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Masterarbeit

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Supply Chain Strategies in Aerospace Industry: Assessment of Approaches to Increase the Competitiveness and Profitability in a Global Environment

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Abstract

Name of Student: Florian Tobias Wendt

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Keywords: Aerospace Industry, Supply Chain Management, Strategy, Assessment, Profitability, Competitiveness, Project Management, Outsourcing, Risks, Lean Management, Procurement, Reshoring

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This master's thesis outlines an opportunity for research in the area of supply chain management in aerospace industry. Based on free accessible data, the focus of this thesis is laid on identifying and discussing current management approaches in the field of long range composite aircraft to improve the competitiveness and profitability.

Supply chain management in modern aerospace manufacturing industry is a field which gained rapidly influence amongst practitioners in the last decade. The market leading companies in this field - Airbus and Boeing - introduced new supply chain management strategies for the development/ manufacturing of their new long range composite aircraft programs Airbus A350 XWB and Boeing 787 Dreamliner. These new aircraft programs promise improvements in efficiency and passenger comfort by utilizing the advantages of carbon fibre materials and applying more efficient power plants. Airbus and Boeing decided to outsource about 70 percent of the development and manufacturing work to decrease cost and to share risks. However, analysing their strategies deeper uncovers questions concerning the rationality of the current trend in aerospace supply chain management which is indicated by increasing outsourcing and offshoring activities: Is offshoring a suitable approach for developing emerging markets? Are suppliers capable to provide aircraft components? Is it reasonable to ship components over long distances? What are the social and environmental consequences in the long term? These questions lead to reconsider the current trend in aerospace supply chain management. However, industry sectors such as the heavy machine industry outpaced offshoring and are starting to reshore manufacturing capacities. In the long run, re-localisation with focus on a collaborative approach towards suppliers could be a suitable development for the companies Airbus and Boeing as well to increase their long-term performance.

Acknowledgements

This master's thesis was completed on the 24th of March 2015. On this day, the worst aircraft disaster in recent European history took place. Personally I would like to dedicate this report in loving memory to the 150 boys and girls/ men and women who lost their life on the Germanwings flight 4U9525.

In deep sorrow.

Foremost, I would like to express my sincere thanks to my supervisors who accompanied me on the journey of my dissertation, Prof. Dr.-Ing. Mark Wiegmann and Thomas Baker. Their encouragement, patience, feedback and enormous experience were key motivations throughout my master's thesis and were always appreciated – thank you. Further, I would like to give a warm thanks to the University of Hertfordshire which provided me the chance to write my dissertation in collaboration with this prestigious organisation.

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Finally, I would like to give special thanks to the most important two persons in my life who always encourage, support and motivate me to give my best and to reach for the stars. Petra and Anita, without your love and understanding I would not have completed this thesis successfully. Thank you!

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List of Abbreviations

A/C	Aircraft
AB	Airline Business
AMB	Aerospace Manufacturing Business
ATAG	Air Transport Action Group
BCA	Boeing Commercial Airplanes
BCG	Boston Consulting Group
BFE	Buyer Furnished Equipment
CEO	Chief Executive Officer
CIPS	Chartered Institute of Purchasing and Supply
CR	Contractual Review
CFRP	Carbon Fibre Reinforced Polymer
CS25	Certification Specifications 25 (EASA)
CSR	Corporate Social Responsibility
EADS	European Aeronautic Defence and Space Company (since 2014 new name – now “Airbus Group”)
EASA	European Aviation Safety Agency
EE	Extended Enterprise
EIS	Entry Into Service
ERP	Enterprise Resource Planning
EU	European Union
FAA	Federal Aviation Administration
FAL	Final Assembly Line

FOB	Free On Board
GLARE	Glass Laminate Aluminium Reinforced Epoxy
HoV	Head of Version
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IPR	Intellectual Property
JIT	Just-In-Time
JIS	Just-In-Sequence
KPI	Key Performance Indicator
LM	Lean Management
LR	Long Range
LRCA	Long Range Composite Aircraft
MEA	More Electric Aircraft
MIT	Massachusetts Institute of Technology
MSN	Manufacturer Serial Number
NSP	New Supplier Policy
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
P&G	Procter & Gamble
PAX	Passengers
PDCA	Plan, Do, Check, Act
PLM	Product Lifecycle Management
QM	Quality Management
R&D	Research and Development

RPK	Revenue Passenger Kilometre
RSCM	Responsible Supply Chain Management
SA	Single Aisle
SCM	Supply Chain Management
SME	Small Medium Enterprises
TPS	Toyota Production System
UK	United Kingdom
UNO	United Nations Organisation
USA	United States of America
USAF	United States Air Force
USD	US Dollar
WBCSD	World Business Council for Sustainable Development
XWB	Xtra Wide Body (Airbus A350 specific branding)

Glossary

Aircraft	Any vehicle, with or without an engine, which can fly.
Airplane	A vehicle designed for air travel that has wings and one or more engines.
Buyer Furnished Equipment	Equipment which is selected by the customer – the aircraft manufacturer only assembles the equipment.
Cash Cow	A product that provides a steady income or profit for a business or a company (based on BCG matrix).
Competitiveness	Ability of a business to offer products and services that meet the quality standards of the local and global markets at prices that are competitive and provide adequate returns.
Industrial Dynamics	Philosophy of structure in procedures and systems.
Just in time	Just In Time (JIT) manufacturing systems is based on preventing waste by producing and supplying only the amount of goods needed at a particular time, and not paying to produce and store more goods than needed.
Just in sequence	Just in Sequence (JIS) originates from production logistics and is an advancement of the just in time concept. JIS extends JIT by the right sequence of supplied goods for the assembly/ production process.

Holism	The theory about that parts of a whole are in intimate interconnection, such as that they cannot exist independently of the whole.
Horizontal Integration	The acquisition of additional business activities that are at the same level of the value chain.
Logistics	The process of planning and organizing to make sure that resources are in the places where they are needed, so that an activity or process happens effectively.
More Electric Aircraft	An airplane which is designed under the philosophy of replacing mechanical/ hydraulic/ pneumatic power by electrical power supply.
Offshoring	The general act of paying someone in another country to do part of a company's work.
Outsourcing	A long term procurement approach used by companies to reduce costs by transferring work packages to external suppliers.
Procurement	The acquisition of goods or services in return for a monetary or equivalent payment. The act of obtaining something in any way including force or pillage.
Productivity	The rate at which a company makes goods, usually judged in connection with the number of people and the amount of materials necessary to produce the goods.
Profitability	The state or condition of yielding a financial profit or gain. Often measured by price to earnings ratio.

Purchasing	The management of external resources in such a way that the supply of all goods, services and materials which are necessary for running the companies' business is secured at the most favourable conditions.
Reshoring	The act of regain outsourced work packages from external suppliers in foreign countries back to the home countries.
Seller Furnished Equipment	Equipment which is selected by the OEM – the airline only can choose between few options.
Strategy	A stream of actions consistency in behaviour whether or not intended. It can be created by a visionary leader who recognises the opportunities and threats facing an organisation.
Subcontracting	Short-term procurement approach to pay a supplier to do part of a work package or to participate in it as part of a service.
Supplier	A company or business that provides a product, or the materials to make a product.
Supply Chain	The system of people and organizations that are involved in getting a product from the place where it is made to customers.
Vertical Integration	When a company expands its business into areas that are at different points on the same production path, such as when a manufacturer owns its supplier and/or distributor.

1. Introduction

This report outlines an opportunity for research in the area of supply chain management in aerospace industry with focus on the identification and discussion of current management approaches to increase profitability and competitiveness in the field of long range composite aircraft programs.

This chapter aims to provide an overview of the research opportunity for this report. Moreover, this chapter names the aim and objectives of the project as well as the thesis structure and the methodology.

1.1. Opportunity

“Sometimes you need suppliers badly to do something and to do it immediately. You won’t want to get bogged down in protracted negotiations before they sort the issues.”, states Dr Thomas Enders[1] to point towards the high importance of a good and sustainable relationship between suppliers and “Original Equipment Manufacturer” (OEM) in aerospace industry (Trimble, 2014).

According to Sinha & Malzahn (2004), the aerospace industry is characterised by a high vigilance of risk awareness - basically related to flight operations and on the other hand referred to a responsible-minded development and production of high complex machines. Moreover, the requirements of the global aerospace industry are reflected by a particular “supply chain management” (SCM) for each part and system of an aircraft (Horng & Bozdogan, 2004). In accordance with Shekar (2011), the development and manufacturing of modern large jet airliners is a highly complex and resource claiming challenge for OEM, such as the world leading aerospace companies Airbus and Boeing. There are thousands of different systems and components within aircraft which need to be defined, developed, certified and manufactured with respect to a strict budget, quality and schedule (Tamaskar, 2014).

[1] Tom Enders (*1958) is a German businessmen and CEO of the Airbus Group.

Current SCM approaches in the field of aviation industry are characterised by a high amount of outsourcing and subcontracting to reduce cost, to share risk and to focus on core competencies (Airbus, 2014). Moreover, these basic approaches differ in various aspects, based on the cultural, political and economic background of the examined companies (Hudson, 2005). This report will investigate the current management approaches and strategies that Airbus and Boeing apply on their SCM.

1.2. Aim and Objectives

The overall aim of this master's thesis is the assessment of supply chain strategies and approaches of the aerospace companies Airbus and Boeing to increase their competitiveness and profitability. This assessment is based on the consideration of the new composite aircraft programs[2] "Airbus A350 XWB" (Xtra Wide Body) and "Boeing 787 Dreamliner". Moreover, this research aspires to create a deeper understanding of mechanisms and requirements in the field of aerospace supply chain management.

Therefore, this research project aims to achieve the following objectives:

1. Investigate and document the specific supply chain requirements in aerospace industry.

2. Compile theoretical foundations of supply chain management and procurement in a global environment.

3. Examine the theoretical foundations concerning the terms "profitability" and "competiveness" with respect to aerospace industry.

4. Illustrate knowledge background for the specific needs in aerospace industry supply chain management with focus on Airbus and Boeing.

[2] This thesis only considers examples and processes in the civil sector of aerospace industry.

5. Outline case studies in the area of supply chain in aerospace industry with focus on the modern composite aircraft “Airbus A350 XWB” and “Boeing 787 Dreamliner”.

6. Assessment of SCM strategies and approaches by a “Porter Five Forces Analysis” for each company.

7. SCM analysis of political, economic, socio-cultural and technological factors of Airbus and Boeing by “PEST analysis”.

8. Determine and analyse the strengths, weaknesses, opportunities and threats (SWOT analysis) of the considered aerospace supply chain strategies.

9. Identify, based on the outlined case studies, the current strategies and key features of Airbus and Boeing with respect to supply chain management in aerospace industry.

10. Identification of SCM best practices and their possible influence on the profitability and competitiveness – even from other industry sectors.

11. Illustration of recommendations how Airbus and Boeing can increase their profitability and competiveness by adjusting their supply chain strategy.

1.3. Methodology

1.3.1. Research Structure

As illustrated in figure 1, this dissertation is structured into seven chapters, starting with the introduction chapter in which the research opportunity and the analytical procedure are outlined. The second chapter depicts the literature survey. Chapter three illustrates the background of the topic in focus of the considered companies in

aerospace. Subsequently, chapter four outlines particular case studies of Airbus and Boeing. Following, chapter five analyses and concludes approaches and strategies which are depicted in chapter four. Furthermore, chapter six outlines risks and consequences and discusses the results of the particular SCM strategies.

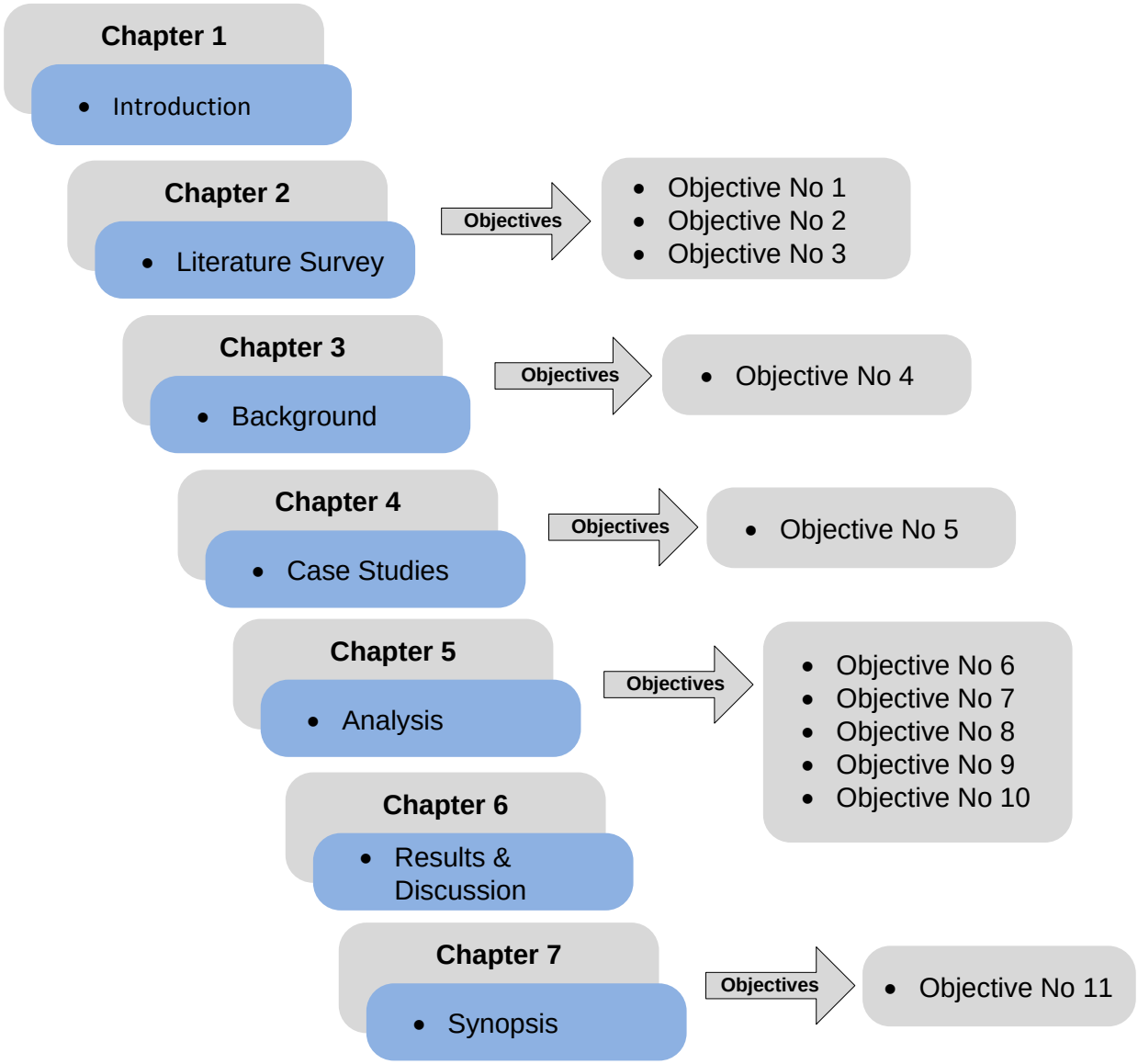
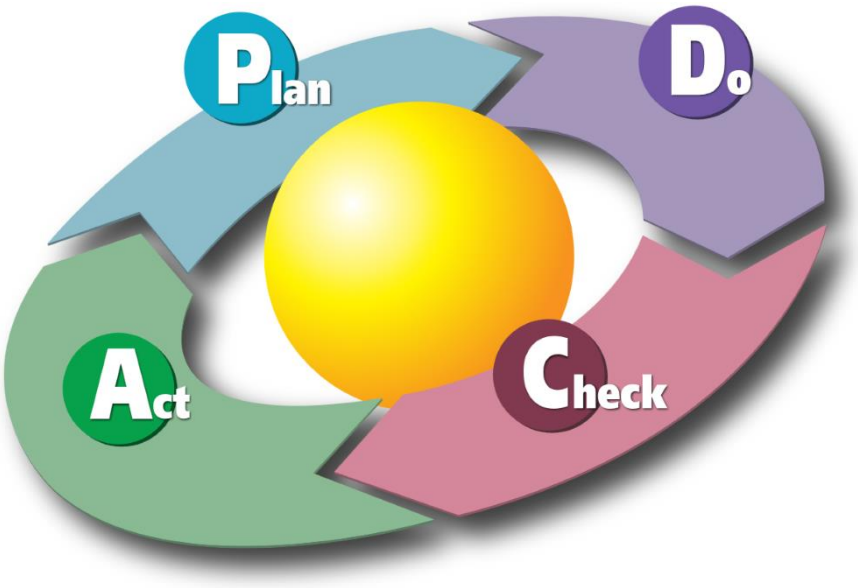


Figure 1: Research structure of this thesis

Finally, this report is concluded by chapter seven ‘synopsis’ which concludes this report and provides recommendations. In addition, an outlook provides a perspective on the future of aerospace supply chain management and further research opportunities.

1.3.2. Analytical Procedure

The methodology used in this project is based on the “Deming Principle” (see figure 2) which is divided in the four phases “Plan”, “Do”, “Check”, “Act”. This principle is named after W. Edwards Deming[3] who created the idea of the principle to improve continuously a product with respect to quality management (Deming, 2000).



Source: The W. Edwards Deming Institute, California, USA

Figure 2: The Deming Principle: Plan, Do, check, Act (PDCA)

The research structure and approach of this project is based on the Deming principle. The first three chapters “Introduction”, “Background” and “Literature Survey” can be considered as the planning phase in which the constraints and theoretical foundations of the project are introduced. Moreover, the chapter “Case Studies” is related to the “Do” phase of the Deming principle in which the SCM approaches of Airbus and Boeing are illustrated.

The examining analysis chapter of this project can be considered as the “Check” phase. Furthermore, the depiction of risks and consequences as well as the discussion of results can be assigned to the “Act” phase of the Deming principle. This analytical procedure supports the project as a basic frame.

[3] W. Edwards Deming (*14 Oct 1900 †20 Dec 1993) was an American engineer and statistics expert.

2. Literature Survey

This chapter reviews the existing literature of the related topic to support the study undertaken in this thesis by laying a proper foundation in terms of the history and definition of SCM. In addition, the terms profitability and competitiveness are defined with respect to aerospace manufacturing industry. Moreover, the existing SCM literature with focus on aerospace industry is investigated and reviewed.

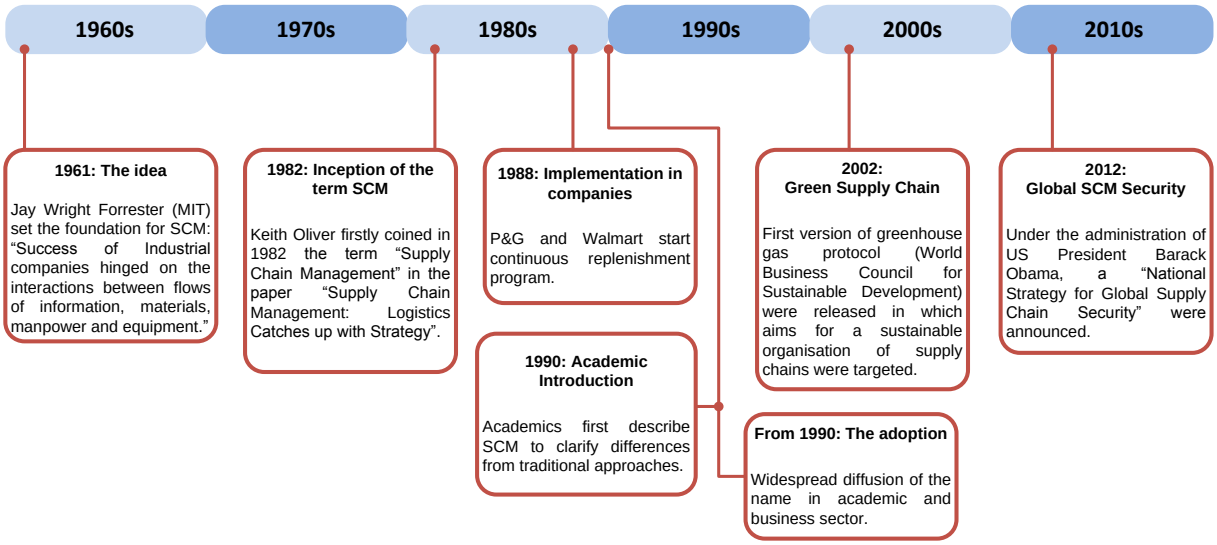
2.1. The Historical Development of SCM

The historical development of the term “supply chain management” is characterized by a comparative small scale of academic research which has been undertaken in the related subject area since it was firstly coined in the year 1982 by the British logistician Keith Oliver (Oliver, 1982); (Van Weele, 2005).

Retrospectively, the basic idea of SCM is based on the holistic consideration of purchasing, which is the basic activity within SCM (MIT, 2014). As illustrated in figure 3, the American computer engineer Jay Wright Forrester laid the foundation for the holistic approach of SCM in the year 1961 with his wide-minded book “Industrial Dynamics” and related research papers (Forrester, 1968). According to Forrester (1968), there must be a structure for any kind of procedure to manage it in an appropriate way. However, Forrester follows the impetus of the term “industrial dynamics” which is a philosophy of structure in procedures and systems – within this context referred to the purchasing process (MIT, 2014); (Forrester, 1968).

As mentioned before, Keith Oliver coined the term of supply chain management by using it within an interview with the business journalist Arnold Kransdorff who wrote an article for the Financial Times London in June 1982 (Heckmann, 2003). Subsequently, Keith Oliver used the term firstly in the paper “Supply Chain Management: Logistics Catches up with Strategy”, which is often considered as the initial paper of SCM (MIT, 2014); (Oliver, 1982). The following time was characterised by a gradually change in purchase philosophy of companies and led to the

implementation of a continuous replenishment program at “Procter & Gamble” (P&G) and Walmart in the year 1988, which is considered as the first explicit implementation of a SCM strategy in international enterprises (MIT, 2014); (Grean & Shaw, 2002).



Source: Based on (MIT, 2014) and data of (Baily & Farmer, 2005); (SCO, 2012)

Figure 3: The historical development of SCM – from idea to adaption

According to Van Weele (2005), there was a gap over a long time between the operational procedure in terms of supply chain management and an academic body of knowledge. However, in the year 1990 the first academic papers were released in the topic area of supply chain management to clarify differences from traditional approaches – particularly American Universities turned towards this subject area as an extension of purchasing and that is why the most of related literature has an American origin (Van Weele, 2005); (MIT, 2014).

In accordance with Baily & Farmer (2005), after 1990 the perception that purchasing is no longer a simple administrative ordering or buying activity was widely accepted in academics and business. In 2002, the “World Business Council for Sustainable Development” (WBCSD)[4] released the first version of the “Greenhouse Gas Protocol” to develop and promote internationally accepted standards for a so-called “Green

[4] World Business Council for Sustainable Development is a CEO-led, global association of some 200 international companies dealing exclusively with business and sustainable development.

