilities of other industry members
2. Lack of information about the processes needed for different families of parts in the aerospace industry
3. Lack of coordination in the purchasing process
4. Lack of digital information about parts and families of parts
5. Lack of collaboration between different companies working in the industry
6. Long Lead Times
7. High Logistic Costs
8. Lack of economies of scale’s advantages
9. Lack of key competences
10. Lack of 3rd and nth tier suppliers

By addressing these opportunities, we improve the process of integration of the industry in to successfully developed and efficient Aerospace Clusters.
1.4 Objectives

General Objective
Design of a Strategic Collaborative Network for the Mexican Aerospace Industry that serves as the cornerstone for a successful world-class Aerospace Cluster.

Specific Objectives
- Do a comprehensive review of different aspects that affect the behavior of SMEs when integrating into global supply chains and about the Aerospace Industry with its special characteristics
- Design of a simplified generic methodology to implement a Collaborative Network (CN) for the Aerospace Industry in a sequential order that prioritizes functions and resources.
- Select, evaluate and develop some of the different functionality to be included in the CN specially the ones required in the first stages
- Partially implement the methodology proposed through a case study with an aerospace OEM’s Supply Chain or through literature review and analysis.

1.5 Research Questions
1. How integrated is the aerospace industry supply chain?
2. What kind of models exists today in order to evaluate Cluster’s potential growth?
3. What kinds of collaboration models exist today? And what are CN?
4. What functionality needs to be implemented in CN?
5. What special functions are required by an Aerospace Industry CN, differing from traditional CNs?
6. What frameworks exist trying to define CN? And what would an Aerospace one need?

1.6 Research Scope and Limitation
The research is done as the result of the interest of the ECOLEAD Project, the Monterrey Tech’s Center for Aerospace Productivity (CAP Aeroespacial) and an Aerospace Original Equipment Manufacturer (OEM) in developing the Aerospace Industry in Mexico. The author will develop a methodology and framework for creating a useful CN for the Aerospace Industry. The CN is mainly composed Mexican SMEs that have been migrating from other metal-mechanical core business to some aerospace related ones. The necessary functionality will be developed. The complete implementation of the proposed CN is not within the reach of this work.
1.7 Structure of the Thesis

The graphic representation of the Thesis can be seen in Figure 1.3. A complete introduction to the Problem including the background from which the research was done is presented in Chapter 1. The objectives of the research are presented and their justification to validate the necessity to help the Aerospace Industry in Mexico to develop.

A very comprehensive review of the literature is presented in Chapter 2. It includes the 3 basic concepts that are the foundation for this research: The Aerospace Industry, Small and Medium Enterprises (SMEs) and Collaborative Networks (CN). After reviewing the Literature, a valid Hypothesis is presented in order to be analyzed in the following chapters.

In Chapter 3 it is presented a complete explanation of the Method that the Author used to analyze the problematic of the Aerospace Industry and translate these problems into concrete solutions for what the author proposes as an Aerospace Industry Collaborative Network.

This methodology includes the creation of an Aerospace Cluster Framework that is presented in detail in Chapter 4. This Framework is based on the ARCON (ECOLEAD, 2006a) reference model. And includes everything from the conceptual definition of the Aerospace Collaborative Network to the detailed explanation of the functionality the Network should be able to address in order to be really meaningful for its members.

Some of this functionality was actually implemented in some of the members of this first instance of the Network. Chapter 5 covers this results and documents them in such a way that can be further replicated for the rest of the potential members.

Finally in Chapter 6 there are presented some general conclusions and recommendations for the Academia and also for the members of the Aerospace Industry that are interested in this work.
Chapter 2. Literature Review

2.1 Introduction

In the last decade, the Economy of Mexico has been showing an important macroeconomic strength. Inflation rates, currency value, interest rates and international reserves have been controlled and in world-class ranges. Despite the fact of this “relative” stability, the growth of the country has been modest and our position in the global game board has been decreasing due to higher growth rates of other developing countries like China, Brazil, Argentina, Korea, Russia and India. Not only our overall place in the world has been decreasing, but the small growth we have had is not helping to improve the real situation of the people in the country.

2.2 SMEs, Aerospace Industry and Collaborative Networks

The economic polarization of Mexico is now bigger than ever before, our Mexican list of billionaires increased, we have now the richest man in the world, the 10 richest percent of population earns almost 40% of the GDP and some important country assets like financial services are foreign-owned. Just a bunch of large global Mexican companies have been growing abroad. These rich people and these few large companies have been the biggest earners of this period of stability and of modest economic growth. Large companies are important for a country to be competitive worldwide, but in order to translate the benefits of globalization to the vast majority of the population, the development of the overall efficiency of the Small and Medium-Sized Enterprises (SMEs) is vital for innumerable reasons.

SMEs are not important just for their capacity of creating employment, but for their key strategic role in creating and increasing the competitiveness of clusters. In “The Competitive Advantage of Nations”, Michael Porter (1990) proposes the hypothesis that nations gain significant competitive and economic advantage where concentrations of firms (clusters) exist in home markets of similar or related industries. Cluster location relationships help produce beneficial advantages such as knowledge spillover, ease of access to skilled labor, better acquisition and assembly of the inputs of production, and competitive pressures to innovate and increase productivity.

---

Table 2.1 Countries by GDP (2006)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>GDP (PPP) M US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>13,020,861</td>
</tr>
<tr>
<td>2</td>
<td>People’s Republic of China</td>
<td>9,984,0621</td>
</tr>
<tr>
<td>3</td>
<td>Japan</td>
<td>4,170,533</td>
</tr>
<tr>
<td>4</td>
<td>India</td>
<td>4,158,922</td>
</tr>
<tr>
<td>5</td>
<td>Germany</td>
<td>2,558,908</td>
</tr>
<tr>
<td>6</td>
<td>United Kingdom</td>
<td>2,121,766</td>
</tr>
<tr>
<td>7</td>
<td>France</td>
<td>1,934,677</td>
</tr>
<tr>
<td>8</td>
<td>Italy</td>
<td>1,790,895</td>
</tr>
<tr>
<td>9</td>
<td>Russia</td>
<td>1,727,349</td>
</tr>
<tr>
<td>10</td>
<td>Brazil</td>
<td>1,701,183</td>
</tr>
<tr>
<td>11</td>
<td>Spain</td>
<td>1,214,930</td>
</tr>
<tr>
<td>12</td>
<td>Mexico</td>
<td>1,171,506</td>
</tr>
<tr>
<td>13</td>
<td>Canada</td>
<td>1,156,463</td>
</tr>
<tr>
<td>14</td>
<td>South Korea</td>
<td>1,155,565</td>
</tr>
<tr>
<td>15</td>
<td>Indonesia</td>
<td>959,834</td>
</tr>
</tbody>
</table>

--- World | 66,228,669

PPP: Purchasing Power Parity
Mexico needs to define a new overall strategy for the country’s economy for the next decades. In the rest of the world, governments have become increasingly involved in motivating regional cluster development as a means of economic development. About 20 years ago we unconsciously turned into manufacturing facilities (Maquiladoras) as an alternative to create employment and diversify the country’s economy. The relative success of the “Maquila” Industry put the country into a sleepy state, in which we were comfortable with that situation, and didn’t realize on time that we should have been looking forward to the next step. Traditional “Maquila” Industry is not able to add much value and most of the jobs created are low-wage, low-education jobs. These jobs are not enough for a country that should be aspiring to become first world. Mexico should not wait to see what happens, private sectors and governments should enable cluster development by concentrating on providing an educated skilled workforce and physical infrastructure.

In his book “The Next Global Stage”, Kenichi Ohmae (2005) explains 3 different scenarios in which Countries or Regions have been successful in redefining their overall strategy. In his book he mentioned the Chinese region of Dalian, Finland and Ireland. For centuries Ireland was a 3rd world country within Europe, they missed the industrialization of England, their people were forced into migration as a way to overcome their sad economic and social situation, even their geographic situation was out of the traditional commerce routes and knowledge flow. Everything changed in the 90’s when the potential role of Ireland in the new Information Technologies (IT) world pop-up. They reoriented the scope of the country and defined a new vision of country as a neuralgic e-HUB of Europe and through education developed new visionary sectors like medical equipment, biotechnologies and health care systems. Ireland now has the world’s largest Gross Domestic Product (GDP) per capita after Luxembourg according to the International Monetary Fund (IMF) and the 4th best Human Development Index (HDI) according to the United Nations Development Programme’s Human Development Report (2006). Ireland redirected their country’s curse within years, now is the time for Mexico to do so. The Aerospace Industry is one of the alternatives that are presented to us as value-added industrial sectors that can close these development and economical gaps of the country.

Nowadays, companies and countries need to innovate in order to be competitive in this changing and demanding new global marketplace. SMEs are not the exception and need to innovate in their products and services, in their processes and business models, even in their external relationships. The world has been watching the creation and growth of complex, international
and interrelated Supply Chains, every company should find the best to integrate to this global Supply Chains like the one of the Aerospace Industry. There has been some work lately in the development of models for collaboration networks to function properly. We propose such Collaborative Networked Organizations (CNOs) as the mean to integrate Mexican SMEs into global Supply Chains.

These 3 concepts: SMEs, Aerospace Industry and CNOs are very strategic concepts in order to create or to develop a new economic model for Mexico. The author understands that importance and bases this literature review in the correct integration of this concepts and the proposal of a plan to use this interesting relationships to improve real situations. In Figure 2.1, these 3 concepts are presented in a broader frame called Mexico. As proposed in the model, each of these 3 concepts turns to look the others because they need each other and because they are tightly interrelated through 3 main and well-studied terms.

**Figure 2.1 Literature Review**

**Aerospace Industry - SMEs:**
- The Aerospace Industry looks for Mexican SMEs because it needs to find competitive, low cost new suppliers.
- Mexican SMEs are interested in the Aerospace Industry as a key strategic decision to diversify their markets and as the opportunity to learn the quality and competitiveness that are characteristic of this Industry.
- A well studied concept that explains the quest of established industries to find for suppliers abroad is Outsourcing.

**Aerospace Industry - CNOs:**

- The Aerospace Industry is interested in CNOs because it needs to improve competitiveness in the global marketplace, and Collaborative Networks provide the workframe to do so by integrating its Supply Chains.
- CNOs are interested in the Aerospace Industry because it is a relatively new discipline and a Low Volume, High Mix of products Industry like the Aerospace one is a very good validation model to do so.
- By creating Collaborative Networks of Aerospace Industry suppliers, different regions will be favored by the creation of stable and recognized aerospace clusters.

**CNOs - SMEs:**

- Mexican SMEs are aware of the necessity of integrating to global Supply Chains, they simply just don't know an easy way to do it. The model of Collaborative Networked Organizations (CNOs) gives the Mexican SMEs a very easy, effective and affordable way to integrate, advantaging from economies of scale and turning them into even more competitive organizations.
- CNOs receive the advantage of working with SMEs because they are their basic building block, and by understanding it better through this Thesis, CNOs will be able to improve itself and be more flexible and more capable of dealing with the special situation of SMEs in the real life.
- Among the several advantages that CNOs can provide to the Mexican SMEs, one of them is the ability to create and understand new competences. Creation of individual competences is not always easy for organizations in the 3rd world in which financial services are limited to large corporations, and any investment for an SME implies the necessity of dealing with really costly loans by small bankers or informal means. With CNOs, SMEs may find a way to create new competences in a more cost-efficient way.

We are aware now of the close relationships these 3 main concepts have with each other. We know that they need each other to be developed in Mexico and that by being understood together, they can provide an important basis for the establishment of value-added industry in Mexico. These 3 concepts will be now explained in more detail.
2.2.1 Small and Medium-Sized Enterprises (SMEs) in Mexico

Also referred as Small and Medium Businesses (SMBs) are companies whose headcount falls below certain limits. The actual classification limit numbers vary from country to country and among different business sectors. The Mexican government defined business size's categories presented in Table 2.1 according to their publication in the Country's Official Newspaper (Diario Oficial de la Federación, 2003).

<table>
<thead>
<tr>
<th>Business Size</th>
<th>Industrial</th>
<th>Commerce</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro Business</td>
<td>0 - 10</td>
<td>0 - 10</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Small Business</td>
<td>11 - 50</td>
<td>11 - 50</td>
<td>11 - 50</td>
</tr>
<tr>
<td>Medium Business</td>
<td>51 - 250</td>
<td>31 - 100</td>
<td>51 - 100</td>
</tr>
<tr>
<td>Large Business</td>
<td>&gt; 250</td>
<td>&gt; 100</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

According to the Mexican National Institute of Informatics and Geographic Statistics (INEGI, 2004) the distribution of the constituted 2,844 K businesses in Mexico is in the way presented in Table 2.3.

<table>
<thead>
<tr>
<th>Business Size</th>
<th>Employees</th>
<th>Annual Sales</th>
<th>% of Total</th>
<th>Total amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro Business</td>
<td>0 - 10</td>
<td>&lt; 90K US $</td>
<td>95.7 %</td>
<td>2,722 K</td>
</tr>
<tr>
<td>Small Business</td>
<td>11 - 50</td>
<td>&lt; 900K US $</td>
<td>3.1 %</td>
<td>88 K</td>
</tr>
<tr>
<td>Medium Business</td>
<td>51 - 250</td>
<td>&lt; 2,000K US $</td>
<td>0.9 %</td>
<td>26 K</td>
</tr>
<tr>
<td>Large Business</td>
<td>&gt; 250</td>
<td>&gt; 2,000K US $</td>
<td>0.3 %</td>
<td>8 K</td>
</tr>
</tbody>
</table>

As stated in Table 2.3, most of the Mexican companies fit in the SME category. All of these companies share some common characteristics. They all have limited capital and are generally family-owned businesses. Owners are often in charge of dealing with all the situations presented because they lack of systematic management processes, human resources and technological solutions. Characteristics of SMEs in Mexico (Mendez, 1996):

- Capital comes from 1 or 2 persons involved in a Society
- Owners are the ones running the company in an empirical way
- They can use machinery and labor, but are based on labor rather than capital
- All SMEs aspire on becoming bigger
- In some cases can be considered as minor contributors by fiscal small-regimen laws.
Just 35% of Mexican SMEs has some way to feel their customers’ level of satisfaction and Desired Customer Outcomes (DCOs) (CiPi, 2004). 86% of them don’t know federal, state or municipal support programs and just 1.8% of them has used those programs.

**SMEs Importance**

Nowadays, developed countries recognize the importance of their SMEs in their production structure, in their ability to create employment and wealth and in the leading role SMEs need to take in order to promote the development of inner cities in rural areas (Porter, 1995). Porter says that Government must shift its focus from direct involvement and intervention to creating a favorable environment for entrepreneurs and small businesses to grow and develop. The businesspeople and entrepreneurs must lead the economic and social revival of small communities. This responsibility is not of social activists, social service providers not even government bureaucrats; these people must support the first ones only. SMEs contribution to the employment of countries is so important because their ability to adapt to new market situations, their flexibility to evolve makes them preserve their human resources. This participation is very important in the creation of added value (Montoya, 2004).

The development of small companies is important not just for economical issues; the role of these minor players is also of great importance because of its impact in the closure of the gap between different social and economical classes around the world (Chapman and Ettkin, 2000).

**2.2.2 Aerospace Industry**

The Aerospace Industry is often referred as the industrial sector engaged in the research, development, and manufacture of flight vehicles, including unpowered gliders and sailplanes (see gliding), lighter-than-air craft (see balloon and airship), heavier-than-air craft (both fixed-wing and rotary-wing; see airplane and military aircraft), missiles (see rocket and missile system), space launch vehicles, and spacecraft (manned and unmanned). Also included among its concerns are major flight-vehicle subsystems such as propulsion and avionics (aviation electronics) and key support systems necessary for the testing, operation, and maintenance of flight vehicles.

*Figure 2.2 Boeing 747 under construction at Washington*
The importance of the Aerospace Industry for the governments of developed countries is so big, that for most of them there are special official policies and laws that give the industry special considerations. The reason behind these special considerations is the amazing economic and social contribution to overall countries’ economies. In the case of the U.S. economy, the aerospace industry accounts for about 15% of the GDP, summing $170 billion in sales during 2005, and about 9.2% up from last year’s (Aerospace commissioners, 2002). Another reason that makes Aerospace Industry to be one of the most powerful industries in the United States, is that the worldwide group of manufacturers who supply a variety of products give the country a great sociopolitical power and influence in most of these countries. It doesn't matter if Venezuela is challenging the U.S. power and trying to be more independent of it, when it comes to aircraft matters, it will have to bend over, swallow its pride, and buy some helicopters from U.S. firms to be able to fight local insurrections or criminals. As stated by the Commission on the Future of the United States Aerospace Industry (2002), “Aerospace will be the core of America’s leadership and strength in the 21st century, this Industry opened up new frontiers to the world, such as freedom of flight and access to space”.

The leadership of the United States is in risk now, as global players are getting more competitive and developing regional high-tech Supply Chains, now the key issues is not merely about producing the aircrafts needed, but about Regional Security, Economic Growth, Quality of Life and Scientific Achievement.

Aerospace Industry Today
Aerospace Industry today is faced with a multitude of engineering, commercial, political, and economical challenges. The global scope of the industry has changed so much in the last century. To understand today’s industry we have to look at a complex global picture including small and big companies in many countries consumers in every country of the world. Another way to picture the magnificence of the aerospace industry is to understand the market sizes, as explained in Figure 2.3
For the purpose of this Thesis, the author refers as the aerospace industry to the commercial and military aircraft programs (See Appendix A for a complete list of aircraft programs). In Figure 2.4 we can appreciate a better picture of the aircraft Supply Chain including related industries, in which the 1st Tier Suppliers of these programs are categorized in 7 different core supplying industries:

- Structural Mechanical components
- Computer, Electronic and Electrical Systems
- Materials, chemicals and hardware manufacturers
- Tools, test equipment
- Interior equipment and furnishing
- Insurance
- Leasing, finance and sales
In the last decades commercial aircrafts market has suffered several changes. The former tough competition in the large planes segment by Lockheed and Douglas ceased, and after the acquisition of Douglas in 1996 by Boeing, the battle has turned into a face-to-face dispute between US-based giant BOEING and EU-based giant AIRBUS. The former broad market dominance by Boeing, finally overturned in 2001 after AIRBUS received more new orders than Boeing, reaching a 52% market size, but just to be regained in 2006 again by Boeing. Some important players that have been gaining power over the last years are Canadian-based BOMBARDIER and Brazilian-based EMBRAER, whose target market has always been smaller jets, and with the emergence of new regional airlines around the world, they have been gaining new markets formerly disregarded by Industry leaders.

