Master Thesis

Operational Excellence to Increase a Companies' Business Value in the Aircraft Industry

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Operational Excellence to Increase a Companies' Business Value in the Aircraft Industry

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Abstract:

After an intensive discussion about *Operational Excellence* in the aircraft industry, the *Business Values* of 5 US-American and 5 Austrian companies from the aircraft industry are calculated by use of the *Discounted Cash Flow* method (WACC-approach). As practical experience shows that financial perspectives (e.g. balance sheets, budget planning) express too little about a companies' current technology status, its prospected production performance in the future and its competitiveness in general, a corresponding *Technology Balance Sheet* is developed, which also consists of assets (products and processes) and liabilities (own and external technologies). The *Technology Balance Sheet* bases on the products, processes and technologies of the final assembly plant of the Cessna Aircraft Corporation in Independence, Kansas.

Keywords:

Operational Excellence, Aircraft Industry, Business Value, Discounted Cash Flow Method, Technology Balance Sheet.

Zusammenfassung:

Nachdem *operative Exzellenz* in der Flugzeugindustrie intensiv diskutiert wird, folgt eine monetäre Unternehmensbewertung von 5 US-Amerikanischen und 5 österreichischen Unternehmen aus der Flugzeugindustrie, basierend auf der *Discounted Cash Flow* Methode (WACC-Ansatz). Praxiserfahrungen zeigen, dass Finanzkennzahlen (z.B. aus Bilanzen, Budgetplans) zu wenig über die aktuelle und zukünftige Produktionsfähigkeit, Technologien und Wettbewerbsfähigkeit eines Unternehmens preisgeben. Ergänzend dazu wird deshalb eine sogenannte Technologie-Bilanz erstellt, die ebenfalls aus einer Aktiva (Produkte & Prozesse) und einer Passiva (Eigen- und Fremdtechnologien) besteht. Im Zuge dieser Masterarbeit wurde für den Flugzeughersteller Cessna Aircraft, basierend auf den Produkten, Prozessen und Technologien des Montagewerks in Independence, Kansas, eine Technologie-Bilanz erstellt.

Schlüsselwörter:

Operative Exzellenz, Flugzeugindustrie, Unternehmenswert, Discounted Cash Flow Methode, Technologiebilanz.

Content

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Last but not least, I want to thank Jannelle for her support, love and encouragement.

1. Introduction

The main motivation of this Master Thesis is the self-responsible solving of a relevant practical problem to receive the Master of Science's degree in the program *Business Engineering*, specialization *Process and Supply Chain Engineering*, at the *University of Applied Science Wiener Neustadt*.

The composition process primarily took place in the United States of America, which is one of the main reasons for the choice of English. Furthermore, the author sought to get a better understanding in the fields of:

- Business Evaluation,
- Aircraft Industry, and
- Production and Operations Management.

1.1 Relevance

Socio-economically speaking, this Master Thesis has the goal to link technological and financial perspectives with each other. As our world mainly consists of more than two dimensions, a company evaluation is probably more meaningful if it bases on both perspectives.

A supposed benefit of this Master Thesis for the society is a rethinking of our monetary system, and its partially grotesque excesses. Our world consists of physical phenomena, and not fictive monetary values. Obviously, money helps to evaluate values in form of created products and services, and also simplifies its trade. However, the financial sector should primarily have a supporting role for the real economy, and not a determining.

In terms of science, this Master Thesis is thought to proof the practical usage of *Technology Balance Sheets*. In case of significant benefit, it might be imaginable that one day companies will not be only committed to create financial balance sheets, but also technology balance sheets.

1.2 Formulation of Problem

The removal of trade barriers, the merging of markets and the consequent of new international competitors force companies to improve their productivity and efficiency for example in their production processes. This striving can be describes as pursuing *Operational Excellence*.

In specific, the author asks himself how *Operational Excellence* looks like in the aircraft industry and what state-of-the-art processes in the production of aircrafts are. A supply chain of an aircraft may begin with the production of raw materials end with the reuse of materials. Therefore, the author wants to specify that only following processes are observed in chapter 2 (theoretical principals):

- Aircraft design,
- Feasibility studies,
- Production planning and control,
- Make-or-buy decisions,
- Assembly and production,
- Quality control and improvement,
- Supply Chain Management,
- Plant maintenance.

It should be noted that the term *Operational Excellence* is not restricted to production processes. Operational processes might be defined as core business activities that create the primary value stream. Since for example the aircraft design, *Supply Chain Management* and also *Plant Maintenance* have a huge impact on the value creation of aircrafts, they can be included as operational activities of aircraft manufacturers.

In a second step it is aimed to calculate the business value with the help of the *Discounted Cash Flow* method (WACC-approach) of 5 US-American and 5 Austrian aircraft companies. In this topic, especially an appropriate interpretation of calculated values will be crucial. What does it mean if a company might have a value of $ 5,000 million?

- Is such a number above or below average?
- Is such a number reasonable?
- Or is such a number only an abstract value that nobody will pay for?

In a last step it is aimed to complement financial perspectives with a technology balance sheet. Beside the proof of its practical implementation, it is also sought to discuss the benefits and advantages of a technology balance sheet, and if a company evaluation is more meaningful in combination with a technology balance sheet.

1.3 Goals and Non-Goals

Derived from the problem formulation can be following goals for the Master Thesis mentioned:

- To get a better understanding of the production and assembly processes in the aircraft industry,
- To get a better understanding of production and operations management (e.g. Six Sigma, moving assembly line, total productive management),

- To get a better understanding of *Discounted Cash Flow* method, and their practical application,
- To get a better understanding of *Balance Sheets* and *Annual Reports*,
- To get a better understanding of the principle of *Technology Balance Sheet*.

However, it is **NOT** the goal:

- To conceive an overall picture of aircraft production; but rather the author focused on personal interest emphasis as *Production Planning and Scheduling, Supply Chain Management* and *Quality Control and Improvement*, and
- To discuss and scrutinize all kinds of valuation methods, but the author focuses on *Discounted Cash Flow* approaches,
- To revolutionize operational activities in the aircraft industry; but rather to give a summary of state-of-the-art processes and applied technologies.

1.4 Thesis Structure

The Thesis can be generally segmented into 4 main chapters.

Chapter 2 discusses:

- *Value Drivers* that influence business values,
- *Production and Operations Management*,
- *Operational Excellence* in the aircraft industry, whereby a lot of practical example should help to explain the mentioned theoretical principals,
- Business Valuation, whereby the focus is on discounted cash flow methods, and
- Technology Balance Sheets, and also
- Reviews the used literature (research questions, issues, hypothesis & methods)

Chapter 3 shows:

- The applied methods of this Master Thesis,
- The research questions of this Master Thesis, and
- The study design of this Master Thesis.