Supply Chain" towards environmental sustainable business activities (WBCSD, 2001). However, a further milestone of SCM is the announcement of the "National Strategy for Global Supply Chain Security" which was created under the responsibility of the current US president Barack Obama (Obama, 2012). According to Obama (2012), the mentioned national strategy shall strengthen global supply chains in order to the welfare and interests of American people and their partners.

2.2. Introducing a General Definition of SCM

According to Van Weele (2005), the subject field of supply chain management is an area in which relatively little academic research has been undertaken. Furthermore, Van Weele (2005) complements that it is far from simple to disseminate knowledge across organizations concerning the discipline of SCM. Hence, an overall accepted definition of SCM is not present in business and academics (Van Weele, 2005). However, in the following different SCM definitions of book and journal authors are quoted to give a broad overview about the implications of the term:

- "Supply Chain Management is concerned with the co-ordinated flow of materials and services from origins through suppliers into and through the organisation and on to the ultimate consumer in such a way as to maximise value added and to minimise cost." (Baily & Farmer, 2005)

- "Supply Chain Management has been defined as the management of networks of organisations that are involved through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer." (Lysons, 2000); (Martin, 1992)

- “Supply Chain Management can be described as the management of all activities, information and financial resources associated with the flow and transformation of goods and services from the raw materials suppliers (…) in such a way that the expectations of the end users of the company are being met or surpassed. (Van Weele, 2005)

- “Supply Chain Management is defined as the management of a set of three or more entities directly involved in the upstream and downstream flows of products, services and finances from a source to a customer.” (Mentzer & DeWitt, 2001)

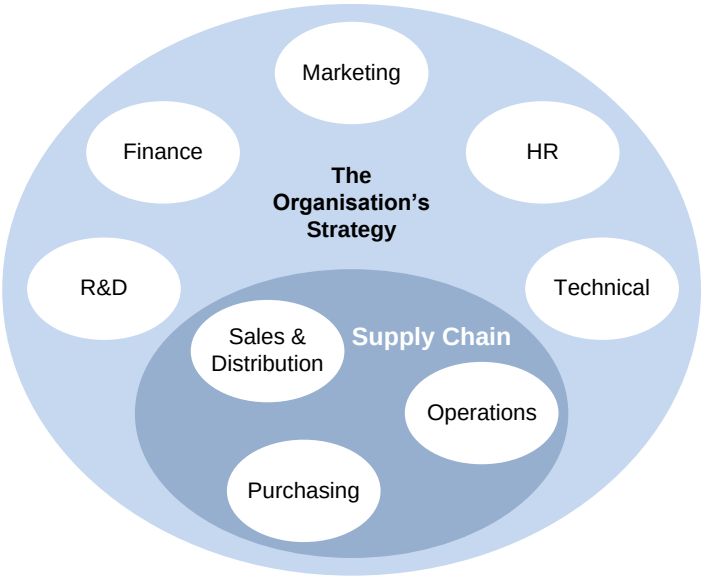
- “Supply Chain Management is largely about integration, communication flows and elimination of waste. It follows, then, that product development must also be an integrated communicative and value-adding activity.” (Harrison, 2001)

Based on these definitions, for the purpose of this report, SCM is defined as:

“The management and coordination of all activities within the value chain of a company – from the specification of work packages, the assessment and selection of supplier, the integrity of production supply, right up to on time logistics to the end consumer.”

As stated by Gunasekaran, et al. (2004), supply chain management is a major component of competitive strategy to increase the organisational productivity and overall profitability of a company. Moreover, the term SCM implies parts of the disciplines “Sales, Distribution & Logistics” as well as the aspect of “Operations Management” related to the SCM context, as depicted in figure 4 (following on page 10). However, the term SCM is often combined or used interchangeably with the terms “Procurement”, “Purchasing” and “Logistics” (Van Weele, 2005); (Baily & Farmer, 2005). In accordance with Van Weele (2005), purchasing is the management of external resources in such a way that the supply of all goods, services, capabilities and knowledge which are necessary for running the company primary activities is

secured at the most favourable conditions. Moreover, he complements that SCM also encompasses all logistics activities. In contrast, “procurement” defines only the activity/ process of buying – it does not imply the management activities around, which are covered by “purchasing” (Cambridge Dictionary, 2014). The so-called CIPS-Model of the “Chartered Institute of Purchasing and Supply” (CIPS) illustrates the strategic framework related to SCM:



Source: Figure is based on Baily & Farmer (2005)

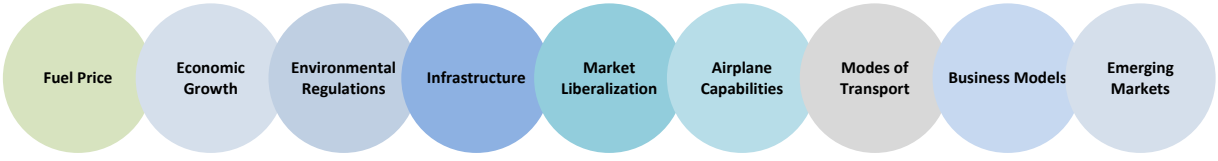
Figure 4: Supply Chain and included disciplines - based on the CIPS model

According to VanOpijnen & Oldenziel (2011), the “European Union” (EU) defines the term SCM by complementing the aspect of “responsibility” within the supply chain and that is why the majority of EU papers use the term “Responsible Supply Chain Management” (RSCM). The European study “Responsible Supply Chain Management” defines the term of SCM as “the management of environmental, social and economic impacts and the encouragement of good governance practices, throughout the lifecycles of goods and services” (VanOpijnen & Oldenziel, 2011); (UNO, 2010). This advanced definition of SCM is commonly considered to play a more important role in future (Lillywhite, 2004). In accordance with ICAO (2013), the term of responsibility is highly relevant to ensure a technically secure and social/ environmentally supply chain. However, the safety requirements in the field of air cargo which are mentioned by ICAO (2013) are very airline specific and not contagious to aerospace industry.

2.3. Profitability in Aerospace Manufacturing Industry

Profitability is the primary aim of all business plans and it is an essential factor to maintain a company's business in the long run (Hofstrand, 2013). According to Michaels (2013) and the market forecasts of Airbus and Boeing, the companies strive to achieve high profitability levels such as Airbus aims to aichive "10% earnings before interest and taxes by 2015" (Michaels, 2013).

As stated by Hofstrand (2013), 'profit' is the result when the total expenses of a business are subtracted from the total revenue (income). Hofstrand (2013) and Peavler (2015) mention further that profitability is a ratio which indicates a company's overall efficiency and performance. This ratio is calculated by dividing a profit by the initial investment (Peavler, 2015). According to Hofstrand (2013), the measurement accuracy of the profitability ratio of a business has a high significance to assess the current situation of a company in the right way and to set the foundation to make right decisions. Manufacturing companies in aerospace industry are facing individual challenges in terms of the cash flow conditions of the market. In accordance to Rowe (2014), 40% of all currently operated aircraft are financed by leasing companies. As mentioned by Boeing Finance (2015), 25% of all aircraft are paid by cash. The high development cost (Airbus A350 XWB: £9 billion; Boeing 787 Dreamliner: £19 billion) of new aircraft lead to high prices for aircraft and a wide timeframe to reach the break-even point with a particular aircraft program (Rowe, 2014), (Mick, 2014), (Trimble, 2015). Hence, aerospace OEM aim to achieve long term profitability (Trimble, 2015). According to Boeing Long Term Forecast (2014), profitability of aerospace OEM is influenced by market forces which lead to a highly dynamic industry.



Source: Figure is based on Boeing Long Term Forecast (2014)

Figure 5: Market forces in aerospace manufacturing industry

As depicted in figure 5, the market forces are fuel price, economic growth and development, environmental regulations, infrastructure, market liberalization, airplane

capabilities, other modes of transport, business models, and emerging markets (Boeing Long Term Forecast , 2014). These forces can lead to a positive and also negative impact on the industry and consequently on the profit of a manufacturing company. The fuel price has a huge impact on the cost structure of an airline – hence this aspect has an influential relevance for airlines when planning the procurement of new aircraft (Boeing Long Term Forecast , 2014). The fuel price is the main driver for the aircraft manufacturer to develop innovative fuel efficient light weight aircraft, such as the Airbus A350 XWB and the Boeing 787 Dreamliner, which allow a profitable operation of their aircraft fleet. Moreover, the economic growth has a further influence on the profitability of companies such as Airbus and Boeing. Moreover, environmental regulations can influence business activities in aerospace.

As further mentioned by Boeing Long Term Forecast (2014), the infrastructure of countries with manufacturing facilities has a relevant significance for aerospace OEM. Moreover, the aspects of market liberalization of a certain location can influence the aircraft manufacturer as well. In accordance to Boeing Long Term Forecast (2014), the capabilities of the aircraft which a company has in its portfolio are another influential factor which has relevance to the development of a long-term profitability. Furthermore, the modes of transport are a further considerable market force which can have a strong influence on the profitability. Generally, it is expected that the air traffic as a mode of transport will grow strongly in the upcoming 20 years.

In accordance to Airbus Group (2014), a yearly growth rate of 4.7% is expectet between 2013 and 2033. The Boeing Company estimates a growth of 5% per year (Boeing Market Forecast, 2014). Moreover, the business models and the strategie to approach and to embrace emerging markets are further forces which need to be considered. In accordance to Hatton (2009), the former Executive Vice President Airplane Production of Boeing, Bob Dryden, states that the key success factors for a profitable aerospace manufacturing company are the continous reduction of costs and the maintaining of access to foreign markets. These two factors are the main drivers for the companies Airbus and Boeing to implement improved SCM strategies for the LRCA programs A350 XWB and 787 Dreamliner (Denning, 2013).

2.4. Competitiveness in Aerospace Manufacturing Industry

The term of competitiveness is commonly applied in all fields of business and politics to represent the ability of a corporation or a country to compete with competitors (Cambridge Dict, 2015). In accordance to Krugman (1994), President Bill Clinton stated that each nation is “like a big corporation competing in the global marketplace" - this point of view became an established opinion under the leaders throughout the world. However, Krugman (1994) also mentions that there is a gap between countries and corporations when defining the term competitiveness.

A corporation which is not competitive will lose money and risks reaching a situation where it cannot afford to pay its expenses such as the payment of workers, suppliers and bondholders – as a result the corporation will go out of business (Krugman, 1994); (Feurer & Chaharbaghi, 1994). Hence, a corporation which is not competitive cannot maintain its market position which is unsustainable (Krugman, 1994).

On the other hand, countries do not go out of business in the same way when they are not competitive – the current example of Greece within the euro-crisis shows that countries underlay another mechanism (Smith, 2012). According to World Economic Forum (2014), Greece is ranked on place 81 in overall competiveness in the world (e.g. UK is ranked on place 9, Germany is ranked on place 5) and has a limping economy.

However, the support of the European Union (EU) and the International Monetary Fund (IMF) prevent that Greece runs out of business (European Commission, 2014). Therefore, in accordance to Krugman (1994), it is necessary to make a difference between countries and corporations when using the term competitiveness. However, large manufacturing companies in aerospace such as Airbus and Boeing are a special case because they are often very influential and interwoven with the governmental system of the related home country (Hitt, 2009).

Aerospace companies such as Airbus and Boeing are an important part of the economy of the related economic zones EU and USA. As a result, these companies are supported and sometimes implicit subsidised by these countries to maintain a

certain level of competitiveness (WTO EU, 2012); (WTO US, 2012); (Thompson, 2012); (Cutler & Lynn, 2011). In accordance to the World Trading Organization (WTO US, 2012), these subsidies cause divergences between the home countries EU and USA which blame each other to distort the competition in aerospace manufacturing market.

However as stated by WTO (2015), members of the WTO - such as the companies Airbus and Boeing - agree the general prohibition of subsidies[5]: "A Member shall neither grant nor maintain subsidies (…)" (WTO, 2015). Hence, both aerospace OEM are not allowed to benefit from subsidies which could have influence on the competitiveness or profitability of the related companies. Nevertheless, there are supportive activities towards Airbus and Boeing by European countries and the USA which could be considered as a 'grey zone of subsidies' such as tax deductions or special loans (Polek, 2015); (Smith, 2015).

This grey zone of subsidisation led to a couple of disputes between Airbus and Boeing which were mediated by the WTO (Banner & Clancy, 2012). As mentioned by Cutler & Lynn (2011), the dipute between the aerospace OEM has a long history. However, as reported by the World Trade Organization (WTO US, 2012); (WTO EU, 2012), both companies derived a benefit from illegal subsidies which distorted the competition between the OEM and the related economic zones (Smith, 2015).

[5] Except subsidies in the agriculture sector.

2.5. Literature Review Applied to Aerospace Industry

The global aerospace industry is characterized by particular aspects which need to be generally considered. This literature review will provide a briefly overview about underlying books, journal papers, magazine articles and annual reports which have a significance related to the report topic.

According to Shekar (2011), modern aircraft systems have reached a level of complexity that requires systematic design methods. Further, Shekar states that a structured design and procurement approach can enable an efficient dealing with high complex projects. This complexity is also reflected by the supply chain for aircraft as mentioned by Horng (2004). In accordance with Horng, the implementation of a long-term SCM strategy can lead to a deep business relationship with suppliers which can overtake complex project aspects and can support the OEM to decrease risks.

However, as stated by Trimble (2014), the supply chain strategies of the world leading commercial aircraft manufacturers Airbus and Boeing are different – especially in terms of the managing approach. According to Trimble (2014), the Boeing Company implemented SCM to decrease cost and to improve the manufacturing performance. Trimble mentions further, that Airbus also faces to improve the efficiency by a well-considered SCM approach - however Airbus main focus is generally to mitigate risks and to develop the supplier to ensure the quality of the final product. In accordance with Sinha & Malzahn (2004), generally the mitigation of supplier risks is a crucial aspect in aerospace industry because of the strict safety requirements and the high complexity of aircraft systems. According to Williams (2001), the political influence on supply chain decisions in large-scale businesses can be quite high. Particularly the aerospace industry is political influenced. As mentioned by Boeing Political Expenditures (2014), the company makes political contributions in such states and localities for the best interests of the company and shareholders. In accordance with Carnegy (2013), the political pressure of shareholder countries on the Airbus Company is even higher than in case of the Boeing Company. However, both companies intend to decrease the political influence over the long term (Carnegy, 2013); (Boeing Market Forecast, 2014).

3. Background

3.1. Defining the Global Aerospace Industry

The global aerospace industry for "large civil aircraft"[6] is dominated by the two competitors Airbus S.A.S. and the Boeing Corporation (CAPA, 2014). This chapter will outline an overview about the global aircraft market. Moreover, this chapter will illustrate the background of the companies Airbus and Boeing.

3.1.1. General Overview of the Business Sector

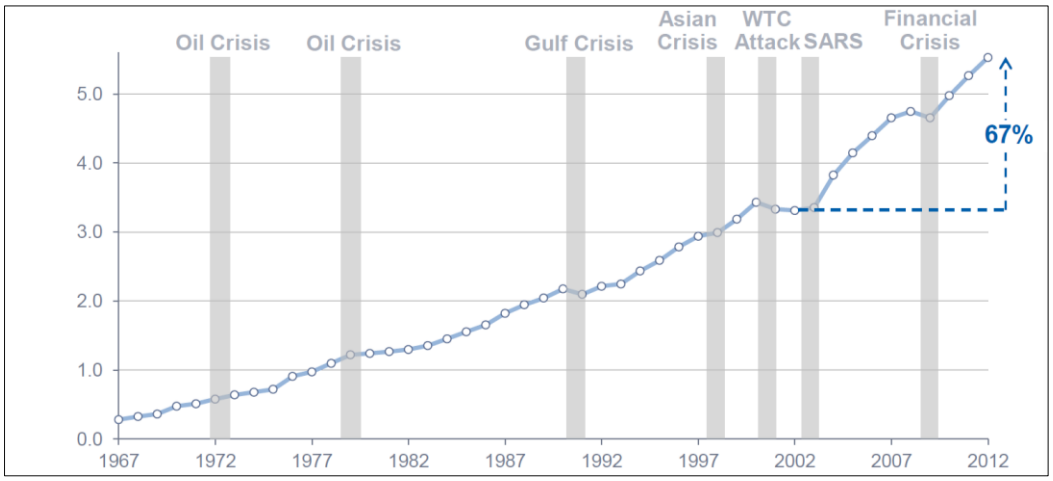
In December 1944, the 32nd president of the United States Franklin D. Roosevelt and 51 delegates of involved countries signed the "Chicago Convention" which set the foundation for the world civil air transport and established the International Civil Aviation Organization (ICAO) (ICAO ATAG, 2011). According to ATAG (2011), the founders of the ICAO emphasised "that the future development of international civil aviation can greatly help and preserve friendship and understanding among the nations and peoples of the world."

Sixty years later, the vision became an evident reality - the global aerospace industry is today one of the most powerful sectors in industry with currently 8.7 million people in global who work in employments related to aerospace industry and a global economic impact of about £1,5 trillion annually (ATAG, 2014).

However, the term "aerospace industry" implies the companies in manufacturing/ development/ and maintenance business of civil aircraft, as well as airline companies. According to Niosi & Zhegu (2005), important and economic powerful locations of the civil aerospace industry are: Seattle (USA, Boeing Corporation), Los Angeles (USA Boeing), Toulouse (France, Airbus Group), Hamburg (Germany, Airbus Group), Montreal (Canada, Bombardier) and São José dos Campos (Brazil, Embraer).

[6] Large Civil Aircraft: Aircraft with usually more than 100 seats (GS.org, 2014).

Moreover, the top 3 player in civil aerospace industry are the following companies (related revenue in GDP): Boeing Commercial Airplanes (£33,3billion; year 2013), Airbus S.A.S. (£26,4 billion; year 2013) and Embraer (£3,92 billion; year 2013) (BoeingCompany, 2014); (Airbus Group, 2014); (Embraer, 2014). Based on the revenues of the companies, it is noticeable that Airbus and Boeing play the key roles in the depicted business, which is why only these two companies will be considered in the following report. In accordance with Airbus Group (2014), the airline industry performs around 32 million commercial flights per year, transporting 3 billion passengers and about 50 million tons of fright in 2013. Moreover, the perspective for the industry is quite positive: Despite all catastrophes and crises, the "Revenue Passenger Kilometres" (RPK), which is an indicator for the number of passengers and the efficiency in aviation, had a growth of 67% between 2002 and 2012, as depicted in the following (Leahy, 2013):



Source: Leahy, 2013

Figure 6: World annual traffic between 1967 and 2012 in trillion RPKs[7]

According to Boeing (2013), there are currently 20,300 airplanes in service all over the world – combined with the estimated airplane fleet growth of around 3.6% per year and the renewal of old airplanes, Boeing and Airbus estimate a demand of over 35,000 new airplanes until 2032 (Airbus Group, 2014); (Boeing, 2013). This number of aircraft demand ensures the manufacturing planning of the OEM and their supplier.

[7] RBK: Revenue Passenger Kilometre – The revenue per passenger and kilometre implies the number of passengers and the economic efficiency of the airline.

3.1.2. Airbus S.A.S.

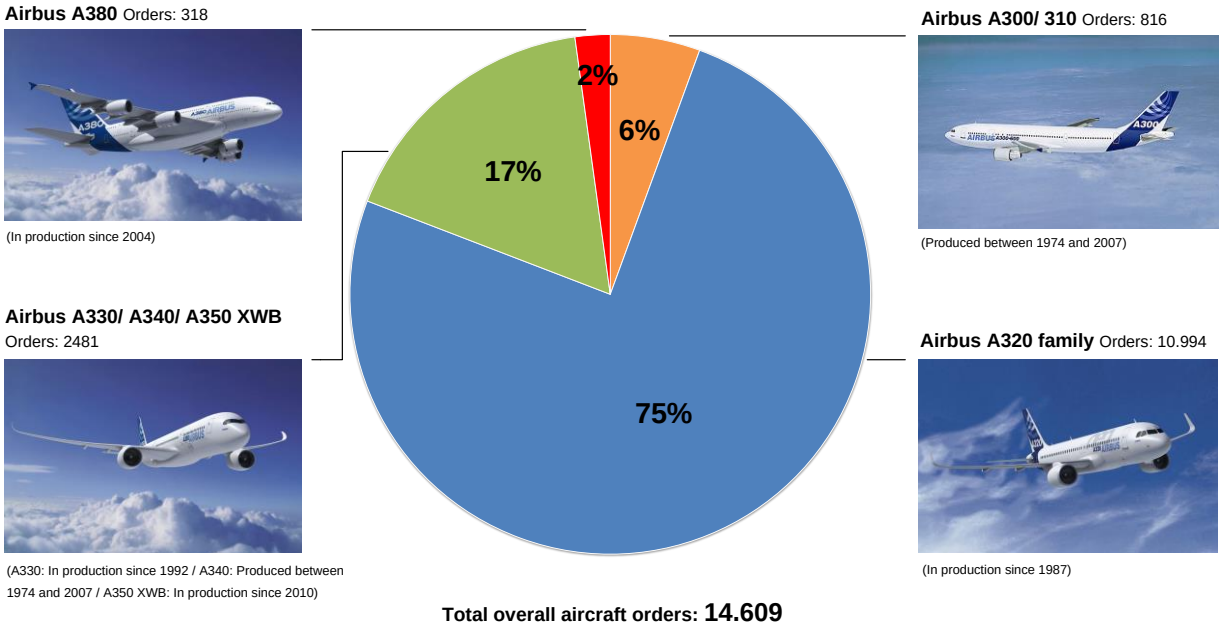
The European civil aircraft manufacturer Airbus is based on the revenue of £26,4 billion (2013) one of the leading aircraft manufacturer and has a share of 71% to the revenue of the related Airbus Group (Airbus Group, 2014). Airbus employs globally more than 59.000 people with production facilities in France, Germany, USA and China (Schaffrath, 2013). Moreover, the company has actually 5.860 orders for new aircraft and has delivered over 8.600 aircraft since the first delivery in 1974.

Source: Airbus Media, 2014

Figure 7: The Airbus A300 maiden flight on 28 October 1972 from Toulouse

In retrospect, the current structure of Airbus is based on the vibrant company history which started in the year 1969 with the political agreement between Germany and France to launch the first common civil aircraft program. Hence, the “Airbus A300” (see figure 6) became the world’s first twin-engine wide body passenger jet and is considered as the start of the European success story called “Airbus”. According to Airbus (2009), the political agreement between France and Germany resulted one year later the official establishment of “Airbus Industry”, based on the cooperation of European aircraft manufacturer such as “Aerospitale” (France), “Deutsche Aerospace” (Germany), “Fokker” (Netherlands) and “Hawker Siddeley” (UK). However, this multinational cooperation is today considered as part of European unification in post-war era in terms of business, cultural and social reconciliation

(Paul, 2011). The success of airbus is based in recent years on a high innovative and customer oriented strategy with focus in the particularly needs of related airlines and their passengers. As illustrated in figure 7, 75% of all ever ordered Airbus aircraft is part of the A320 family[8] which is the aircraft type for short continental distances.