Aerospace Industry Tomorrow

As stated by the Commission for the Future of the Aerospace Industry (2002), America envision a future in which anywhere, anytime mobility will enable dramatic improvements in the
productivity of U.S. companies, military capabilities and the lives of the citizens. Because of the natural advantages of aviation (Fast, security, reliability), the whole industry should rely on this to provide a better service for passengers, air-freight users, military and private jet users. The greatest issues the U.S. Aviation industry faces are:

- Lack of coordinated government policies and integrated actions
- International issues, including world governments supporting competitors
- Diminishing of the U.S. influence in the definition of global aviation standards
- The recent year financial crisis of Airlines
- The dramatic decline of the U.S. workforce
- The need of a new air-transportation and air-traffic systems

Another important key driver for the future of the industry is to understand where the Airlines are going, and by understanding this you can anticipate the effects in the whole industry. The expected growth of the traffic flights is greater in developing regions, particularly in the Far East, as can be seen in Table 2.4.

<table>
<thead>
<tr>
<th>Top Passenger Regions</th>
<th>AAGR</th>
<th>Top Freight Regions</th>
<th>AAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within Asia-Pacific</td>
<td>6.8%</td>
<td>Middle East – Asia-Pacific</td>
<td>8.8%</td>
</tr>
<tr>
<td>Middle East – Asia-Pacific</td>
<td>6.7%</td>
<td>Within Asia-Pacific</td>
<td>8.5%</td>
</tr>
<tr>
<td>Europe – Middle East</td>
<td>6.6%</td>
<td>Trans Pacific</td>
<td>6.0%</td>
</tr>
<tr>
<td>Europe – Asia-Pacific</td>
<td>5.9%</td>
<td>Europe – Asia-Pacific</td>
<td>5.7%</td>
</tr>
<tr>
<td>Trans Pacific</td>
<td>5.8%</td>
<td>Europe – Middle East</td>
<td>5.1%</td>
</tr>
<tr>
<td>Europe – Africa</td>
<td>5.7%</td>
<td>Within Latin America</td>
<td>5.0%</td>
</tr>
<tr>
<td>North Atlantic</td>
<td>5.3%</td>
<td>North Atlantic</td>
<td>4.6%</td>
</tr>
<tr>
<td>Within Europe</td>
<td>5.1%</td>
<td>Europe – Africa</td>
<td>4.5%</td>
</tr>
<tr>
<td>North America – Latin America</td>
<td>4.6%</td>
<td>Within Europe</td>
<td>4.1%</td>
</tr>
<tr>
<td>Within Latin America</td>
<td>4.2%</td>
<td>North America – Latin America</td>
<td>3.7%</td>
</tr>
<tr>
<td>Total Intl.</td>
<td>5.6%</td>
<td>Total Intl.</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

AAGR: Annual Average Growth Rate

This international growth has been forcing leading competitors to focus in very expensive projects that will differentiate them, for example the Airbus A 380 and the Boeing 787 who target completely different markets. The development of these new Aircraft Programs has been characterized by the increased percentage of parts outsourced by assemblers, the Supply Chain integration challenge for broad groups of suppliers in most of the world and the increased use of Information Technologies (IT) in the administration and tune-up of their Supply Chains.
2.2.3 Collaborative Networks and the European Collaborative Networked Organisations Leadership Initiative (ECOLEAD)

For academic purposes, the author will consider the Collaborative Networks model and framework proposed by the European Collaborative Networked Organisations Leadership Initiative (ECOLEAD) as an important information reference for the Supply Chain integration process of the Mexican Aerospace Industry. ECOLEAD is an "Integrated Project" co-funded by the European Commission of which Monterrey Tech is part of the academic consortium. It started in April 2004 and is a 4-year project involving 20 partners from 14 countries across Europe and Latin America.

ECOLEAD VISION

"In ten years, in response to fast changing market conditions, most enterprises and specially the SMEs will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations"

ECOLEAD OBJECTIVE

European Collaborative networked Organisations LEADership initiative, ECOLEAD, aims to create strong foundations and mechanisms needed to establish the most advanced collaborative and network-based industry society in Europe."In ten years most enterprises will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations in response to fast changing market conditions.

The fundamental assumption in ECOLEAD is that a substantial impact in materializing networked collaborative business ecosystems requires holistic approach. Area's complexity and the multiple inter-dependencies among the involved business entities, social actors, and technologies, substantial breakthroughs cannot be achieved with incremental innovation in isolated areas. On the other hand, project plans must remain manageable. Thus ECOLEAD addresses the most fundamental and inter-related focus areas, which form the basis for dynamic and sustainable networked organizations: the Virtual Organization (VO) Breeding Environments, Dynamic Virtual Organizations and Professional Virtual Communities. In addition to these three vertical focus areas, the holistic approach is reinforced and sustained on two horizontal areas: the theoretical foundation for collaborative networks and

Figure 2.6 ECOLEAD Theoretical Foundation

Raúl A. Esquivel Rincón

Source: ECOLEAD © Raúl A. Esquivel 2007
the horizontal Information and Communication Technologies (ICT) infrastructure.

The horizontal activities support and affect all three vertical focus areas. The theoretical foundation shall provide the basis for technology-independent understanding of the area and its phenomena. The existence of an invisible, low-cost ICT infrastructure is a pre-condition for the establishment of truly dynamic collaborative networks. ECOLEAD is expected to impact industrial competitiveness and societal mechanisms, by providing means to effectively exploit opportunities deriving from the deployment of Virtual Organizations (VOs), and by designing and enabling new professional work paradigms, capable of enacting the knowledge-based society throughout Europe. The concept of Collaborative Networks will be further explained later in this chapter.

2.3 Strategic Management in a Global World

The playing field in a growing number of industries is globalizing as companies increasingly expand their horizons from local to global markets and resources. There are great challenges and opportunities for companies operating or willing to operate internationally. Global competition enhances the necessity to focus on different aspects of strategy needed in an international context. Friedman (2005) stated that “This thing called globalization can explain things in more ways than anything else”. He said that globalization has gone into overdrive; that Chinese and Indians can compete for the work like never before. The world is becoming flat, several technological and political forces have converged, and that has produced a global, web-enabled playing field that allows for multiple forms of collaboration without regard to geography or distance nor even language.

One of key concepts extracted from the book “The World is Flat: A brief history of the twenty-first century” by Friedman (2005) is that we are immersed now in Globalization 3.0. In Globalization 1.0 that happened with the discovery of America in 1492, the world shrank to a medium size. In Globalization 2.0 started with the growth and development of multinational companies, shrinking into a small size. But in year 2000, Globalization 3.0 made the world shrink to tiny. He stated “There’s a difference between being able to make a long distance phone call cheaper on the Internet and walking around Riyadh with a PDA where you can have all of Google in your pocket. It’s a difference in degree that’s so enormous it becomes a difference in kind”.

Raúl A. Esquivel Rincón
Global strategic management is “global” in terms of understanding organizations as open systems and the world they operate in. They deal with a global milieu of economic, social, ethical, political, legal, technological and physical environment characteristics when managing these global businesses. It is no longer used that phrase that asked to “Keep it simple”, to be able to please a global audience in a simple way it is now complicated thanks to globalization (Galbraith, 2000).

2.3.1 Strategic Management

Strategic Management was officially depicted with that name in 1962, when Chandler published its seminal work Strategy and Structure (Rumelt et al., 1994). Chandler defined strategy as “the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out the goals” while defining structure as “the design of organization through which the enterprise is administered”. Another important works were from Ansoff’s Corporate Strategy in 1965, Ansoff had a more scientific approach than Chandler’s. Together, they founded the science field of Strategic Management.

The development of this science field has grown exponentially in the last two decades. The current field of strategic management is strongly theory-based with some empirical research (Hoskisson et al., 1999). Perhaps, one of the more significant contributions to the development of strategic management came from industrial organization (IO) economics, specifically the work of Michael Porter.

A firm’s “strategy” is its business model of how to gain competitive advantages when trying to compete successfully in a global marketplace. These firms need to deal with business policy formulation, strategic planning, market identification, identification of core business activities, retaining customers, finding capital and developing relationships within their firms. Taken together, strategic management will provide strategic perspective in addressing the types of problems globalization poses to businesses:

- Managing across cultures
- Local execution of global strategy
- Coping with different regulatory environments
- Outsourcing
- Global expansion
- Strategic partnering
- Hostile foreign companies and governments

2.3.2 Strategic Management evaluation

Despite the fact that many companies have some sort of a strategy in their minds, there are many different approaches in the way they translate this strategy into ground and in the criteria that validates it. Robert Kaplan and David Norton (1992) defined Strategy Maps to relate the Strategic Plan (Vision, Mission, Objectives...) with obtained results in a visual reference frame. It includes the following elements:
- Desired productivity and growth results
- Value proposal to the customer
- Internal processes outperformers
- Intangible assets results

Every company has its own strategy to create value in their customers and stakeholders. One of the best ways to present it is the Balanced Scorecard (Kapland and Norton, 2004) in which the previously mentioned value creation capacity of companies will be in function of the following 4 factors of perspectives:
- Financial perspective
- Customer perspective
- Internal perspective
- Growth and learning perspective

2.3.3 Strategic Management in the Aerospace Industry

The aerospace industry is an industry with cyclic ups and downs over the years. This behavior is mainly because of its large proportion of Military contracts among the Industry. The biggest Aerospace Industry customer in the world is the United States Department of Defense (DOD). All the industry depends on the defense budget as a big contributor to revenues. This budget varies depending on the fiscal approach and socio-political situation in the World, like it happened in the 70s where the Cold War made the Aerospace Industry the most attractive among all Industrial Sectors in the U.S. There were plenty of contracts for all the companies and these good times made aerospace companies and their management becomes less efficient, less competitive and more relaxed in the way they conducted their long term business operators (Papin and Kleiner, 1998).
The aerospace's management strategy used to be growth because companies became short-sighted and focused on immediate profits. Eventually, the defense budget declined about 1986 and that lead to fierce competition among military business units of all aerospace companies. The commercial aircraft divisions of companies has also been hit due to an erosion in profit margins caused by severe airline competition (Papin and Kleiner, 1998) together with the events of 9/11 and the increased amount of subsidies by European countries to AIRBUS that changed the Aerospace Industry forever.

Good days were over and companies were immersed in a management crisis with their current strategic plans. A few academic studies are being done in the utilization of strategic management for the aerospace industry and Aerospace Companies responded with organizational changes and several different strategies. Companies now can only compete in three different ways; as technology leaders, cost leaders or adaptable niche leaders. The following strategies have been adopted by aerospace companies in order to increase their competitiveness and efficiency (Papin and Kleiner, 1998):

- **Acquisition, merger, diversification and abandonment**
  By trying to increase market share by merges, like the case of Lockheed and Martin Marietta that in 1995 created Lockheed-Martin, the largest defense contractor. Boeing also grew by acquiring McDonnell-Douglas in 1997 to end-up being the only American large aircraft assembler and the Merge of United Technologies and Sundstrand to create Hamilton-Sundstrand in 1999. Even some companies like Alliant Technologies and Textron abandoned some of their core businesses.

- **Reorganization and consolidation**
  So far, almost all of the consolidations or reorganizations that have occurred in the Aerospace Industry have been reactive rather than proactive to particular situations, like the increased competition within the industry. Of all the steps that McDonnell-Douglas implemented to improve its critical situation, the massive reorganization announced in August 1992 was the most meaningful. This program streamlined the decision-making process and consolidated 6 groups into just 2 (Velocci, 140). Boeing’s defense and space group which once was composed of 6 different businesses, consolidated into one. They improved from 450 labs to 250, just due to overlap in overhead (Banks, 1991).

- **Niche strategies around core competences**
When you are not big enough to compete with larger conglomerates that monopolize the ever-shrinking markets, you may opt to focus on your strengths and find a particular niche within the industry in which you can become leader. Wyman-Gordon’s Co. which produces aluminum and titanium forging for jet engines increased its capital investment to focus on just one niche. They have heavily invested in specialized equipment and even bought a company that manufactures plastic composite materials. Now they are in the path of becoming a supplier of ultra-high technology aerospace materials (Slutsker and Zweig, 1989).

- **Flexibility through cost reduction strategies**
  Furthermore, companies need to look for more than just the previously mentioned strategies. Companies try to become more flexible within the industry by lowering inventories, fixed costs and capital spending and increase internal financial goals. Liquidity, low debt, and strong cash flow are becoming top priorities in the whole industry. Boeing former CEO Frank Shrontz strategy was to hoard billions in cash to finance large development programs.

- **Total Quality Management and human resources strategies**
  Total Quality Management (TQM), originally proposed by Deming and Juran, has gained some popularity in the last 2 decades as an effort to become more efficient. The adoption of these quality practices by the DOD prompted the rest of the companies in the Industry to implement TQM too. The potential bottom-line benefits of reduced costs, improved quality and better customer satisfaction have made aerospace companies to invest millions of US $ in training, new equipment and facilities to promote competitiveness. (Scott, 131)

### 2.4 Supply Chain / Value Chain Management (SCM/VCM)

#### 2.4.1 Supply Chain vs. Value Chain

The Value Chain concept was developed and popularized in 1985 by Michael Porter in his classic book “Competitive Advantage”. Porter defined value as the amount a buyer is willing to pay for any product he can acquire. In consequence, the “Value Chain” is the combination of nine generic activities that generate value in a company that combined within firms to form what he called a Value System. In this global era with more outsourcing and collaboration linkages within companies, value creating processes has more commonly been named as the “Value Chain”. The main focus of Value Chains is to provide the customer with some valuable product, and to
manage the processes that generate it and the resulting demand and capital flows created (Feller et al., 2006).

In Figure 2.7 we can appreciate a typical order fulfillment value chain. The value chain starts from customer requirements, because like beauty, value is in the eye of the beholder, in counterpart with the traditional Supply Chain in which the product was the driving force of the whole chain.

Supply Chain Management (SCM) emerged in the 80’s as an integrative philosophy to manage the total flow of goods from suppliers to the ultimate user (Cooper et al., 2007) and was first coined by Keith Oliver in 1982 (Laseter and Oliver, 2003) when Oliver was Vice President in Booz Allen London’s Office. The concept evolved from managing mostly logistic issues in the whole chain of supply as a single entity, to what now integrates even all the business processes along it.

Supply Chains need to synchronize the flows of supply with the flows of value from customers presented in Figure 2.7, in the form of rapidly shifting tastes, preferences and demand. We need to stop thinking of Supply Chains and Value Chains as different entities; rather, we should integrate the two. Third generation Supply Chains synchronize material flows and product deliveries, with information, knowledge and financial flows in a lean, integrated and instantaneous way. For the purpose of this Thesis, the author will refer as Supply Chain Management to the concept of managing extended enterprises relationships as defined in SCM 3.0. The concept of supply network or value network is also implied in the definition of Supply Chain that the author considers.
2.4.2 SCM in Small and Medium Sized Enterprises (SMEs) in Mexico

Because of these characteristics of the SME, the relationship it has with the rest of the Supply Chain is complicated. And it has been studied that the effects that Supply Chain Management (SCM) has on the SME are very different to those in the Large Enterprise (LE). Some studies have identified problems of such a magnitude that SCM implementation is negatively correlated with SME performance (Arend and Wisner, 2005 cited in Vaaland and Heide, 2007). According to Vaaland, the lack of performance between SMEs after the introduction of SCM compared with LEs is mostly because the difference in the way of implementing it. In a study by Quayle (2003), issues such as new technology, R&D and e-commerce were considered low priority items by 288 UK SMEs contrasting the global tendency to focus on these topics of the typical LE.

The diversity of the SMEs also affects its different ways to implement SCM in its operations:

- Cultural differences: Around the world, SMEs in developing countries face a strong problem of lack of capital and credit. It is very hard to obtain a credit in developing countries that have high credit risks.
- Global Supply Chain differences: Depending on the other members of the Supply Chain, SMEs involved in successful Supply Chains usually receive financial and technology aid when implementing Supply Chain procedures.
- Type of business: Whether the SME is involved in a manufacturing SC or in a service one, some issues affect its levels of implementation. Service companies tend to think that there is no such a need to be up to date in those topics.

The reasons for lack of implementation can also be related to structures in the SC (Lambert et al., 1998):

- Resource structures: Differences in the way some assets are linked and shared between the different links of the SC. Effective resource structures are crucial when developing virtual companies and virtually integrated Supply Chains (Skjoett and Larsen, 2000).
- Reduction of inventories: According to Lee and Billington (1993), when reducing inventory due to some other reasons, structural changes need to be done in the company in order to apply the logistics new needs and physical flow.

Another group of issues faced by SMEs when implementing SCM deals with the management components of the SC:
- Behavioral side of management: These issues include the management aspect of power relationships. Sometimes when SMEs are immersed in SC with big players, they are undervalued when sharing companies' risk, or in the reward structure they have.

- Bargaining power of supplier (Porter, 2000): SMEs also face the problem of implementing SCM to full extent because they are managed at arm's length by larger customers and have to follow the norms stipulated by the buyer (Arend and Wisner, 2005).

- Lack of influence of SMEs: Because many of the large companies running Supply Chains see SMEs as links in the SC that can be easily replaced in case they need. That thinking is not helpful when trying to create strong relationships or when trusting your partners in sharing information either. The SMEs are left apart.

- Lack of technology resources: While LEs have the money and will to invest in new technological business strategies like E-business and E-supply, the SME will continue to be challenged by resource limitations (Wagner et al., 2003).

Despite all the issues mentioned above, we are sure that SCM is a vital strategy for the SME. The large companies have been successful when implementing SCM, now is the time to turn into a win-win-win situation with SMEs, as stated by Mike Doyle (1998):

“In America, the little guys who are vitally important to making the whole thing work have not been at the table. Some of the big guys now realize that it is in their enlightened self-interest to bring the smaller guys along because they can not optimize their Supply Chains without their participation and help”

According to Demirbag et al., SCM management practices will influence positively the SMEs directly and indirectly in operational and organizational performance. The measures of the operational performance may be (Demirbag et al., 2007):

- Flexibility: When adapting to changes in business environment, SC practices enhance the capability to develop many suppliers and reduce Supply Chain risks. Outsourcing and Third party logistic providers (3PL) are some of the practices that also provide flexibility to internal capacity.