Chapter 4 illustrates the results of this Master Thesis. Contents are:

- The business values of 5 American and 5 Austrian aircraft manufacturers,
- The development of a *Technology Balance Sheet* of the Cessna Aircraft Corporation in Independence, Kansas.
- A Technology-Finance-Portfolio that combines business values and technology surpluses (based on *Technology Balance Sheet*),
- And the answers regarding the research questions.

Finally, this Master Thesis is completed with a discussion and outlook (Chapter 5 & 6).

2. Theoretical Principals

Chapter 2.1 gives an overview regarding *Value Drivers*. Chapter 2.2 deals with *Production and Operations Management* in general. Chapter 2.3 discusses *Operational Excellence* in the aircraft industry, which can be connected to chapter 2.1 and actually shows operational *Value Drivers* in the aircraft production. Chapter 2.4 focuses on the calculation of business values of companies. Chapter 2.5 illustrates the topic of technology balance sheets. And Chapter 2.6 finally reviews the used literature and sources.

2.1 Value Drivers

Value drivers are methods and opportunities within business units, which have an above-average influence on the value of a company. As Figure 1 shows it is possible to distinguish them in terms of *forecast uncertainty* and *controllability*. In these perspectives one may conclude to following value drivers [1: p.2]:

- Operational value driver (Cash flow driver)
- Strategic value driver (potential driver)
- External value driver

Operational value drivers are part of the daily business and have direct influence on a companies' value within the current period. Strategic value drivers are also controlled by a company; however they primarily deal with potentials on the long-term and very uncertain future. External value drivers are only slightly influenceable by a company, but may have an impact on short-term and long-term. Examples may be political, business, technological and socio-cultural developments [1: p.30].

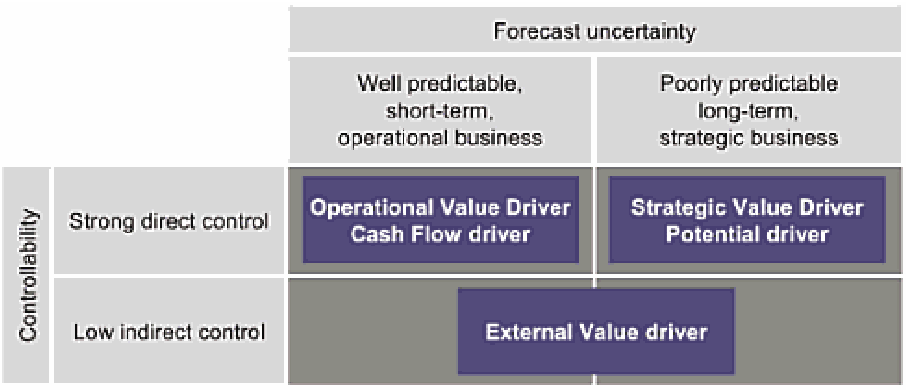

Figure 1: Types of Value Drivers [1: p.31]

Due to profit expectations of companies, all investments for improvements should generally pay off and consequently increase a companies' business value. The business value can be calculated for example by the use of the DCF-method, which generally consists of three main components. These are the (see Chapter 2.4) [2: p.27]:

- Free Cash Flows,
- Amount of debt capital (liabilities) in a companies' balance sheet, and
- Discount rates.

Furthermore, following factors have a main impact on the just mentioned components [2: p.27]:

- Durability of value drivers,
- Increase of revenue (e.g. more sold items, higher accepted prices by customer for example because of a higher product quality) or,
- Decrease of costs (e.g. increased productivity, faster development time, lower inventories),
- Tax rates (group taxation, tax optimization),
- Investments (less investments and consequently less bounded capital),
- Costs of capital (less interest rates on bonds, loans and credits)

Figure 2 shows the connection between business goals, the components of business values, value drivers and management decisions.

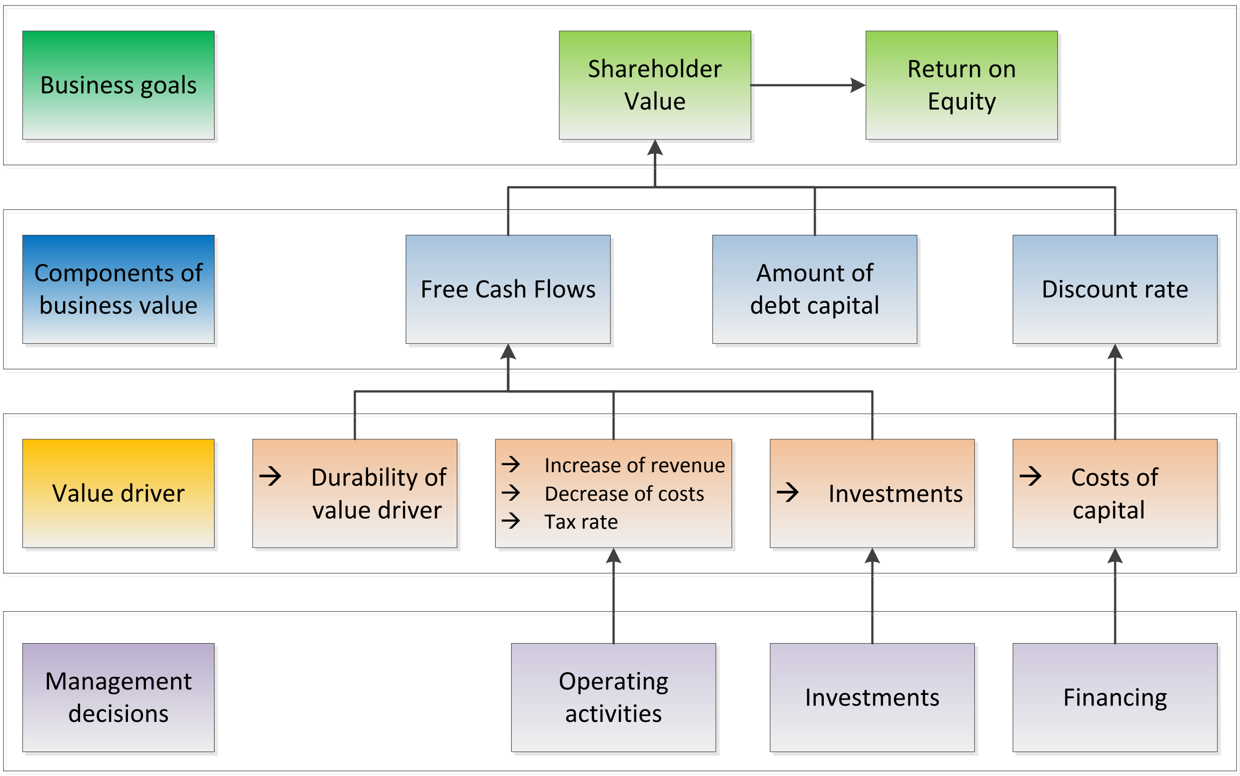

Figure 2: Types of Value Drivers [2: p.27]

The following chapters primarily focus on operational value drivers. It is aimed to discuss operational methods, measures, concepts and techniques in the aircraft industry, which promise a positive influence on a companies' business value.