Source: Figure is based on photos of Airbus Media, 2014 and data of Airbus Data, 2014

Figure 8: Overall orders of Airbus aircraft between 1974 and 2014

According to Airbus Data (2014) and Gates (2014), the Airbus A320 aircraft family is the "cash cow" of Airbus and leads to the high company's profit of £1.3 billion in the financial year 2013 (Keller, 2014). However, the flagship of the company's portfolio is the "Long Range" (LR) aircraft A380 which has a number of 318 orders in 2014. Moreover, the no longer produced aircraft A300/ A310 are still mentioned in official statistics. Nevertheless, the LR aircraft A330/ A340 and the new program A350 XWB are an important aspect to compete with Boeing (Gates, 2014). Airbus has more than 2.000 supplier in more than 20 countries and sources their required materials and components by up to 70% from external suppliers (Airbus, 2012). However, the future SCM strategy of Airbus is to increase procurement activities in USD to avoid currency uncertainties and to get access to new markets, as India and China (Airbus, 2012).

[8] The Airbus A320 family implies the aircraft programs A318, A319, A320 and A321.

3.1.3. Boeing Commercial Airplanes

“Boeing Commercial Airplanes” (BCA) is a division of the Boeing Company and has with £33.3 billion a share of 61.2% to the revenue of the related parent company. However, BCA employs globally more than 83.000 people with head offices in 19 countries and subsidiaries in 64 countries – moreover the company manages a global network of more than 21.000 suppliers and partners (Hill, 2014). In accordance with Boeing Data (2014), BCA has actually 5.536 orders for new aircraft and has delivered 19.806 aircraft since the first delivery of a Boeing 707 airplane in 1958.

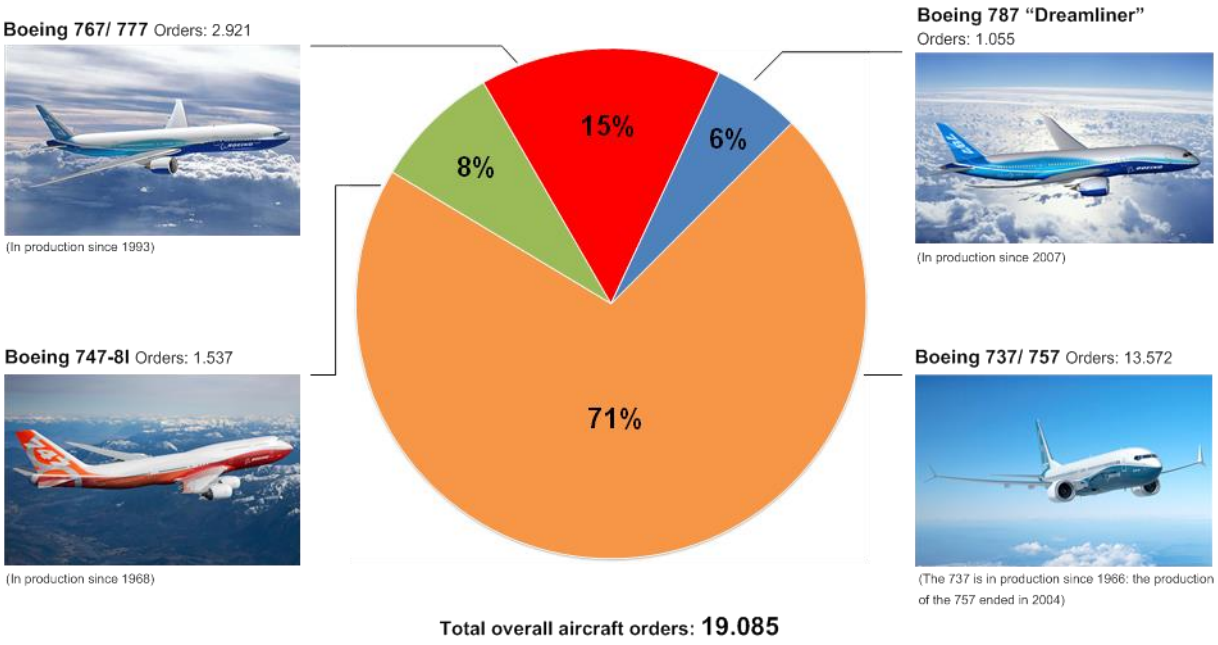
Source: Boeing Images, 2014

Figure 9: The Boeing 707 jet aircraft on its maiden flight - July 15, 1954

Retrospectively, the Boeing Company has a long-standing corporate history which starts in the year 1916 with the American engineer William Edward Boeing[9], son of German immigrants, who founded in Seattle (Washington state) the “Pacific Aero Products Company” which designed and built a wooden seaplane – today called “Boeing Model 1” (Boeing History, 2014). During World War I and World War II, Boeing constructed military aircraft for the US Air Force (USAF) which participated in the victory against Nazi Germany in 1945 – this period of time supported the development of Boeing to a powerful and highly appreciated American aerospace

[9] William Edward Boeing (*Oct 1, 1881 †Sept 28, 1956) was an American aviation pioneer.

company (Serling, 1991). In the year 1929 William E. Boeing mentioned in a local newspaper of Seattle that “We are trustees of a veritable revolution that is taking place once more in the economic, social, and political fabric with the advent of this new speed medium.” (Boeing, 1929). William E Boeing is generally seen as one of the pioneers in civil air travel who recognized early the global implications of global air travel in terms of social, cultural and business aspects (Hickey, 2012). As depicted in figure 8, a remarkable milestone for the civil aircraft division of Boeing was in July 1954 the maiden flight of the Boeing 707 jet which is considered as the starting point of the success story of Boeing commercial aircraft (Boeing History, 2014).



Source: Figure is based on photos of Boeing Images (2014) and data of Boeing Data (2014)

Figure 10: Overall orders of current Boeing aircraft models

However, the current aircraft programs of BCA are all methodical based on the former 707 aircraft, why it is easy for pilots to learn new Boeing aircraft types (Paur, 2010). As illustrated in figure 9, the current portfolio of Boeing is based on the SA family “737” and the LR jets “767/ 777”, “747” as well as the new LR composite jet “787 Dreamliner”. In contrast to Airbus, BCA has a higher revenue based on LR aircraft and that is why Boeing is the market leader in this area (Airbus Data, 2014); (Boeing Data, 2014). However, BCA assembles all aircraft in two factories in the US state Washington – Everett (747, 767, 777, and 787) and Renton (737) (BCA, 2014).

3.2. Characterization of Long Range Composite Aircraft

The development of LR aircraft which consist of a high percentage of composite materials is a current trend in aerospace industry (Michaels, 2013). This chapter defines the term “Long Range Composite Aircraft” (LRCA) related to the current trends in aerospace industry and outlines the theoretical foundations.

3.2.1. Introduction of Long Range Composite Aircraft

The term LRCA is used in this report to describe the special type of LR aircraft which is characterised by a high percentage of composite materials. Foremost, there is no prevalent accepted definition of the term and that is why LRCA are defined for this report as “airplanes which provide civil air transport for in min. 100 passengers (PAX) over in min. 6 hours with an airframe which consists in min. of 50% composite materials”. The definition of “composite materials in the airframe” implies the materials which are commonly used in aerospace industry: “Carbon-fibre-reinforced Polymer” (CFRP, wings, and fuselage), “Glass Laminate Aluminium Reinforced Epoxy” (GLARE, inner structure, panels), sandwich structured composite (sidewall/ sealing panels, floor panels, overhead bins) (Royal Aeronautical Society, 2010).

As mentioned by Michaels (2013), the development of composite airplanes in civil sector is a current trend in aerospace which is based on the fuel saving potential by decreasing the weight of the airframe and to make the aircraft by this action more cost effective. According to the market forecasts of Airbus and Boeing, the airplane models Airbus A350 XWB and Boeing 787 Dreamliner represent the segment of LRCA which is expected to loom until 2033 (Airbus Group, 2014); (Boeing, 2013). Moreover, both companies introduced new process structures by the planning for the new LRCA programs to increase the operative profitability of the aircraft types as well as the economic success of the production processes. With reference to Boeing Vision (2013) and Airbus Group Vision (2015), both companies are striving for innovations to achieve and expand the leadership in aerospace manufacturing industry – hence the development/ production of the LRCA programs A350 XWB and 787 Dreamliner is part of Airbus’ and Boeings ambitious corporate strategies.

3.2.2. Airbus A350 XWB

The Airbus A350 XWB twin engine jetliner is the most recent commercial airplane in the world - it made its maiden flight on 14th of June 2013 and received on the 30th of September 2014 its type certification from the “European Aviation Safety Agency” (EASA) (EASA, 2014). In accordance with Airbus FAST (2013), the airframe of the airplane consists up to 53% of composite material which leads in combination with improved power plants and optimized aerodynamics to 25% less operating costs.

Source: Airbus Media, 2014

Figure 11: The A350 XWB MSN02 on its maiden flight from Toulouse, France

The A350-900 XWB can carry up to 350 passangers in a typical three-class seating layout and in maximum 440 passengers in a high density layout[10] over the distance of 14.350 km (Airbus FAST, 2013). However, the twin aisle airplane is positioned as a successor of the Airbus A330/ A340 and is competing with the mentioned Boeing 787 Dreamliner and 777. According to Criou (2007), a significant aspect of the A350 is the design philosophy which was applied by Airbus to plan the airplane. In contrast to Boeing, Airbus decided to build the composite aircraft based on the design philosophy of the former aluminium airplanes - this means that the A350 is made of composite materials but it is assembled like an aluminium airplane (Airbus FAST, 2013). Moreover, Airbus introduced the aircraft as a “Seller Furnished Equipment” (SFE) product to its customers which has a significant impact on the overall project and supply chain management (Airbus Info, 2014).

[10] High density layout: The max. amount of seats in an one class cabin layout airplane.

3.2.3. Boeing 787 Dreamliner

The Boeing 787 Dreamliner is a LR twin engine “More Electric Aircraft” (MEA)[11] which is made of 50% composite materials - it made its maiden flight on 15th December 2009 (Boeing Dreamliner, 2014). According to Buerk (2011) and Boeing (2013), the 787 airplane has a 20% fuel efficiency improvement over earlier aircraft generations. This is based on less weight, improved aerodynamics and high efficient power plants.

Source: Boeing Images, 2014

Figure 12: The first delivered Dreamliner of All Nippon Airways, 26th of Oct 2011

The Dreamliner can carry up to 323 passengers in the 787-10 version and a typical three class layout and in maximum 420 passengers in a high density layout (Boeing Dreamliner, 2014). Moreover, the airplane has a maximum range (fully loaded) of 15.400 km. Since the first 787 delivery in 2011, Boeing delivered 204 airplanes until 31st October 2014 (Boeing Data, 2014). In accordance with Hale (2006), the overall new aircraft design in terms of composite materials, new system architecture and reliable maintenance design will offer aircraft operators a reduction of maintenance and operational costs of up to 30% in comparison to the 767 airplane. However, Boeing had to face in recent times a couple of incidents which are based on the new design philosophy and the applied approach in supply chain (Pasztor, 2014). According to Denning (2013), Boeing introduced an auspicious and risky new supply chain strategy with the SFE program 787 which is outlined and discussed in chapter 4 of this report.

[11] MEA: An airplane which is designed under the philosophy of replacing mechanical/ hydraulic/ pneumatic power by electrical power supply.

3.3. Constraints in Aerospace Manufacturing Business

The aviation industry is a remarkable field of global business, especially in terms of continuous growth - the number of carried passengers increased by 45% during the period from 2000 to 2010 (Leggett, 2011). In accordance with Riwo-Abudho & Njanja (2013), the aerospace business needs to be considered separately, firstly in focus of "Aerospace Manufacturing Business" (AMB) and secondly with respect to "Airline Business" (AB)[12] to satisfy the particular requirements of both sectors.

According to the market forecasts of Airbus Group (2014) and Boeing (2013), they have common business goals to achieve a high profitability and a leading position in aerospace manufacturing market in terms of competitiveness and customer satisfaction. Significant impact factors in AMB for companies like Airbus and Boeing are often called "Supply Chain Performance Factors" which are based on several sub-factors such as the location of the plant, the political system of the related country and the skills level of available employees (Bhatnagar, 2005). Nevertheless, aerospace manufacturing companies are liable to the usual constraints of a manufacturing business such as the level of wages, the energy price as well as the infrastructure and security situation of the manufacturing location (BBC, 2013).

In accordance with the European regulation (EC) No 2042/2003 and the American regulation 14 CFR Part 21, companies related to AMB need to apply for certificates which enable them to develop, produce and maintain aircraft parts as an approved aerospace organisation (EASA AMC GM P21, 2012). Besides the resource consuming application process to become a certified aerospace organisation, supplier which have the intention to collaborate with Airbus or Boeing also need to be accredited by the related purchasing department of the companies (AirbusSupplier, 2014); (Boeing Quality Management, 2014). Furthermore, these certificates are a significant legal factor for OEM with respect to aerospace SCM due to the fact that the airworthiness certification process for aircraft parts requires - among others - the evidence for all sub tier suppliers which are involved in the value chain (EASA AMC GM P21, 2012).

[12] The AB will not be considered in this project because of the focus on AMB.

4. Case Studies

The world class aerospace manufacturer Airbus and Boeing implemented new supply chain strategies for the aircraft programs A350 XWB and 787 Dreamliner which differ from former purchasing approaches (Airbus, 2012); (Boeing, 2013). According to Economist (2009), Airbus and Boeing created for these aircraft programs some of the most complex and extended supply chains in industrial history[13]. Therefore, this chapter investigates and outlines based on technical examples the current SCM approaches to manufacture profitable and competitive long range composite aircraft. Moreover, this chapter illustrates the general purchasing philosophy which Airbus and Boeing apply in development and manufacturing processes.

The first step in supply chain investigation is the illustration of a general overview of the aircraft specific SCM. These boundaries enable the analysis of high complex supply chains by focusing on significant technical areas of the considered airplanes. Secondly, boundaries are defined to outline the SCM strategy in a focused and specified way. Following, one considerable purchasing area with a related example is chosen to outline the supply chain and the allocation of work packages in detail. Because of the complexity and the requirement of free accessible data in this report, the area of the airframe is chosen to outline the specific supply chain approaches of the OEM. Subsequently, the particular SCM characteristics of the chosen examples are illustrated and concluded.

[13] Industrial history - including automotive-, heavy machine-building- and ship industry.

4.1. Supply Chain Approach of Airbus A350 XWB

The supply chain strategy of Airbus in terms of the A350 XWB program is closely related to the history of development which started in the year 2004 with the purpose to relaunch a modified version of the Airbus A330 airplane, named “A350” (Flightglobal, 2008). However, after enormous criticism of various airlines regarding the lower cabin wideness in comparison to the Boeing 787 Dreamliner airplane and the low innovations level, Airbus announced in 2006 a completely new aircraft program – the composite airplane “A350 XWB” (Airbus Info, 2014).

According to the 2012 annual report of airbus commercial airplanes, the external procurement of goods, materials and equipment had a share of 70 percent of the companies’ revenue in 2012. Moreover, Airbus stated that 29 percent of the external procurement activity is related to propulsion systems and 14 percent are related to aircraft systems and the airframe. Furthermore, the general purchasing strategy of Airbus is to increase the share of procurement in USD to be more independent from the exchange rate fluctuation between USD and Euro, as more than 56 percent of sold aircraft are paid in USD (Airbus, 2012). Nevertheless, Airbus (2012) mentions the intention to expand the supply chain beyond Europe to get access to growth markets such as China, India and Latin America - in 2011, 30 percent of goods were procured from suppliers beyond Europe and 50 percent as target until 2024.

In accordance with Trimble (2014), the CEO of Airbus - Dr Thomas Enders - mentioned in 2014 that Airbus don not use temporary weaknesses of their suppliers to drive down cost. Enders stated further that “Airbus’ philosophy is a reflection of the long-term nature of industrial relationships in the aerospace industry, when a single production programme can span decades from launch to line closure.” Moreover, Trimble quotes Alan McArtor - the CEO of Airbus USA - who has the opinion that “Airbus want to get best value with the supply chain Airbus think it’s better to work with our suppliers and their processes, as opposed to dictating suppliers to carve 15% out of their cost”. Based on these statements, Airbus fulfils a partnership approach in managing their suppliers. As mentioned by Trimble (2014) and Airbus Group Vision (2015), the supply chain approach of Airbus is called internally

“extended enterprise”. Furthermore, Trimble states that this system allows Airbus to have a detailed and broad knowledge about the supplier. Therefore, Airbus is able to assist and develop suppliers by knowledge transfer and specifically financial support (Trimble, 2014).

According to Wall (2014), Airbus acquired in February 2014 the Salzburg München Bank to create an in-house bank. As mentioned by Wall (2014), Airbus purchased this bank to ensure access to liquidity over the whole supply chain from suppliers until the customers as part of a corporational in-hose solution.

However, the announcement of Airbus to develop a new aircraft family with the A350 XWB was a milestone in Airbus supplier strategy. In accordance with Airbus (2012), the communication with established suppliers was increased within the A350 development program to address noted challenges in aircraft development and to involve the suppliers in an earlier stage of development. If necessary, Airbus sends consultants to suppliers to support their production and delivery performance. Further, Airbus stated that the A350 program was the starting point to decentralise the procurement department by allocating more responsibility to the particular purchasing divisions related to the aircraft and procurement field. This decision was based on the exchange of best practices of other company parts of the Airbus Group.

According to Airbus (2012), a further implemented best practice is the involvement and support of European “Small Medium Enterprises” (SME) to strengthen the European Supply Chain. In relation to this aspect, the development and support of companies with a high specialisation of innovative technology is an aim of Airbus’ future oriented supply chain strategy (Airbus, 2012); (Airbus Group, 2014).

Related to the A350 XWB development program, Airbus introduced an improved procurement philosophy by laying the focus on supply chain management to handle the complexity in aircraft design, manufacturing and customizing more efficiently and to increase the profitability in purchasing activities (Airbus, 2012); (Cauquill, 2010). As depicted in figure 12, the procurement philosophy of the A350 XWB program is structured into the areas “Procurement Strategy & Business Operations” and “Supply Chain Management & Quality”.

Source: Figure is based on photos of Airbus Media (2014), Pixelio (2014) and data of Cauquill (2010)

Figure 13: The organisational procurement structure - Airbus A350 XWB specific

In accordance with Cauquill (2010), at Airbus the procurement of goods and materials is separated into the following six fields which set boundaries in technical aspects: 1. Material, hardware and fastener; 2. Propulsion systems; 3. Equipment & systems; 4. Airframe; 5. Cabin; 6. General procurement of capital goods and services. These six fields cover all parts of an aircraft (Cauquill, 2010).

The first area “Material, hardware and fastener” is characterised by a high amount of small parts like screws, nuts, rivets as well as all materials and fasteners which are required to assemble the airplane. According to Sankaran (2006), global sourcing of subcomponents, materials and fasteners is increasingly faced by the OEM to benefit from the development in material science. Hence, this approach promises the improvement in manufacturing performance and operation of the airplane. Furthermore, Sankaran mentions the positive long term cost impact of lighter and more efficient materials for the aircraft operators. Airbus considers generally the strategically aspect of decisions in global material sourcing and faces in recent times increasingly the sourcing in China by announcing to reach a sourcing value of $1 billion by 2020 (Yan & Miller, 2014)

The second procurement field is related to the propulsion systems which have an overall procurement share, as mentioned before, of 29 percent. In terms of the A350 aircraft family, only the engine company Rolls Royce is offering a specific power plant – the so called “Trent XWB” (Airbus Engine, 2013). On the other hand, also the power plant corporation Engine Alliance announced in 2006 to negotiate with Airbus to develop an own engine for the A350 XWB (Ezard, 2006). However, this did not happen and that is why customers can actually only choose the Rolls Royce engine. Nevertheless, the aspect that only one type of engine is used in the A350 aircraft family simplifies the supply chain in comparison to other projects and allows the power plant supplier to produce a higher quantity of engines (Johnson, 2014).

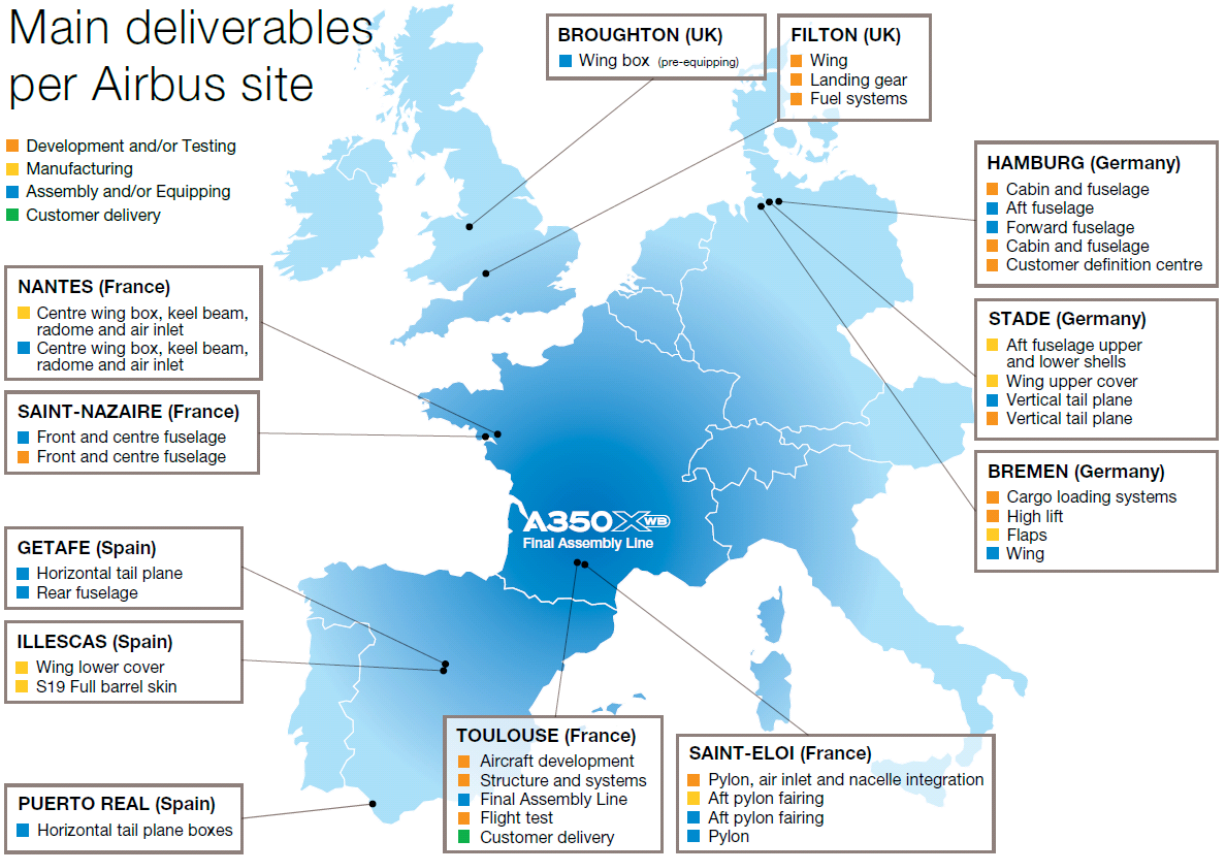
Moreover, the third procurement field is focused in the purchasing of equipment and systems. Parts of this area are for instance the flight avionics system, the hydraulic system, the cabin intercommunications system, electrical power systems and the air conditioning system. In accordance with Airbus FAST (2013), the OEM decided to involve suppliers at the systems level. Therefore, the development and research is done by Airbus and the supplier is supposed to design the system based on the requirements based specification which is provided by Airbus.