- Reduced lead time in production: Practices like E-procurement, delivery form stock, single sourcing and JIT delivery may reduce lead time and increase responsiveness.

- Forecasting: As defined by Demirbag et al. (2007) this is one of the most important features of performance of Supply Chains. It includes supply of material, manufacturing, production planning and customer demand prediction.
- Resource planning and cost saving: A strategic level decision that can help you allocate resources in a better way, reducing lead times and improving performances.
- Reduced inventory level: JIT supply allows minimum inventory holding through supplies when delivering them when needed.

Besides the features of operational performance like financial states that are always highlighted by traditional companies, some other non-financial measures of performance may be of some importance. The following factors are proposed by Demirbag et al (2007) when doing a study of 203 manufacturing SMEs in Turkey:

- Increase in sales: With a competitive Supply Chain, reduction in costs will cause a decrease in cost, better product quality, faster response and eventually higher market share.
- More accurate costing: Costing is all about information, with practices like e-procurement and JIT supply, companies can reduce the variability due to information sharing, order lead times. Also contracts with 3PLs and outsourced providers establish costs more accurately than by doing those services in-house.
- Increase in coordination between departments: Information retrieval and sharing may increase the communication between departments, to be able to be in coordination as part of a Supply Chain, first you need to be well organized inside.
- Increase in coordination with suppliers: With the practice of having few suppliers, the logistic cost may be reduced. Fewer suppliers mean less relationships and consequently more deep relationships.
- Increase in coordination with customers: To establish a close relationship with your customers will always be beneficial for any business. With improvements in data sharing, you could be able to easily change your processes to adapt to a new demanded product or to new specifications.

After mentioning the good and bad aspects of SCM practices when applied by the SME, we can conclude that despite it is a difficult process, the integration of the SME to the SC is very important when seeking to improve its operational performance.

2.4.3 Benefits of SCM in SMEs

With the improvement of big role companies in logistic aspects, the next step when tuning up the Supply Chain, is to focus on those minor players. Traditionally, the Supply Chain leader has only worried about its own performance. With the realization that whole Supply Chains are now competing against each other, a good understanding of the methodology needed to integrate
minor players in global competition manners is vital for all parties involved. Some of the primal problems faced when addressing the question we stated before according to Arend and Wisner are:

- Vulnerability inherent in the reliance on SCM partners for relation-based rents
- Lack of modification of the underlying SCM theories to account for the effects of firm size
- Self-selection of effects in the relevant strategy = choice, strategy – outcome link

There are at least five good reasons for SMEs to be interested in the integration to Supply Chains according to Chapman and Sharon (2000):

1. Whether they know it or not, SMEs are involved in the Supply Chain.
2. Many small firms are still young to make necessary changes to adopt SCM into their business strategy as it develops.
3. Size and flexibility they possess is advantageous to the entire Supply Chain.
4. The availability of information systems makes things more easy
5. SCM provides a method to assess the challenges that are faced today.

2.5 Supply Chain Integration Process

The integration between links of the Supply Chain is vital to improve the performance of individual members, as well as to the Supply Chain as a whole.

2.5.1 Supply Chain Integration for SMEs

With traditional research and practices, the SME was not enhanced to participate in the Supply Chain. Campbel and Sankaranl (2005) propose a framework that is empirically achievable with very fine and well tuned mechanisms and diagnostics for Supply Chain Integration. They developed this workframe motivated in SMEs, because most frameworks previously defined are based on experiences by consulting companies mostly with large, already successful enterprises.

Examples of this vague works include:

1. Charting the Course to successful Supply Chain Management (Fox, 1999)
2. Benchmarking Success Stages of Supply Chain Excellence (Benchmarking Success, 2001)
3. Riverola: SCM Maturity Model (Riverola, 2001)
4. DRK: Supply Chain Maturity (McCormack, 2001)
In Table 2.5 they propose an SCI enhancement framework for self-administration by the SME. The process includes the formulation of two basic questions for each of the sub-themes that need to be answered continuously:

1. If the user-enterprise is using a SCI management concept/idea, is it fully utilizing the potential from this concept/idea?
2. If the user-enterprise is not using a SCI management concept/idea to a sufficient degree, does it have sound reasons for not doing so?

### Table 2.5 Enhancement framework by Campbell and Sankaranl (2005)

<table>
<thead>
<tr>
<th>Theme</th>
<th>Sub-theme (Items in the framework)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Internal integration</td>
<td>I.1 Organizational structure – multi-divisional businesses</td>
</tr>
<tr>
<td></td>
<td>I.2 Organizational structure – cross-functionality</td>
</tr>
<tr>
<td></td>
<td>I.3 Organizational structure – the supply chain</td>
</tr>
<tr>
<td></td>
<td>I.4 Organizational structure – PC/IT</td>
</tr>
<tr>
<td></td>
<td>I.5 Supply chain segmentation</td>
</tr>
<tr>
<td></td>
<td>I.6 Activity-based costing (ABC)</td>
</tr>
<tr>
<td></td>
<td>I.7 Information technology/Information systems</td>
</tr>
<tr>
<td>F. Forward integration</td>
<td>F.1 Relationship management</td>
</tr>
<tr>
<td></td>
<td>F.2 Development of win-win relationships</td>
</tr>
<tr>
<td></td>
<td>F.3 E-commerce connectivity with customers</td>
</tr>
<tr>
<td></td>
<td>F.4 Benefits of e-commerce</td>
</tr>
<tr>
<td></td>
<td>F.5 Effort on behalf of the focal organization for e-commerce</td>
</tr>
<tr>
<td></td>
<td>F.6 Initiatives to &quot;encourage&quot; customers to interface electronically</td>
</tr>
<tr>
<td></td>
<td>F.7 Information technology employed at the customer base</td>
</tr>
<tr>
<td>B. Backward integration</td>
<td>B.1 Differential selection of suppliers</td>
</tr>
<tr>
<td></td>
<td>B.2 Differential management of suppliers</td>
</tr>
<tr>
<td></td>
<td>B.3 Performance measurement of suppliers</td>
</tr>
<tr>
<td></td>
<td>B.4 Closeness of relationships with key suppliers</td>
</tr>
<tr>
<td></td>
<td>B.5 Technology in the supply chain</td>
</tr>
<tr>
<td></td>
<td>B.6 Technology interfaces with suppliers</td>
</tr>
</tbody>
</table>

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Each of the sub-themes is addressed in more detail by Campbell and Sankaranl (2005) as an assessment to companies to diagnose their potential integration.

On the other side, Samaranayake (2005) proposes an integrated framework for the SC, not for the integration process. The framework is based on a unitary structuring technique that combines manufacturing and distribution networks. The framework proposes that bills of materials, warehousing operations, project networks and operations routings should be integrated in the same model. This integration provides visibility, flexibility and maintainability of components involved in the structural level. The motivation to develop such a model is to address the statement by Lamming et al. (2000) that SMEs could benefit from a Supply Chain model when implementing it does not cost a lot of work. Because one of the problems in former techniques was the differentiation between ERP systems when combined with MRPs or DRPs, Woxvold...
(1992) proposed a “unitary” structuring technique. This unitary structure allows critical path method (CPM) network links and 3 forms of precedence: Parent-component, process routing and component-component, for 4 different types of components: materials, activities, resources and suppliers. The example shown in Figure 1 illustrates an example of it.

In general, a Supply Chain consists of a large number of partners including customers, distributors, manufacturers and suppliers. This framework can represent bill of materials (BOMs) and operation routing. Traditionally, these activities happen on the lead time; in this case, they are all part of the global BOM that has a set of single level BOMs in a relational database. After using this unitary structure to represent both the operations and the distribution networks, the next step in the development of Supply Chain framework according to Samaranayake (2005) is the combination of individual networks. It is good to notice that in order to achieve a global integration; the networks involved should have a proper integration at the structural level.

2.5.2 Supply Chain Integration Practices

Since the conception of Supply Chain Management, specific practices had been developed in the literature. Power (2005) proposes the following categories to summarize Supply Chain Integration practices:

- **Information flows:**
  Refers to the different ways to apply information technologies (IT) to favor the integration of Supply Chain activities. There are two different types of complexity related to these practices: detail and dynamic. Detail occurs when there is a great number of variables that need to be monitored and managed; dynamic exists where cause and effect are separated and difficult to associate in time and space. “Bullwhip effect” is one good example of a situation that is dynamically complex (Chen et al., 2000). Some practices like: demand forecast updating, order batching, price fluctuation and rationing and shortage gaming can be helpful when dealing with problems like that. The use of internet technologies and general information systems are very useful when seeking to establish a better flow of information.

- **Physical Logistics:**
  Good policies to manage inventories, transportation systems, distribution plans, facility location and other logistic related decisions are of great importance when trying to improve the performance of overall Supply Chains.
- **Partnerships, alliances and collaboration:**

Trying to leverage supplier relationships is very well recommended, some relationships include “arm’s length” model (Dyer et al., 1998). There is a great need that all the parties involved recognize the “common interest” of all the parties to collaborate with each other. Trust is one of the most important values needed, it leads directly into cooperation and commitment. There are several well-studied ‘popular’ terms in the literature referring to supply chain integration practices through partnerships, alliances and collaboration (Supplier Development, Outsourcing, Offshoring, and Collaborative Networks among others).

### 2.5.3 Outsourcing

Outsourcing is commonly referred as the delegation of non-core operations from internally to an external entity that specializes in the management of that operation (Corbett, 2006). Not so long ago, some observers predicted Outsourcing to be dead after some remarkable failures like the ones from DELL, J.P. Morgan or Sears (Couto & Divakaran, 2006), but these predictions have proven wrong. So far the industry has not stabilized to the point where outsourcing every aspect of your business guarantees you success. The pioneers of Outsourcing practices are now known as Outsourcing Virtuosos (Couto & Divakaran, 2006), they are creating instruments of unprecedented power to address all the global needs. In the demand side, these Virtuosos are becoming masters in the area. There are 2 different kinds of Services Outsourcing Practices; on one hand there are new firms from different segments, mainly IT that develop applications to be used worldwide. On the other hand, there is a major wave of consolidations of big companies that just want to expand their capabilities. In this case, it becomes very difficult for companies that want to remain competitive in the business of offering single processes against established market leaders without an expanded offering that can be found in world-class technology platforms (Couto & Divakaran, 2006). These technology platforms that provide the basis for NETWORKED organizations has been studied widely by authors like Charles Handy, Shoshana Zuboff or Charlie Karlsson (2005), but ironically, the complexity and intrinsic necessity of emerging markets in China, Portugal and other Asian countries has created actual networked businesses as a model for the future. “Outsourcing has become the sine qua non of the successful global corporation” (Couto & Divakaran, 2006).

### 2.5.4 Supplier Development

This is a good example of the benefits of Supply Chain integration practices applied for a specific purpose. Dunn and Young (2004) proposed a conceptual model for the specific purpose of
developing suppliers using the concepts of SCM. Because most of the new suppliers that are required in any given process start small, it is easy to notice our interest in the review of this model. The model underscores the fact that suppliers can be logical extensions of the purchaser’s firm, furnishing those goods and services that purchasers have chosen to outsource. Thus the core objective is to synchronize supplier capabilities with the customer expectations. When trying to close this gap, the initiatives based on Supply Chain management and other practices are used as shown in the Figure 2.5.8