2.2 Production and Operations Management

Within a company the production department primarily interacts with the core entities of *Finance, Marketing & Sales, Personnel and Purchasing*, whereby subsequently the *Marketing & Sales* stays in contact with *Customers*, and *Purchasing* with *Suppliers* [3: p.5]. Other relevant entities, which are not mentioned in figure 1, but also play an important rule within a company, are the departments of *Logistics, Research and Development, IT, Sales, Customer Service, or as well Facility Management*.

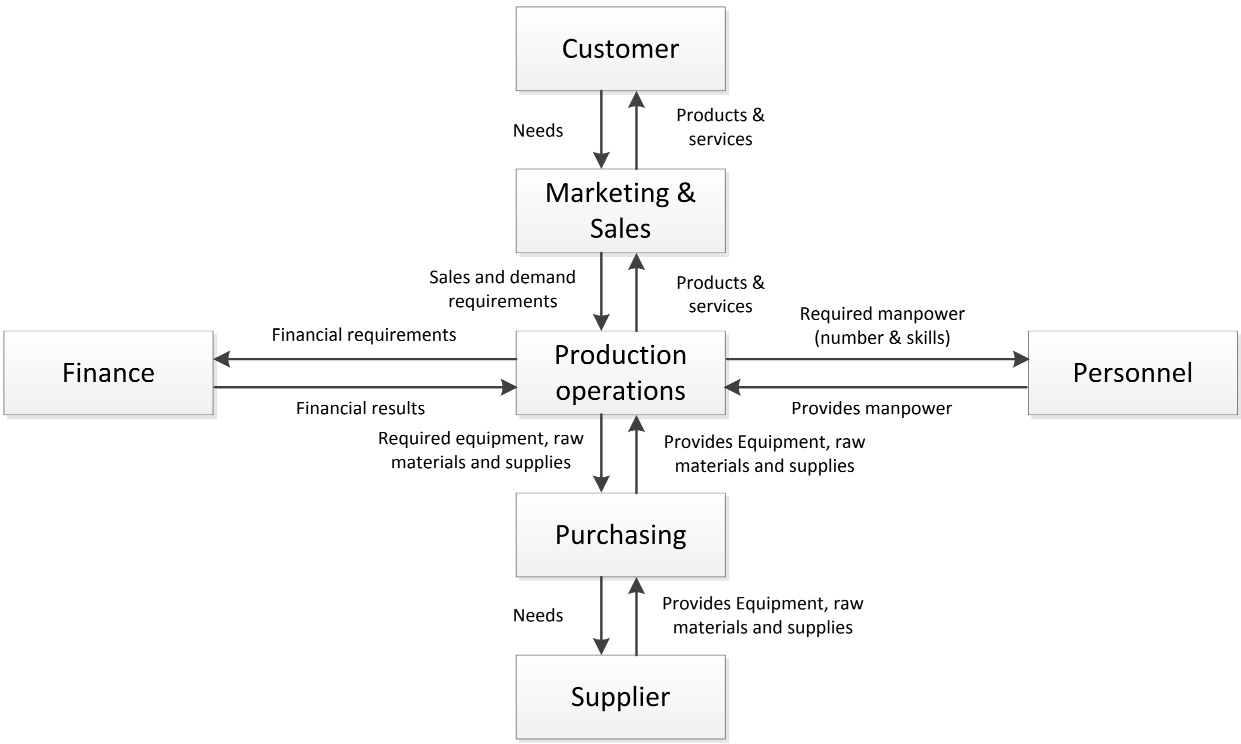

Figure 3: Relationships between Production Operations and other Entities [3: p.5]

In supply chains arise customer demands, which are subsequently met by tangible products or intangible services. Customers can be internal (other working stations, deparment etc.) or external (end-user or other companies) and are actually the reasons for the existence of processes in a company [3: p.3], whereby the process of satisfying a customer demand can be generally divided into five steps [3: p.4]:

Step 1. The customer need is identified and requirements for the products are gathered.

Step 2. The results of Step 1 are analzyed and corresponding products or services are designed. Furthermore, the necessary materials and resources are estimated.

Step 3. The necessary products and resources are procured either from inside or outside of the company.

Step 4. The materials and resources (inputs) are used for the transformation process to produce the designed output (products or services).

Step 5. The output is delivered to the customer

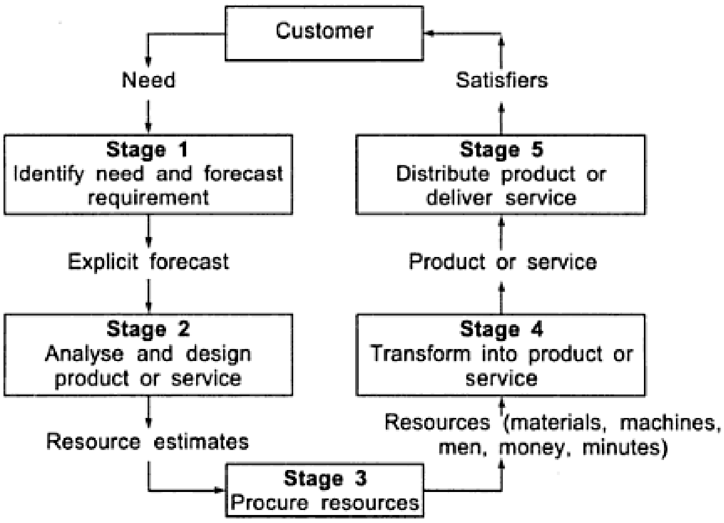

Figure 4: Stages of a Product Development [3: p.4]

In reference to figure 4, the steps 2, 3 and 4 form the main processes of production and operations management [3: p.4].

"Production activities are planned, scheduled and controlled to transform inputs as raw materials, capital, machinery, labor, information and time into outputs as products and services of higher value than the inputs [3: p.6]." Production management might be also defined as "the conversion of inputs into outputs, using physical resources to provide the desired utilities in place and possession to the customer while meeting other organizational objectives" as for example effectiveness, efficiency and adaptability [4: p.1-5]."

According to German-language literature, objectives of an enterprise can be generally expressed as general goals and business goals [5].

General goals are indicators of the physical performance of a company. It is aimed to evaluate goods and services in terms of type, quantity and quality. Usual KPIs are [5]:

- Productivity,

- Lead time,
- Reject rate, and
- Customer Satisfaction.

Business goals primarily reflect the monetary performance of a company. Typical goals are:

- Profitability,
- Revenue,
- Liquidity,
- Equity or insolvency rate,
- Costs, and
- Gross margin.

Regarding production and operations management, three basic tasks have to be done to realize a sustainable success [6: p.2].