In accordance with Cauquill (2010), the fourth procurement field of Airbus is related to the airframe. These structural parts are the bearing elements of aircraft and are made of CFRP in case of the Airbus A350 XWB. As mentioned by Airbus FAST (2013), the term airframe implies all structural elements of an aircraft such as the wings, the fuselage, the ailerons, the landing gear and the empennage.

However, the high complexity of the subject field requires the definition of focus areas within the SCM investigation. Therefore, object of consideration within this case study is a closer depiction of the A350 XWB airframe supply chain. The illustration of this procurement field aims to identify the related purchasing methodology of Airbus and to depict as detailed as possible the applied supply chain approaches.

According to Airbus FAST (2013), the supply chain structure of the A350 XWB airframe is highly complex and that is why it is separated into an internal supply chain and an external supply chain. The internal supply chain is characterised by the

diversity of part and equipment supplying Airbus subsidiaries all over Europe. As depicted in figure 13, airframe providing subsidiaries are located in Spain, UK, France and Germany which are delivering components to the “Final Assembly Line” (FAL) in Toulouse, France.

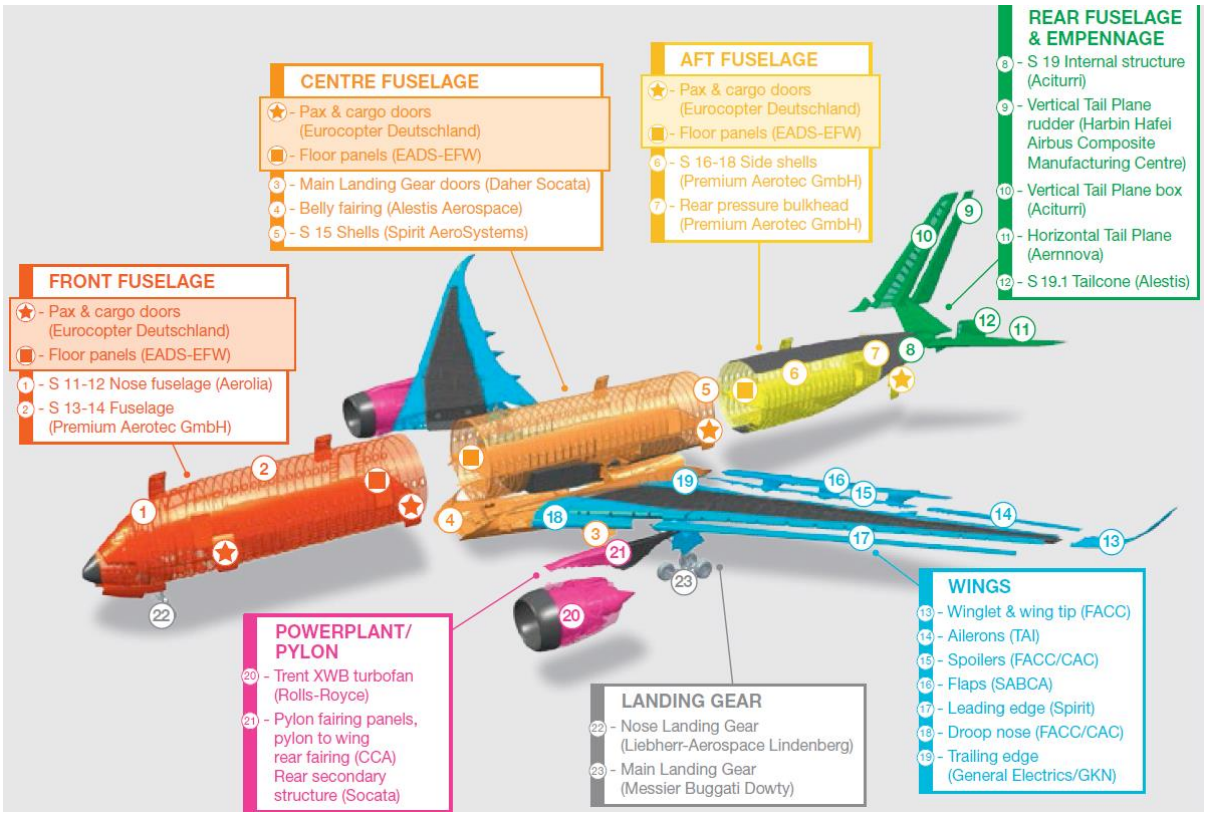


Source: Airbus FAST (2013): 14

Figure 14: The internal supply chain structure of Airbus for the airframe

However, the structure of the internal supply chain is related to the historical and political background of Airbus. As mentioned by Gordon (2014), the company structure and the applied manufacturing strategy are highly political influenced by the countries in which subsidiaries are located. According to Tatje (2011) and Morrison (2010), the locations of production/ development facilities as well as the location of subsidiaries are associated to the complex ownership structure of the Airbus Group. As mentioned by Morrison (2010), in 2010, more than 50% of the shares were owned by shareholders with a political influence of the related country. Particularly, France and Germany own both 22.46% of the shares with the assistance of governmental

related banks and corporations (Morrison, 2010). Therefore, the production locations of the Airbus A350 XWB aircraft were carefully chosen to fit in this corporate framework (Airbus FAST, 2013). In accordance with Airbus FAST (2013), the fuselage is assembled and equipped in Hamburg and partitioned manufactured by Premium Aerospace (Germany) and Aerolia (France). The equipped fuselage parts are shipped afterwards to the FAL in Toulouse. As depicted in figure 14, the internal supply chain is complemented by external suppliers which provide materials and equipment to the sectional responsible subsidiaries, such as Hamburg, and the FAL in Toulouse.



Source: Airbus FAST (2013): 14

Figure 15: Main component partners of the external airframe supply chain

According to Airbus (2013) and Airbus FAST (2013), even other divisions of the Airbus Group - such as Airbus Helicopters - are considered as external partners. Related to the introduction of the A350 program, Airbus has moved towards a greater reliance on its suppliers to test the systems and the structural parts which is based on the so-called “New Supplier Policy” (NSP) (Airbus FAST, 2013). This philosophy aims

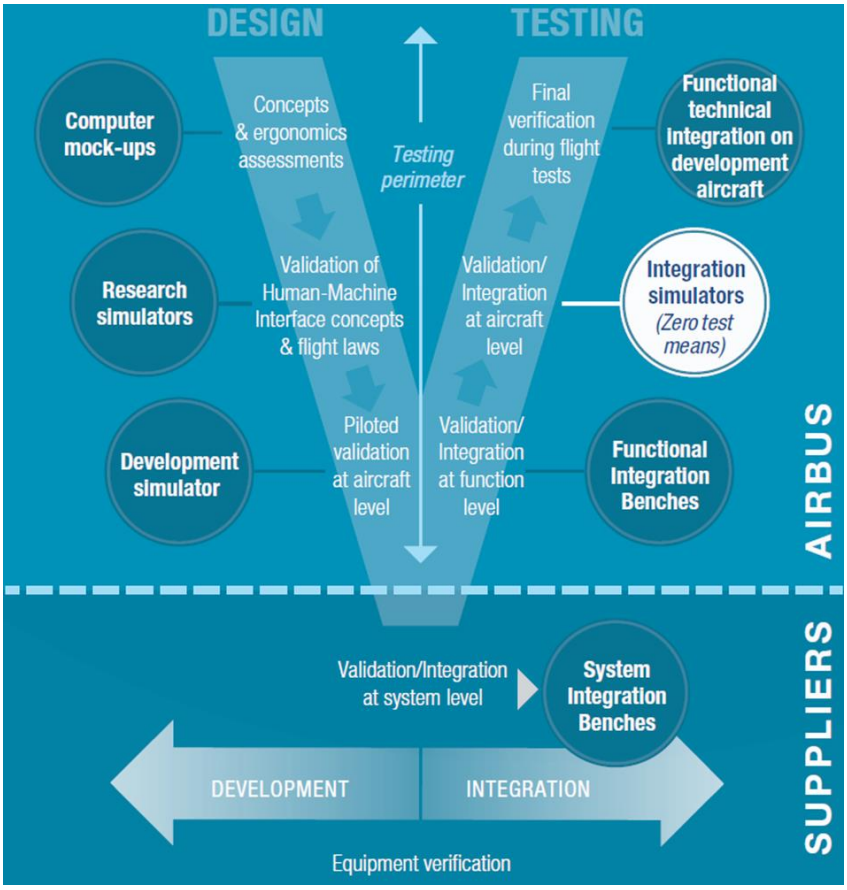
to achieve the improvement of efficiency in development and manufacturing projects by moving the responsibility for bigger work packages towards the suppliers (Airbus FAST, 2013); (Airbus Annual Report 2013, 2014). Based on the NSP, the integration of systems and the testing of materials are in the responsibility of the component partners. The implementation of NSP is based on an earlier strategically alignment to involve suppliers earlier in the development and manufacturing process to share risks and to access new markets (Airbus, 2012). Moreover, figure 15 illustrates detailed the Airbus A350 XWB suppliers in UK:

Source: Airbus UK (2014)

Figure 16: Airbus A350 XWB - the major suppliers in UK

According to Airbus UK (2014), the company provided work packages in a broad way to suppliers. As depicted in figure 15, Airbus has only two own facilities in the country – the rest of in minimum 28 suppliers are SME[14]. For instance, the supplier for mechanical actuators is located in St Albans (Hertfordshire) and employs a workforce of 35 people (Airbus UK, 2014); (Premier LTD, 2013). This company is mentioned as a representative of SME supplier companies in UK and all over Europe.

As mentioned by Airbus FAST (2013), the company envisions oneself as an integrator which is defining the requirements for a system and which is integrating the supplier provided and tested equipment. Figure 16 depicts the border between OEM and supplier in the verification and validation procedure of the Airbus A350 related NSP.



Source: Airbus FAST (2013): 8

Figure 17: Verification and validation procedure of the Airbus A350 related NSP

[14] SME: Small-medium enterprises

As mentioned by Cauquill (2010), the fifth procurement field is related to the purchasing of cabin equipment. In accordance with Kirby (2010), Airbus introduced a cabin equipment catalogue for the A350 XWB – hence airlines can choose out of different solutions which imply varying component and material supplier. Kirby mentions further, that Airbus introduced a new supplier category - the “Airbus Contracted Supplier” (ACS) - for items and equipment to ensure suppliers participate in the joint definition phase of the programme and understand the design language in an early project phase.

Beside the ACS supplier category, Airbus differentiates between “Seller Furnish Equipment” (SFE) and “Buyer Furnished Equipment” (BFE) suppliers (Kirby, 2010). As stated by Naughton (2014), BFE are items, such as the IFE in the Airbus A380, which are selected and ordered by the customer (airline) and which are assembled by the OEM on behalf of the customer. Moreover Naughton (2014) mentions, that SFE items are items such as lavatories and galleys which are only less customized within the A350 program.

However, Airbus has signed ACS contracts with the leading aerospace component suppliers such as B/E Aerospace, Recaro, Zodiac Group and Sogerma (Kirby, 2010). In accordance with Kirby (2010) and Airbus Annual Report 2013 (2014), Airbus intents to implement the ACS contracting approach on more fields than the A350 cabin equipment field to reduce the complexity in development, manufacturing and maintenance.

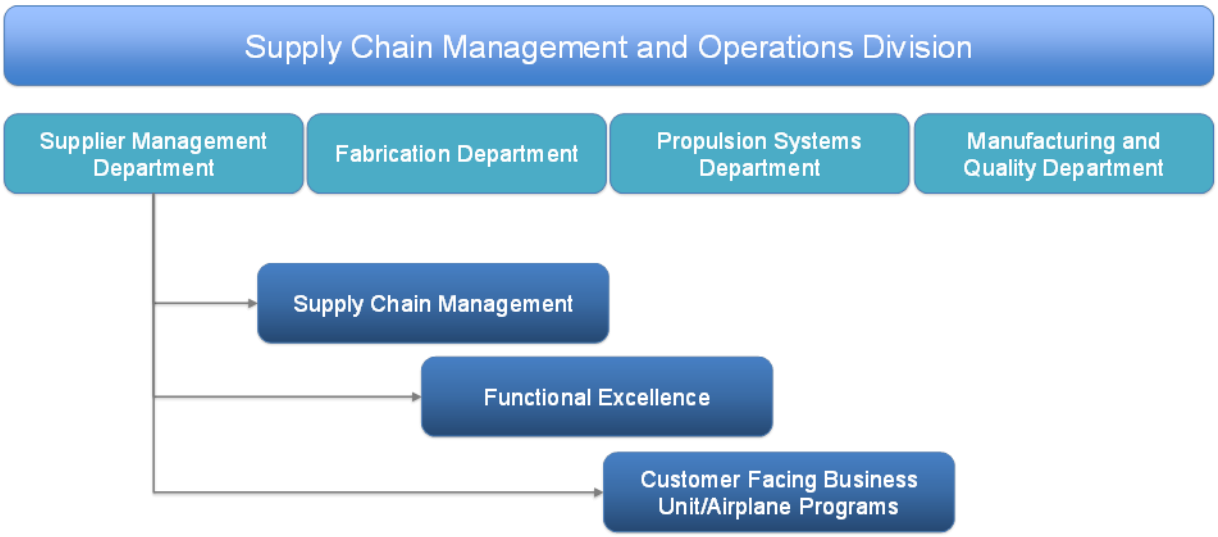
4.2. Supply Chain Approach of Boeing 787 Dreamliner

The supply chain strategy of Boeing Civil Airplanes in terms of the 787 Dreamliner program is closely related to the competition to Airbus airplanes. As mentioned by Denning (2013), after losing market share to Airbus in the late 1990, Boeing could have changed the focus on reducing cost of the existing airplanes and all new developments. As a result of that, Boeing planned to introduce the 787 Dreamliner program to create a bigger value for customers (Denning, 2013). As stated by Denning, Boeing aimed to increase the travel experience for the passengers by using composite materials for the fuselage which allows a higher humidity in the cabin, a higher cabin pressure and larger windows. On the other hand, Denning mentions further that Boeing aimed to improve the value for its immediate customers (airlines) by an improved operational performance of the 787 Dreamliner. This improved operational performance is based on the usage of light-weight composite materials, modern power-plants and a new electrical design philosophy – also called MEA[15] (Tang, et al., 2009); (Hale, 2006). In accordance with Denning (2013), the main focus of Boeing within the 787 development project was to decrease the acquisition and the operational cost as much as possible and that is why the aircraft was promoted as high efficient and much cheaper than comparable Airbus airplanes. Hence, the 787 became the fastest selling plane in aviation history (Denning, 2013).

According to Exostar (2013), the supply chain strategy of Boeing is to leverage global partners to reduce cost, to reduce the time-to-market, and to increase the customer value while maintaining the highest level of safety. In 2009, Boeing planned to reduce the development cost of the 787 airplane from £6,5 to £4 billion and the development time from 6 to 4 years by using an unconventional supply chain approach (Tang, et al., 2009). As further mentioned by Tang, et al. (2009), the complex 787 supply chain was created to keep manufacturing and assembly costs low, while spreading the financial risks of development to the responsible suppliers. However, after the maiden flight in the year 2011 the development costs reached the mark of £20 billion and the development time increased to 7 years (Gates, 2011).

[15] MEA: More Electric Aircraft

In accordance with Boeing SCM (2014), the Boeing Commercial Airplanes Supplier Management is an own department under the supervision of the Supply Chain Management and Operations Division. Figure 17 outlines the organizational approach of the BCA supply chain management.



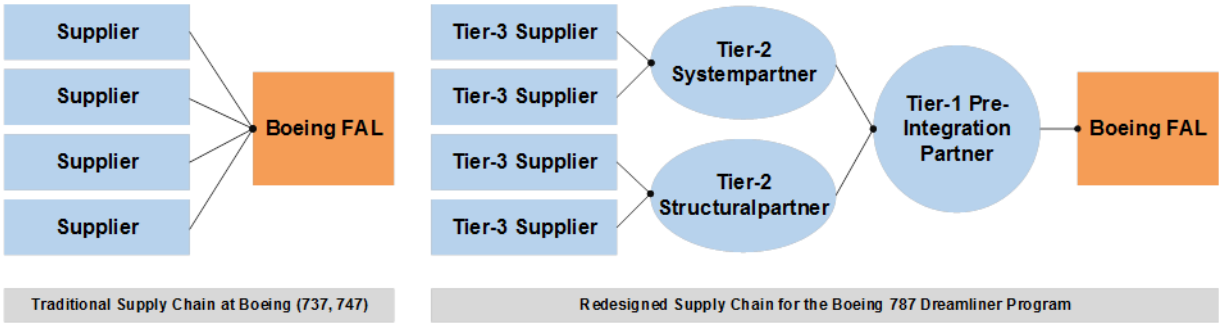
Source: Figure is based on Boeing SCM (2014)

Figure 18: Functional organization approach of Boeing Commercial Airplanes

As depicted in figure 17, the Supply Chain Management Sub-Department is under supervision of the Supplier Management Department and is responsible for the coordination of all external procurement activities for the related aircraft programs. Further stated by Boeing SCM, the sub-department Functional Excellence is in charge of the process management with special focus on supplier contracts, quality and operations. Moreover, the sub-department Customer Facing Business Unit/Airplane Programs manages all requirements of the supply related to the particular aircraft program. According to Boeing SCM (2014), the Supplier Management Department employs over 3000 people which coordinate more than 1.400 production suppliers in over 30 countries.

In accordance with Denning (2013) and Tang, et al. (2009), Boeing implemented a new supply chain strategy with the 787 aircraft program which seperates the supplier related to the system level in “Tier-1”, “Tier-2” or “Tier-3” supplier. This SCM approach is different from the usually used aproach for current Boeing airplanes such as the

747 airplane. Figure 18 depicts the two different managing approaches which Boeing applies on older aircraft programs and the new 787 Dreamliner program:

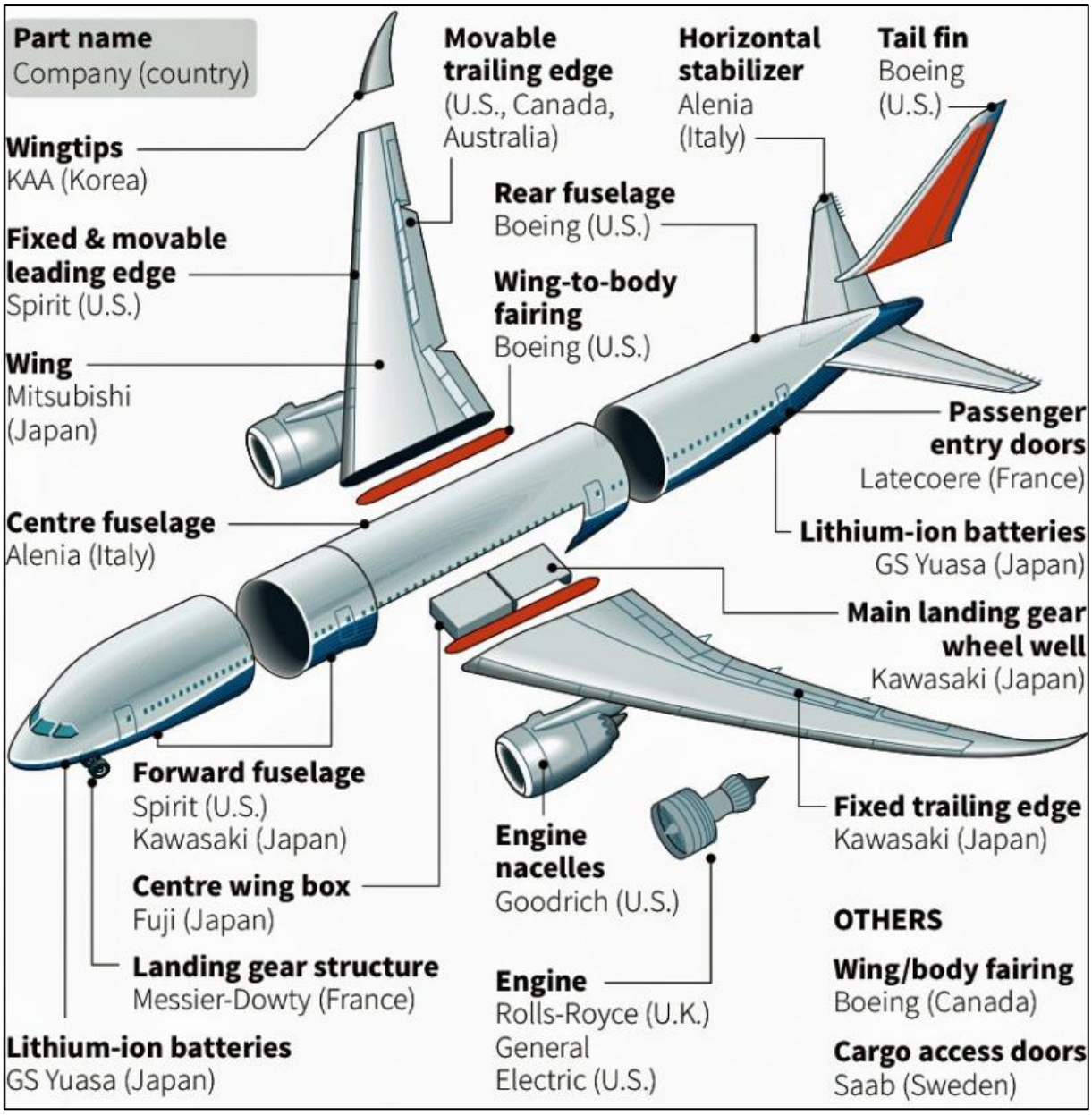


Source: Figure is based on Tang, et al. (2009)

Figure 19: Boeing supply chain approaches - traditional vs. redesigned approach

According to Tang, et al. (2009), Boeing used for the older aircraft programs a traditional supply chain approach in which all suppliers provide their materials and parts directly to the OEM. On the other hand, Boeing redesigned the supply chain for the 787 aircraft program by introducing “tier-suppliers”, as depicted in figure 18. Tier-3 suppliers provide materials and parts to Tier-2 system- and structural partners which pre-assemble components and sub-systems. Subsequently, the pre-assembled components and sub-systems are shipped to tier-1 pre-integration partners which serve the Boeing FAL as integrators (Tang, et al., 2009); (Denning, 2013). The term of “integrator” means in this case that tier-1 companies provide Boeing operative and tested equipment which only needs to be installed into the airplane. As further mentioned by Tang, et al. (2009), Boeing fosters partnerships with about 50 tier-1 strategic partners. Moreover as stated by Tang, et al. (2009), the contractual basis differs from the approach of further Boeing aircraft programs – Boeing concluded risk sharing contracts with tier-1 strategic partners for the 787 program. In accordance with Horng & Bozdogan (2007), the philosophy of lean manufacturing is deep rooted in the 787 supply chain approach and stipulated why Boeing anticipates a just-in-time (JIT) supply of components and systems from tier-1 partners. However, the borders for this investigation of the Boeing supply chain are set in the same field as for Airbus to keep this investigation comparable. Hence, the field of investigation is the airframe which is a significant part for an aircraft. According to Horng & Bozdogan (2007),

Boeing has outsourced the entire wing design and manufacturing to tier-1 strategic suppliers, such as Fuji Heavy Industries, Kawasaki Heavy Industries and Mitsubishi Heavy Industries. Boeing only assembles the supplied wing components in Everett. Figure 19 illustrates the 787 airframe supplier structure – including landing gear, power plants and batteries.