**Figure 2.8 Supplier Development Model**

```
<table>
<thead>
<tr>
<th>What is it? (Item/service)</th>
<th>Nature of the Supplier market</th>
</tr>
</thead>
<tbody>
<tr>
<td>What matters? (expectations)</td>
<td>Current supplier assessment</td>
</tr>
<tr>
<td>Buyer-seller behaviors</td>
<td>Relationship type</td>
</tr>
<tr>
<td></td>
<td>GAP</td>
</tr>
<tr>
<td></td>
<td>Development activities using SCM</td>
</tr>
</tbody>
</table>
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### 2.6 Collaborative Networks (CN)

Thomas L. Friedman, the most influential newspaper columnist in the U.S. since Walter Lippmann and who writes twice a week in a foreign affairs column in the New York Times, published the book “The World is Flat” in 2005. In his book, Friedman (2005) talked about the globalization of our days and the fundamental statement that the world is flat now because every people and every country in the world compete in a leveled field with no intrinsic advantages. He mentioned the 10 flatteners that had created this situation:

1. The Fall of the Berlin Wall: Merged 2 worlds into a mainstream
2. Netscape’s initial public offering: Opened Internet to a broader audience
3. Software Workflow: Allows machines to communicate to each other with no human involved
4. Open Sourcing: Communities COLLABORATING on online projects like wikipedia or linux
5. Outsourcing: Split service and manufacturing activities into components to be cost-efficient
6. Offshoring: Relocation of production or other business processes to better competitive advantages
7. Supply Chaining: COLLABORATION happening horizontally, vertically and in networks
8. Insourcing: Companies COLLABORATING horizontally and within each other to finish tasks
9. In-Forming: Possibility to acquire knowledge through COLLABORATIVE processes results
10. The Steroids: Digital, Mobile, Virtual and Personal enhance COLLABORATION of the other 9
He considers his first three flatteners have become a “crude foundation of a whole new global platform for collaboration.” The other seven have one thing in common: Collaboration, it can be the cause, the medium or the benefits but all of them have that in common. He mentioned a convergence of the 10 flatteners and said that in a global market, they are able to enhance HORIZONTAL COLLABORATION across the globe. This convergence of the flatteners results in the development of global competencies based on collaboration, through persons and among them, as well as between companies. This era has been transforming every aspect of business, society and our lives.

2.6.1 Defining Collaboration

Collaboration is a widely understood term, almost always referred as the process in which two or more people (or entities) work together toward a common goal, especially an intellectual one. Collaboration could be confused with other terms like networking or cooperation. Camarinha-Matos and Afsarmanesh (2006) propose a distinction of the terms presented in Figure 2.9 that distinct collaboration from the rest in the fact that it implies the presence of Joint goals, identities and responsibilities and not just that they can be compatible.

![Figure 2.9 Examples of Joint Endeavors](image)

According to ECOLEAD there are some specific requirements for the correct and meaningful implementation of Collaboration:

- Must have a purpose
- Must meet some basic requirements or pre-conditions (Collaboration Agreement, knowing each other, shared goal, vision and understanding of the problem)
- Requires a collaboration environment
- Good addressing of shared resources
- Common perception of exchanged values to deal with incentives and rewards
- Commitments
- Shared responsibilities commitment

All this conditions must be settled beforehand through common working and sharing principles and with a common motivation factor (Expected Results not possible by the individual parts).

2.6.2 Models of Collaboration

Collaboration can be seen in different aspects as presented in the list of Strategic Alliances proposed by (Todeva & Knoke, 2005) that are based and determined by the search of organizations for new competitive advantages:

1. Hierarchical Relations
2. Joint Ventures
3. Equity Investments
4. Cooperatives
5. R&D Consortia
6. Strategic cooperative agreements
7. Cartels
8. Franchising
9. Licensing
10. Subcontractor networks
11. Industry standards groups
12. Action sets
13. Market relations

This classification uses common referenced names for the different types of collaboration. One broader name lately given by ECOLEAD is Collaborative Networks (CN). Due to this great diversity of names and terminology, it is important to define a taxonomy of the various organizational forms possible (Camarinha-Matos & Afsarmanesh, 2005). Figure 2.10 shows this organizational model and group all forms in a logical way:
2.6.3 Collaborative Networks (CN) by ECOLEAD

A variety of entities that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are supported by computer network. Most forms of collaborative networks imply some kind of organization over the activities of their constituents, identifying roles for the participants, and some governance rules.

For the case of this Thesis we will be focus on the creation of Long-term strategic CNs, the development of Virtual Organization Breeding Environment (VBE), specifically the case of an Aerospace Cluster in Mexico.

2.6.4 ARCON: CN Reference Framework

In order to be able to model this relatively new science field of Collaborative Networks, ECOLEAD proposed ARCON (2007b) in order to capture the complexity of this topic. The Collaborative Networked Organizations (CNOs) inherit their complexity from both aspects related to collaborations and aspects related to networks, and thus no exception to this rule. Inspired by the modeling frameworks introduced in the literature related to these two areas, and considering the complexity of CNOs and their wide variety of aspects and constituting elements, the ARCON modeling framework is developed to divide this complexity into a number of perspectives, in order to comprehensively and systematically cover all relevant aspects of the CNOs.

ARCON is based on 3 different perspectives to model CNs:
- **Life-Cycle Stages**: Refers to the way to represent long-term organizations like CNs in such a way that can be analyzed their main life-cycle stages (Creation, Operation, Evolution and Dissolution or Metamorphosis)

- **Environment Characteristics**: Refers to the representation of both internal and external aspects of CNs. In the internal point of view, endogenous aspects are addressed (Structural dimension, componential dimension, functional dimension, behavioral dimension). In the external point of view, exogenous interactions are explained in detail (Market dimension, support dimension, societal dimension and constituency dimension).

- **Modeling Intents**: Refers to the deepness in which a CN can be represented according to the level of abstraction desired by the CN modeler. The 1st is the General Representation Layer that includes general aspects common to all CNOs independent of the application domain. The 2nd is the Specific Modeling Layer that includes more detailed models focused on different classes of CNOs. And the 3rd is the Implementation Modeling Layer that represents models of specific CNOs

Figure 2.11 represents in a 3 dimensional view the interaction of these 3 main perspectives of modeling CNs proposed by ECOLEAD.

**Figure 2.11 ARCON Reference Modeling Framework by ECOLEAD**

*2.7 Clustering*
Globalization has made that you can find your product requirements from every corner of the world at competitive prices. According to this, you could think that localization would not be that important, if this were to be true, why is there a higher probability of finding high performance automotive companies in southern Germany, film studios in Hollywood, high-tech firms in Bangalore or aerospace-related companies in Toulouse than almost any other region in the world. In a more local perspective, why shoe and leather companies in Guanajuato, agribusiness in Sinaloa or financial services in Mexico City are more developed than in the rest of the country? According to Porter (1998), the economic map of the world is dominated by what he calls Clusters, unusual competitive success of some regions in a particular field.

2.7.1 Defining Clusters
Clusters are geographic concentrations of interconnected companies and institutions in a particular field and encompass an array of linked industries and other entities important to competition. They include strategic suppliers of specialized inputs like components, machinery and services and providers of specialized infrastructure (Porter, 1998).

According to ECOLEAD, Clusters are one of the earliest forms of VO breeding environments, consisting of a group of companies, typically located in the same geographic region and operating in a common business sector, that keep some “binds” with each other in order to increase their general competitiveness in the larger area. These binds may include sharing some buyer-supplier relationships, common technologies and tools, common buyers, distribution channels or common labor pools, all contributing to some form of cooperation or collaboration when business opportunities arise. Earlier forms of clusters did not require a strong ICT infrastructure but more and more collaboration resorts to such support.

2.7.2 Cluster Foundation Model
According to Porter (1985), a nation (or region) achieves international success in particular industries as a consequence of the improvement of 4 elements that he considers to be a Determinant Diamond. This diamond represents the playing field that countries (or regions) establish for their industries:

1. **Factor Conditions**: Nation’s position in factors of production. E.g. skilled labor, technological base, etc.

2. **Demand Conditions**: Nature of home demand for the industry’s product or service that can lead to comparative advantage when exporting.
3. **Related and Supporting Industries**: The presence of supporting supplying industries for the industry’s product or service that can lead firms to enjoy cost effective and innovative inputs.

4. **Firm Strategy Structure and Rivalry**: Conditions in the country that govern how companies can be created or organized. This includes cultural or social conditions that favor the development of specific industries for certain countries.

The individual factors of the diamond affect 4 ingredients that lead to competitive advantages:

1. Availability of resources and skills
2. Information that firms use to decide which opportunities to pursue with those resources and skills
3. Individuals Goals
4. Pressure on companies to invest in innovation

In the context of the Lean Aerospace Initiative that is led by MIT, Nystrom (1995) proposed a model to evaluate and measure Cluster Foundations based on Porter’s Determinant Diamond. It evaluates the possibility of a specific cluster to perform competitive in a global stage now and in to the future as seen in Figure 2.12.

**Figure 2.12 Cluster Foundations’ Evaluation Model**

It is a simple and easy model in which a hierarchical approach is used, all high-level determinants are defined by lower-level ones. Lower-lever determinants are filled from -5 to 5.
representing the level in which the factors support or limit growth. High-level determinants are estimated according to the following relationship:

**Figure 2.13 Cluster Foundations’ Determinant relationship equation**

<table>
<thead>
<tr>
<th>If:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D$ is the determinant value of the higher-level determinant</td>
</tr>
<tr>
<td>$n$ is the number of lower-level determinants</td>
</tr>
<tr>
<td>$D_1$, $D_2$, ... $D_n$ are the lower-level determinant values</td>
</tr>
<tr>
<td>$DL$ is the lowest of the $D$'s</td>
</tr>
<tr>
<td>$W_1$, $W_2$, ... $W_n$ are the weight factors for lower-level determinants</td>
</tr>
<tr>
<td>Then:</td>
</tr>
<tr>
<td>$D = \left( \frac{\sum W_i D_i}{\sum W_i} + D_i \right) / 2$, for $i = 1$ to $n$</td>
</tr>
</tbody>
</table>


This model is very appropriate to identify Cluster Growth issues or detractors and the potential impact of specific projects or solutions. It should be used in the context of a broader process for the internationalization of clusters proposed by Nystrom (1995):

1. **Learn re:** Opportunities: Education and Training
2. **Recognize Opportunities:** Data Bases, Directories and Linkages
3. **Communicate:** Language and Culture
4. **Strengthen Factor Conditions:** Financing, Physical Infrastructure, Human resources and Technological Resources.

**2.7.3 Clusters as Strategic Competitive Advantage**

Competitive advantages in our times are no longer about the access to inputs such as natural resources, it is all about productivity. Productivity rests on how companies compete, not on the particular fields they compete in. Such companies can be very productive in any industry if they employ sophisticated methods, use advanced technology and offer unique products and services (Porter, 1998).

The sophistication with which companies compete in a particular location is strongly influenced by the quality of the local business environment. Companies cannot employ advanced logistical techniques without excellent transportation infrastructure, nor can they compete on sophisticated services without well educated people. Some aspects of the business environment, such as the legal system, or corporate tax rates, affect all industries. In advanced economies, the more decisive aspects of the business environment are often specific for clusters; these constitute some of the most important microeconomic foundation for competition.
Clusters affect competitive aspects in three different ways (Porter, 1998):

- By increasing the productivity of companies based in the area
- By driving the direction and pace of innovation, which anticipates future productivity growth
- By stimulating the formation of businesses that expands and strengthens the cluster itself

A cluster allows each of its members to benefit from it as if they had greater scale or as if they had joined with others without sacrificing its flexibility. Being part of clusters help companies to benefit their productivity in the following aspects:

- Better access to employees, suppliers and inputs
- Access to specialized information
- Complementarities
- Access to institutions and public goods
- Better motivation, measurement and easy benchmarking

Poor countries and regions don’t have well developed clusters. Like Mexico has mostly been doing, these countries compete on cheap labor, natural resources and strategic geographic situations. In order to improve this non-value-adding situation, the development of clusters plays a strategic and essential role for those economies.

Japan, for example, has the largest number of SMEs among industrialized countries, more than 99% of Japanese manufacturing are classified as SMEs (Yamawaki, 2002). One of the most important characteristic in Japan’s economy is that these SMEs often form clusters. The economic significance of them varies from manufacturing exports clusters, to food processing, textiles and even indigenous goods. These clusters development were the key for the recovery of the economy of Japan, they were formed because of some historical circumstances, prior existence of large manufacturers, prior existence of supporting industries, prior existence of related industries in neighboring areas, reduction in transportation costs, regional government policy and technology transfer.

Following the example of Japan, for a pathway out of underdevelopment, China is relying on clusters to enjoy such a huge manufacturing cost advantage over the rest of the world (Wu et al., 2006). Is a known fact that China has firmly established its position as the world’s factory at a breathtaking pace with its abundant labor resources, ability to quickly expand production capacity and low-cost competitive advantages. China is aiming now to saturate the world of low-
priced products in categories as apparel, footwear, electric appliances, furniture, toys, computers and accessories. Low labor cost has become the rationale for justifying outsourcing to emerging countries, but in the case of China, it is not just about low labor costs when reflecting it in low manufacturing costs. Countries like Vietnam, Zimbabwe or El Salvador have lower labor costs than China, and none of these countries can compete with China’s prices in the same products. Although the cost of labor is important in creating cost advantage for low-cost countries, it is only one of a number of factors. These factors include lower capital investment costs, low domestic sourcing costs, greater economies of scale and government incentives (Wu et al., 2006). At least a couple of these factors are related to the presence of industrial supply clusters in China. They have two kinds of clusters:

- Hub-and-spoke: where a large company (mostly state-owned) is surrounded by a large number of suppliers

- SMEs agglomeration: When a large number of SMEs, which don’t receive support such as loans, land or tax cuts from the government, gather in specific region and fight for their economic survival.

The second kind of cluster has proliferated across China in recent years; there are now more than 1,000 supply clusters for export products. Entire cities are focused on specific products like the case of Datang township, thousands of sock manufacturers produce 6 billion pairs of socks annually or the Zhili township in Zhejiang province where the whole city produce different gadgets exclusively for children. Recognizing the supply cluster’s role within the supply chain is a first step in simplifying the complexity of the world’s marketplace.

2.8 Hypothesis Statement

After a complete review of the literature, the author has now the ability to state the following hypothesis based on the comprehensive understanding and integration of relevant information done about it.

2.8.1 Hypothesis

It is feasible to create Strategic Collaborative Networks of Aerospace SMEs in Mexico that will address the following issues for it and its members:

- Lack of information about the Aerospace Industry and about successful and tested ways for SMEs to integrate into Supply Chains
- Lack of information about the competences and capabilities of Industry members
- Lack of coordination in purchasing and sourcing processes
- Lack of digital information about parts and families of parts
- Lack of prestige in the global Aerospace Industry
- Lack of collaboration between different companies working in the industry
- High Logistic Costs
- Lack of economies of scale's advantages
- Lack of key competences
- Lack of 3rd and nth tier suppliers
Chapter 3. Research Methodology

3.1 Introduction

In order to develop the research proposed in the previous chapters, the author will follow a research methodology that includes 2 different main pathways. These 2 different pathways refer to the 2 different sources of information and analysis that will help develop the project and that converge in a point in which both of them contribute in the work proposed:

1. **Literature Review and Success Cases Analysis**: Review of the literature and cases around the world that provide insightful information about the problematic that the aerospace industry faces, specifically the problematic faced by the Industry in Mexico. These research include the comprehensive understanding of the situation of SMEs around the world, the need of them to be globally competitive and different frameworks for integrating them into global supply chains.

2. **Specific Aerospace Projects**: Projects done as a result of the joint work of the Tec de Monterrey’s Center for Innovation in Design and Technology (CIDYT) and an Aerospace Original Equipment Manufacturer (OEM) with operations in Mexico. These projects resulted of the analysis of specific issues that the Aerospace Industry is facing in Mexico. They aim to improve the overall efficiency of it and the methodologies and results will be presented in the following chapters.

Both sources of information complement each other in a very interesting way as presented in Figure 3.1.
3.2 Overall Steps

3.2.1 Work flow perspective

In Figure 3.2 a representation of the steps followed for the complete research process is presented. As a watermark in the left part, the projects specific methodology is shown and has two different key procedures: The Background of it that gave birth to the projects and the analysis of the results after its completion are shared with the main part of the diagram, this means that the problematic they address is the same as the rest of the thesis and the solutions are one piece of the overall process presented. The main steps are as follows:

1. **Context Analysis:** This includes formal and informal talks with more than 10 members of the aerospace industry in Mexico, the initiative of different government levels, research on the Aerospace Industry Supply Chain done by the author at Monterrey Tech and at Arizona State University and the need of Monterrey Tech to validate new programs that focus on the development of the Aerospace Industry in Mexico.

2. **Topic Selection:** After defining in the previous step the need to develop the Aerospace Industry Supply Chain in Mexico, the author look up for the best way to do this. Understanding all the particularities of the Aerospace Industry, of the Mexican culture, context and socio-economic situation and of the newer trends in the world to create collaborative work, a tentative topic is narrowed to trying to create a particular model for the development of aerospace clusters in Mexico through collaborative networking principles.

3. **Literature Review:** All the aspects involved in the research topic selection were studied and understood from the general aspects to the particular ones. One of the main focus of the Literature Review was to address strategic aspects of the aspects mentioned in the project topic. Because trying to develop an entire cluster is a very strategic decision for a country, a region or even for people and companies, a systemic approach was used to be able to integrate strategic level decisions and planning for the project.

4. **Hypothesis Definition:** After reviewing the literature, a conclusion was reached proving that the topic of interest is worthy to do an investigation likes this. That there is real possibilities to achieve the expected results and that the topic of interest is something novice for the particular field of study. A hypothesis stating these aspects is written.

5. **Methodology of Analysis and Evaluation Design:** In order to do everything necessary to prove the hypothesis right, a complete and detailed research method needs to be done, and is written explicitly.
6. **Framework Design**: In this part the author proposes specific methodologies and functions. Because of the complexity of this step, the author presents in more detail in section 3.3 and in Figure 3.4.

7. **Case Study Specific Results**: The project was done as the joint interest of Monterrey Tech, an OEMs and different Government instances contributing with information. This phase of the project integrates the results obtained in the different specific projects with the results of the research and broader analysis done. A team of five Tec de Monterrey’s undergrad students worked in this implementation phase.

8. **Further Steps Definition**: As stated in the scope of this project (Section 1.6), this project has a limited time frame and intends to be the cornerstone for the creation of a globally recognized and world-class aerospace cluster in Mexico. Because of this limitations and ambitions, an important part of this project is the definition of furthers steps in the areas of Research, Implementation and Business Development.

9. **Conclusions**: Such integrating and complex research project like this that innovates in many different aspects of the way of doing business in Mexico naturally gives plenty of conclusions and insightful comments about it.

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**Figure 3.2 General Steps in the Research Process**

![Diagram of General Steps in the Research Process]

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3.2.2 Conceptual research perspective