- "Ensuring quality in production processes → ensures that customers will receive a product of desired, guaranteed quality"
- "Effective management of production orders → ensures that a product will be manufactured and delivered on time"
- "Control of production costs → enables cost control and optimization"

2.3 Operational Excellence in the Aircraft Industry

An aircraft is "a machine for flight in the air supported by buoyancy or by the dynamic action of air on its surfaces [7]." Examples are powered airplanes, gliders and helicopters [7]. In the following, the focus is on airplanes, whereby it is possible to distinguish the production of military (e.g. jet fighter) and civilian (also: commercial) airplanes (e.g. passenger and cargo airplanes) from each other [8: p.27]. In addition, civilian airplanes are often classified in terms of their size. They may provide seats only for 1 or 2 persons, but as well for 853 persons (Airbus 380, in the all-economy class configuration).

Figure 5: Airbus 380 [9]

The production of airplanes involves high-complex technologies, which are interwoven with each other. Some of them are:

- Mechanical and machine engineering,
- Telecommunication,
- Optoelectronics,
- Avionics and Electronics, and
- Material composition.

If one observes a segment of the supply chain of the Airbus 380, it seems apparent that a far-reaching integration of *Original Equipment Manufacturers* (OEMs), suppliers and customers is crucial "to create integrated solutions that make manufacturing more cohesive, efficient and cost-effective [8: p.27]."

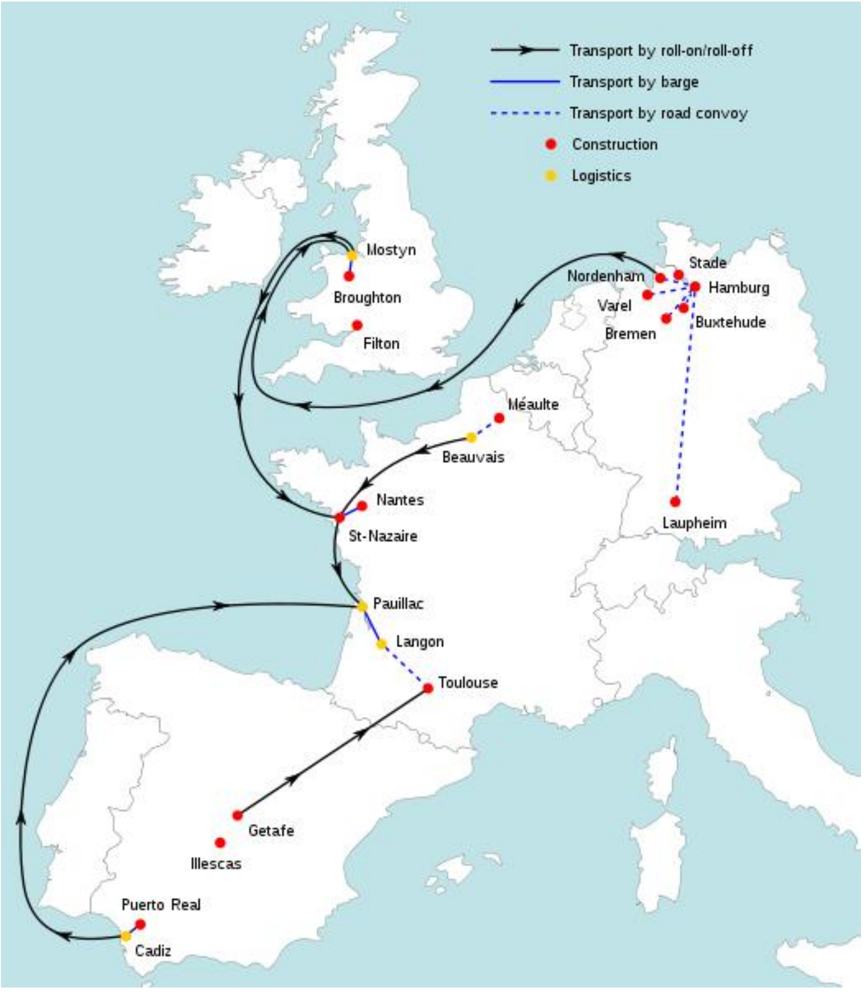

Figure 6: Supply Chain of the Airbus 380 [10]

One of the main goals of operations management is to minimize the unit production cost, whereby the required quality standards still has to be met, or even surpassed.

However, this seems especially for aircraft companies very difficult to achieve, as they have to meet very high Military, Civil or Federal aviation standards [11: p.1]. The high standards can be justified with the fact that an airplane accident always causes drastic consequences for human and environment. However, it may be still possible to decrease production unit costs for example with the help of [8: p.27]:

- Improved technologies,
- Enterprise resource planning, and also
- Computer-based modeling techniques, to design and develop avionics systems faster.

The example of the Boeing 380 represents very well the general supply chain structure of the aircraft industry. For the complete production of an aircraft are usually a lot of plants involved, which requires an excellent coordination and communication from one level to another. Especially if flows (generally: knowledge, materials, cash) between advanced organizations and underdeveloped organizations (e.g. the third world) take place, the coordination and communication processes become even more complex [8: p.27]. Typical core activities in aircraft production are [11: p.1]:[1]

- <u>Conception of the aircraft design,</u>
- <u>Conduction of feasibility studies,</u>
- <u>Production planning and control,</u>
- <u>Make-or-buy decisions (in- or outsourcing & in- or offshoring),</u>
- <u>Assembly and production,</u>
- <u>Quality control and improvement,</u>
- <u>Supply Chain Management,</u>
- <u>Plant maintenance,</u>
- Comprehensive management information systems,
- Human resources management (development programs),
- Operational testing of products and certifications to meet the Military, Civil or Federal Aviation standards.

In the next subchapters follows a discussion of the above topics in terms of *Operational Excellence* in the aircraft industry.

2.3.1 Digital Aircraft Design

The construction of aircrafts are highly influenced by the weight and high safety standards. It is possible to reconcile both goals with the help of 3D CAD (*Three-*

[1]Only the <u>underlined</u> topics are observed in the following sub-chapters.

dimensional Computer Aided Design) tools, whereby usually 2D and 3D models are drawn. The main advantages of CAD are the possibilities to analyze aerodynamics (e.g. digital wind tunnel testing) by use of *Computational Fluid Dynamics* (CFD), to conduct precise and detailed stress tests (e.g. calculations of structural strengths) by use of Finite Element Analysis (FEA) and to create photo-realistic visualizations. All three features simplify the subsequent production processes, and obviously also decrease cost and time investments. The state-of-the-art does not use any hardcopy 2D drawings anymore, which traditionally supported the communication of the engineering and manufacturing departments, but only creates digital data, which is automatically forwarded to the production. Therefore, manufacturing workers are meanwhile often integrated into the actual design process [12: p.28-29].

2.3.1.1 Computational Fluid Dynamics

The *Computational Fluid Dynamics* (CFD) is an essential step in the design process of aircrafts and is mainly used to simulate aircraft aerodynamics (e.g. digital wind tunnel tests), whereby one of the main focuses is on the viscous flow[2]. In the early days only “simple wings or simplified aircraft configurations were observed (e.g. fuselage, wings, engines and pylon)[3] [13: p. 3].” Meanwhile, also “complex aircraft configurations with almost all features of the geometry (e.g. slats, flaps, fairings, engines and spoilers)[4]” are analyzed with the help of CFD [13: p. 3-5].