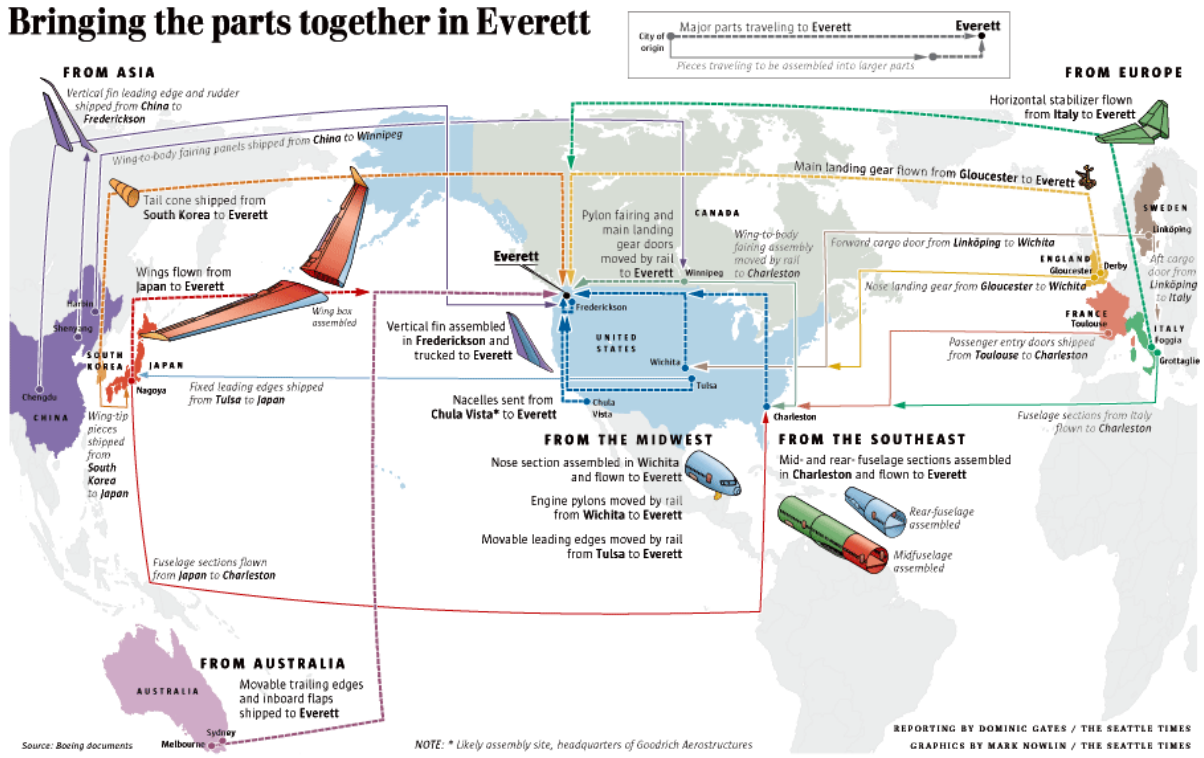


Source: Petterson (2011)

Figure 20: Boeing 787 airframe supplier structure

As depicted in the figure above, the companies which are responsible for airframe parts can be considered as tier-1 supplier. According to Tang, et al. (2009), the

general amount of outsourcing within the 787 program reached more than 70 percent (30 percent from oversea). As mentioned by Petterson (2011), Boeing manufactures only two airframe components on its own – the tail fin and the wing-to-body fairing. As further stated by Petterson (2011), this modular approach decreased the complexity for Boeing in development, manufacturing and testing. However, the management and coordination work increased by the applied 787 approach and that is why Boeing spends an extraordinary effort to organize the supply chain which is often considered as one of the most complex ever created supply chains in industry history (Denning, 2013); (Batey, 2010). Figure 20 illustrates the supply chain of tier-1 airframe supplier located all over the world in combination with the related shipping paths (for a larger picture please see appendix 1).



Source: Gates & Nowlen (2012)

Figure 21: Boeing 787 tier-1 supplier supply chain map

In accordance with Gates & Nowlen (2012), the supply chain of Boeing involves tier-1 partners in all important industry areas, such as Europe, Australia, Japan, South Korea and China. On one side, Boeing accesses markets in all powerful and wealthy

areas, which enables the company to receive more sympathy and goodwill from local airlines which intend to order new airplanes. On the other hand, Boeing and their partners need to face a lot of challenges to develop, manufacture, test and ship all components in time, quality and budget to the FAL in Everett (Petterson, 2011).

According to Tang, et al. (2013), the setup and implementation of the dreamliner supply chain was accompanied by serious difficulties and challenges. As further mentioned by Tang, et al. (2013), the Dreamliner became a nightmare for Boeing after the first machines had their “entry into service” (EIS). The chapter 6.1 “risks and challenges” will outline the general difficulties which Airbus and Boeing need to face – however, according to Petterson (2011), it is for the sake of completeness to mention a particular challenge in case of the supply chain which Boeing faced during the development and manufacturing process. Moreover, this challenge provide a deeper view on the SCM approach of Boeing.

Firstly, the managers of Boeing underestimated the complexity of the supply chain by offshoring more than 70% of the component/ system development and manufacturing (Levick , 2013). Moreover, Levick (2013) quotes Dr. L. J. Hart-Smith, a highly esteemed and now retired aerospace engineer of Boeing, who warned as early as 2001 that “without onsite quality management and technical support for suppliers, the performance of the prime manufacturer can never exceed the capabilities of the least proficient of the suppliers”. Hence, the aspect of deep rooted quality management were not applied in a way that all supplier levels were monitored by Boeing in an appropriate way (Levick , 2013); (Denning, 2013). Moreover, Levick points out that an OEM is only as good as the weakest part/ link in the supply chain. According to Denning (2013) and Beech, et al. (2014), the battery fire accidents of a Japan Airlines and an All Nippon Airlines 787 aircraft were widely recognized as a weakness of Boeing´s Quality management process. Furthermore, this incident also indicates that Boeing focuses and rely on the responsibility of tier-1 supplier to ensure the quality and certification process (Levick , 2013).

However, Levick (2013) underlines that Boeing builds a safe and innovative airplane with the 787 dreamliner – the company just pays a high price for that.

5. Analysis

Based on the outlined case studies of the Airbus A350 XWB and the Boeing 787 Dreamliner aircraft programs, this chapter will provide a proper analysis of the key features, approaches/ strategies related to the considered supply chains. Foremost, the following analyses are particularly focused on the aspects of competitiveness and profitability in the field of SCM.

5.1. Identifying Key Features and Strategies

This chapter will identify and compare the individual key features of Airbus and Boeing. Moreover, the specific strategies of the OEM are identified and compared with focus on the 787 Dreamliner and the A350 XWB. Furthermore, the general managing strategies and supplier relationship philosophy of both OEM is depicted with respect to SCM. However, this chapter will also name approaches and key features which are not particularly mentioned in the illustrated case studies. The methodology of the comparison is based on Tang, et al. (2013).

5.1.1. Comparison of Individual Supply Chain Key Features

Table 1 identifies and compares considerable key features of the Airbus A350 XWB and Boeing 787 Dreamliner supply chain.

Table 1: The individual key features of the OEM

Sources: Airbus Annual Report 2013 (2014), BoeingCompany (2014), Flottau (2014), Parken (2006)

Key Feature	Boeing 787 Dreamliner	Airbus A350 XWB
Business formation	Founded in 1916 by the engineer William Edward Boeing.	Founded in 1970 as part of a political decision to create a European aerospace company.
Number of suppliers	About 50 tier-1 partners	213 external partners.

Key Feature	Boeing 787 Dreamliner	Airbus A350 XWB
Amount of outsourcing	More than 70%.	Up to 70% (including companies within the Airbus Group which are seen as external partners).
Production facilities	2 FAL in Everett and Renton (USA).	4 FAL in Toulouse (France), Hamburg (Germany), Mobile (USA), Tianjin (China). Moreover, 13 production facilities all over Europe.
SCM management tool	Exostar Supply Chain Platform	SAP / Airbus ePROC tool

As depicted in table 1, Boeing focuses mainly on 50 tier-1 strategic partners in supply chain management. On the other hand, Airbus manages about 213 external partners. Furthermore, the amount of outsourcing is different in case of the 787 and the A350. As mentioned in table 1, the amount of outsourcing is about 70% for both aircraft programs. Nevertheless, the external partners of Airbus even include subsidiary within the Airbus Group such as Premium Aerotec (manufacturing of fuselage parts; 100% subsidiary) and Eurocopter (manufacturing of doors; 100% subsidiary). Moreover, Airbus usually does not use the term of “tier-1” suppliers – the OEM rather calls them System and component responsible “risk sharing partners” (Mock, 2007). However, the structure of the production facilities of both OEM is different related to the number and distance of locations. Boeing has FAL in Everett and Renton – the production of components is also included in the facilities. The distance of both Boeing production locations is only 60 km. However, the 787 airplane is only manufactured in Everett. On the other hand, Airbus runs generally FAL in 4 different locations and further production locations 13 facilities all over Europe. Nevertheless, the A350 XWB airplane is only assembled in Toulouse. Furthermore, the OEM implemented each a particular SCM management tool which enabled the creation and management of the related complex supply chain.

5.1.2. Comparison of the Particular Corporate LRCA Strategies

Based on the outlined case studies, table 2 depicts the different corporate strategies of Airbus and Boeing with focus on SCM and related to the LRCA programs A350 XWB and 787 Dreamliner.

Table 2: Comparison of Airbus and Boeings particular corporate LRCA strategies

Sources: Airbus (2012); Tang, et al. (2009); Kirby (2010); Boeing SCM (2014); Trimble (2014)

Strategy	Boeing 787 Dreamliner	Airbus A350 XWB
Sourcing strategy	Outsourcing No known subcontracting and reshoring	Outsourcing Rarely subcontracting No known reshoring
Supplier relationship strategy	Strategic partnerships with tier-1 suppliers	System and component responsible risk sharing partners
Supplier structure	Worldwide	Mainly European
Supply contract strategy	Risk-sharing contracts	Airbus contracted supplier contracts on a risk sharing base
Assembly supply strategy	Just in time	Just in time/ just in sequence
Supplier support strategy	Suppliers are set under pressure to achieve the contracted aim.	Support on all levels by workforce, knowhow and financial support.
Supplier strategy	Imperative approach	Cooperative Approach

As depicted in table 2, the sourcing strategy of Airbus and Boeing is generally more similar than different. Outsourcing as a long-term procurement approach is applied in both companies. However, the short-term approach of subcontracting is not used by Boeing and rarely used by Airbus.

As depicted in table 2, both companies do not plan to reshore production facilities or work packages from suppliers. Nonetheless, the supplier structure of Boeing differs from Airbus by a worldwide approach. The majority of Airbus supplier is located in European countries. As mentioned before, also Airbus intends to increase the procurement activities in non EU countries – mainly to avoid currency uncertainties and to get access to new markets, as India and China (Airbus, 2012).

According to Kirby (2010) and Tang, et al. (2009), Boeing concludes risk sharing contracts with strategic partners and Airbus applies the ACS contract system on suppliers which are generally risk sharing contracts. Moreover, both companies follow the lean management approach in terms of the manufacturing strategy. Hence, both OEM expect their suppliers to supply just-in-time. However, the extended approach of JIT, called “just-in-sequence”, is faced by Airbus as well (Recaro, 2012).

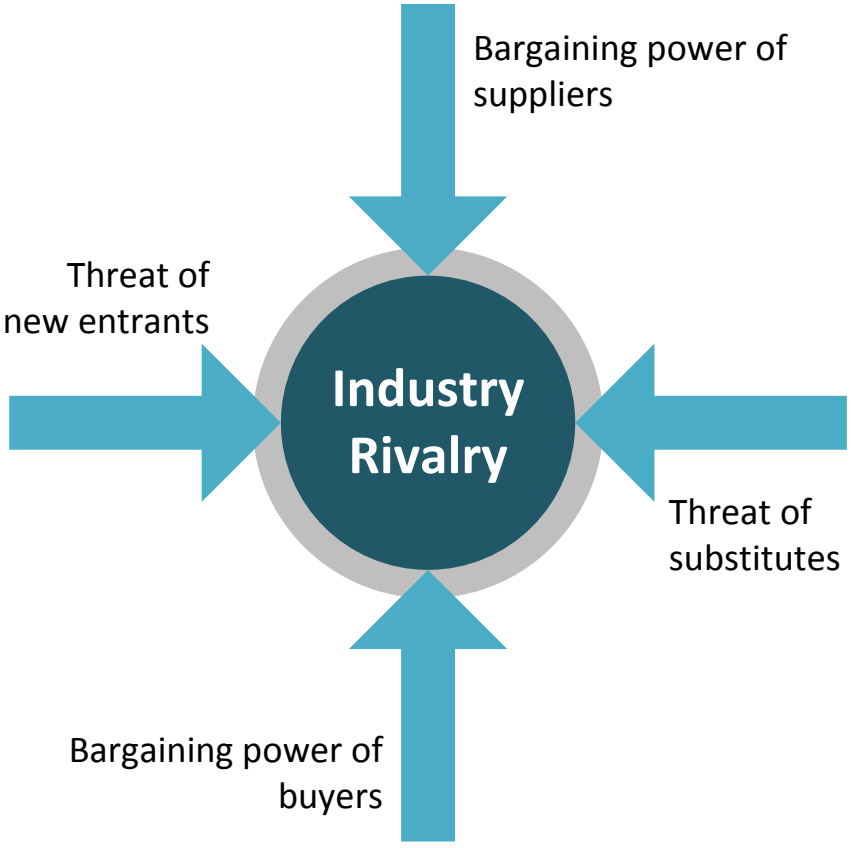
According to Trimble (2014), Airbus applies a cooperative supplier strategy by supporting partners in case of urgent challenges by workforce, knowhow and financial support. On the other hand, Boeing applies more an imperative approach in their supplier strategy (Trimble, 2014). Nevertheless, both companies expect their suppliers to apply a professional project management on their work packages (Statham & Brian, 1996).

5.2. Porter Five Forces Analysis

This chapter aims to provide the definition of the porters five forces analysis and the profound analysis of the approaches/ strategies of Airbus and Boeing. Moreover, the results of the porters five forces analysis are discussed and concluded.

5.2.1. Introduction of Porters Five Forces Analysis

The Porter Five Forces Analysis is a framework which aims to achieve the analysis of a company's strategy and the level of competitiveness in the market. The following figure illustrates the framework and the forces which are considered by Porter (2002):



Source: Figure is based on Tang (2014)

Figure 22: Porter Five Forces Analysis

According to Tang (2014), the Porters Five Forces Analysis is a powerful tool to analyse the current situation and strategy of a company's business. The centre of the analysis depicts the competitive rivalry between the considered company and its

competitors. The aspect of supplier power assesses how easy it is for suppliers to negotiate new and better prices for them. Generally, the fewer the supplier choices a company has, the more powerful the suppliers are.

On the other hand, the aspect of buyer power is considered on the opposite of figure 22. This part of the Porters Five Forces Analysis considers how easy it is for the customers to negotiate better prices for them. Companies which only trade with few buyers, often have a weaker position in negotiating prices. Moreover, the threat of new entrants is illustrated on the left side of the figure 22. This aspect analyses the entry barriers for new competitors to the market of the considered company. Finally, the threat of substitutes is considered on the right side of figure 22 which represents the Porters Five Forces Analysis. The threat that customers find substituting solutions for the products of the considered company is necessary to analyse to prevent a wrong strategic focus (Tang, 2014), (Porter, 2002).

The Porters Five Forces Analysis was developed by Michael Porter and published in his first book “Competitive Strategy: Techniques for Analysing Industries and Competitors” in the year 1980. As mentioned by Chapman (2013), the Porters Five Forces Analysis can be used as a proper basis for further analytical methods such as the SWOT Analysis and the PEST Analysis which are provided in this report in chapters 5.3 and 5.4.

According to Porter (1980) and Chapman (2013), companies and their business models can be assigned to five generic descriptions of industries: Fragmented (gift shops), Emerging (space travel), Mature (automotive), Declining (printed newspapers) and Global (micro-processors). The following chapters will assess the strategy and situation of the companies Airbus and Boeing by the Porters Five Forces Analysis to provide a comprehensive picture of the SCM strategies and approaches which are applied by the considered companies.

5.2.2. Porter Five Forces Analysis - Airbus A350 XWB

The Porters Five Forces Analysis of Airbus with focus on the A350 XWB aircraft program aims to provide a comprehensive picture and assessment of the current situation of the company's business and the related strategy. Referring to Porter (1980) and Chapman (2013), the Airbus Company and in general the aerospace industry as a whole can be considered as a mature industry sector. Figure 23 illustrates the analysis and gives an overview about the assessment of the related areas of investigation:

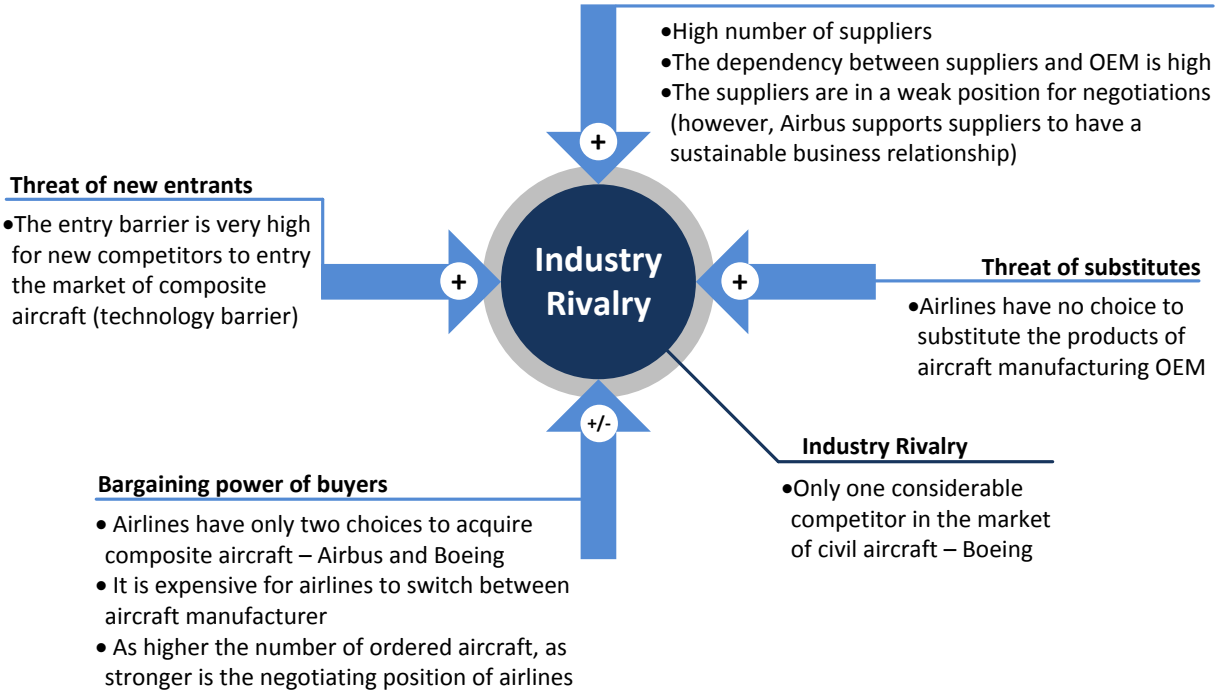


Figure 23: Porters Five Forces Analysis related to the Airbus A350 XWB

The industry rivalry for Airbus is high - even there is only Boeing as a considerable competitor in the growing market of composite aircraft (Hollinger, 2014). As depicted in figure 23, the Airbus Company is in a powerful position to negotiate with suppliers. As a result of the new implemented A350 SCM strategy of Airbus, it is expected that the negotiating power of suppliers will rise in the long run (Ram, et al., 2013). The high number of suppliers in the Airbus A350 XWB aircraft program in combination with the high amount of outsourcing (internal and external) causes a high dependency between suppliers and the OEM.

However, Airbus applies an appropriate balance between the management of own interests and to satisfy their suppliers by a cooperative SCM approach which can be considered as an advantage for their strategic position within the aircraft market (Trimble, 2014).

On the other hand, the bargaining power of the customers - in this case the airlines – is high which leads to advantages and disadvantages for the aircraft OEM (Michaels & Carey, 2011). In accordance to Michaels & Carey (2011), airlines have a high influence and power on the manufacturer when ordering a large amount of aircraft. Hower, Michaels & Carey (2011) mention further that airlines make themselve dependant on aircraft manufacturer - especially in focus on the training of pilots, the maintenance processes and further technical and marketing aspects when ordering aircraft only at one manufacturer. Generally, a commonly accapted concept is that “As higher the number of ordered aircraft, as stronger is the negotiating position of airlines” (Boelke, 2014). According to Johnsson, et al. (2014), a majority of the airlines in the world maintain a balanced aircraft fleet with airplanes from Airbus and Boeing to prevent an adverse dependancy on a manufacturer.

As depicted in figure 23, the threat of substitutes is generally quite low for the Airbus Company. Airlines as direct customers of the OEM do not have other choices to substitute the procurement of aircraft. Only the customers of the airlines - the passengers - have the opportunity to find a alternative to flying by e.g. taking the train or a ship for transport.

The last aspect which is considered by the Porter Five Forces Analysis with respect to the Airbus A350 XWB aircraft program is the threat of new entrants. As stated by (Hatton, 2009)Hatton (2009), the aerospace industry is a mature and well established industry which requires very high investments for companies to compete. Moreover, Denning (2013) further mentiones, that composite aircraft - such as the A350 XWB - require special manufacturing processes and a high level of technical competence. Hence, the entry barrier for potential competitors is generally high to access the new market of LRCA which can be considered as an advantage for the Airbus Company.