In Figure 3.3 a completely different representation of the research method is proposed. This perspective focuses on the conceptual explanation of the relationships involved in the research. Five different general steps are presented in the integral representation:

1. **Aerospace Industry Cluster Concept Definition**: A conceptual definition of the Aerospace Cluster is done, including its strategic plan and life-cycle expectations. Some aspects about the governance of the Cluster will also be defined here.

2. **Definition of features for the Cluster**: A complete list of functions for the collaborative network will be proposed, this list will include 14 characteristics already proposed by ECOLEAD to be available in any given collaborative network, plus a list of characteristics that were determined based on different aspects of Mexico and the Aerospace Industry.

3. **Evaluation of the features**: Because the economic and global situation of the involved entities, the project has a limited timeframe and the need of results is urgent. Because of these special characteristics, an evaluation of the features is done based on different aspects. The ultimate result is a differentiation of the functionalities in 3 different groups that will be based on the urgency of each of them.

4. **Specific implementation strategies**: The differentiation done in the previous step leads you the need of creating a master strategic plan of the cluster based also in the time axis. This implementation will program each activity.

5. **Global implementation strategy**: In order to integrate the master strategic plan in the timeframe, general implementation activities for the network should be planned in advance to guarantee the growth of the collaborative network.

Figure 3.3 Steps in the Research Process (Conceptual view)
3.3 Framework Design

3.3.1 General Steps
In Figure 3.4 a summary of the 5 steps done in the pursuit of creating the Aerospace Industry Cluster is proposed. Each of this 5 general steps will be further explained in more detail next.

Figure 3.4 General Steps in the Research Process

3.3.2 Conceptual Definition of the Aerospace Industry Collaborative Network
Based on ECOLEAD’s ARCON reference language, a concrete conceptual definition of the Aerospace Industry Collaborative Network is developed. In this section all 3 basic dimensions will be defined briefly but; the life-cycle dimension will be better explained as part of the strategic plan in step 2 of Figure 3.4 and the environment characteristics dimension will be better addressed in steps 3 and 4 because it is the main purpose of this work.

3.3.3 Strategic Plan Definition
In this part a complete Strategic Plan is created for the network and is to be ready to be replicated separately as a mean to completely explain the nature and objectives of the network. It will include the following sections:
- Background
- Mission Statement
- Vision
- Values and Convictions
- Goals
- Strategies
3.3.4 Definition of functionality per strategy
One of the main outputs of the Strategic Plan is the definition of 6 global strategies for the collaborative network that can be seen in Figure 3.4. These global strategies can be further deployed into specific functionalities. The functionalities will basically come from 2 different sources: from the functionalities defined by the ARCON reference model and some of the ECOLEAD tools and also from an analysis of specific requirements by the Aerospace Industry in Mexico.

3.3.5 Analysis and development of different functionality
Of all the possible functionality previously defined for each strategy, a first analysis will be done in order to prioritize a group of functions that will be the base for the implementation of the collaborative network, a second group will be functions that are known to be desired immediately but because of the scope of this research project, they will not be developed in detail in this work, the third group of characteristics are considered functionalities desired for the network but that they are not planned to be implemented or addressed in the immediate future.

After having the selected group of functions to be further developed, a more complete development of each of them will be done. This development will include background, justification, objective, actors, governance rules, complete concept explanation, models of execution and an explicative sample.

3.3.6 Definition of General Instantiation Process
For the three different groups of functions and following the strategic life-cycle plan, a general instantiation process is presented that includes the requirements for the functions to be implemented an a tentative schedule for this to happen.
Chapter 4. Aerospace Cluster Framework

4.1 Introduction

For the purpose of this research, we understand a framework as the conceptual structure used to give a better understanding (or to give a preferred approach) to the Aerospace Industry Collaborative Network (AICON) idea. As stated in the previous chapters, a framework is needed in order to be able to create a Collaborative Network (CN) for the Aerospace Industry in Mexico in a systematic and organized way. The framework will include the following main sections:
- Conceptual Definition (4.2)
- Strategic Plan (4.3)
- Complete Functionality (4.4)
- Functionality Implementation Analysis (4.5)

4.2 Conceptual Definition

4.2.1 Generalities

The Aerospace Industry Collaborative Network is an innovative business concept that works with the objective of developing a World-class Aerospace Supplier Cluster in Mexico. It was originally created as a joint venture project between Monterrey Tech’s Center for Innovation in Design and Technology (CIDyT) and an Aerospace Industry Original Equipment Manufacturer (OEM) in their quest to improve the competitiveness of Mexico in this Industry. In Figure 4.1 a diagram of the 3 main perspectives that will be used to define the Aerospace Industry Collaborative Network (AICON) in Mexico are shown based on ARCON.

4.2.2 Life-Cycle Stages Perspective

In order to completely define the business case of the Aerospace Industry Collaborative Network (AICON), the Life-Cycle perspective helps to define the different stages that the network will go through. In Figure 4.2 a representation of this model proposed by ECOLEAD is presented. It is
important to notice, that since there has not been any work before this of such a network, in this research we define since Stage 1 (Creation) and not just operative Stages. In a typical well established long-term organization, Stage 2 (Operation) constitutes its entire livelihood and therefore is the one analyzed in detail. Because of the scope of this research, Stage 4 (Metamorphosis and Dissolution) will not be addressed; we plan this project to stay for a long time. Life-Cycle Stages briefly explained for AICON:

**Figure 4.2 Life-Cycle Perspective for the Conceptual Definition of the Aerospace CN**

1. **Creation**: This is one of the most important parts of any project, and represents what is mainly discussed in the first 3 sections of this Chapter. As it can be seen in Figure 4.2, it is further divided in two different phases:
   a. **Initiation**: Deals with the initial incubation of the network and the definition of the concept, business case and strategic plan. This information can be seen in detail later in this Chapter.
   b. **Foundation**: Deals with the constitution and start up, because of the scope of this project, it will only be mentioned but its realization is included in the Further Steps and Research Section of this work in Chapter 6.

2. **Operation**: This is the most important phase and its planning is discussed in Section 4.4, 4.5 and 4.6 of this Chapter. For the case of this Aerospace Industry Collaborative Network, the operation of the network will be based in 6 strategies. These strategies serve as the main guidance towards the achievement of the goals presented in Section 4.3.

3. **Evolution**: Refers to the changes to the strategic plan or business structure of the network that could be done later. For the case of AICON, evolution is presented as part of the S-Curves graph in Section 4.3.7. It is based on the anticipation of changes in the needs that
originally gave birth to this specific business concept. The evolution will be done basically in 3 different directions:

a. **Membership and Structure:** Refers to the further replication of the concept to different regions in Mexico and other countries, always looking for the integration of these new regions as sub-networks belonging to the general AICON. This can be further analyzed in the Environment Characteristics Perspective.

b. **Production outputs:** Refers to the ability to expand the core aerospace gamma of products, from the original focus of metal-mechanical components (Sheet Metal) stated in the Strategic Plan in Section 4.3, to other electro-mechanical components, system assemblies and more. This expanded production outputs change the overall strategic plan of the network and unleash a change in the structure and organization of members, competencies and quality standards.

c. **Governance:** Because of the Scope of this Research, eventual changes in the leadership of the network must be anticipated. These changes in leadership may be the causal for a wave of changes in the strategic plan.

4. **Dissolution or Metamorphosis:** Because the Aerospace Industry Collaborative Network (AICON) is designed as a Long-term alliance of members, its increasingly valuable bag of assets can not be ignored from one day to the next. The dissolution of the network is not yet planned. As mentioned in the previous remark, the most probable thing to happen is to lead AICON through a series of evolutionary processes. These evolutionary processes are planned to be accomplished in small and anticipated phases, discarding the possibility to be considered as a metamorphosis change.

In general, the whole Life-cycle perspective can be appreciated in the Strategic Plan of Section 4.3, mainly on the Strategic Life-Cycle plan of it that includes the S-Curves graph.

**4.2.3 Modeling Intents Perspective**

In order to be able to define the different levels of abstraction for any CN, ARCON proposed that a CNO reference model can be defined at three multiple levels. Following this perspective, and due to the nature of AICON, the three levels will be briefly explained according to ECOLEAD:

- **General Representation layer:** That includes the most general concepts and related relationships, common to all CNOs independently of the application domain (e.g. all kinds of VBEs independent of the area).
- **Specific Modeling layer**: An intermediate level that includes more detailed models focused on different classes of CNOs (the CNO typology).

- **Implementation Modeling layer**: Represents models of concrete CNOs.

A more detailed explanation and representation will be done to place the work of the research in this frame. In Figure 4.3 can be appreciated that the General Representation (1) will not be addressed in this research. It will be assumed that ARCON is the general framework for this layer and therefore, no analysis is done. The main purpose of Chapter 4 is to present the adaptation of the Specific Modeling (2) to the Aerospace Industry, creating in this way the Aerospace Industry Collaborative Network (AICON) framework and business basis. Furthermore, the Implementation Modeling (3) for AICON is the specific CNs derived from it, and with some of its initial results presented in Chapter 5.

The two different layers of the model-intents perspective that are addressed are the following:

1. **Specific Modeling**

   It refers to the creation of the adaptation of ARCON Model to the Aerospace Industry into what the author calls Aerospace Industry Collaborative Network (AICON) and that differs from ARCON in the ability to address the interesting and distinct problematic of the Aerospace Industry. AICON is proposed to be the basis for a Nationwide Virtual Cluster.

   Besides being the framework for the different IMPLEMENTATION MODELS that could be generated, the specific modeling layer is used as the basis for the creation of an integrative CN for the whole Mexican Aerospace Industry with a project also called AICON. The author proposes that AICON will integrate all the traditional Aerospace CNs that may be generated across Mexico as shown in Figure 4.4.
2. Implementation Modeling

As mentioned before, AICON that is the network at the Specific Modeling level will integrate different Aerospace CNs across Mexico. There are basically two different kinds of implementation CN models for AICON: The regional CN that will be based on agglomerations of Aerospace Industries in a certain geographic position and Hub-&-Spoke CNs that refer to the implementation of CN for an OEM and their network of suppliers. These 2 different implementation models rely on the traditional approach to Clusters (Not necessarily virtual ones). The justification to propose these 2 different models is that there are always security, traceability and intellectual property issues in the Aerospace Industry that create the necessity of trying to keep private channels of communication for certain issues in the OEM-Driven CN. In the other hand, Regional CNs are based in common issues and information for certain locations and that not necessarily need to be kept privately.

Region and OEM driven CNs will also be integrated in AICON in such a way to look for the general improvement of the Country, specially the Mexican Brand Image. It could be suggested that for this case it would not be necessary to create region-driven CNs but after the understanding of the Mexican cultural context, region CNs are primarily proposed because of the lack of cooperation possible between regional or state governments. And because a strong player in the behavior of CNs (ultimately Clusters) are governments (because of their project funding, infrastructure creation and coordination abilities), the necessity to keep some other functionality in private for such subnets is taken into account.
4.2.4 Environment Characteristics Perspective

In order to be able to comprehensively model a CN, the environment characteristics are very important. As environment characteristics, ARCON proposed that you will include all the aspects necessary to explain the network. All these aspects can be further grouped in 2 main categories or subspaces as can be seen in Figure 4.5.

**Figure 4.5 Environment Perspective for AICON**

Endogenous and Exogenous Subspaces of the Environment Characteristics Perspective are explained in more detail in order to better explain AICON.

1. **Endogenous elements**: Models the network for every internal aspect. This perspective aims at providing an abstract representation of AICON from inside, namely the identification of a set of characteristic properties that can together capture the elements constituting it. As can be seen in Figure 4.5, endogenous elements can be organized in the following four dimensions:

   a. **Structural Dimension**: As stated in the Modeling Intents perspective, there will be two main different kinds of CN among AICON, the Regional and the Hub-&-Spoke. In the Regional CN, all participants of the network will be equal and from the same region, meaning that the leadership will be done by the network manager and its board of regents. In the Hub-&-Spoke, due to privacy issues, the Hub (in this case the OEM) will have responsibilities shared with the network manager, decisions will be done together and affect the rest of the membership.
b. **Componential Dimension:** Referred to all the tangible and intangible elements in AICON, most of these resources will be shared among the Subnets. Among the resources shared for all Subnets are Managerial human, technological, infrastructure, software and hardware resources and even some knowledge resources. Knowledge resources are some of the basic differences that could exist between the variety of Subnets in AICON.

c. **Functional Dimension:** This refers to all the functions and operations available in the network for the management team and for the members of it. This is the main distinction of AICON from traditional researched CNs like ECOLEAD and is the main part of this research. Because of the level of detail of the functionality proposed for the network, Section 4.4 will be used to propose and explain the reasoning of this, and Section 4.5 to analyze the timing in which the different functionality should be implemented for AICON.

d. **Behavioral Dimension:** According to ARCON, this dimension explains the principles, policies, and governance rules of the CNO. This section is based on the principles proposed by ECOLEAD to manage collaboration, trust, contracts and policies. The only difference is the commitment of AICON members to be continuously improving and assuring their quality levels. This seek for continuous improvement will be based in the fact that to be member you need to approve evaluations by AICON. This evaluations are basically a Self-assessment tool to diagnose the situation of the company at that time and will be further explained in Section 4.5.

2. **Exogenous elements:** Models the network for every external aspect. This perspective aims at reaching an abstract representation of the CNO as seen from the outside, i.e. which characteristic properties the CNO reveals in its interaction with its “logical” surrounding environment. The purpose here is not to model the surrounding environment but focus on the interactions between the CNO and this environment. As can be seen in Figure 4.5, exogenous elements can be organized in the following four dimensions:

   a. **Market Dimension:** As stated by ARCON, This dimension covers the issues related to both the interactions with customers and with competitors. For
AICON as a whole, customers will be generally OEMs and companies in Northamerica, because of its closeness. Customers in Europe and South America may be attended in some degree. As stated before, Mexico is the 10th largest supplier for the U.S., if we speak of AICON as the Mexican Industry, competition comes from countries in Europe, Brazil, Korea, China and Japan. For the Subnets, they will have to develop themselves thinking as other regions or hubs as competition, but never forgetting that the development of all of them is good for all in the long term. The target market is selected to be mainly metal-mechanical components, specially fabrications and sheet metal, this aspect evolving according to the Life-cycle perspective in a future. The value proposition of AICON and its subnets will include the highest quality, high responsiveness and competitive prices in that order of priority. Most of this dimension can be appreciated in Section 4.3 the Strategic Plan.

b. **Support Dimension:** Third party service providers are considered for AICON. For example the theoretical foundation will be worked jointly with CIDYT’s ECOLEAD Project, continuous education by CIDYT’s CAP Aeroespacial and Monterrey Tech other departments, accounting, insurance, auditing, business coaching, logistics and other areas could also be outsourced for the network.

c. **Societal Dimension:** This dimension explains both the societal implications in AICON and also the other way around. AICON is ruled by the society and economic situation prevailing around the world. It assumes democratic governments to rule and make respect the legal frame of Mexico and of the different regions involved. A free-trade economy in which AICON will have to be price competitive to succeed and despite possible, Government aid and subsidies are not vital for such competitiveness. About the role of AICON in the society, AICON will be the center of new strategic communities’ orientation. It will have strong nexus with Colleges, Technical Schools, Government and Civil Groups in the quest to reshape the society into a knowledge-based one. Economic aspects are going to be a key factor of the success of AICON, the amount of money that this Industry can spill over the regions (in the form of employment, infrastructure investment, taxes, complementing services) and in the development of the Small and Medium-Sized Enterprises (SMEs) in Mexico.
4.3 Strategic Plan

4.3.1 Background

The Aerospace Industry represents almost US $500bn around the world and for some countries like the U.S., more than 15% of their economy is related to this Industry. Mexico is trying to become a new player, despite supplying just US $600m to the U.S.-based Industry, it has been showing several signs of growth and consolidation. We supply just 0.9% of U.S. aerospace imports, despite being one of their biggest providers in the rest of the economy. Mexico needs to innovate to the traditional way of doing business if it wants to succeed in the Aerospace Industry. Mexico needs to become highly competitive in a market in which we are incumbents and in which our traditional core competencies (cheap labor, closeness to the U.S. and strategic position in the global economy) are not great differentiators. The Mexican Federal Government has defined the Aerospace Industry as one of the key strategic sectors for Mexico in the 21st century, but the HOW of this has not been approached by anyone yet. This opportunity for the Mexican economy cannot be overlooked. Therefore an entity in charge of looking for the overall good of the Industry needs to be proposed and implemented.

4.3.2 Mission Statement

To assist and excel the development of an Aerospace Industry Collaborative Network in Mexico, by supporting the creation, development and success of its members.

4.3.3 Vision

To be recognized by 2015 as the cornerstone and anchor of an internationally renowned cluster of Aerospace Suppliers in Mexico.
4.3.4 Values and Convictions
To attain the success formulated in our Mission, the CN believes in the following values: Innovation, leadership, excellence, passion, risk pooling, commitment, empowerment and integrity.

4.3.5 Strategies
For the accomplishment of the CN goals, the strategy will focus all its activities in 6 different main strategies:

1. **Fair and efficient management**: Refers to the management of the CN itself in an efficient and streamlined way. The network should always be careful about promoting fair agreements among the members.

2. **Growth and consolidation**: General strategy that looks for the continuous success and growth of the CN.

3. **World-Class Quality and Operations**: Groups all the functionality and management activities that ensure the quality in the CN management operations and promote it among its members. Every functionality and operation of the network and

4. **Recognized Cluster Image Development**: In order to achieve the goal of being recognized by 2015 as an international renowned cluster, different activities should be done systematically to promote the cluster outwards and improve the cluster inwards.

5. **Self-Sustainability**: No entity can survive on charity, so the CN needs to define a price policy according to the economic situation in Mexico but good enough to be able to implement the functionality required.

6. **Knowledge-Based Networking**: The CN should serve as a promoter of technology transfer among its members and the rest of the Industry world-wide. This includes the seek for knowledge-based work and decision-making for the network and for its members operations

4.3.6 Goals
We seek for the integration of the Aerospace Industry in the Mexican economy and will organize specific goals in the categories created by the 6 strategies:
1. **Fair and efficient management**
   a. Manage the collaborative network in a transparent way to all the members, making public 100% of the information and financial states upon request.
   b. Streamline the process of managing collaborative networks and attain ISO 9000 certification for management purposes by 2009.

2. **Growth and consolidation**
   a. Increase participation of quality aerospace members. To have 20 participating members by the end of 2008, 40 by the end of 2009 and have enough companies by 2015 to represent 70% of the Mexican Aerospace Production.
   b. Increase the position of Mexico as a supplier of Aerospace products for the U.S. in order to become the 6th largest supplier by 2015.

3. **World-Class Quality and Operations**