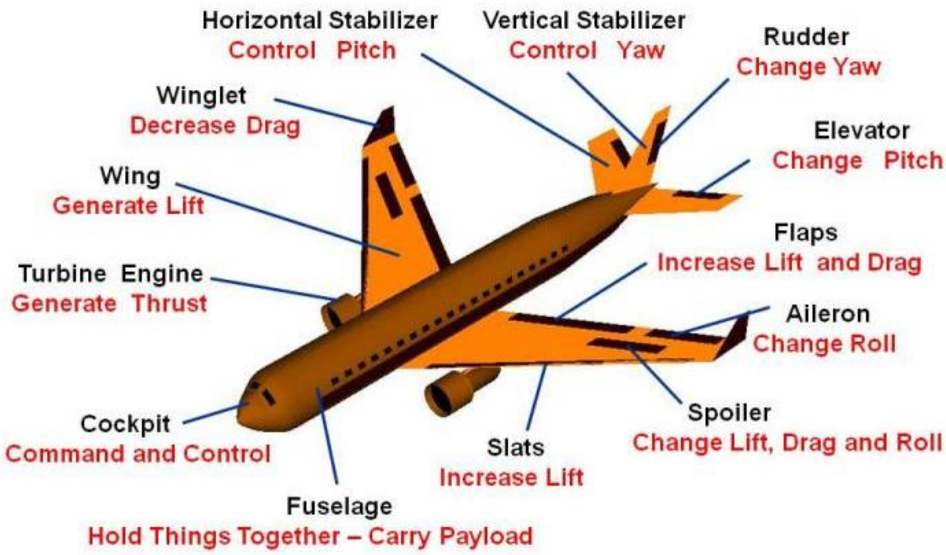

Figure 7: Airplane Parts and Functions [14]

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[2] viskose Strömung = Zähflüssigkeit/Fließfähigkeit einer Strömung → Strömungslehre
[3] Rumpf, Flügel, Motoren und Triebwerkaufhängung
[4] Vorflügel, Landeklappen, Verkleidung, Motoren und Störklappe

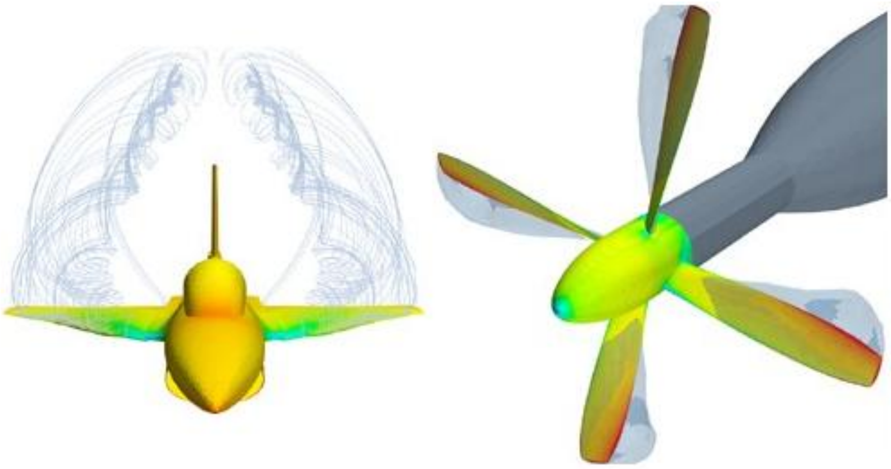

Figure 8: CFD Models [15: p.4]

Summarized can be said that the main usages of CFD are [15: p.4]:

- Design development,
- Control system analysis (S&C)
- High lift,
- Icing accumulation,
- Propulsion,
- Acoustics, and
- Aeroelastics.

2.3.1.2 Finite Element Analysis

The Finite Element Analysis (FEA) is also a computer-based simulation and generally used to analyze reactions of material under loads. It is the most common method to observe large and complex structures if certain impacts are affecting an entire system (e.g. aircrafts, helicopters, ships etc.), whereby following parameters are normally considered [16: p.545]:

- Fluid dynamics,
- Heat transfer,
- Electromagnetic fields,
- Electrical circuits and
- Vibrations.

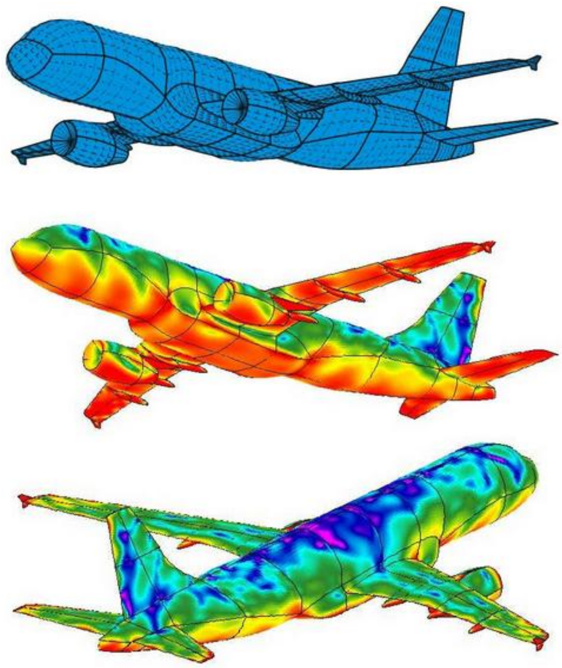

Figure 9: Computational electromagnetic analysis of an aircraft [17]

If a FEA is conducted, a system (e.g. aircraft) is separated "into a large number of individual elements." The individually observed elements are then only connected by node points through which the different forces run. The final goal is to reveal weak spots, and correct them for example by choosing other materials or another structure [12: p.28].

2.3.2 Feasibility Studies

Feasibility studies are conducted to find out if project concepts are viable, cost beneficial, and match to a company's strategy. Table 1 shows a possible structure of a feasibility study, whereby the focus is usually on following key points [18]:

- Analysis of positive and negative effects and side effects,
- Cost-benefit analysis,
- Risk analysis,
- Research regarding state-of-the-art and associated subjects.

Table 1: Example of a Feasibility Study [18]

Section	Description
1	Executive Summary
2	Background Information
3	Description and Current Situation/Problem
4	Description of Proposed Idea
5	Project Timelines
6	Feasibility Review Board
7	Go/No-Go Decision

As a consequence, feasibility studies often prevent companies of wasting time and costs on projects that only have a small or unsustainable benefit, involve potentially re-works (see also: *Murphy's Law*[5]) or imply high (financial, organizational, technological etc.) risks for a company. Aircraft production companies especially apply [18]:

- "Schedule feasibility studies: Analyze how long it will take a project or process to complete and what the go/no-go decision point will be.
- Technical feasibility studies: Analyze if a technical concept will work within the current environment."