5.2.3. Porter Five Forces Analysis - Boeing 787 Dreamliner

The Porters Five Forces Analysis of Boeing with focus on the 787 Dreamliner aircraft program aims to illustrate and to assess the current situation of the company's business and the related strategy. The analysis of the Boeing Company is superficial similar to the analysis on the Airbus company – however, in detail there are differences which are depicted in figure 24 and discussed as followed:

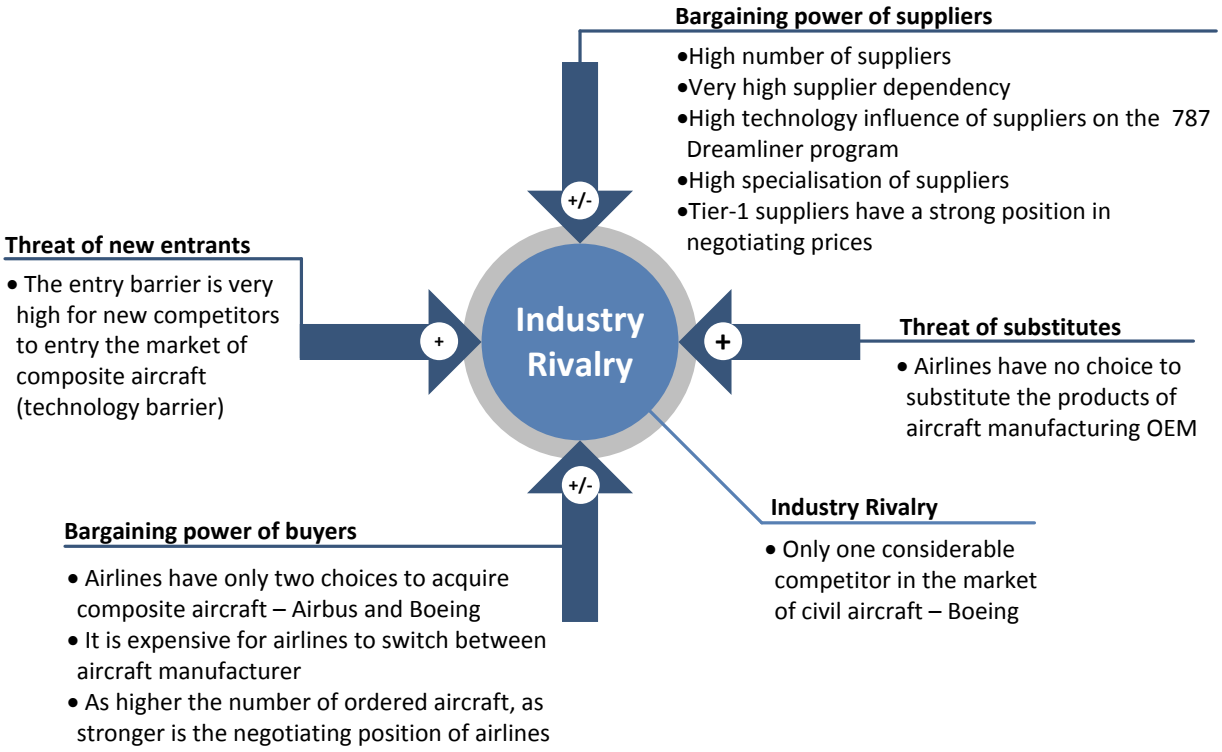


Figure 24: Porters Five Forces Analysis related to the Boeing 787 Dreamliner

The Boeing Company is facing a strong competition with the Airbus Company – in all types of aircraft. As depicted in figure 24, the bargaining power of suppliers varies dependant on the type of suppliers. Tier-1 suppliers are important and powerful partners for the Boeing Company. Tier-2 and tier-3 suppliers are less powerful and why Bowing focuses mainly on tier-1 strategic partners. Moreover, the development and manufacturing for the majority of all systems and components is based in the responsibility of tier-1 supplier. As mentioned by Denning (2013), Boeing outsourced within the 787 Dreamliner program "mission critical components" such as the electrical system and the avionics system. As a result, the Boeing Company became

highly dependent on these suppliers which can be considered a disadvantage. On the other hand, suppliers of the Boeing Company are also highly dependent on the OEM as their main customer why this force of the model can be considered as even/ mediums. The bargaining power of buyers with respect to the Boeing Company can be considered as the same force as mentioned before for the Airbus Company. Due to the different power of airlines - which is mainly related to the number of bought aircraft – this force can also be considered as even. Furthermore, the threat of new entrants as well as the threat of substitutes can be estimated as low which is an advantage for the Boeing Company.

5.2.4. Results of Porter Five Forces Analyses

The Porter Five Forces Analyses of Boeing and Airbus led to insights in the corporate strategies of the considered companies and created a deeper understanding of the general aerospace market. Considerable results are depicted as followed:

- The challenge of industry rivalry for both Airbus and Boeing with respect to LRCA are the same.
- The bargaining power of suppliers is more powerful at Boeing.
- The bargaining power of buyers varies in both companies and the level of varying is similar.
- The threat of new entrants is low when it comes to get access to the highly specialised market of LRCA.
- The threat of substitutes is low for both companies due to the highly specialized traits of the industry.

The main difference between the companies Airbus and Boeing within the Porter Five Forces Analysis is based in the area of the bargaining power of suppliers. As illustrated in the case studies of Airbus and Boeing, these two companies follow different SCM strategies. Due to the aspect that Airbus kept more competencies in-house, the company can be considered as being in a stronger position when facing supplier negotiations.

5.3. PEST Analysis

The PEST Analysis aims to outline an analysis of the environmental/ boundary factors which have influence on the supply chain strategy for the companies Airbus and Boeing related to the considered LRCA programs. Moreover, the present analysis shall provide a deeper understanding of the dependencies in aerospace SCM.

5.3.1. Introduction of PEST Analysis

According to Bensoussan & Fleisher (2012), the PEST Analysis is a framework to analyse the macro environment of a companies strategy by investigating the influence factors which are depicted as followed in figure 25:

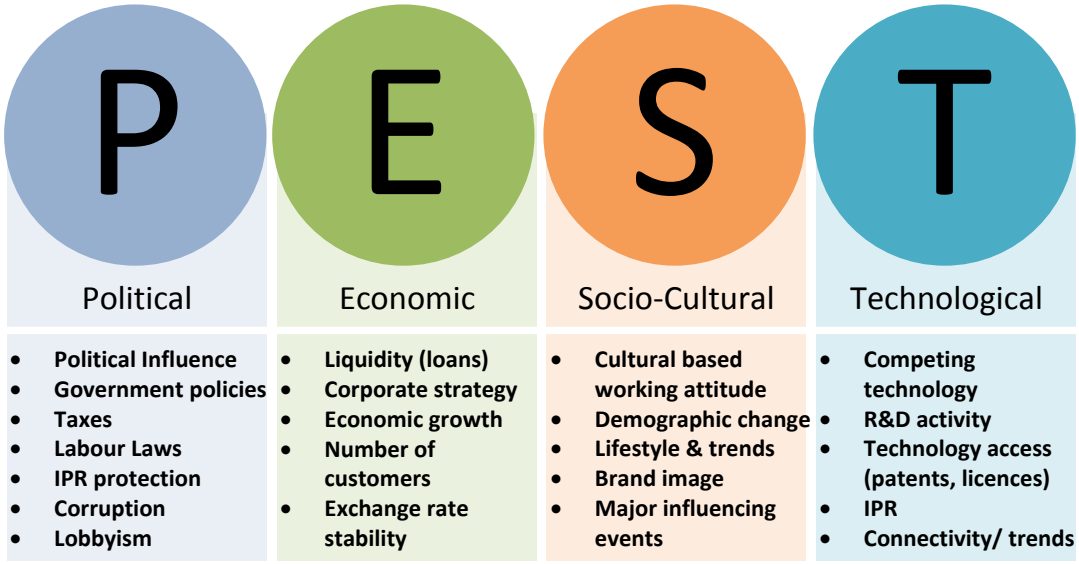


Figure 25: The PEST Analysis

The PEST Analysis investigates the macro environment of a business related to political, economic, socio-cultural and technological factors. This report focuses on particular aspects within the framework of the PEST Analysis which are illustrated in figure 25. Hence, the analysis of the companies Airbus and Boeing with reference to the aircraft programs A350 XWB and 787 Dreamliner is applied based on these factors. As a result, the PEST analysis shall lead to a comprehensive picture of external factors which are influencing profitability and competitiveness in aerospace manufacturing business.

5.3.2. Political Factors

According to Shah (2002), big corporations and the political body of the related home country influence each other in various ways. This mutual influence leads to individual challenges for the considered aerospace companies – especially in terms of SCM. Figure 26 depicts particular aspects related to the companies Airbus and Boeing:

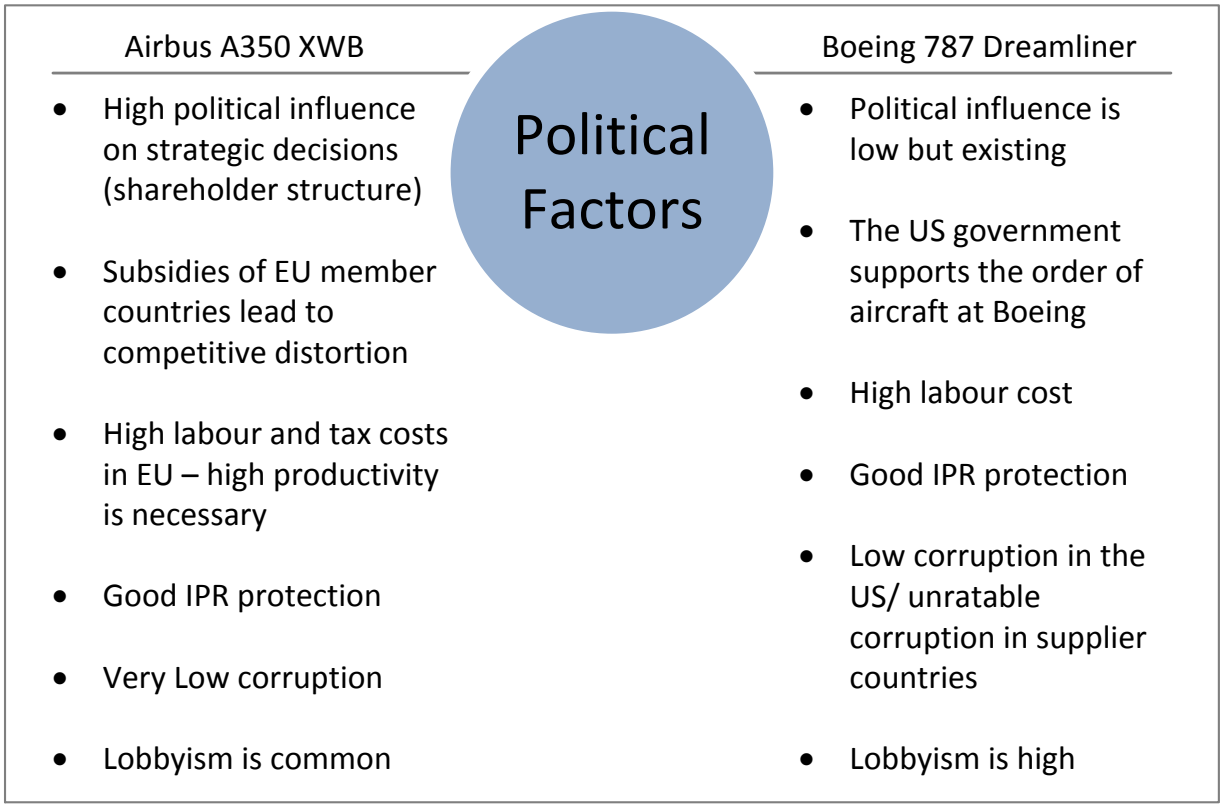


Figure 26: Political factors on the SCM strategy of Airbus and Boeing

As illustrated in figure 26 and stated by Carnegy (2013), the Airbus Company is generally high influenced by its European shareholder countries such as Germany, France, Spain and the United Kingdom. This influence is reflected by the organisational structure of the company, its development/ manufacturing locations and the close cooperation with governmental authorities such as the European Space Agency (ESA) (Airbus, 2012); (Carnegy, 2013).

However, the high taxes and labour costs in Europe lead to the requirement of a high productivity of the manufacturing facilities to be competitive – sometimes also

supported by subsidies (Thompson, 2012). On the other hand, Airbus and Boeing are proceeding lobbying to take influence in political decisions which affect their business (Foust, 2009). The supply chain strategy of the companies' airbus and Boeing influences massively the job situation in Europe and the USA – hence the involved countries and trade unions try to keep as many jobs in the related countries by taking influence e.g. by campaigning (Petterson, 2011). According to Transparency International (2012), corruption related to politics and partners in the supply chain is an emerging challenge in global business. Moreover, a consequent protection of IPR is an important aspect for OEM such as Airbus and Boeing which intend to ensure comprehensively their supply chain.

5.3.3. Economic Factors

As stated by Blanchard (2009), Economic factors can highly influence the supply chain strategy for a certain product and can cause several risks. Following, figure 27 illustrates particular economic factors related to the companies Airbus and Boeing:

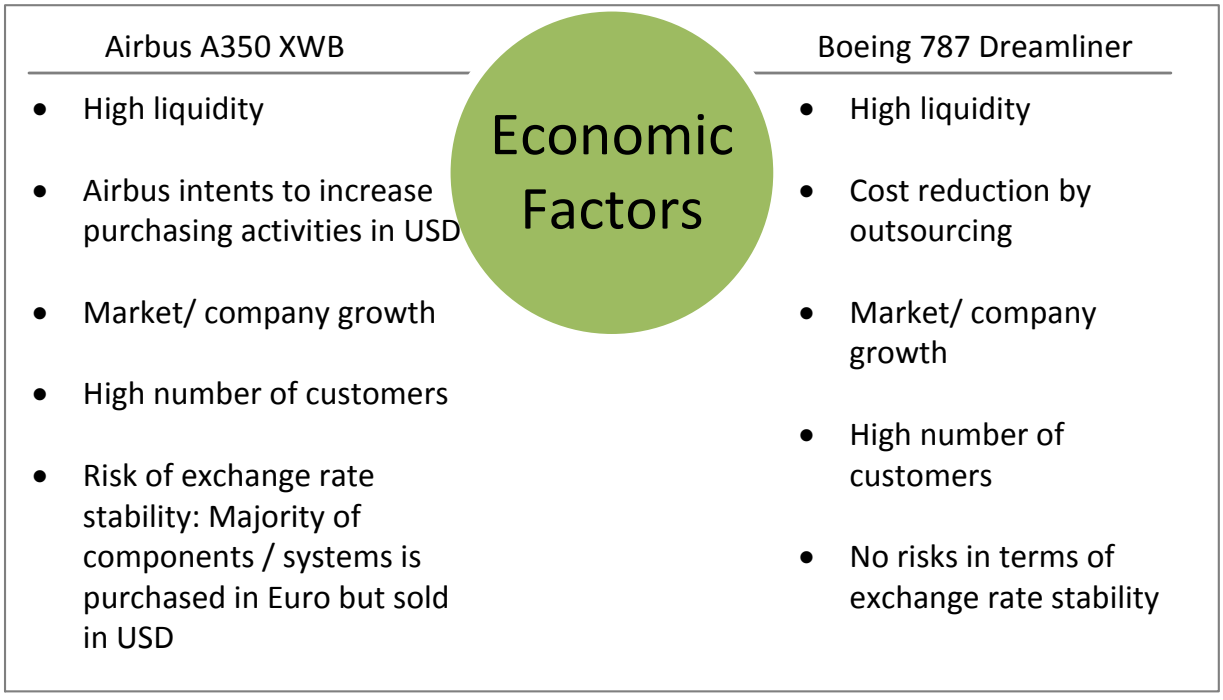


Figure 27: Economic factors on the SCM strategy of Airbus and Boeing

The important factor of liquidity is ensured by both companies – as mentioned before, the Airbus Company owns an in-house bank to ensure a continuous liquidity and Boeing has close partnerships to several US banks (Wall, 2014). Moreover, the development of the world economy is a considerable factor for aircraft manufacturer. However, a main economic risk factor is the fluctuation of currency exchange rates – aircraft are usually sold in USD. The Airbus Company is purchasing the majority of components and systems in Euro – as a consequence, Airbus intents to increase the procurement activity in USD by outsourcing to related countries (Airbus, 2012). On the other hand, Boeing is facing criticism by US trade unions and US citizens against the decision to outsource jobs and not to keep them in the US (Petterson, 2011).

5.3.4. Socio-Cultural Factors

Country-dependent socio-cultural factors have a high influence on the strategy and supply chain of aerospace companies (Merrit & Maurino, 2004). Following, figure 28 depicts considerable influence factors on the companies Airbus and Boeing with respect to the aircraft programs A350 XWB and 787 Dreamliner. The socio-cultural findings in terms of Airbus and Boeing are similar – hence they are drawn together:

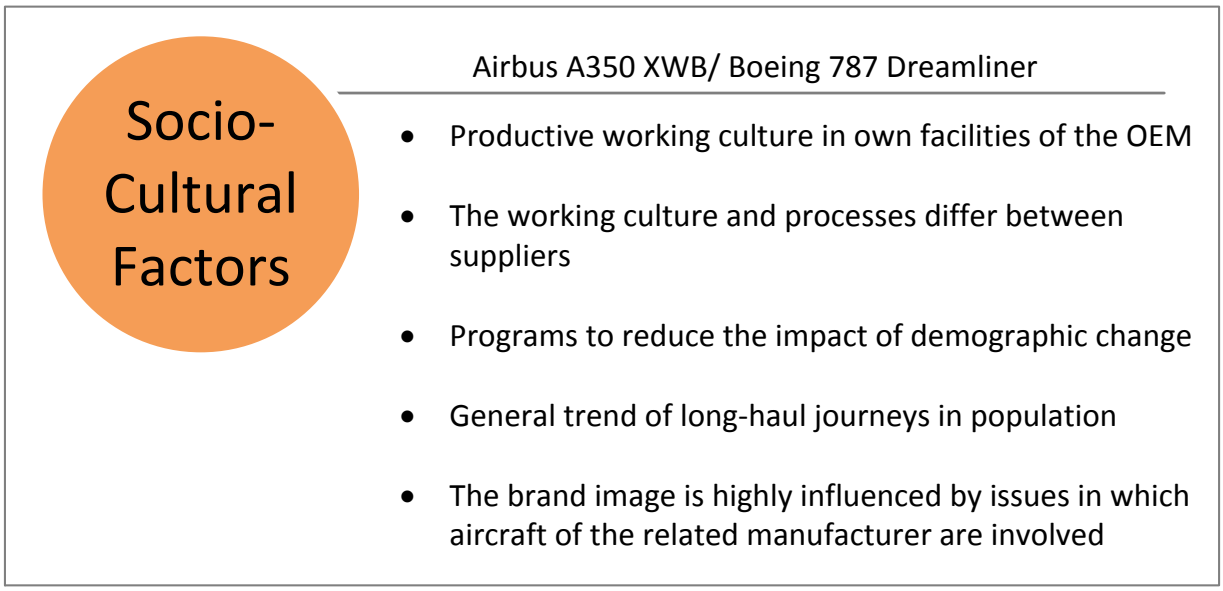


Figure 28: Economic factors on the SCM strategy of Airbus and Boeing

According to the Organisation for Economic Co-operation and Development (OECD, 2015), the USA (Boeing Company) and the European Union (Airbus Company) are locations with a productive working culture. However, the situation changes when the companies decide to outsource components and systems. As stated by (Denning, 2013), cultural differences between suppliers and OEM in terms of aerospace supply chains can cause several risks. Moreover, the processes between suppliers and OEM are not synchronized – therefore the aspect of quality management and reporting is an essential aspect for aerospace companies to enable a continuous verification process for the aircraft certification approval which is released the American/ European airworthiness authorities (EASA AMC GM P21, 2012).

As mentioned by Kotelec (2014), the trend of changing labour demographics in industrial countries is an emerging socio-cultural factor. Generally, the societies of major industry countries are aging (means that the average age of is increasing) and the same trend is despicable in large manufacturing companies. In the long haul, manufacturing companies, such as Airbus and Boeing, need to find a strategy to prevent the average aging of their staff and to keep/ transfer relevant knowledge and manufacturing skills.

Moreover, as stated by (Airbus Group, 2014) and (Boeing Long Term Forecast , 2014), there is a general trend for long-haul journeys under the world's population. This trend will have a significant influence on the development of LRCA and the general situation of the aircraft manufacturer Airbus and Boeing in the upcoming 20 years. As further mentioned by Airbus Group (2014), the economic development of threshold countries such as China and Brazil (IMF, 2010) will play an important role in the positive development of aerospace industry until 2033.

Furthermore, a considerable socio-cultural factor is the aspect 'fear of flying' which comes up everytime again when an airplane has an incident. Especially the brand image of the related aircraft manufacturer is negativly affectet by an aircraft crash. Hence, this factor could have a high influence on the manufacturer of involved aircraft. However aircraft become more safe as more incidents happen, why the trend of serious aircraft incidents decreased by 13% in 2013 (ICAO Safety Report, 2014).

5.3.5. Technological Factors

In accordance to Shih (2015) and Rhodes, et al. (2015), the factor of technology is an influenceful factor for the aerospace industry. As mentioned by (Rhodes, et al., 2015), the development of aerospace related technology requires high skilled professionals and a high amount of research. Figure 29 depicts considerable technology factors which have impact on the LRCA programs of the companies Airbus and Boeing:

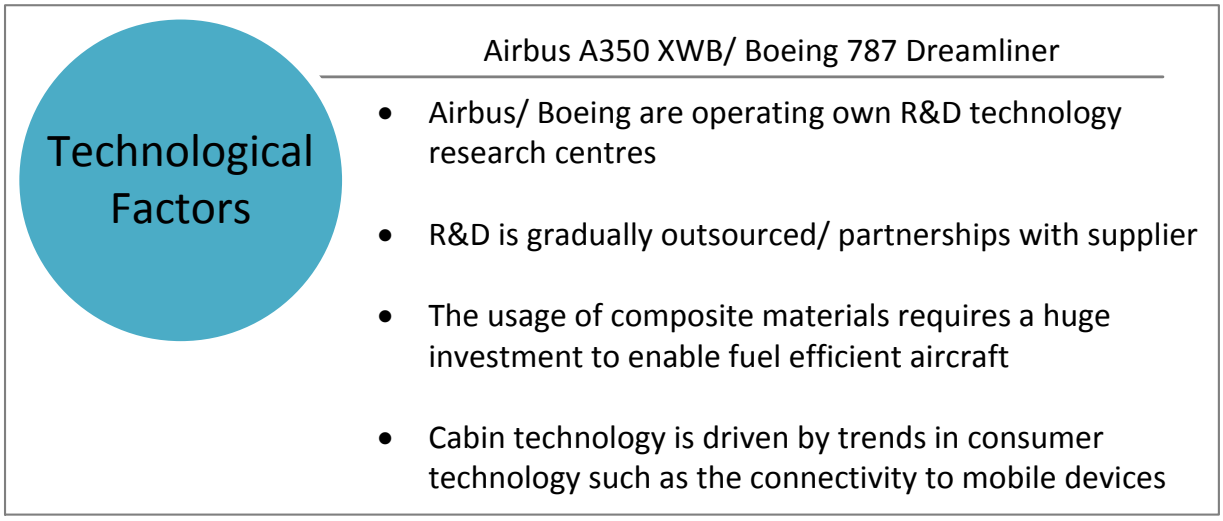


Figure 29: Technological factors on the SCM strategy of Airbus and Boeing

With reference to Shih (2015), technology trends of the consumer technology sector have a high influence on the technology within aircraft cabins. Moreover, Shih (2015) mentions that aircraft passengers appreciate all conveniences they have on the ground – as an example, the latest generation of Inflight Entertainment Systems (IFE) are based on the Google operating system Android which enables smartphone connectivity and the usage of commonly known apps. Moreover, the factor of technology is also driven by the continuous demand of airlines to acquire more efficient aircraft to be competitive in a market of increasing fuel prices and high ticket pricing pressure (Jacobs, 2012). As Airbus and Boeing illustrate in their annual reports, both corporations operate own or university joint R&D research centres to develop innovations and to foresee future trends (Airbus, 2009); (BCA, 2014). According to Tulder, et al. (2007), R&D activities are gradually outsourced by enterprises such as Airbus and Boeing. Moreover, Tulder, et al. (2007) mentiones that the general trend in R&D leads to partnerships between OEMs and suppliers.