   a. Ensure high quality operation in the management of the Collaborative Network and achieve at least once the Mexican National Quality Award (Premio Nacional de Calidad) by 2015.
   b. Have more than 50% of members certificated ISO or AS 9000 by 2010, and increase to 75% by 2015.
   c. Have high quality operations and be successful in all the functionality defined in detail in Sections 4.4 and 4.5 of this research and attain their specific implementation goals.

4. **Recognized Cluster Image Development**
   b. Increase the position of Mexico as a supplier of Aerospace products for the U.S. in order to become the 6th largest supplier by 2015.
   c. Creation of annual marketing campaigns to promote the cluster in Mexico and abroad.

5. **Self-Sustainability**
   a. Ensure positive figures by the end of 2008 and brake-even point by the end of 2009.
6. **Knowledge-Based Networking**
   a. Involve 80% of the network members in any of the options for technology transfer available in the network services by 2010.
   b. Generate at least 10 research papers and case-study reports of projects originated within the network by 2010.

**4.3.7 Strategic Life-Cycle Plan**

An important part of the Strategic Planning is to know exactly where AICON is heading. For the timeframe that has been considered, 2015 is the horizon year for all purposes. The proposed life-cycle plan in Figure 4.3 includes the presence of 2 different technology S-CURVES. These curves represent the natural limits of the network against different critical dimensions. The following key dates are planned ahead:

a. **CREATION - Initiation:** The complete and detailed definition of the business concept. Done in this research and during the first semester of 2008.

b. **CREATION - Constitution:** Deal with the official start-up planned for Summer 2008. At this point of time, the registration of network members will start and the first services planned in Section 4.4 of this research will take place.

c. **OPERATION - 1st Phase Integral Growth:** Region of the S-curve between the two slow growth stages of Creation and Evolution. Growth in this region is maximum and also other critical dimensions like profit, expansion and consolidation indices.

d. **EVOLUTION:** Point in time (2012) in which the main focus of metal-mechanical components will not be enough for a Mexican Aerospace Cluster eager to continue its growth and development. A shift in the prioritization will happen in order to deal with more value-added aerospace components, like larger subassemblies, electro-mechanical components and a greater integration of the Supply Chain by developing raw material suppliers.

e. **OPERATION - 2nd Phase Integral Growth:** Region of the S-curve after dealing with the evolution into more complex products and before reaching the natural limit of this second s-curve. Growth in this region is also maximum and the other critical dimensions like profit, expansion and consolidation indices too. It approaches the revised limits in a
steady state and levels the terrain for another continuous evolution or maybe a METAMORPHOSIS of the network.

Figure 4.3 S-Curves Life-cycle

4.4 AICON Functionality

4.4.1 Introduction

As mentioned before, due to the scope of this research, a complete definition of the Aerospace Industry Collaborative Network will only be done in the Endogenous Elements Perspective, specially the Function Dimension. This Functionality Dimension is analyzed in this section 4.4.

ARCON Proposed to analyze every endogenous perspective elements in the following four categories according to their nature. This serves to better represent their modeling semantics:

- **Active entity**: a tangible object that can behave and/or perform an action in the CNO, e.g. an organization, or an individual, e.g. the CNO member/partner organizations.
- **Passive entity**: a tangible object that cannot behave and/or perform any action in the CNO; rather it is a “object” on top of which actions can occur, e.g. an information resource, or an ICT resource.
- **Action**: A procedure or operation that is executed within the CNO, e.g. the CNO’s member registration, competency management, contract negotiation, conflict resolution processes.
- **Concept**: An intangible aspect in the CNO that can be also associated with Active/ Passive Entities or Actions, e.g. the role (associated with an organization in the
CNO), brokerage principles (associated with the VO creation processes), or conflict resolution policies (associated with the CNO operation management processes).

For the Functional Dimension, ARCON defined concepts only for Action and Concept Categories. In the following sections we will deal with the definition of the Action Functionality of AICON. It is important to mention that some of the functionality proposed is included in ARCON as a standard for every kind of CNO. Because AICON is defined as a Long-Term Strategic Alliance (LA) of companies, it can be categorized as a Virtual Breeding Environment (VBE) according to ECOLEAD terminology. And because AICON is a VBE, it will include the Action Functions proposed by ARCON for this kind of CN.

Besides the standard functionality proposed by ECOLEAD for VBEs, a set of special functionality is proposed for the case of an Aerospace Industry CN in Mexico. This new set of functions was derived from the Analysis of this Industry. Proposed functionality will not necessarily mean that it will be implemented in the first stages of the network. Section 4.5 will give the proper analysis in order to establish the importance of each function and the optimum timing in which it should be implemented.

In order to list this functionality that will be provided to the members and also for management purposes, the author proposes to organize the Action Category Functionality in the Global Strategies proposed earlier in the Strategic Plan of AICON. Functionality marked * is novice for this research, the rest has been previously documented by ECOLEAD.

4.4.2 Strategy 1: Fair and efficient management

1. Membership management
2. Profile and competency management
3. Trust management
4. Sub-network Inheritance/Performance management
5. Value System information management
6. Support institutions information management
7. Bag of Assets management
8. Creation of repositories
9. Setup LA management system
10. Bulk registration of founding participants
11. LA inheritance management
12. Decision support management

13. Continuous improvement management *

Look for the continuous ability to innovate and assure AICON is achieving goals, not diverging from concept definition and respect for global strategies.

4.4.3 Strategy 2: Growth and consolidation

14. Member enrolment

15. Member Self-Assessment *

Online tool open for members or interested companies that through a survey, can diagnose the ability of the company to meet aerospace standards needed for AICON and states the current gaps for that.

16. Roles/responsibility update requirements

17. Participants trust assessment

18. Sub-network creation

19. Sub-network registration

20. Members' rewarding

21. Investment opportunities finder *

Tool that provides different analysis of Functionality 21 in order to detect capabilities requirements of the network and if they were feasible.

4.4.4 Strategy 3: World-Class Quality and Operations

22. Aggregated demand Database *

For the Regional or OEM-driven implementation subnetworks, it contains an aggregated analysis of demand and its market value.

23. Sourcing process assessment and tutorial *

Gives recommendations in the sourcing process of AICON members in order to lean the supply chain.

24. AICON overall value-stream analysis *

Value-stream mapping of current supply chains created from the network in order to detect opportunity areas.

25. AICON Supply Chain/Logistics analysis and specific projects development *

Complete analysis done periodically that detects the biggest logistic issue at that time in order to generate concrete network projects to improve overall efficiency.

26. Virtual marketplace of resources *
Online tool that provides the ability for every member to share resources at fair prices. It includes the sell among members of scrap materials, machinery and tools leasing and human resources lending and assessment.

27. **Ontology adaptation/evolution management**
28. **Performance measurement**
29. **Virtual Organizations (VO) Creation general procedures**
30. **Opportunities finder and brokerage**

   Looks for new parts and products required globally and that may be feasible for the network and serves as an automated broker for AICON members.

### 4.4.5 Strategy 4: Recognized Cluster Image Development

31. **Aggregated demand analysis and market valuation**

   Creates analysis from functionality 21 in order to have a market value idea of AICON to leverage negotiations and for marketing purposes.

32. **Joint Marketing**

   Promotes AICON for the good of all its members. Is in charge of the creation of AICON and Mexican Aerospace Industry brand image.

33. **Promotion opportunities finder**

   Looks globally for fairs, workshops and congresses in which AICON can promote the industry as a whole.

### 4.4.6 Strategy 5: Self-Sustainability

34. **Membership pricing analysis**

   Defines the price for membership and other services.

35. **Brokerage services pricing analysis**

   Defines the price for brokerage services.

36. **Governments’ sponsorship management**

   Negotiates with Federal and State governments for funding, sponsorships and tax/aid agreements.

### 4.4.7 Strategy 6: Knowledge-Based Networking

37. **Virtual Forum**

   Online service in which members and externals can share experiences, ask for technical support and educate themselves in AICON taxonomy related topics.

38. **Joint Continuous Education Program**
Creates workshops and training programs open to all AICON members in order to share risks and costs.

39. Joint Research Program (Collaboratories) *

Coordinates joint research between members, programs and colleges.

40. IP Management

4.5 AICON Functionality Analysis and Development

4.5.1 Introduction

Of the 40 different functions included in the Action perspective of the Functional Dimension of the environment characteristic of the conceptualization of AICON, 18 of them are new to the earlier works by ECOLEAD and the ARCON modeling framework. These 18 new functions need to be justified in order to be included for the Aerospace Industry VBE proposed by this research.

4.5.2 Analysis of proposed functionality

The Definition, Justification and Expected Benefits of each of these 18 functions are presented next:

13. Continuous improvement management
   a. Definition:
   Looks for the continuous ability to innovate and assure AICON is achieving goals, not diverging from concept definition and keeps all the operations aligned to the global strategies.
   b. Justification:
   Like ISO:9000 standard states, organizations should not assume that continuous improvement will be done by just mentioning it in the Strategic Plan. There should be a specific management program in the organization to keep track of all these efforts.
   c. Expected Benefits
   A management system that will cover all the key processes in the network to be recorded, evaluated and continuously improved according to Six Sigma Methodology of DMAIC (Design-Measure-Analyze-Improve-Control) for every function.

15. Member Self-Assessment
   a. Definition:
Online tool open for members or interested companies that through a survey, can diagnose the ability of the company to meet aerospace standards needed for AICON and states the current gaps for that.

b. Justification:
There is no standardized way to diagnose the ability of a company to start doing business with the aerospace industry. Different Aerospace OEMs have different assessment tools when seeking to develop new suppliers, the integration of this different assessment tools could provide an easy way for companies to see how far are they of Aerospace Industry. It will also be a requirement for companies to enter AICON, they must have at least certain score in the self-assessment tool to guarantee a successful incursion into this industry.

c. Expected Benefits
Automatic online system that will give any company the ability to see if they are potential aerospace suppliers. The assessment will be in such a way that will be able to encourage companies that tend to avoid entering the Aerospace Industry due to some misunderstandings. It will also indicate the necessary gap to reach different aerospace supplier levels, giving companies a good development plan. And by asking certain score to enter AICON, this tool guarantees that every company in the network has proved capacity.

21. Investment opportunities finder *

a. Definition:
Tool that provides different analysis with the information of the aerospace parts' demand database presented in Function 22 in order to detect capabilities requirements of the network and if they were feasible.

b. Justification:
Nowadays, there are some competences that no member of the Aerospace Industry in Mexico has and that are reducing the pool of potential parts to be manufactured in Mexico. If a systematic tool could be able to detect which processes, or capabilities would be useful in order to increase by X% this pool of parts, companies will have more certainty about where to invest their valuable resources.

c. Expected Benefits
Periodical recommendations to all the members of AICON telling them which competences that no one have, are the most demanded in parts and the financial analysis to relate those demanded parts with the investment cost and profit expectations.
22. Aggregated demand Database *
   a. Definition:
   For the Regional or OEM-driven implementation subnetworks, it contains an aggregated analysis of demand and its market value that includes process requirements, general information and market value of every demanded part.
   b. Justification:
   Every Aerospace OEM doing business in Mexico or anywhere else deals with this issue. There is no recorded information about the historic demand of aerospace parts that were potentially assigned to Mexican suppliers. And even worse, there are no attempts to organize this historic demand in order to classify it in a logic way. Complete sets of parts’ drawings are sent now to potential suppliers in Mexico when asking for part quotes. These sets of parts were never analyzed and require a lot of time of the Mexican supplier, so at the end, just 1 or 2% of the parts in these sets are feasible for the company.
   c. Expected Benefits
   The ability to have a db of classified parts will improve the process of assigning demanded aerospace parts to potential suppliers by filtering this sets and automatically send packs to quote to all suppliers in the network.

23. Sourcing process assessment and tutorial *
   a. Definition:
   Analysis of the sourcing process taking place in the OEM-driven implementation models of AICON. This function gives recommendations in this sourcing process in order to lean the supply chain.
   b. Justification:
   Very long lead times are occurring now in the Mexican Aerospace Industry much earlier than the point of time in which the parts are actually produced. Mexican suppliers may be technically skillful but in order to be price competitive, they need to lean their processes and improve their value proposition to OEMs.
   c. Expected Benefits
   A reduction in the lead time between the definition of parts to be potentially manufactured in Mexico, to the time in which the parts actually start their production. The human resources needed to accomplish this tasks will also be reduced and the economical implications of this too.
24. AICON overall value-stream analysis *
   a. Definition:
   Value-stream mapping of current supply chains created from the network in order to
detect opportunity areas.
   b. Justification:
   There are no analyses of the entire supply chain in order to check for the level of leanness
of it. In order to be competitive as a country, a lean and streamlined value-stream is
necessary.
   c. Expected Benefits
   Value-stream mapping of the different supply chains that emerge from members of the
network. A periodical analysis of the red-light spots in the value stream in which
potential improvements have not been done yet.

25. AICON Supply Chain/Logistics analysis and specific projects development *
   a. Definition:
   Complete analysis done periodically that detects the biggest logistic issue at that time in
order to generate concrete network projects to improve overall efficiency.
   b. Justification:
   There is no capacity by any single company to coordinate analysis of logistic procedures
as a whole. SCM/Logistics include transportation, inventory, packaging, facility location,
and many other components of cost that need to be improved in order to be price-
competitive. And this logistic cost may even reach 35% of the final product price, if a
systematic analysis could be looking periodically to analyze this cost in components,
significant cost savings may take place.
   c. Expected Benefits
   Periodical projects implemented in order to reduce overall logistic costs for the network
members based on the fundamental approach of seeing it as a whole. Some of the main
benefits may include and increased risk pooling, inventory consolidation and arms-
length influence on suppliers.

26. Virtual marketplace of resources *
   a. Definition:
   Online tool that provides the ability for every member to share resources at fair prices. It
includes the sell among members of scrap materials, machinery and tools leasing and
human resources lending and assessment.
Due to the low volume and the high raw materials price that takes place in the Aerospace Industry, Mexican companies are dealing with the problem of having to buy raw materials in the U.S. or Europe in the smaller batch size possible, but that still may be 6 or 10 times larger than the amount required. This raw material remaining implies a huge inventory cost due to the low mobility of materials in this industry for any given supplier. If scrap materials could be shared, the inventory consolidation benefits derived from it will mean win-win situations for all the members of the network. Another problem is when raw materials are bought abroad, lead times may be as high as 6 to 8 weeks for the company in Mexico.

c. Expected Benefits
Reduction in inventory holding costs, buy-out prices and lead times.

30. Opportunities finder and brokerage *

a. Definition:
Looks for new parts and products required globally and that may be feasible for the network and serves as an automated broker for AICON members.

b. Justification:
With the arm-length of representing the whole Mexican Industry, larger opportunities may be found for parts and subassemblies with potential to be worked in Mexico. Nowadays, Mexican aerospace SMEs don’t have the visibility to reach all potential aerospace customers, and therefore don’t have access to big-enough markets.

c. Expected Benefits
Increased amount of parts assigned (or at least quoted) to the Mexican Aerospace Industry.

31. Aggregated demand analysis and market valuation *

a. Definition:
Creates analysis from Function 22 in order to have a market value idea of AICON to leverage negotiations and for marketing purposes.

b. Justification:
There is no certain information about the real market size of the aerospace industry in Mexico. Nobody knows the market and this affects the industry in many ways.

c. Expected Benefits
By having a better estimate of market value by segments, by regions or by contractor, this information will be available for the network and its members and better business intelligence may be used for many reasons.

32. Joint Marketing *
   a. Definition:
   Promotes AICON for the good of all its members. Is in charge of the creation of AICON and Mexican Aerospace Industry brand image.
   b. Justification:
   Mexico has no reputation in the global Aerospace Industry, and the Aerospace Industry has no reputation in Mexico.
   c. Expected Benefits
   An excellent quality, price and responsiveness brand image for the entire Aerospace Industry in Mexico.

33. Promotion opportunities finder *
   a. Definition:
   Looks globally for fairs, workshops and congresses in which AICON can promote the industry as a whole.
   b. Justification:
   Many Mexican SMEs may not be noticed of international events and aerospace fairs in which they could have been doing business. There are no specific or easy ways to promote the image of a country’s industry.
   c. Expected Benefits
   Complete calendar of events around the world with business opportunities and also a database of aerospace organizations around the world.

34. Membership pricing analysis *
   a. Definition:
   Defines the price for membership and other services.
   b. Justification:
   A good pricing policy needs to be done in order to guarantee sustainability for the network, but it should also not be high enough to discourage companies to join the network.
   c. Expected Benefits
Guarantee self-sustainability.

35. Brokerage services pricing analysis *
   a. Definition:
   Defines the price for brokerage services
   b. Justification:
   A good pricing policy needs to be done in order to guarantee sustainability for the network, but it should also not be high enough to discourage companies to join the network.
   c. Expected Benefits
   Guarantee self-sustainability.

36. Governments’ sponsorship management *
   a. Definition:
   Negotiates with Federal and State governments for funding, sponsorships and tax/aid agreements.
   b. Justification:
   Every Country’s Aerospace Industry in the world is being supported financially by their respective governments. AICON should be the leading Mexican organization to receive this government aid and make it work for its members.
   c. Expected Benefits
   Increased funding by federal and state governments for research and implementation projects. A joint definition of tax policies, subsidies and foreign trade agreements to increase the competitiveness by government and the private sector represented by AICON.

37. Virtual Forum *
   a. Definition:
   Online service in which members and externals can share experiences, ask for technical support and educate themselves in AICON’s taxonomy related topics.
   b. Justification:
   There are abundant web forums around the internet on almost any topic. Somewhat, Aerospace Industry is not very common on these forums, so AICON will provide this virtual tool. Members of the network may have technical questions, meaningful experiences or simply may want to inform the rest of the members about different things.
38. Joint Continuous Education Program *
   a. Definition:
   Creates workshops and training programs open to all AICON members in order to share risks and costs.
   b. Justification:
   Nowadays, some training courses in quality, accounting, foreign trade, lean, supply chain management are generally very expensive for independent companies to afford it. Also the hiring of international consultants for specific issues is something practically impossible.
   c. Expected Benefits
   An increased amount of training courses, certifications, conferences and a greater participation of companies due to the cost sharing of them.

39. Joint Research Program (Collaboratories) *
   a. Definition:
   Coordinates joint research between members, programs and colleges.
   b. Justification:
   Some specific areas and core processes of companies need to be deeply researched and improved. Different SMEs may be dealing with the same kind of issues in their work floors and does not have the resources needed to solve them. The Aerospace Industry needs to be linked tightly to Colleges and Universities.
   c. Expected Benefits
   Joint research papers and projects addressing common situations of the Mexican Industry, and that eventually could give the whole industry an edge technological advantage against the rest of the world.
4.6 AICON General Instantiation Process

4.6.1 Introduction
As mentioned before, a complete one-time implementation that includes all the functionality proposed for the Aerospace Industry CN (AICON) in section 4.5 would be very unreal and practically impossible to achieve. Therefore, all the functionality needs to go through several analyses to define the timing for their implementation.