Furthermore, feasibility studies are usually used to analyze new airplane designs in terms of costs, lifespan, manufacturing time, market need, and safety considerations [18]. Regarding aircrafts, one of the most crucial questions is, whether it is able to fly or not. Superficially speaking this depends on [19]:

- The weight,
- The power of the jet engines, and consequently the speed of movements, and
- The design (and size) of wings (also: airfoil).

"Airplanes fly when the movement of air across their wings creates an upward force on the wings (and thus the rest of the plane) that is greater than the force of gravity

[5] Murphy's Law says that if a system consists of an error, the error will also appear and distract the system in its performance.

pulling the plane toward the earth [20]." This phenomenon is also known as the *Bernoulli Principle*, which was first described by the mathematician and scientist Daniel Bernoulli in the 18th century [20].

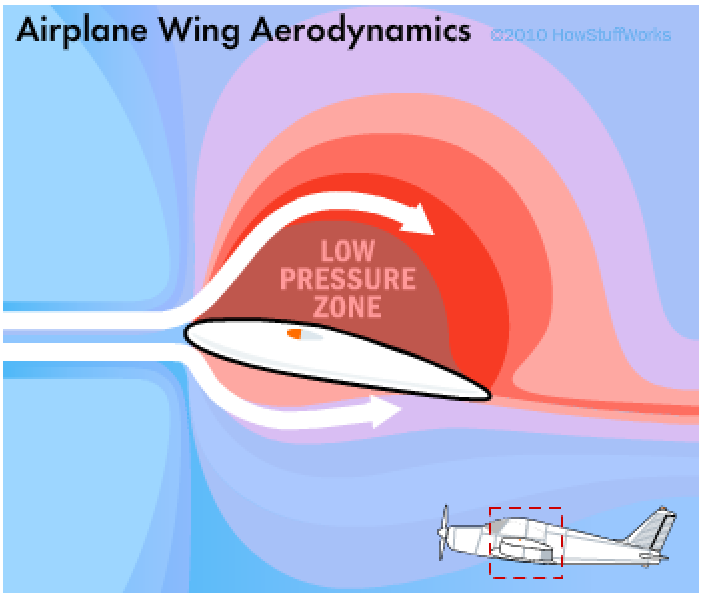

Figure 10: Principle of Flying [21]

Generally speaking, is the uplift of an aircraft a combination of the movement, air drag on the below side of the aircraft, the asymmetric design of the wings (the air needs to pass on the upper side longer than on the lower side), and as a result the thereby caused low pressure zone on the upper side of the wing [20].

2.3.3 Production Planning and Control

In 1943, Hector Donald MacKinnon already stated in his book *Aircraft Production: Planning and Control* that planning and scheduling have the goal "to acquire parts and assemblies in the order in which they are needed" [22: p.10].

Planning is a systematic preparation for an uncertain future based on assumptions and projections [23: p.1]. It supports the processes of finding measures, solutions and activities to accomplish defined goals [24: p.67]. Main characteristics of planning are [23: p.1]:

- A **future-orientation**, which always implies uncertainties and a lack of information availability.
- A **result-orientation**, which means that specific situations and states should be established.

- An **objective-orientation**, which is related to the achievement of quantitative target (time, profit, output etc.) and qualitative target values (customer satisfaction, safe working environment etc.).

In general, controlling is referred to *target-actual comparisons*[6] and can be defined as evaluating current situations and taking corrective actions if the achievement of predefined goals is in danger.

In literature, "Production Planning" and "Detailed Scheduling" are generally distinguished from each other. Both terms imply the planning of activities to achieve goals. However, "Production Planning" is more related to a mid- and long-term outlook, and "Detailed Scheduling" is more related to a short-term outlook. Figure 11 shows the respective duties in relation to the planning time and period [25: p.25 ff.].

		Planning horizon	Time planning periods
Production planning	Planning of primary demand	3-24 months	Weeks
	Planning of secondary demand	3-24 months	Weeks
	Time and capacity planning	1-3 month(s)	Days or weeks
Detailed scheduling	Order approval	1-2 weeks	
	Operation scheduling	1-2 weeks	Hours or days
	Order monitoring		

Figure 11: Duties of Production Planning and Detailed Scheduling [26]

The first step of *Production Planning* is the demand planning of primary materials (generally: semi-finished and finished products) [7], which can be found in the heads of bill of materials (BOM). For the manufacturing of finished products are raw materials, sub-assemblies, intermediate assemblies, sub-components and parts necessary, which can be described as secondary materials. As secondary materials can go into other sub-components, there might be more levels of BOMs than one [25: p.25].

[6] Soll-/Ist-Vergleich
[7] In the following only mentioned as finished products.

After quantities of finished products are determined (either consumption-based or forecast-based), the needed quantities of secondary quantities can be derivated. The planned quantities of primary and secondary materials now determine the needed production scope. Appropriate resources (generally: machineries and human resources) are chosen, capacities are set, initial schedules are worked out and consequently the needed secondary materials (raw, auxiliary and operating materials) also must be procured on time [25: p.26 f.]. In addition, all these points are strongly linked to make-or-buy decisions, which are discussed in 2.2.4 in detail.

As planned finished-products approach their process starting dates, the process of *Scheduling* starts. At first orders are approved, then they are detailed scheduled, set in operation sequence, matched to resources with free capacities, and finally a simultaneous monitoring accompanies the processing. A typical question, which can be solved for example with the help of linear and non-linear optimization, would be which products (a, b, c) should be produced on which resources (x, y, z), whereby typical restrictions are operation times, availability of resources, set-up times and loading/unloading times respectiveley [25: p.26 f.]. Techniques as MTM *(Methods-Time-Measurement)*, *Multi Moment Method* can be used to determine actual and planned times of specific activities under casual conditions executed by an average worker.

Aircrafts are very complex products and might consist of more than six million parts (e.g. Boieng 747) [26], which obviously require a comprehensive production planning, controlling and scheduling. To handle this amount of parts might be following tools helpful:

- A work breakdown structure (WBS),
- Gozintograph, and
- GANTT charts.

Work Breakdown Structure illustrate the major structure of systems. WBS of aircrafts may show components and their individual parts, sub-assemblies, installed systems in each major component, the sequence of manufacture of the individual parts and the stages of assembly [27: p.93].