5.3.6. Results of PEST Analysis

The companies Airbus and Boeing are located in a highly complex area of tension, influenced by a huge variety of stakeholder. However, the PEST proves that the companies have a stable and partly emerging environment. The key behind the stability of the global aerospace market might be the increasing demand of transportation for a growing number of passengers in the upcoming 20 years. Moreover, the development of the world's economic situation has a deep influence on the growth of the considered aerospace manufacturing companies. The supply chain strategy of Airbus and Boeing can also be impacted in the long run by the right assessment of the fuel price development, armed conflicts in the world, epidemics and technical innovations.

Moreover, the mutual influence of politics and powerful aerospace corporations is a further influence factor which could have an impact on decisions related to the supply chain. Hence, Governmental restrictions, requirements of the aerospace authorities and the fluctuation of currency exchange rates which is a result of the related policy of a country can affect the positive development of Airbus and Boeing to increase their profitability and competitiveness.

5.4. SWOT Analysis

This chapter aims to analyse the internal/ external success factors of the aerospace companies Airbus and Boeing in depth with focus on the LRCA programs A350 XWB and 787 Dreamliner.

5.4.1. Introduction of SWOT Analysis

In accordance to Humphrey (2005) and University of Washington (n/a), the SWOT Analysis is a research and assessment tool which was created by Albert S. Humphrey - based on primary research of the MIT and Harvard - to find a management tool to prevent mistakes in corporate planning and to create a new system for managing change processes for the Fortune 500 companies in the 1960s.

Albert S. Humphrey designed at the Stanford Research Institute (SRI) a 250-item questionnaire and interviewed between 1960 and 1969 over 5,000 executive managers – the results were the basis for the creation of the SWOT which became a standard tool to analyse internal/ external factors of a corporate strategy.

However, according to Washington (n/a), the SWOT Analysis is often combined with the PEST Analysis to provide a comprehensive investigation of all influence factors for a company’s strategy. The results of both analyses often point at opportunities to improve the corporate strategy to become more profitable and competitive in the long term.

5.4.2. Strengths

The internal strengths of the OEM and their applied supply chain are individual based on their purchasing philosophy. The following table depicts and compares considerable strengths of Airbus and Boeing in terms of their supply chain and based on the previous outlined case studies and the related references.

Table 3: The individual strengths of Boeing and Airbus

STRENGTHS	
Boeing	**Airbus**
More efficient and focused networks due to tier-1 supplier structure.	Risk sharing supplier networks by implementing the ACS system.
Close relationship to banks and strong support by the US governmental owned – Export-Import Bank.	High and ensured liquidity due to the acquirement of the Salzburg München Bank.
Established lean manufacturing and just-in-time supply chain.	Established lean manufacturing and just-in-time (+just-in-sequence) supply chain.
Internal technical competence will be kept.	High internal technical competence.
High professional in-house SCM competence.	In-house SCM competence is rising.
Strong negotiation to decrease cost.	Cost, quality and schedule focused negotiation.

The individual strengths of Airbus and Boeing differ in terms of their SCM philosophy and the way how it is applied. Boeing has a management advantage by focusing only on 50 tier-1 suppliers. On the other hand, Airbus implemented the ACS system to build up risk-sharing partnerships with powerful suppliers such as Zodiac Aerospace. Moreover, Airbus ensured a high corporal liquidity due to the acquirement of the

Salzburg München Bank. This bank also supports suppliers in terms of financial support and gives loans to airlines. Boeing use to have a close relationship to American business banks - especially to the US governmental owned Export-Import Bank - to ensure liquidity. Strength of both OEM is the deep entrenchment of lean management and the just-in-time approach in terms of the supply chain.

The aspect of ‘how to keep the technical in-house competence while outsourcing’ is faced in a different way by Airbus and Boeing. Airbus tries to keep most of the traditional system competences in-house while collaborating with close suppliers for the manufacturing and testing. On the other hand, Boeing has still a high technical in-house competence – however, the company could lose it gradually with the started outsourcing approach. Moreover, the SCM in-house competence of Boeing is very high as the company started to apply SCM in a professional way from 2001 on. However, Airbus is increasing their SCM competence by the employment of SCM professional and by the help of consultants.

A further strength of both OEM is the strong negotiation ability. Nevertheless, Boeing focuses strongly on the reduction of cost to make the production more efficient. On the other hand, Airbus follows a cooperative approach in SCM and focuses on cost, quality and schedule.

5.4.3. Weaknesses

The internal weaknesses with focus on SCM of Boeing and Airbus are often based on wrong management decisions or the size and fixedness of the corporate body. Table 4 illustrates the weaknesses of the supply chain of Airbus and Boeing based on the previous outlined case studies and the related references.

Table 4: The internal weaknesses of Boeing and Airbus

WEAKNESSES	
Boeing	**Airbus**
High dependency on US government orders and contracts.	High dependency on political decisions and pressure of the shareholding EU countries.
High dependency on suppliers.	High dependency on suppliers.
Slightly delivery date liability.	Slightly delivery date liability.
High amount of legal proceedings.	Average amount of legal proceedings.
Complexity of logistics to connect worldwide all suppliers in time to the FAL in Everett.	Complexity of logistics to connect Europe-wide all suppliers in time to the FAL in Toulouse.

As depicted in table 4, the general weaknesses are very similar between Airbus and Boeing. The high dependency on suppliers is a challenge with is the result of the outsourcing decision. As mentioned before, both companies face this problem by implementing tight monitoring systems. Furthermore, the slightly delivery date liability of Airbus and Boeing is a common problem which is often based on late suppliers. As a consequence, both OEM need to face legal proceedings. Another weakness is based on the complexity of the supply chain. In case of Boeing, the worldwide located suppliers require a high logistical effort to ship the goods in time to the FAL in Everett. On the other hand, Airbus also needs a similar challenge because of their complex internal supply chain – with companies and subsidiaries mostly located in Europe.

5.4.4. Opportunities

The analysis of external opportunities is based on the business environment of the aerospace industry. As followed, table 5 outlines the opportunities the OEM based on the previous outlined case studies and the related references.

Table 5: Opportunities of Boeing and Airbus.

OPPORTUNITIES	
Boeing	**Airbus**
The global air traffic growths each year by 5.7% (RPK); (Airbus Group, 2014).	
Access to new and emerging markets such as India and China.	
Easy access to innovations by the help of high innovative suppliers.	
Enhancement of acquisition synergies.	

The third step in the SWOT analysis is considering Airbus' and Boeing's opportunities with respect to SCM. As forecasted by the market forecasts of Airbus and Bowing, a major opportunity is the constant growth of global air traffic. Particularly, the growth of regional connections requires increasingly airplanes such as the Boeing 737 and the Airbus A320. Hence, these aircraft programs will have an increasing significance for both OEM. Moreover, the access to new and emerging markets is a considerable opportunity for the OEM. The decision to involve companies of new and emerging markets - such as China and India – in the development and manufacturing of new airplanes will participate in the development of these markets. However, another opportunity for both OEM is the easy access to new technologies by the collaboration of high innovative partners. These partnerships can also create and enhance acquisition synergies between the OEM and the supplying company. Hence, the main opportunity for both companies is the collaborative enhancement of their strategic partnerships to get access to the latest technologies and to gain flexibility.

5.4.5. Threats

The last step in SWOT analysis is the consideration of external threats. However, this part of the chapter will combine the threats of Boeing and Airbus as these points are congruent. As followed, table 6 depicts the external threats the OEM based on the previous outlined case studies and the related references.

Table 6: External threats Boeing and Airbus are facing

THREATS
Boeing & Airbus
Emerging competitors from oversea in the field of short- to medium-range aircraft.
Technical issues with the composite materials in the long run / possible incidents which could influence negatively the trust of the passengers in the products.
Insufficient quality of subcontractors which are not directly monitored by the OEM.
Governmental constraints and political influencing.
Obstruction of business activities by aviation authorities.
Labour issues in production facilities of suppliers.

One of the major threats to Boeing and Airbus is the intense competition in the jet airplane market. The competition between Airbus and Boeing is very intensive - however, new competitors from China (COMAC) and Brazil (Embraer) will increase the competition in future – especially in the important market of short- to medium-range aircraft. Short termed there is no other/ new competitor in the market of LRCA. Another threat Airbus and Boeing need to be aware of is the continuous monitoring of all suppliers in the value chain. The burning batteries incident of the Boeing 787 Dreamliner illustrates the risks within this aspect. Furthermore, this example is pointing of a general risk for both aerospace OEM – the technology risk of new developments. Albeit Airbus and Boeing are developing the new technology on their

own or they outsource the development – at the end it is crucial if there come up incidents related to the new product technology. These possible incidents can influence the trust of airlines and passengers deeply concerning the new airplanes.

Moreover, governmental constraints and political intervention can influence the companies as well - especially in terms of outsourcing decisions. Furthermore, the influence of the aviation authorities (EASA, FAA) on business activities is another considerable factor. However, another threat is the labour situation in facilities of suppliers. Due to the global supply chain structure, the labour requirements of the related countries differ - hence there is no general labour standard.

5.4.6. Results of SWOT Analysis

The SWOT Analysis illustrates a proper overview about the strengths, weaknesses, opportunities and threats of the considered aircraft manufacturer Airbus and Boeing with focus on the LRCA programs A350 XWB and 787 Dreamliner. As a result of the analysis, it can be considered that the strengths of both companies are dominating.

Especially the high competence of both manufacturers in the area of aerospace composite processing in combination with reliable suppliers is a key success factor for Airbus and Boeing. As mentioned before, both OEM follow different ways in their SCM strategy and implemented different management approaches – in fact, the economic success of both companies is an indicator of their prevailing strengths, even that the success is also based on other aircraft types beside the considered LRCA (Clark, 2015). Moreover, according to the market forecasts of Boeing and Airbus, the general development of the market is evaluated as very positive especially in terms of new emerging markets such as Asia and gradually Africa. On the other hand, the weaknesses and threats of both companies are mainly based on risks as a result of the outsourcing activities in combination with political/ governmental influences. Hence, the illustrated aspects have a considerable influence on the overall profitability and competitiveness of Airbus and Boeing and lead to best practices and recommendations for actions which are depicted in the following chapter.

5.5. Best Practices & Recommendations

The identification and adaption of best practices across the whole value chain can support the organisation of the OEM and supplying partners in improving their long term performance (McLaughlin, 2013). This chapter provides an introduction of aerospace SCM best practices - following the best practices are briefly illustrated. Based on the best practices, this chapter is concluded by recommendations for the companies Airbus and Boeing.

5.5.1. Introduction of SCM Best Practices

As stated by Paskiewicz (2001) in a memorandum of the Federal Aviation Administration (FAA), best practices in aerospace "provide timely information related to good operating practices identified within the aerospace community". Moreover, Paskiewicz (2001) mentions that best practices need to be outlined with a structured approach.

According to McLaughlin (2013), aerospace companies which learn from best practices generally perform better in their particular business sector. Further, McLaughlin (2013) states that "finding, adapting and implementing best practices can deliver significant competitive advantage and lead to increased market share". Hence, profitability and competitiveness of a business are positiv influenced by the identification and adaption of best practices. The best practices depicted in this document will focus on three areas related to SCM in aerospace manufacturing industry:

1. Design of supply chain architecture.
2. Supplier engagement in design and development.
3. Management of technical data exchange.

Nevertheless, the best practices will also mention examples from other industry sectors such as the automotive industry which is widely known as a leading industry sector in manufacturing business.

5.5.2. Depiction of SCM Best Practices

In the first place, companies which are outsourcing development and manufacturing work packages have to decide about suitable supply chain architecture with reference to their particular capabilities and needs. As outlined before in the case studies of the LRCA programs A350 XWB and 787 Dreamliner, Airbus and Boeing pursue individual SCM strategies with respect to their corporate strategies. In addition to the existing SCM architecture approaches, there are several opportunities in the design of a supply chain which can be characterised by the following aspects:

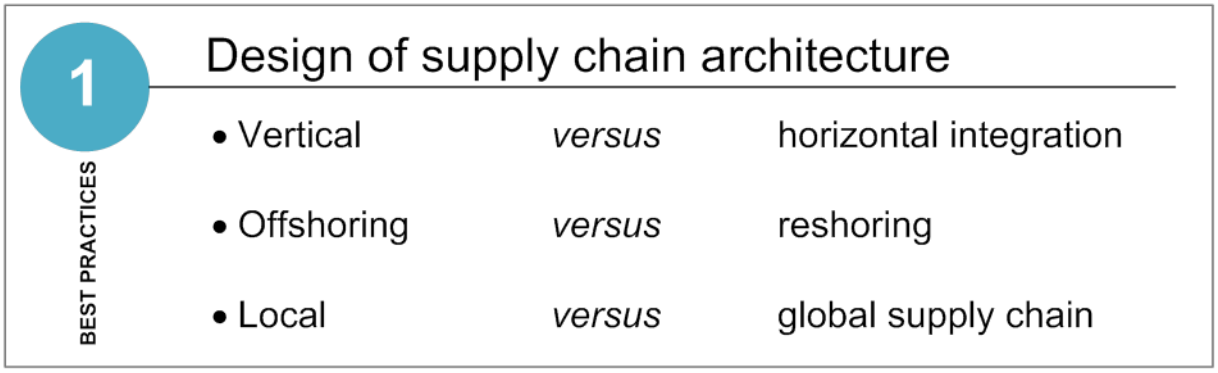


Figure 30: Design of supply chain architecture best practices

As mentioned in figure 30, companies have different choices when deciding about a SCM strategy. The organisational structure of a company is part of the SCM approach – hence the decision about vertical or horizontal integration is crucial. In accordance to McElroy (2012), the car manufacturer Volkswagen is a good example for a high performance manufacturing company with a vertical integration approach. As stated by WARC (2013), the supply chain best practice of Volkswagen shows that offshoring to emerging markets such as China, Mexico and India can be the key to access the market no matter whether an own facility is arranged or strategic partners are involved. Hence, Volkswagen is applying offshoring with a vertical integrated approach – however the design of the supply chain architecture is mostly local what means that relevant suppliers are usually close to the main assembly facility of the OEM (Jacobs, 2008). Further, Jacobs (2008) mentions that the arrangement of a localised supply chain philosophy ensures the cost-competitiveness in the related market.

Moreover, the world leading manufacturer in automotive industry, the Toyota Motor Corporation (Forbes, 2014), also trusts local sourcing as a strategic approach in SCM (Toyota Motor Corporation , 2015). Nevertheless, certain manufacturers proceed 'reshoring', which means that production capacities are retrieved to the country of origin of the related corporation (UK Government, 2014). This approach is currently eagerly discussed in the USA and UK with respect to the job situation in the countries (Rivkin, 2014); (Denning, 2013). However, reshoring is currently not applied by big corporations – rather SME are currently really returning manufacturing capacities to their origin countries (Goodfellow, 2014); (Bridge, 2013).

Secondly, the area of supplier engagement in design and development covers various best practice examples which are depicted briefly in the following figure 31:

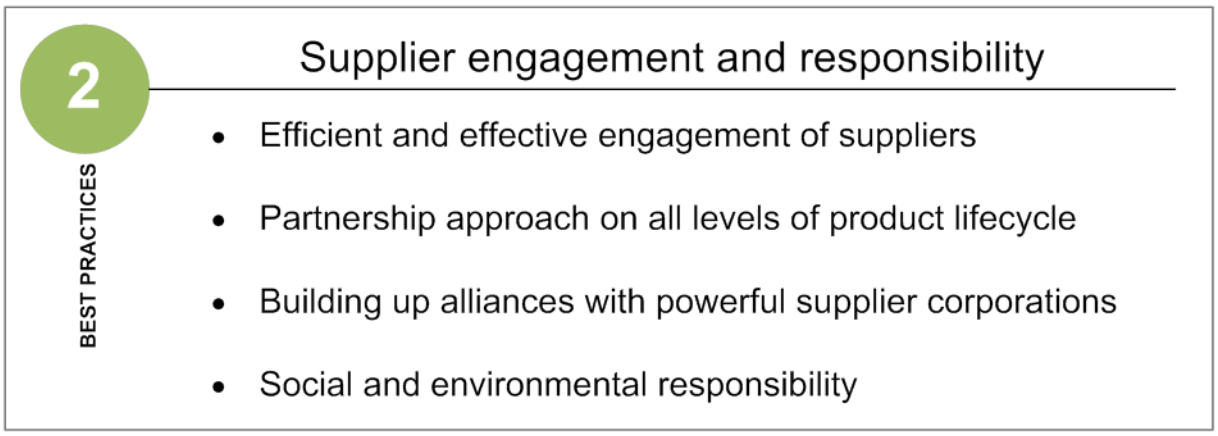


Figure 31: Best practices of supplier engagement in design and development

As stated by Gunasekaran, et al. (2004), supply chain management in combination with a high collaborative approach lead to increased financial and operational performance as well as an improved sourcing efficiency. However, as mentioned by Cecere (2014), "the most efficient supply chain is not the most effective". Hence, companies should not look unliteral after best practices to improve their performance. Cecere (2014) further reprots based on investigations in the automotive industry that pushing costs and waste backwards to suppliers will give only a short-term benefit to the OEM – in longe-term timeframe this approach causes challenges. Therefore, focussing on a partnership approach in collaboration on all levels of the product lifecycle in combination with risk-sharing contracts is a best practice from automotive

industry which can also improve the performance of aerospace companies. However, with reference to the case studies, the method how Airbus is managing its supply chain is already close to the approach of automotive manufacturing companies. Moreover, Gunasekaran, et al. (2004) mentions that the continuous evaluation and monitoring of suppliers is a key success factor for OEM to ensure effective and efficient processes for all types of suppliers (tier-1 to tier-3). Furthermore, in accordance to Engel (2011), the establishment of alliances with key suppliers is a best practice from various industries. Sourcing alliances in compbination with standardisation can lead to a massive reduction of cost and can improve the overall performance of a company.

On the other hand, the technical arrangement of data exchange between OEM and suppliers/ between suppliers have a high influence on the supply chain performance (Gunasekaran, et al., 2004). Figure 32 depicts particular best practices in terms of technical data exchange management:

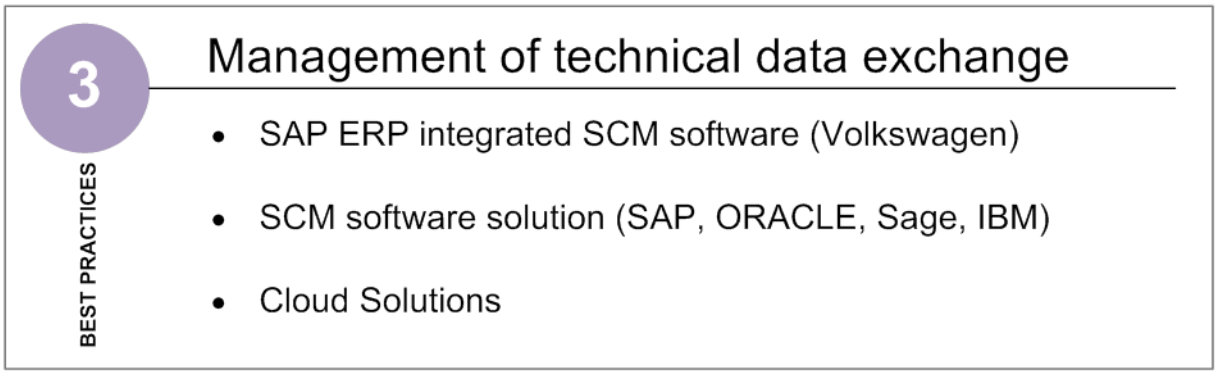


Figure 32: Best practices for the management of technical data exchange

Supply chain software solutions can enable an efficient data exchange and communication between all involved players in the supply chain of a company. Especially the implementation of integrated Enterprise Resource Planning (ERP) software in combination with a supply chain solution - such as provided by SAP - is a common approach of various Fortune 500 companies from different industry sectors (Palevich, 2014). Moreover, cloud based SCM software solutions are currently emerging – especially SME which have MRP/ MRPII systems rely on these technical solutions (Industry Week, 2014); (Dube, 2013).

6. Results & Discussion

This chapter will conclude the risks and consequences which are a result of the supply chain strategies of Airbus and Boeing. Moreover, the results of this report are discussed and critical evaluated.

6.1. Risks and Consequences

A comprehensive risk management in the field of SCM is a significant part to ensure the development and manufacturing process. Table 7 depicts general risks and their consequences which are related to the supply chain of the OEM.

Table 7: Risks and consequences

Risks and Consequences	
Risks	**Consequences**
Tier-1 suppliers outsource development and manufacturing work packages to tier-2 suppliers which may not have appropriate technical knowhow.	Uncertainty for the OEM – the quality and technical standard is not ensured. Delays in schedule can occur.
Usage of new and innovative technologies/ materials.	Uncertainty about the certification capability of new products. This aspect could cause delays.
Inexperienced team in terms of SCM.	Caused ambiguities under employees.
Bad working atmosphere due to outsourcing and possible job cuts.	The efficiency of staff can decrease by a bad temper.
Leak of intellectual property (patents etc.)	Loss of unique selling points.
Logistical challenges/ long distances	Problems in schedule/ budget and quality.

As illustrated in table 7, most of the risks are based on the complexity of the related supply chain. Firstly, the quality of supplied components cannot be completely ensured by the OEM. Tier-1 suppliers often outsource work-packages to tier-2 suppliers which may not have appropriate technical knowhow to develop a component or system in the quality which is required. As a consequence, the OEM has a planning uncertainty by this. Furthermore, insufficient quality of tier-2 suppliers can cause rapidly delays in development and manufacturing schedule.

Secondly, the leak of intellectual property due to outsourcing is a significant risk. Suppliers often need to have access and support from OEM to supply their work package in the required quality. However, the consequence can be that the OEM lose slowly their unique selling points as well as patents. According to Savitz (2011), especially China is a risky country in terms of intellectual property. However, Airbus decided to construct a facility right there and Boeing outsourced the vertical fin leading edge and the rudder to suppliers in China.