For the purpose of this research, the author illustrates the organizational structure of the implementation procedures for the functionality of AICON in two different presentations.

- **Gantt Diagram**: Clearly specifies the Start and End dates of all the functionality.
- **Network Diagram**: Exemplifies the dependency relations of all the functionality.

There are 3 different main categories in which the events and functionality is organized in both diagrams.

1. **Key Events**: Sets the specific dates for the 4 milestones in the project in advance. This 4 fixed dates help organize all the rest of the functionality in different implementation categories, depending on the period in which they are planned to be implemented:
   a. **Project Planning Start**: Date in which AICON was conceived
   b. **Project Plan Review**: Research thesis proposing first steps by AICON evaluation
   c. **AICON Start-up**: Official operation start-up after being constituted
   d. **Anniversary Progress Review**: Periodic review done 1 year after the research review took place

2. **Concept Definition**: Sets the timing of the original conceptual definition for AICON.

3. **Strategically Organized Action Functionality**: For all the 40 action functions proposed for AICON, the timing in which they are planned and implemented is stated here for each of the 6 Global Strategies of the network.

For the purpose of this thesis, there are mainly two different kinds of activities and blocks in the GANTT diagram and in the NETWORK diagram respectively:

- **Blue Boxes or Charts**: Represent planning and general steps.
- **Green Boxes or Charts**: Represent the implementation period of that specific activity

4.6.2 GANTT Diagram
The following GANTT Diagram represents the implementation process:
**Project: Implementation Plan**

**Date:** Wed 12/5/07

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**Key Events**

1. Project Planning Start
2. Project Plan review
3. Start-Up
4. Anniversary Progress Review

**Concept Definition**

7. Idea generation
8. Life-cycle stages planning
9. Modeling intents planning
10. Environment characteristics planning

**Strategic Plan write-up**

12. Strategy 1: Fair and efficient management
   - Membership management
   - Implementation
   - Profile and competency management
   - Implementation
   - Trust management
   - Implementation
   - Sub-network Inheritance/ Performance management
   - Implementation

21. Value System information management
   - Implementation

22. Support institutions information management
   - Implementation

25. Bag of Assets management
   - Implementation

27. Creation of repositories
   - Implementation

29. Setup LA management system
   - Implementation

31. Bulk registration of founding participants
   - Implementation

33. LA Inheritance management
   - Implementation

35. Decision support management
   - Implementation

37. Continuous improvement management *
   - Implementation

**Strategy 2: Growth and consolidation**

40. Member enrolment
   - Implementation

42. Member Self-Assessment *
   - Implementation

44. Roles/responsibility update requirements
   - Implementation

46. Participants trust assessment
   - Implementation

47. Sub-network creation
   - Implementation
Chapter 5. Case Study Results

5.1 Introduction

Upon request of an Aerospace OEM in a joint project with Monterrey Tech’s Center for Innovation in Design and Technology, a partial implementation of AICON is reported in this Chapter. The idea is to implement some of the functionality proposed in Chapter 4 for this new Collaborative Network of the OEM and its suppliers. This partial implementation of AICON is done under the Hub-&-Spoke model proposed in the structural dimension of AICON as seen in Figure 5.1.

Figure 5.1 OEM Driven Implementation Model (Subnet)

This particular CN will be integrated lately to the nationwide AICON as a subnet. Members of this network may belong to more than one subnetwork, therefore, all the functionality will be implemented to the whole AICON and to this particular subnet according to the Implementation plan proposed in Section 4.6. Due to the scope of this project, just some of the designed functions were planned and partially implemented to this subnetwork and the results will be presented in the following section trying to cover at least the following points for each functionality: Background, Definition, Justification, Development, Results, Future Work.
5.2 Member enrollment (Planning & partial implementation)

5.2.1 Background
For the Collaborative Network (CN) driven by the OEM in this Case Study, a pool of companies needs to be addressed in order to implement the functionality required. At least 4 suppliers were already working with the OEM and partially collaborating to each other. Eventough for the moment 4 suppliers are OK, a larges amount of suppliers is desired in order to truly achieve economies of scale, risk and cost pooling and efficient management for AICON Subnets.

5.2.2 Definition
Functionality that looks for the continuous growth of the CN through the search and rollment of new members.

5.2.3 Justification
No network can work properly without enough members. With the increase of new members, new competences will be created and the overall efficiency of the network will tend to increase.

5.2.4 Development
The following general steps were done in order to implement this functionality:

1. Research of potential suppliers: First it was researched in public databases (Sistema de Informacion Empresarial Mexicano SIEM) about suppliers that could match desired competences for the industry. A visit to the OEM actual suppliers was also done to see which characteristics should the potential suppliers have.

2. Database (DB) fields definition: According to the information actually required by the OEM to its actual suppliers, the following field were defined as vital for the DB proposed:
   a. General Information: Supplier Type, Name of Company, Address, Neighborhood, City, State, ZIP, Country, Telephone Number, Fax, Corporate E-mail, Corporate Webpage
   b. Contact Information: First Name, Middle Name, Last Name, Title, Telephone Number, E-mail
   c. Company Profile: Areas of Involvement, Certifications, Business Ranking, Related Products, Actual Production, Machines & Number, Raw Material, Manufacturing Processes
3. **Database fillout**: Data obtained from the OEM was filled in a Database (DB) file in Microsoft Excel. Also a research was done with the pool of potential suppliers researched in Step 1 of this functionality.

4. **Database Filtering**: In order to be able to filter all unwanted companies, the following criteria was used:
   a. **Company Seriousness**
   b. **Number of employees**
   c. **Production volumes**
   d. **Number of machines**
   e. **Level of use of information technologies**
   f. **Level of interest in becoming aerospace suppliers**

5.2.5 Results

A complete database of potential members was done that included most of the information required by the previously defined fields. The DB includes 59 companies, all of them located within a radius of 40 km. from the OEM headquarters in Mexico. It is important to notice, that for this particular OEM driven AICON subnet, the same companies can be used as the foundation for the regional subnet in Monterrey, N.L.

5.2.6 Future Work

In order to have a better pool of suppliers, different methods should be used in order to have the first pool of suppliers. Many potential suppliers were left out due to the methodology used in the first step. The information missing for many of the companies should also be researched, it was noticed that many companies don’t even know some of the information, so Field Visits should be done by the team to be able to have a better diagnosis for each potential member.

5.3 **Sub network creation (Planning)**

5.2.1 Background

It is not enough to have a pool of potential suppliers like the DB created by the Member Enrollment Function. In order to be able to start working as a real CN (Specifically Virtual Breeding Environment VBE), some sort of commitment and planning needs to be done for the subnetwork.
5.2.2 Definition
Functionality that is in charge of inheriting AICON reference model functions necessary to create the subnet. It also starts the actual recruiting of founding members and defines the objective and governance of such sub-networks.

5.2.3 Justification
In order to be able to implement all the functionality of AICON in a pragmatic way for companies, real creation of the network needs to be done.

5.2.4 Development
This function was not implemented, but the following general steps were done in order to plan this functionality:

1. **Invitation to potential suppliers:** A first letter of invitation was sent to the DB researched in the MEMBER ENROLLMENT function to explain more about the concept of collaboration and the potential benefits of such network.

2. **Planning:** Overall planning for this subnetwork was done in this research as a whole that serves for the implementation of this subnetwork in the near future. This includes the creation of workshops to talk to potential suppliers in a way that can be interested.

5.2.5 Results
Many companies of the Potential Suppliers DB replied mentioning they were interested and asking for the further steps, but the big majority didn’t specifically answer to this invitation. It is completely understandable this situation because of the situation in which companies work every day. This invitation was mostly to have a better sense of the recruiting methods that should be implemented for a truly significant convocatory.

5.2.6 Future Work
Really implement this sub-network using any mean possible. With the development and planning of the rest of the functionality, the creation of this subnetwork will be becoming easier each time.
5.4 Aggregated demand database (Planning & implementation)

5.2.1 Background
The OEM which the author worked with, didn’t have historic information about the parts that it has required from Mexican Suppliers in the last years. The OEM neither had a database (DB) in which it could record all the information of each part in order to improve the process of requesting quoting and analysis from its pool of suppliers. A lot of time was lost by the OEM and its suppliers trying to organize the packages of demanded parts and in trying to group them by families of parts or at least in any comprehensive way. It is known that none of the aerospace companies has this kind of information either.

5.2.2 Definition
For the Regional or OEM-driven implementation subnetworks, it contains an aggregated analysis of demand and its market value that includes process requirements, general information and market value of every demanded part.

5.2.3 Justification
Every Aerospace OEM doing business in Mexico or anywhere else deals with this issue. There is no recorded information about the historic demand of aerospace parts that were potentially assigned to Mexican suppliers. And even worse, there are no attempts to organize this historic demand in order to classify it in a logic way. Complete sets of parts’ drawings are sent now to potential suppliers in Mexico when asking for part quotes. These sets of parts were never analyzed and require a lot of time of the Mexican supplier, so at the end, just 1 or 2% of the parts in these sets are feasible for the company.

5.2.4 Development
The following general steps were done in order to implement this functionality:

1. **Technical drawing analysis training course:** In order to be able to analyze demanded parts’ drawings, a training course needs to be given to the people filling out this DB. The course should include the following topics; (Object Views, Section and shear views, Dimmensioning,, rivet specifications, dimmension tolerances, geometric tolerances and welding anlaysis.

2. **Actual part analysis and quoting research:** In ordert to know the particular aspects that have been happening in the analysis fo parts by metal-mechanical suppliers, a research needs to be done to understand the status quo of this process.
3. **Aerospace required manufacturing processes taxonomy**: In order to be able to unify the analysis of the parts in a standardized lang

4. **Database creation and human-machine interface (HMI) design**: For the DB Creation, an analysis of the requirements was done by the OEM and was later organized in sections as follows:
   
a. **General Information**: Customer, Date, Part Number, Cage Code, Part Name, FileName, Revision, Classification, Requirements, Description, Demand(Units), Estimated Market Value

b. **Material Specifications**: Sheet Stock, Tube, Bar, Plate/Block and for each of this forms the Material, Alloy Number, AMS Specs, Other Specs and Critical Dimensions

c. **Special Processing**: Process, specs, Comment, for different kinds of NDT, Chem film, annodizing, passivating, paint, heat treat and plating

d. **Processing**: Process and Comments, in the process field are available options all of the ontology proposed in the network ontology function.

e. **Hardware**: Hardware, Hardware code and quantity per drawing.

In order to facilitate the filling of this DB, an interface was designed in Microsoft Access as can be seen in Figure 5.2.

**Figure 5.2 Aggregated Demand Database HMI**
5. **Parts’ drawings analysis and DB fill-up:** Historic drawings were analyzed according to the proposal of this function. The drawings were the demand that the OEM wanted to outsource to Mexican suppliers in the last year.

5.2.5 Results

500 different parts’ drawings were analyzed for the OEM and the information was filled in the DB. The work was done in two teams of two people each and took about 2 weeks.

5.2.6 Future Work

The HMI should be improved to allow all the fields to be mistake-proof. With the integration of more suppliers demand to AICON nationwide network, complete diagnosis could be done from this.

5.5 Sourcing process assessment and tutorial (Planning & partial implementation)

5.2.1 Background

In the case of the relationships that the OEM has today with its suppliers, it has been noticed that lead time is very large. Lean is a tool that has been globally implemented in different sectors. Despite the fact it was originally used by Toyota in car production, now you can find lean in almost everything you can imagine, from Lean Manufacturing, Lean Government, Lean Hospital and Lean Services.

5.2.2 Definition

Analysis of the sourcing process taking place in the OEM-driven implementation models of AICON. This function gives recommendations in this sourcing process in order to lean the supply chain.

5.2.3 Justification

Very long lead times are occurring now in the Mexican Aerospace Industry much earlier than the point of time in which the parts are actually produced. Mexican suppliers may be technically skillful but in order to be price competitive, they need to lean their processes and improve their value proposition to OEMs.

5.2.4 Development

The following general steps were done in order to implement this functionality:
1. **Diagnosis of actual Flow Diagram for new parts**: Several meetings were done with the OEM and its suppliers in order to create a complete process mapping that include the different issues presented in each step. The diagnosis included the modeling of this steps in a common modeling language: Unified Modeling Language (UML).

2. **Identification of main issues**: After finding all the issues involved in the bipartite process of assigning parts from the OEM to the supplier, an evaluation of the main components was done to preselect the steps that required the most attention and analysis. The selected steps were the following ones:
   a. Part Numbers to Quote
   b. Drawing Transportation
   c. Technical Review
   d. Part Analysis Quote
   e. Quote
   f. Purchase Order for Part

3. **Improved flow diagram proposal**: After detecting inefficient processes and redundancies, an improved proposal was done. The proposal included the Cases diagram and the Activity diagrams of UML done in Microsoft Visio.

5.2.5 Results
The 6 steps that were analyzed had some issues that were improved in the new proposals. The conclusions include the development and utilization of tools to automate the process. Some of this functionality is also proposed by AICON.

5.2.6 Future Work
In order to be able to share this knowledge in a standardized way for the rest of the members of the network, Tutorials need to be designed in order to serve as a guide for the sourcing process between the SMEs and Aerospace OEMs and in the relationships between them. The

5.6 **AICON Supply Chain/Logistics analysis and specific projects development (Planning & partial implementation)**

5.2.1 Background
Every successful company in the world has been using Supply Chain Management as a way to increase its competitiveness. If the emerging Mexican Aerospace Industry wants to be competitive globally, they should manage their supply chain properly, and that includes an
efficient logistic management. Logistic costs represent as high as 40% for companies in the world. For the emerging aerospace industry, logistic costs represent about 20% of its final market prize.

5.2.2 Definition
Complete analysis done periodically that detects the biggest logistic issue at that time in order to generate concrete network projects to improve overall efficiency.

5.2.3 Justification
There is no capacity by any single company to coordinate analysis of logistic procedures as a whole. SCM/Logistics include transportation, inventory, packaging, facility location, and many other components of cost that need to be improved in order to be price-competitive. And this logistic cost may even reach 35% of the final product price, if a systematic analysis could be looking periodically to analyze this cost in components, significant cost savings may take place.

5.2.4 Development
The following general steps were done in order to implement this functionality:

1. Definition of logistic aspects' costs to be evaluated for the network:
   - Distribution Systems
   - Inventory Management
   - Purchase Orders
   - New facility location
   - Transportation
   - Warehousing & distribution centers
   - Demand forecasting
   - Reverse Logistics
   - Raw materials availability
   - Packaging

2. Evaluation of this logistic aspects for initial potential member: An empirical analysis done to understand which of the logistic aspects contributed the most to the overall cost of the network. This is done in order to find the first aspect to solve for the network. Field visits were done to aerospace suppliers to analyze their operations and their cost structure.

3. Selection of logistic aspect to address: Due to the present situation of the network members, RAW MATERIALS AVAILABILITY is selected as the highest priority aspect to be tackled. Aerospace companies in Mexico are facing the high logistic costs implied in purchasing materials and hardware abroad. Due to the low volume characteristic of the Aerospace Industry, the customers cost of importing material, transportation and lead times are decreasing the overall competitiveness in an important way.

4. Solution Proposal: In order to solve this logistic aspect that is slowing the correct development of the aerospace network and of the individual members, the analysis of
the potential establishment of an aerospace materials and hardware distributor in Mexico is proposed as a solution to this problem.

5.2.5 Results
Because of the low profitability of establishing an aerospace material and hardware supplier that has enough inventory to satisfy the variable demand of the network. It was proposed to first establish an office of aerospace material and hardware foreign supplier that offers the services of importing the materials and consolidate orders. It will not have so much stock in place, but it will have the advantage of having the know-how to do the import/export procedures, direct ordering to their matriz abroad and the possibility to consolidate inventories and risk pooling for inventory management and transportation cost.

5.2.6 Future Work
The potential application of the analysis for the different sub-networks (regional clusters) around Mexico to be able to identify the potential establishment of a complete distribution center. Also with the establishment of such company, the development of potential mexican raw materials suppliers will be desirable and will signify an increase in the overall efficiency of the network.

5.7 Virtual marketplace of resources (Planning)

5.2.1 Background
Due to the low volume and the high raw materials price that takes place in the Aerospace Industry, Mexican companies are dealing with the problem of having to buy raw materials in the U.S. or Europe in the smaller batch size possible, but that still may be 6 or 10 times larger than the amount required. This raw material remaining implies a huge inventory cost due to the low mobility of materials in this industry for any given supplier.

5.2.2 Definition
Online tool that provides the ability for every member to share resources at fair prices. It includes the sell among members of scrap materials, machinery and tools leasing and human resources lending and assessment.

5.2.3 Justification
If scrap materials could be shared, the inventory consolidation benefits derived from it will mean win-win situations for all the members of the network. Another problem is when raw materials are bought abroad, lead times may be as high as 6 to 8 weeks for the company in Mexico.
5.2.4 Development

The following general steps were done in order to implement this functionality:

1. **Definition of the resources to be shared among the network**: The following 3 main categories were defined to group the resources that could be shared among members of the network.
   a. **Physical Resources**: Including scrap and new material, hardware leftovers and tools.
   b. **Human Resources**: Including qualified technicians, engineers and NADCAP certified personnel.
   c. **Technical Resources**: Including specific processes and services, tutorials and books.

2. **Definition of the variables that should be included in the tool**: Definition of the variables that every transaction should include (Company name, product and services offering, certifications, prize and availability of placing orders online etc.)

3. **Definition of a general sharing policy**:
   a. Every company is free to decide what to share.
   b. Every company has the right to reserve for itself the know-how of their products, even if they are shared.
   c. The final use of the resources is the responsibility of the purchaser, but it should follow the legislation in the country of residence.
   d. Only network members have access to the shared resources.

4. **Tool planning**: In order to easy the implementation of the tool, the development of all the necessary class and use diagrams was done using Unified Modeling Language (UML) to do so.

5.2.5 Results

A compete set of policies and diagrams was done preparing for the programming of the tool.

5.2.6 Future Work

The obvious future work is the finishing of the development of the tool, including the online release of it and the start of the operations in the near future.
5.8 Virtual forum (Partial Planning)

5.2.1 Background
One of the most popular uses of internet lately are Forums, you can find forums in almost any kind of subject and that includes any kind of people you can imagine. Mexican SMEs have been left behind, not just because of their size, but because of their lack of knowledge. Technology and Knowledge have been very expensive through the traditional ways (Universities, R&D programs, Consulting firms or even books and seminars), forums could represent an easy and unexpensive way to learn and share knowledge for SMEs.

5.2.2 Definition
Online service in which members and externals can share experiences, ask for technical support and educate themselves in AICON’s taxonomy related topics.

5.2.3 Justification
There are abundant web forums around the internet on almost any topic. Somewhat, Aerospace Industry is not very common on these forums, so AICON will provide this virtual tool. Members of the network may have technical questions, meaningful experiences or simply may want to inform the rest of the members about different things.

5.2.4 Development