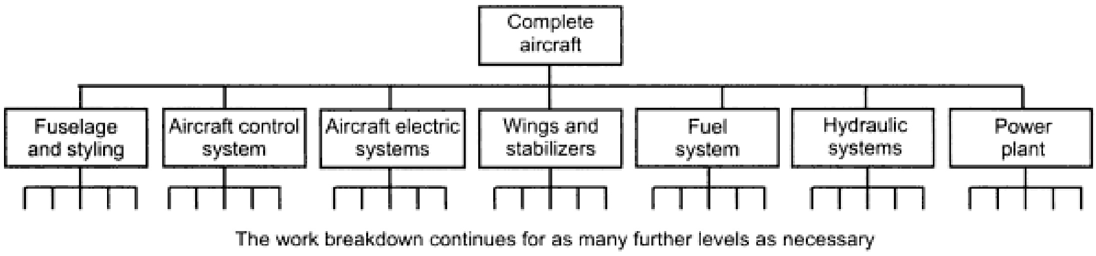

Figure 12: Example of a Work Breakdown Structure [27: p.93]

In the aircraft industry, production planning and control is usually done by the *production and engineering department*, whereby other departments (e.g. departments of procurement, distribution, R&D, personnel, finance) might be also involved. Normally, there are 6 different groups in the production and engineering department, which all have certain responsibilities. These are [28: p.3]:

- Central or program planning group
- Methods engineering group
- Tool engineering group
- Material planning group
- Scheduling group
- Shop Progress Group

The central/program planning group stays in close contact to the departments of marketing, R&D, personnel, purchase and finance, and work out the requirements for the production (in terms of resources and capacities) and also manage their fulfillment. They generally work with aggregate plans, which contain all future-planned produced products for the next 1-3 years. Thus, their main tasks are providing appropriate resources, assigning tasks to the other groups and evaluating the performance of the execution and control. Other typical tasks of the central/program planning group is to plan the plant layout and taking "Make or Buy" decisions [28: p.3].

The methods engineering group usually knows product specifications in detail, produces manufacturing drawings and also forward process instructions "to the shops for each operation." These instructions normally tell the time standards, inspection stages and requirement of production tools, standard tools, machine tools, production equipment and materials [28: p.3].

The tool engineering group usually executes the process instructions issued by the methods engineering group. It plans, designs, provides, stores, issues and readjusts production tools [28: p.3].

The material planning group specifies the actual needed materials for the production in certain time periods (usually in weeks). The needed quantities of material can be derived from the process instructions, which were issued by the methods engineering group [28: p.3].

The scheduling group schedules the sequence, priority and time periods of the production processes. It assigns production tasks to the shops and working stations, organizes the provision of the required resources for the production, which include drawings, process instructions, production tools, standard tools, machinery and equipment, materials and manpower [28: p.3].

The shop progress group stays in direct contact to the shop and working stations, and usually directs the planned jobs to the shop workers. This includes an optimal job-preparation of the shop workers, which should consist of handing-over and explaining job cards, drawings, process instructions, tools and materials. One of the biggest goals of this group is to establish an efficient flow production between the different working stations, so that no time is lost due to unnecessary processes (e.g. further explanations). As this groups stays in direct contact to the production, it also delivers feedback on the execution of the plans to the central/program planning group [28: p.3].

2.3.4 Make-or-Buy

Every company has to define in which make-or-buy ratio it wants to produce their market-offered products. The decision of producing certain parts internal or outsourcing them external is primarily influenced by the question of costs (e.g. improvement by economies-of-scale) and quality of processes and products (e.g. improvement by more precise technologies). The main advantages of both options can be seen in Figure 13, whereby the disadvantages of each side are the logical opposite of the other sides' advantages [29: p.208]:

	Pros of Make Decision	Pros of Buy Decision
1	Lower production cost	Lower acquisition cost
2	Ensure adequate supply	Preserve supplier commitment
3	Avoid unreliable suppliers	Obtain superior capabilities
4	Utilize surplus resources	Avoid investment in additional capacity
5	Obtain desired quality	Reduce inventory costs
6	Avoid supplier collusion	Ensure constant supply of items
7	Make unique items that may be difficult to buy	Limited internal resources
8	Avoid layoffs	Reciprocity
9	Protection of intellectual property	Items that are protected by patents
10	Increase the size of the company	Focus on core competency

Figure 13: Pros of Make or Buy [30: p.531]

Especially international companies tend to purchase many items from other suppliers. Beside other countries (e.g. Britain, Australia, Italy, Korea, Brazil, Singapore, and Ireland) the American aircraft manufacturer Boeing for example sources 20% of its components from Japan for the production of the Boeing 777 (see in detail in sub-chapter SCM) [31: p.107]. This strategy is generally influenced by cost-saving arguments, but also by the ulterior motive to enter another market and also commit a national economy (market, companies) to its products, as Japanese companies become a part of the Boeing Supply Chain [32: p.209].

Figure 14 shows the different integration types, whereby *Vertical Integration* and *Outsourcing* are the extremes.

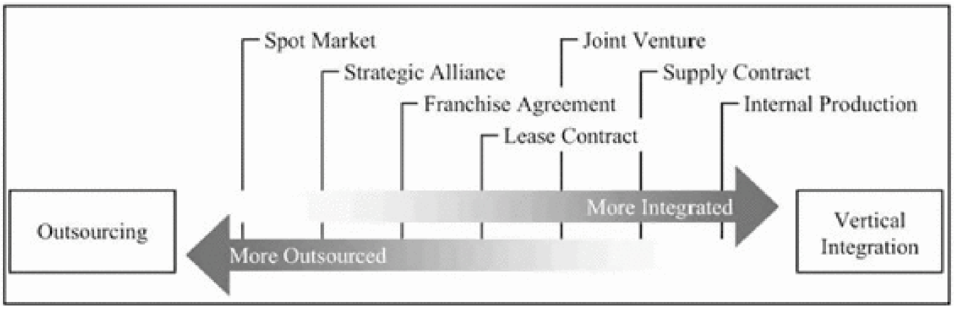

Figure 14: Degrees of Company Cooperation [32: p.209]

Chapter 2.2.7 (Supply Chain Management) will show that aircraft production is generally characterized by complex supply and purchase relations between various companies and a low vertical manufacturing range per company.

Two main processes, which can be demonstrably differentiated from each other, are:

- The composition of materials, and
- The assembly of these parts.

Compositing materials is the process of merging and combining 2 or more different materials that have also different physical or chemical properties. The goal is to achieve a win-win situation. For example carbon-fiber composite parts make aircrafts stronger and lighter at the same time [33: p.432 ff.].

Cessna Aircraft for example (see also 2.2.5.1) purchases several semi-finished composited parts from other suppliers and also produces those in 2 self-owned plants in Wichita (Kansas) and Chihuahua (Mexico); however, the final assembly is done at a plant in Independence (Kansas).

2.3.5 Production and Assembly

The production and assembly of an aircraft has been traditionally a labor-intensive, manual process that was originally conducted as a job floor production, which means that the final aircraft did not move during their final assembly. The main reasons for these circumstances have been [34]:

- Conservatism in terms of aircraft/components design and production processes.
- Government regulations, as each change in production cause an expensive and time consuming certification process.
- Low production volumes, rare material composites and large components with complex shapes.