Thirdly, logistical challenges could be a high risk in terms of the supply chain and the schedule. As illustrated in figure 20 (Boeing case study), the suppliers are located all over the world which causes very long distances to reach the FAL JIT in Everett. As a consequence of this complex logistical challenge, delays can be caused by unpredictable influences such as weather, import difficulties and transport problems. Moreover, the transport of large components is a expensive task for suppliers. Contingent on the contract, the OEM could expect their supplier to ship their components “delivered duty paid” (DDP)16 which means that the supplier is in charge for delivering the components to the facility of the OEM and pays all costs including duties and taxes.

Fourthly, a major risk is the usage and application of new technologies and materials by suppliers. This could cause uncertainties concerning the certification process of the aviation authorities. As depicted by the battery fire example in the case study of Boeing, the usage of new technologies is a high risk – especially if the components

[16] DDP is an INCOTERM which are international commercial terms (rules) in logistics.

are not tested appropriately for the application in aerospace. According to Denning (2013), the battery fire issue is a direct consequence of underestimating the usage of new technologies in combination with outsourcing.

Fifthly, an inexperienced SCM team in the corporate body of OEM and on the supplier-side could be a risk factor for the supply chain. Especially the different cultural backgrounds and mentalities between the involved suppliers and the American employees of Boeing can cause uncertainties and challenges. Moreover, ambiguities under employees could be a further result of an inexperienced SCM team. All employees who are involved in SCM need to have a common vocabulary which needs to be trained.

Finally, another major risk is the temper of the OEM staff. Outsourcing often produces worries under employees concerning their workplace security. The possible resulting consequence is a general bad temper under employees which can decrease the productivity over the whole production facility. However, the temper of the supplier staff is another important factor - this is only manageable by the OEM in providing economical security for the partners and to arrange common working conditions for all suppliers which are involved in the supply chain.

6.2. Discussion of Results

The big players in global commercial aerospace industry are in recent times under pressure to develop and manufacture competitive airplanes in a profitable way. For the purpose to keep the competitiveness, Boeing and Airbus decided to increase the amount of outsourcing by up to 70 percent for the new aircraft programs 787 Dreamliner and A350 XWB.

However, people who are affected by the consequences of outsourcing often raise the question whether this approach is really reasonable. “Many companies that offshored manufacturing didn’t really do the math,” states Harry Moser, an MIT graduate and founder of the American Reshoring Initiative (Denning, 2013). The argument which is mentioned by Mr. Moser is often argued by opponents of outsourcing and offshoring. Foremost, Outsourcing describes the act of transferring work packages to external suppliers in the home country or to foreign countries (OED, 2014). On the other hand, the term offshoring characterises the act of moving production capacities to foreign countries and often includes the term outsourcing (CDO, 2014). In accordance with Coates (2013), the opposite of offshoring is reshoring which is a current trend in global supply chain management.

However, the current strategies of Airbus and Boeing are rather based on outsourcing and offshoring activities to decrease cost (Horng & Bozdogan, 2004). In contrast to other industry sectors such as the automotive industry, the aerospace industry started late with outsourcing and offshoring activities. In previous aircraft programs such as the Airbus A320 and the Boeing 737, both OEM developed and manufactured the airplanes almost with their own capacities (Petterson, 2011).

According to SupplyChain24 (2014), Boeing announced in August 2014 that nearly two-thirds of the £4 billion in cost cutting will come from savings based in its network of suppliers. However, these savings need to be considered related to the financial investments Boeing has done into the supply chain. Unfortunately it is not commonly known how much Boeing invested in its supply chain. On the other hand, Airbus focuses more on a balanced mixture of cost saving, quality improvement and schedule compliance (Trimble, 2014).

However, the mentioned intention of Airbus to develop suppliers by building up a close relationship also points on another aspect: Supplier dependency. The dependency of suppliers and OEM in aerospace industry is generally much higher than in other fields of business due to the uniqueness of aircraft systems and components (Busch, 2010). Airbus intents to incorporate suppliers in their in-house development and manufacturing process - this strategy is often called “extended enterprise” (EE) among Airbus managers (Weimer, 2013). Moreover, both OEM consider oneself as system integrators (Gramolla, 2012).

Developing the LRCA programs 787 Dreamliner and A350 XWB have been a new chapter for Boeing and Airbus. The usage of composite materials in this type of shape is an innovation in aerospace industry. The mentioned key factors and particular strategies are often based on the corporate history, the general management philosophy or the cultural background of the related company. As mentioned before, Boeing was founded by William Edward Boeing and had a moving history during the world wars. On the other hand, Airbus was politically initiated by European politicians to create a competitor to Boeing. Hence, the competition between Airbus and Boeing was probably already planned as Airbus was founded. The amount of outsourcing is another considerable key factor which needs to be discussed. As mentioned before, both OEM state the number of about 70 percent outsourcing for the aircraft programs A350 XWB and 787 Dreamliner. However, the numbers are deceiving. The main question is where an OEM draws the line between own subsidiaries and suppliers. Airbus, as the commercial aircraft division of the Airbus Group, draws the line around the own main division. Hence, all subsidiaries – such as Airbus Helicopters or Airbus Defence and Space - of the Airbus Group which are assigned to supply services or goods are considered as external suppliers. On the other hand, Boeing considers only companies as external suppliers which are not related to the Boeing Company. This aspect distorts the outsourcing comparison of Airbus and Boeing. Nevertheless, it is not assessable for an external researcher where the borders need to be applied to achieve comprehensible comparability.

Moreover, the general SCM and corporate strategy of both OEM is slightly different. As mentioned before, Boeing introduced verifiable a particular tier-1/ tier-2/ tier-2

supplier structure within their SCM strategy. Airbus papers also sometimes mention “tier-1 suppliers” - however, there is no academic source to prove it. Publications of Airbus often mention the corporate focus on system responsible risk sharing partners.

Furthermore, Boeing and Airbus hold slightly similar strengths concerning their SCM strategy. Especially the aspect of continuous liquidity is an important factor for aircraft manufacturer. Boeing maintains a close relationship to several US banks and especially to the governmental owned Export Import Bank. On the other side, Airbus acquired a bank to establish it as an in-house bank to support the own activities, suppliers and customers. In retrospect, the euro-crisis in 2008 revealed the importance of a continuous liquidity for large industry sectors such as the aerospace industry. Moreover, the internal technical competence among both OEM is traditionally very high. However, outsourcing of important work packages brings along the risk of losing gradually the latest technical competence.

On the other hand, the weaknesses of the OEM are closely related to the risks and consequences. As mentioned before, the logistical challenge for both OEM is very high. For instance, the wings of the Boeing 787 Dreamliner are assembled in Japan, mainly by Mitsubishi Heavy Industries. However, the fixed leading edges are manufactured by Spirit Aero Systems in Tulsa (USA). Hence the fixed leading edges are shipped to Japan and the fully assembled wings are flown back to the States. Nevertheless, Airbus has a similar complex supply chain. The major difference between Airbus and Boeing is in this case that Airbus suppliers are mainly located in Europe; therefore, the shipping distances of Airbus components are generally shorter.

On one hand, the close collaboration of OEM with supplier leads to the mentioned supplier dependency. However, another consequence is the empowerment of component and system suppliers. Especially the supplier structure in the field of cabin equipment and cabin systems changed in a considerable way. Companies such as Zodiac Aerospace (France), B/E Aerospace and DIEHL Aircabin (Germany) absorbed a couple of small-medium suppliers.

This aspect points in the future that the power of suppliers will increase as long the OEM are willing to outsource components, systems and services.

7. Synopsis

The aim of this chapter is to conclude this report and to provide particular recommendations for the supply chain strategies of the companies Airbus and Boeing. Finally, this report is closed up with an industry and research outlook.

7.1. Recommendations

Foremost, this report investigated and analysed properly the supply chain strategies of the companies Airbus and Boeing with respect to the LRCA programs A350 XWB and 787 Dreamliner and in focus on the enhancement of competitiveness and profitability. As mentioned before, this research were realised without internal insights of the considered companies.

However, with reference to the applied free accessible sources and data, there are particular recommendations which can be made in terms of the supply chain strategy of Airbus and Boeing to achieve a long-term improvement of their competitiveness and profitability:

- Focus on a collaborative/ partnership approach towards suppliers.
- Establish strategic alliances with powerful suppliers.
- Establish sourcing alliances with competing companies.
- Localising the supply chain architecture to decrease logistical effort.
- Evaluate offshoring activities accurately and objectively by metrics and KPI.
- Avoid outsourcing of mission-critical systems and components.
- Considering social and environmental responsibility of SCM.
- Involve supplier deeply in processes and IT solutions – ERP SCM software.
- Focus on the improvement of efficiency and effectiveness in processes to reach a long-term enhancement of profitability and competitiveness.

According to the outlined best practices, the companies Airbus and Boeing can extend the supplier collaboration based on a partnership approach. As mentioned by Eames (2014) and Gunasekaran, et al. (2004), the aspect of close collaborations filled with mutual trust between OEM and supplier is a key success factor for a profitable business. Hence, Eames (2014) states that “If customers and suppliers work well together and have good information flows, profitability will automatically follow”. Moreover, the car manufacturer Volkswagen launched in February 2015 the ““Volkswagen FAST” initiative which aims to redefine the cooperation between Volkswagen and suppliers (Adomat, 2015). As mentioned by Adomat (2015), Volkswagen intents to redefine the cooperation with powerful suppliers to be ready for future challenges in automotive industry. Moreover Adomat (2015) mentions that the Procurement Director of Volkswagen Garcia Sanz states: “In future, a key success factor will be a highly efficient global supplier network”.

Moreover, the establishment of strategic alliances with powerful suppliers is a considerable recommendation for the companies Airbus and Boeing. However, as mentioned before, the general trend in aerospace industry is towards OEM and suppliers with an equal economic strength which means that the position in negotiations will be more balanced in future. On the other hand, alliances with competitors can be recommended – particularly in terms of material sourcing and fundamental research for new technologies. Especially emerging competitors such as Embraer (Brazil) and Comac (China) can be involved in strategic sourcing projects to reduce the cost for particular components or systems.

With reference to Welch (2013), alliances between competing OEM can lead to competitive advantages for both collaborating companies. This recommendation is particularly applicable for niches or emerging sectors of an industry – such as electric mobility in automobile industry in which the established manufacturer Mercedes-Benz collaborates with the electric car company Tesla Motors (Welch, 2013). Hence, it could be a considerable suggestion to develop future technologies with a collaborative and standardised approach - such as electrical power plants or full electric commercial airplanes.

In accordance to the outlined best practices, it can be further recommended to strive for a more localised supply chain architecture to decrease the logistical effort and to enable synergies between supplying companies. Nevertheless, as mentioned before, the supply chain approach of Airbus is generally European localised – hence the logistical distances of the A350 XWB supply chain are lower than the distances of the 787 Dreamliner. However, the depicted best practices of the automotive companies Volkswagen and Toyota point to a market-orientated supply chain. With reference to Denning (2013), it can be recommended to evaluate all offshoring and general outsourcing activities accurately and objectively by metrics and KPI to keep the supply chain efficient and effective. Hence, the continuous monitoring of the applied SCM decisions is an relevant factor to maintain an efficient and effective supply chain.

Furthermore, the implementation of a customised ERP system with a related SCM solution can be a further recommendation to enable an efficient communication and data exchange process between all actors in the supply chain. With reference to the risks and challenges, it can be further recommended to avoid outsourcing activities of mission-critical systems and components. As stated by Denning (2013), Boeing outsourced in the 787 Dreamliner LRCA program mission critical components such as the electrical system including the batteries which led to various incidents. Although outsourcing is a suitable approach for companies to focus on their core competencies, the risks need to be evaluated precisely to prevent any issue and to fulfil the high standards of the aerospace authorities in verification to receive airworthiness certificates.

Finally, the increased consideration of social and environmental supply chain aspects is a recommendation for the companies Airbus and Boeing to fulfil the responsibility of a Fortune 500 company. However, both OEM acknowledged increasing their expenses in social and environmental sustainability related to their manufacturing facilities and supply chains (Boeing Sustainability, 2013); (Airbus Responsibility, 2015). However, as generally mentioned by Time (2012), an enhanced focus on corporate responsibility can lead in the long-term to a positive influence on the competitiveness and profitability of the aerospace companies Airbus and Boeing.

7.2. Conclusion

Supply chain management in modern aerospace manufacturing business is a management approach which gained rapidly influence in the last decade. Airbus and Boeing as the market leading companies in the field of aircraft manufacturing introduced a professional SCM for the development and manufacturing of their new LRCA A350 XWB and 787 Dreamliner. These new airplane programs promise improvements in efficiency and passenger comfort by utilizing the advantages of carbon fibre materials and applying more efficient power plants. Airbus and Boeing decided to outsource about 70 percent of the development and manufacturing work of their new aircraft programs to decrease cost and to share risks.

As a result of this thesis, it can be considered that the competitiveness of the OEM with respect to their supply chain cannot be measured based on free accessible data. However, based on the analysis part, Airbus has significant advantages. The OEM follows the philosophy of a collaborative and long-term supplier relationship which ensures the planning certainty for suppliers and motivates the staff. Moreover, the suppliers of Airbus are mainly located in central Europe which simplifies the logistics.

In addition, Airbus has an assured access to loans due to the acquired Salzburg München Bank. The mentioned aspects do not state that Airbus is more profitable or competitive than Boeing – however, the Airbus A350 XWB procurement strategy combines a conservative in-house manufacturing approach in combination with outsourcing by the application of professional supply chain management.

On the other hand, Boeing is facing a global approach in their procurement strategy for the 787 Dreamliner aircraft. According to Boeing, this approach is saving cost - however, the logistical effort is very high and challenging. In addition, the environmental impact of the related Boeing supply chain can be considered as high due to the massive shipping activities. In principle, the aspect of environmental sustainability in SCM will gain more influence as Airbus and Boeing intend to reduce the corporate carbon footprint.

As a result of the depicted case studies, the current trend in global aerospace manufacturing industry is mainly based on the approach of outsourcing to reduce cost and to share risks and further to offshore these activities to suppliers in emerging markets. Nevertheless, the analysed strategies and risks are raising questions concerning the rationality of the current trend in aerospace SCM:

Is offshoring the best approach for developing emerging markets? Are suppliers capable to provide aircraft components? Is it reasonable to ship aircraft components around the world to the FAL? What are the social and environmental consequences in the long term?

These questions could lead to a reconsideration of the current trend in aerospace supply chain management. Offshoring should not be mandatory to develop new markets and to access new technologies. As stated by SupplyChain24 (2014), other industry sectors outpaced offshoring and start to reshore manufacturing capacities. On the long run, this could be a possible development for the aerospace industry as well.

Moreover, system suppliers and their subcontractors which are inexperienced in the field of aerospace components are a high risk. Dependent on the internal corporate strategy, it could be a considerable solution to keep the competence in-house. As mentioned before, the distance of suppliers to the FAL combined with the shipping efford could be another reason to decrease offshoring activities. Moreover, the social/ environmental consequences in the long term cannot be clearly forseen.

Lastly, the decision of supply chain strategy in aerospace is influencing the life of thousands of employees in various countries who are working for OEM or suppliers. SCM decisions often have a strong social impact - Airbus and Boeing need to consider carefully their social responsibility with respect to their own employees and the people who rely on jobs in supplying companies. Finally, Sir Richard Branson (2014) states: “Every risk is worth taking as long as it's for a good cause, and contributes to a good life.”

7.3. Outlook & Future Work

Based on the market forecasts of Airbus and Boeing, the global aerospace industry will grow intensively between 2015 and 2030. Especially the Asian market will grow strongly. Hence, the OEM need to ensure their marketability. The mentioned SCM approaches of the OEM are facing to access the Chinese and Indian market by offshoring work packages to suppliers in these countries. However, various acquisitions of smaller suppliers by big and influential suppliers are an indicator that the supplier structure will change in future.

As a consequence of this trend, the number of suppliers will foreseeable decrease in future. On the other hand, the size and influence/ power of the left big supplier corporations will increase strongly. Hence, Airbus and Boeing as powerful aerospace OEM could have the advantage to make contracts with fewer suppliers in future. However, the consequence of this trend is that the supplier dependency will probably increase because of increasingly powerful suppliers. In addition, price negotiations could become more unfavourable for the OEM.

The research in the topic area of SCM in aerospace industry is impeded by a lack of quotable academic sources and the confidentially of internal papers of the related companies. However, there is a high potential for research in this subject area. The possible future research - based on this thesis - could consider the following aspects:

- Collaboration with the companies Airbus and Boeing to create a research paper with highly accurate and significant numbers/ data.

- Preliminary design of a new SCM strategy for aerospace OEM which is based on this report and involves the future trends in aerospace.

However, the aspect of confidentially is always a drawback in aerospace. On the other hand, there is a big potential for academic research in this industry and the OEM can strongly benefit from the latest discoveries and research results.

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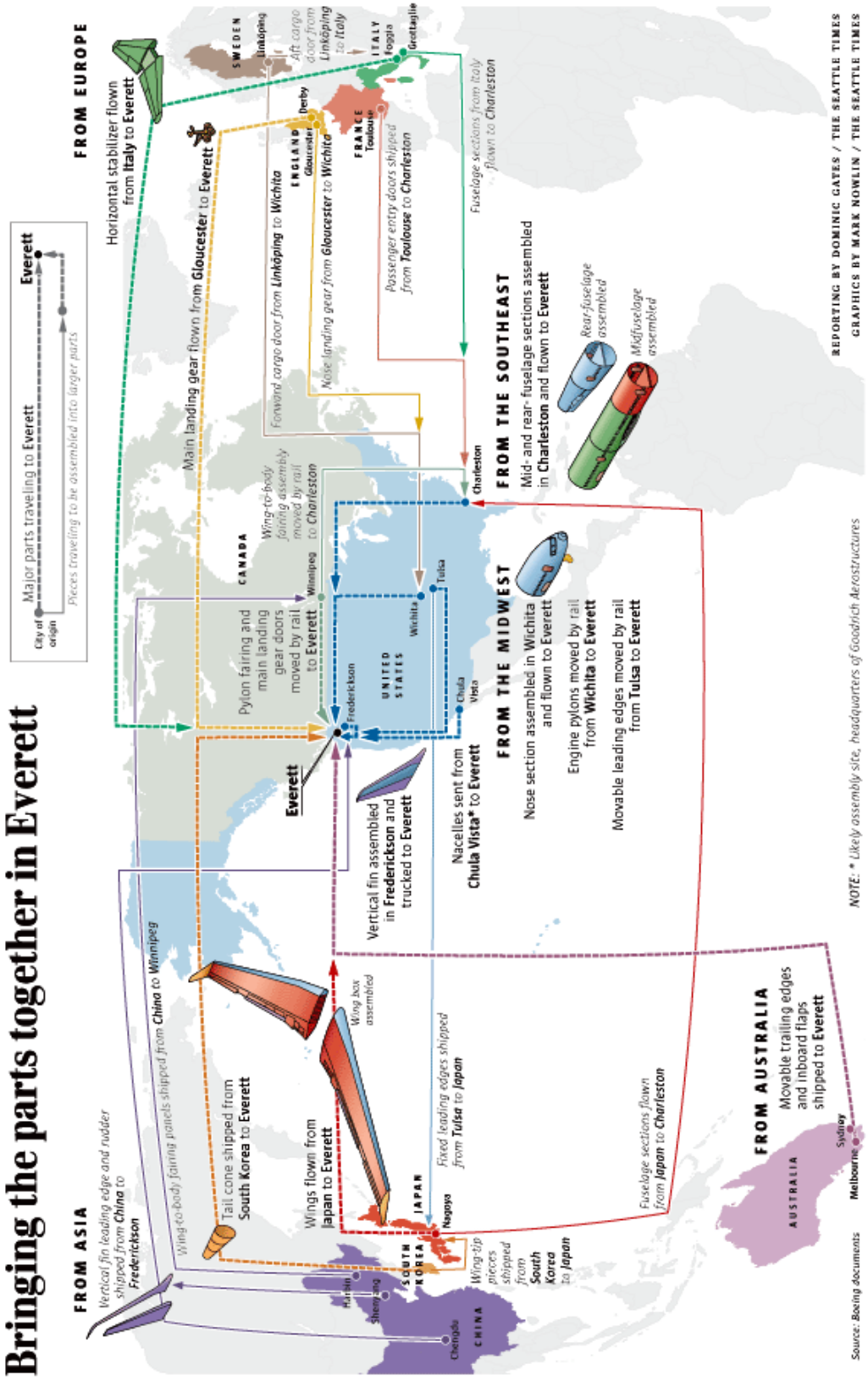
Appendix

Appx. 1 – Boeing 787 Dreamliner Supply Chain Map



Appx. 2 – Erklärung zur selbstständigen Bearbeitung einer Abschlussarbeit

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Erklärung zur selbstständigen Bearbeitung einer Abschlussarbeit

Gemäß der Allgemeinen Prüfungs- und Studienordnung ist zusammen mit der Abschlussarbeit eine schriftliche Erklärung abzugeben, in der der Studierende bestätigt, dass die Abschlussarbeit „– bei einer Gruppenarbeit die entsprechend gekennzeichneten Teile der Arbeit [(§ 18 Abs. 1 APSO-TI-BM bzw. § 21 Abs. 1 APSO-INGI)] – ohne fremde Hilfe selbständig verfasst und nur die angegebenen Quellen und Hilfsmittel benutzt wurden. Wörtlich oder dem Sinn nach aus anderen Werken entnommene Stellen sind unter Angabe der Quellen kenntlich zu machen."

Quelle: § 16 Abs. 5 APSO-TI-BM bzw. § 15 Abs. 6 APSO-INGI

Dieses Blatt, mit der folgenden Erklärung, ist nach Fertigstellung der Abschlussarbeit durch den Studierenden auszufüllen und jeweils mit Originalunterschrift als letztes Blatt in das Prüfungsexemplar der Abschlussarbeit einzubinden.
Eine unrichtig abgegebene Erklärung kann -auch nachträglich- zur Ungültigkeit des Studienabschlusses führen.

Erklärung zur selbstständigen Bearbeitung der Arbeit

Hiermit versichere ich,

Name: Wendt

Vorname: Florian Tobias

dass ich die vorliegende Masterarbeit bzw. bei einer Gruppenarbeit die entsprechend gekennzeichneten Teile der Arbeit – mit dem Thema:

Supply Chain Strategies in Aerospace Industry: Assessment of Approaches to Increase the Competitiveness and Profitability in a Global Environment

ohne fremde Hilfe selbständig verfasst und nur die angegebenen Quellen und Hilfsmittel benutzt habe. Wörtlich oder dem Sinn nach aus anderen Werken entnommene Stellen sind unter Angabe der Quellen kenntlich gemacht.

- die folgende Aussage ist bei Gruppenarbeiten auszufüllen und entfällt bei Einzelarbeiten -

Die Kennzeichnung der von mir erstellten und verantworteten Teile der -bitte auswählen- ist erfolgt durch:

Hamburg	02/04/2015	
Ort	Datum	Unterschrift im Original