The following general steps were done in order to implement this functionality:

1. **Research on the functionality of Forums**: A research was done in order to validate the necessity of Forums for SMEs. This included a benchmark of different forums and the way they present the information.

2. **Definition of Forum main subjects**: In order to be able to organize the topics that could be discussed in the Forum, the following categories are proposed:
   a. **Aerospace industry related**: Aerospace industry marketing, U.S. based industry, Europe-based industry, Quality systems AS9000, nadcap, OEM certifications, new technologies and materials and traceability
   b. **Technical issues**: Maintenance, industrial safety standards, production, automation and control
   c. **Legal aspects**: Laws and regulations, export regulations
   d. **Training**: Human resources management, training areas, news and schedules
   e. **Financing**: Availability and access to credit and capital, investment, microfinancing, alternative financing
f. **New technologies**: Innovation and development, investment and new technologies, information technologies (IT), networking, virtual marketing and e-business

g. **Quality and productivity Systems**: Quality management systems ISO:9000, 6 sigma, statistical quality control, just in time

h. **Questions and suggestions**: Any other question in particular

5.2.5 Future Work

Complete analysis in order to decide if the function will be developed from scratch or if any available built-in service would be the best option.
Chapter 6. Conclusions and Recommendations

6.1 Conclusions

6.1.1 Literature Review

After a complete and comprehensive review of the most important topics related to the implementation of an Aerospace Industry Collaborative Network (AICON) of SMEs in Mexico in order to create a world-class competitive Aerospace Virtual Cluster in Mexico, the following worths to be remarked:

- SMEs DO need to be treated specially by countries in order to help them develop and therefore, contribute to a countries employment and economy.
- The Aerospace Industry IS one of the key strategic sectors for the world’s economy in this new Century and needs to receive the congruent interest and development by countries like Mexico.
- As stated by ECOLEAD, in the near future, almost every company, specially SMEs, will be somehow integrated to some sort of collaborative network in order to survive. CNs emerge as a new and innovative discipline with the power to transform societies and integrate economies.
- Strategic management is fundamental for industries, regions or people in order to be succesful in a global competitive world like ours.
- There is no room anymore for empirical decisions when planning and implementing any kind of business, specially an innovative one like a CN.
- Clusters and the implicit conditions they provide, are a key competitive advantage of regions and countries around the world, but they should be helped in order to emerge as good, as fast and as frequently as a country (Mexico) needs it.

6.1.2 AICON Framework

Altough some research has been done lately in the field of CNs and Cluster development, no pragmatic approach had been done before this in Mexico. Some remarkable insights:

- ECOLEAD’s proposed model for CN is a wonderful project with the potential ability to radically change economies and societies.
- REAL IMPLEMENTATION cases should always emerge from deep research and innovative SCIENTIFIC PROGRAMMS to validate its theories and to receive some tangible benefits from their knowledge.
- It is possible and profitable to integrate scientific research with real enterprises, and the best linkage possible is in the Academia.
- Projects should not be planned extremely ambitious, but should be planned and implemented step by step.
- AICON should integrate the whole country’s industry in a way that has not happened before in Latin America.
- Transoceanic projects are good for involved parties and cultural differences among members in research teams are no longer an impediment but a strength in our days.

6.1.3 Case Study

Because this research is not intended to end up in books and research papers, the case study presents itself as the best tangible asset emerging from it. Some useful comments:

- The integration of different regional and OEM-driven Mexican aerospace (virtual) clusters in a way they can share their strengths and pool their weakness and risks is one of the major results of this research.
- The ability to think globally strategic, but always having the capacity of acting locally and flexible is the best example of AICON and its adapted model from ARCON.
- Even the best research and the best ideas are reduced to nothing, when the appropriate quorum is not gathered. The interest of companies to participate of this network is the best single hope for the future of this Industry in Mexico.
- The systematic integration of different specific projects in a common workframe and with the same language synergizes the effects of its individual benefits.

6.2 Recommendations and Future Work

The development and implementation of ARCON is going perfectly under the scheduling proposed in Chapter 4. As we mentioned in the implementation, this is a project that should continue its implementation according to that plan. The implementation of all the functionality is the obvious next step to do. Particularly, the further research of the 18 functions proposed for the Aerospace Industry and that are not defined here in Chapter 4. Also a better evaluation of the functionality proposed by ECOLEAD to be able to take advantage of all the work done there.

Despite the fact that AICON is a global reference framework for Aerospace Industries, its application into different markets than the Mexican one needs further research to be able to capture the essence of it, that is its flexibility to adapt to solve the Mexican situation.
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Appendix A. Glossary of Terms

Short Abbreviations

AI: Aerospace Industry
AI: Aerospace Industry Collaborative Network
ARCON: A Reference model for Collaborative Networks
CAP Aeroespacial: Centro de Articulación Productiva Aeroespacial
CN: Collaborative Network
CNO: Collaborative Networked Organization
EE: Extended Enterprise
ECOLEAD: European Collaboration Networked Organizations Leadership Initiative
GDP: Gross Domestic Product
MAI: Mexican Aerospace Industry
OEM: Original Equipment Manufacturer
PVC: Professional Virtual Community
SC: Supply Chain
SCM: Supply Chain Management
SME: Small and Medium-Sized Enterprise
VBE: Virtual Organization Breeding Environment
VE: Virtual Enterprise
VO: Virtual Organization
VT: Virtual Team
VOM: Virtual Organization Management

Term definitions

- **Collaborative Network (CN):** A is a network consisting of a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are supported by computer network.

- **Supply Chains (SC):** a stable long-term network of enterprises each having clear roles in the manufacturing value chain, covering all steps from initial product design and the
procurement of raw materials, through production, shipping, distribution, and warehousing until a finished product is delivered to a customer.

- **Virtual government**: an alliance of governmental organizations (e.g. city hall, tax office, cadastre office, and civil infrastructures office) that combine their services through the use of computer networks to provide integrated services to the citizen through a common front-end.

- **Virtual Enterprise (VE)**: Represents a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks.

- **Virtual Organization (VO)**: Represents a concept similar to a virtual enterprise, comprising a set of (legally) independent organizations that share resources and skills to achieve its mission / goal, but that is not limited to an alliance of for profit enterprises. A virtual enterprise is therefore, a particular case of virtual organization.

- **Dynamic Virtual Organization**: Typically refers to a VO that is established in a short time to respond to a competitive market opportunity, and has a short life cycle, dissolving when the short-term purpose of the VO is accomplished.

- **Extended Enterprise (EE)**: Represents a concept typically applied to an organization in which a dominant enterprise “extends” its boundaries to all or some of its suppliers. An extended enterprise can be seen as a particular case of a virtual enterprise.

- **Virtual team (VT)**: Similar to a VE but formed by humans, not organizations, a virtual team is a temporary group of professionals that work together towards a common goal such as realizing a consultancy job, a joint project, etc, and that use computer networks as their main interaction environment.

- **VO Breeding Environment (VBE)**: Represents an association of organizations and their related supporting institutions, adhering to a base long term cooperation agreement, and adoption of common operating principles and infrastructures, with the main goal of increasing their preparedness towards rapid configuration of temporary alliances for collaboration in potential Virtual Organizations. Namely, when a business opportunity is identified by one member (acting as a broker), a subset of VBE organizations can be selected to form a VE/VO.

- **Industry cluster**: One of the earliest forms of VO breeding environments, consisting of a group of companies, typically located in the same geographic region and operating in a common business sector, that keep some “binds” with each other in order to increase their general competitiveness in the larger area. These binds may include sharing some buyer-supplier relationships, common technologies and tools, common buyers, distribution...
channels or common labor pools, all contributing to some form of cooperation or collaboration when business opportunities arise. Earlier forms of clusters did not require a strong ICT infrastructure but more and more collaboration resorts to such support.

- **Industrial district**: Term mostly used in Italy that represents a concept quite similar to an industry cluster. It can be focused on one single sector or cover a number of sectors in a given region.

- **Business ecosystems**: Inspired by the mechanisms of the biological ecosystems, these networks try to preserve local specificities, tradition, and culture, and they frequently benefit from (local) government incentives.

- **Disaster rescue networks**: A strategic alliance of governmental / nongovernmental organizations specialized in rescue operations in case of disasters is another recent form of VBE aimed at facilitating a rapid and well-coordinated response in case of a disaster. This VBE could have a local / regional coverage or a global geographic span.

- **Virtual Laboratory (VL) networks**: Represent the alliance of autonomous research organizations, each having their own resources (equipments, tools, data and information related to their past experiments, etc.), enabling their researchers, located in different geographically-spread centers to be recognized and considered for taking part in potential opportunity based problem-solving collaborations (forming a kind of VO for each problem solving). During a problem-solving collaboration process, it is typical that some expensive lab equipments owned by one or more organizations is made available for (remote) use by the other collaboration partners.

- **Professional virtual community** (PVC): Alliance of professional individuals, and provide an environment to facilitate the agile and fluid formation of Virtual Teams (VTs), similar to what VBE aims to provide for the VOs.

- **Lean Aerospace/Advancement Initiative (LAI)**: The MIT Lean Advancement Initiative, formerly known as the Lean Aerospace Initiative, and its educational network (EdNet) enable members to effectively, efficiently, and reliably create value in complex and rapidly changing environments. LAI's engaged scholarship research model is based on members working collaboratively to define key enterprise transformation challenges and then supporting LAI research to address those challenges.
Appendix B. Main Aircraft Programs 2007

Long Haul Passenger Jets
- Airbus A 300-600 Wide-Bodied Long Range Airliner, Europe
- Airbus A 310 Twin-Engine Wide-Bodied Airliner, Europe
- Airbus A 330 Wide-Bodied Medium/Long-Range Twin-Engine Airliner, Europe
- Airbus A 340-200 and A 340-300 Wide-Bodied Four-Engine Airliners, Europe
- Airbus A 340-600 Wide-Bodied Four-Engine Airliner, Europe
- Airbus A 380 Superjumbo Twin-Deck, Twin-Aisle Airliner, Europe
- Boeing 747-400 Twin-Aisle Jet Airliner, USA
- Boeing 757 Single Aisle Twin Jet Airliner, USA
- Boeing 767 Widebody Jet Airliner, USA
- Boeing 777 Twin-Aisle Twinjet Airliner, USA
- Boeing 787 Dreamliner Long-Range, Mid-Size Airliner, USA
- Tupolev Tu-214 Medium to Long-Range Airliner, Russia

Regional Jets
- Airbus A 318 Single-Aisle Medium-Range Airliner, Europe
- Airbus A 320 Single-Aisle Medium-Range Airliner, Europe
- ARJ21 Regional Jet Aircraft, China
- BAE 146 Short / Medium-Range Airliner, United Kingdom
- BAE Avro RJ Regional Jet, United Kingdom
- Beriev Be-200 Amphibious Multirole Twinjet Aircraft, Russia
- Boeing 717 Single-Aisle Twinjet, USA
- Boeing 737 New Generation Twin-Engine Airliner, USA
- Bombardier CRJ200 Canadair Regional Jetliner, Canada
- Bombardier CRJ700 Canadair Regional Jet Airliner, Canada
- Bombardier CRJ900 Regional Jet, Canada
- Embraer 170 Commercial Jetliner, Brazil
- Embraer 190 Commercial Regional Jet, Brazil
- Embraer ERJ-135 Regional Airliner, Brazil
- Embraer ERJ-145 Regional Jet Airliner, Brazil
- Sukhoi Superjet 100 - Russian Regional Jet (RRJ), Russia
**Business Jets**

Airbus ACJ Corporate Jetliner, Europe  
Boeing Business Jet (BBJ) Long-Range Business Jet, USA  
Boeing Business Jet 2 (BBJ 2) Long-Range Business Jet, USA  
Bombardier Challenger 300 Super Midsize Corporate Business Jet, Canada  
Bombardier Challenger 604 Intercontinental Business Jet, Canada  
Bombardier Global 5000 Long-Range Business Aircraft, Canada  
Bombardier Global Express Ultra Long-Range Business Jet, Canada  
Bombardier Learjet 31A Light Business Jet, Canada  
Bombardier Learjet 45 Super-Light Business Jet, Canada  
Cessna Citation Bravo Light Business Jet, USA  
Cessna Citation CJ3 Business Jet Cessna Citation CJ3 Business Jet, USA  
Cessna Citation Mustang Light Business Jet, USA  
Dassault Falcon 2000/ 2000EX Widebody Twinjet, France  
Dassault Falcon 50EX Mid-Size Business Jet, France  
Dassault Falcon 7X - Long-Range Business Jet, France  
Dassault Falcon 900C Trijet Business Aircraft, France  
Dassault Falcon 900EX Long-Range Business Tri-Jet, France  
Eclipse Aviation - Eclipse 500 Very Light Jet, USA  
Embraer Legacy Super Mid-Size Corporate Jet, Brazil  
G150 Mid-Size Business Jet - Gulfstream Aerospace, USA  
Gulfstream G200 (Galaxy) Intercontinental Business Jet, USA  
Gulfstream G450 Long-Range Business Jet, USA  
Hawker Beechcraft Hawker 4000 Super Mid-Size Business Jet, USA  
Hawker Beechcraft Hawker 400XP Light Business Jet, USA  
Hawker Beechcraft Hawker 800XP Mid-Size Business Jet, USA  
Hawker Beechcraft Premier 1 Light Business Jet, USA  
Sino Swearingen SJ30-2 Light Business Jet, USA

**Freighters**

Airbus A 300-600ST Beluga Super Transporter, Europe  
Airbus A 310-200F Freighter Aircraft, Europe  
Airbus A 380-800F Wide-Bodyd Freighter, Europe  
Antonov An-124-100 Long-Range Heavy Transport Aircraft, Russia
Boeing 747-400F Four-Jet Intercontinental Freighter, USA
Boeing 767-300F Wide-Bodied Freighter, USA
Boeing 777F Freighter Aircraft, USA
Utility Aerospace Industries FF-1080-300 Twin-Engine Turboprop Utility Freight Aircraft, USA

Helicopters

AgustaWestland A 109 Power Light Multi-Role Helicopter, Italy
AgustaWestland A 119 Koala Single-Turbine Light Helicopter, Italy
AgustaWestland AW139 Medium Twin-Engine Helicopter, Italy / UK / USA
AgustaWestland EH101 Medium-Lift Helicopter, Italy / United Kingdom
AgustaWestland Grand Intermediate Twin-Turbine Helicopter, Italy
Bell / Agusta Bell 412 – Medium Transport Helicopter USA / Italy
Bell 407 Seven-Seat Light Helicopter, USA
Bell 429 – Light Twin Helicopter
Bell 430, Twin-Engined, Nine-Seat Helicopter, USA
Bell Agusta BA 609 Tiltrotor VTOL Aircraft, Italy / UK / USA
Eurocopter EC 120 Colibri Hummingbird Five-Seat Light Helicopter, Europe
Eurocopter EC 130 Light Multi-Mission Helicopter, Europe
Eurocopter EC 135 Lightweight, Twin-Engine, Multipurpose Helicopter, Europe
Eurocopter EC 145 Multi-Purpose Helicopter, Europe
Eurocopter EC 155 Medium-Lift Twin Engine Helicopter, Europe
Eurocopter EC 225 Super Puma Mark II Multirole and Offshore Support Helicopter, Europe
Kaman K-1200 K-MAX Light-Lift Multi-Purpose Helicopter, USA
Kamov Ka-32A Multi-Role Helicopter, Russia
Kamov Ka-226 Sergei Light Multipurpose Helicopter, Russia
MD Helicopters MD 500E / 530F Light Helicopter, USA
MD Helicopters MD Explorer Twin-Engined Light Helicopter, USA
MD Helicopters MD600N Multi-Purpose Light Helicopter, USA
Schweizer Model 333 Light Helicopter, USA
Sikorsky S-92 Medium-Lift Multi-Role Twin-Engine Helicopter, USA

Space Craft

Ariane 5 - Heavy Payload Launch Vehicle, International
Boeing Satellite Systems 702 Satellite, USA
Bristol Spaceplanes Ascender Sub-Orbital Space Plane, United Kingdom
Chandra Space Observatory, USA
Envisat Earth Observation Satellite Kourou, Europe
Geosynchronous Satellite Launch Vehicle (GSLV), India
Hubble Space Telescope, International
International Space Station (ISS), International
Lunar Prospector Space Probe, USA
Mars Polar Lander Space Probe, USA
NASA X-43 (Hyper-X) Hypersonic Aircraft, USA
Near Earth Asteroid Rendezvous (N.E.A.R) Shoemaker Spacecraft, USA
Rosetta Space Probe, Europe
Stardust Space Probe, USA
XMM-Newton (X-ray Multi Mirror) Space Telescope, International

**Turboprop Aircraft**

ATR 42 Twin Turboprop Passenger Aircraft, Europe
ATR 72 Twin Turboprop Passenger Aircraft, Europe
BAE ATP Advanced Turboprop, United Kingdom
BAE Jetstream 31 and 32EP Twin Turboprop Airliners, United Kingdom
BAE Jetstream 41 Regional Airliner, United Kingdom
Bombardier Canadair 415 Superscooper Amphibious Aircraft, Canada
Bombardier Q300 DHC-8 Dash 8 Regional Turboprop Airliner, Canada
Bombardier Q400 Dash 8 Turboprop Regional Airliner, Canada
Cessna 208 Caravan Light Utility and Passenger Aircraft, USA
Embraer EMB-120 Twin-Turboprop Airliner, Brazil
Fairchild Dornier 328 Regional Transport Aircraft, USA
Hawker Beechcraft Beech King 1900D Twin-Turboprop Regional Airliner, USA
Hawker Beechcraft Beech King Air 350 Twin-Turboprop Passenger Aircraft, USA
Hawker Beechcraft Beech King Air B200 Twin-Turboprop Transport and Utility Aircraft, USA
Piaggio P180 Avanti II Twin-Engine Turboprop Business Aircraft, Italy
Pilatus PC-12 Single-Turboprop Executive Aircraft, Switzerland
Saab 2000 Regional Transport Aircraft, Sweden
Saab 340B Regional Aircraft, Sweden
Appendix C. US Census Bureau NAICS

(North American Industry Classification System) codes and definitions for the AI

3364 Aerospace Product and Parts Manufacturing
This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing complete aircraft, missiles, or space vehicles; (2) manufacturing aerospace engines, propulsion units, auxiliary equipment or parts; (3) developing and making prototypes of aerospace products; (4) aircraft conversion (i.e., major modifications to systems); and (5) complete aircraft or propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft to original design specifications).

336411 Aircraft Manufacturing
This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing or assembling complete aircraft; (2) developing and making aircraft prototypes; (3) aircraft conversion (i.e., major modifications to systems); and (4) complete aircraft overhaul and rebuilding (i.e., periodic restoration of aircraft to original design specifications).

336412 Aircraft Engine and Engine Parts Manufacturing
This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing aircraft engines and engine parts; (2) developing and making prototypes of aircraft engines and engine parts; (3) aircraft propulsion system conversion (i.e., major modifications to systems); and (4) aircraft propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft propulsion system to original design specifications).

336413 Other Aircraft Parts and Auxiliary Equipment Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing aircraft parts or auxiliary equipment (except engines and aircraft fluid power subassemblies) and/or (2) developing and making prototypes of aircraft parts and auxiliary equipment. Auxiliary equipment includes such items as crop dusting apparatus, armament racks, in-flight refueling equipment, and external fuel tanks.
336414 Guided Missile and Space Vehicle Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing complete guided missiles and space vehicles and/or (2) developing and making prototypes of guided missile or space vehicles.

336415 Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing guided missile and/or space vehicle propulsion units and propulsion unit parts and/or (2) developing and making prototypes of guided missile and space vehicle propulsion units and propulsion unit parts.

336419 Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
This U.S. Industry comprises establishments primarily engaged in (1) manufacturing guided missile and space vehicle parts and auxiliary equipment (except guided missile and space vehicle propulsion units and propulsion unit parts) and/or (2) developing and making prototypes of guided missile and space vehicle parts and auxiliary equipment.
Appendix D. AECMA Product Segment Descriptions

AIRCRAFT
- Complete systems of and/or airframes for aeroplanes, helicopters and gliders, ground installations, their subsystems and parts, spares and maintenance
- Piston engines, turboprops, turbojets, jet engines, their subsystems and parts, spares and maintenance, for installation in aircraft systems
- Finished products, subsystems and parts, spares and maintenance, also for test and ground-training equipment, for installation in aircraft systems
- Service Providers, Consultants, etc.

MISSILES
- Complete systems of and/or airframes for missiles, ground installations, their subsystems and parts, spares and maintenance
- Engines, their subsystems and parts, spares and maintenance, for installation in missile systems
- Finished products, subsystems and parts, spares and maintenance, also for test and ground-training equipment, for installation in missile systems
- Service Providers, Consultants, etc.

SPACE
- Complete systems of and/or airframes for space vehicles, satellites, launchers, ground installations, their subsystems and parts, spares and maintenance
- Propulsion devices, their subsystems and parts, spares and maintenance, for installation in space vehicles, satellites, launchers
- Finished products, subsystems and parts, spares and maintenance, also for test and ground-training equipment, for installation in space vehicles, satellites, launchers
- Service Providers, Consultants, etc.
Appendix E. AECMA Product Sector Descriptions

SYSTEMS & FRAMES
- Complete systems of and/or airframes for aeroplanes, helicopters and gliders, ground installations, their subsystems and parts, spares and maintenance
- Complete systems of and/or airframes for missiles, ground installations, their subsystems and parts, spares and maintenance
- Complete systems of and/or airframes for space vehicles, satellites, launchers, ground installations, their subsystems and parts, spares and maintenance

ENGINES
- Piston engines, turboprops, turbojets, jet engines, their subsystems and parts, spares and maintenance, for installation in aircraft systems
- Engines, their subsystems and parts, spares and maintenance, for installation in missile systems
- Propulsion devices, their subsystems and parts, spares and maintenance, for installation in space vehicles, satellites, launchers

EQUIPMENT
- Finished products, subsystems and parts, spares and maintenance, also for test and ground-training equipment, for installation in aircraft systems
- Finished products, subsystems and parts, spares and maintenance, also for test and ground-training equipment, for installation in missile systems
- Finished products, subsystems and parts, spares and maintenance, also for test and ground-training equipment, for installation in space vehicles, satellites, launchers