In the last years, one of the main innovations in the production of aircrafts was the establishment of moving assembly lines. The principle follows the idea of a continuous flow (see also 2.3.6: Quality Control and Improvement) and generally aims [35: p.18]:

- To reduce production and subsequent lead times,
- To decrease work-in-progress and inventories,
- To lower transport effort,
- To diminish waiting time and non-value-adding processes.

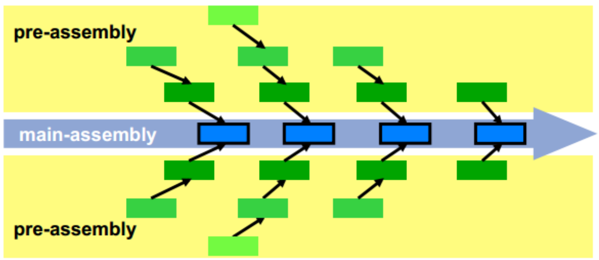

Figure 15: Principle of the Flow Production [35: p.21]

In a flow production lead-times can be generally reduced due to the fact that processes are then parallelized:

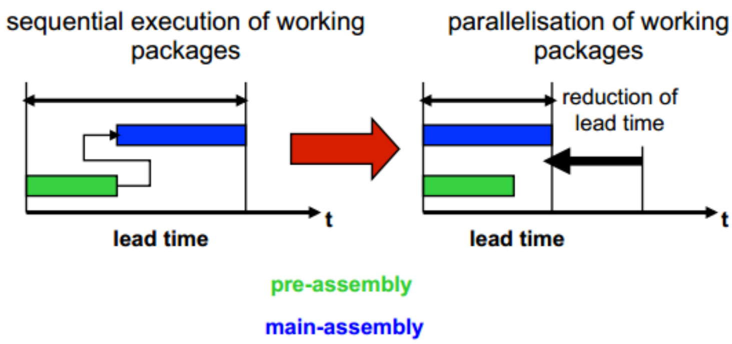

Figure 16: Parallelization of Processes [35: p.21]

Another state-of-the-art is the application of the 5S principle. It is based on the *Toyota Production System* and generally says that working stations should respect following key points [36: p.112]:

- Sorting (Seiri),
- Set in order (Seiton),
- Systematic cleaning (Seiso),
- Standardizing (Seiketsu), and
- Sustaining (Shitsuke & Shukan).

This working environment enables a clear and efficient production system.

Figure 17: Application of the 5S Principle [35: p. 29]

The left picture of Figure 17 shows the supply of small and medium-sized components, materials etc. in size-customized boxes, which also enables the application of a KANBAN replenishment system. A KANBAN replenishment system has its customer order decoupling point (CODP) at the supermarket and usually consists of [37: p.337 ff.]:

- A supermarket, where the (generally: small and medium-sized) components, materials etc. are stored centrally,
- Boxes, that contain a specific number of similar parts,
- Logistician or an automated conveyor system that moves the filled and empty boxes between the supermarket and the several working stations, and sometimes also of
- A refilling worker at the supermarket, who refills empty boxes with demanded material and generally manages the boxes at the supermarket. However, this task might be also executed by the logistician, if there is one.

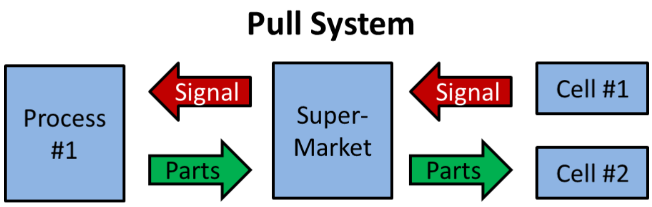

Figure 18: Principle of KANBAN Replenishment [38]

One of the main advantages of a KANBAN system is the fact that materials have a shorter flow time through processes, and consequently processes also have a lower work-in-progress. This can lead to a decrease in inventory and a release of liquid assets, if the then obsolete inventory and corresponding safety stock is effectively cut [37: p.337 ff.].

The right picture of Figure 17 can be even more related to the 5S principle. The parts are presented in a clean way, which saves space and also delivers a good overview. Other advantages are that the materials are supplied process-related, which means that they are ordered according to the installation steps and that the parts can be picked out without any unpacking activities. Both circumstances simplify the effort for assemblers [35: p. 29].

2.3.5.1 Cessna Aircraft Company

The assembly plant of Cessna in Independence was visited personally by the author, whereby conclusions in terms of following topics have been done:

- Supply Chain Management,
- Produced products,
- Executed processes, and
- Moving assembly line.

The facility is located in the Southeast of Kansas, is 213 acres big, consists of 5 main buildings (1. assembly, 2. painting & avionics implementation, 3. paint preparation, 4. flight and 5. delivery center), and is also connected to a small airport, which is also used for test flights and customer deliveries (generally, either deliveries to an agreed airport, or *Ex Works*).

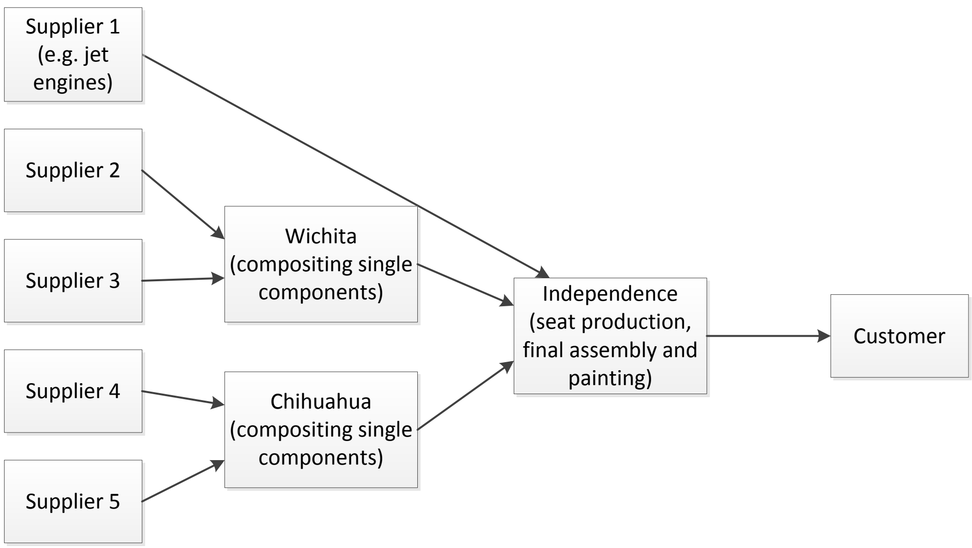

Figure 19: Supply Chain Cessna - Independence

The plant receives sub-components from a plant in Wichita, KS and a plant in Chihuahua, Mexico and is responsible for the final assembly of the Cessna models Skyhawk, Skylane, Stationair, Corvalis TT, Citation Mustang and Citation M2. The plants in Wichita and Chihuahua are responsible for the material composition and production of single parts (e.g. wing, fuselage, rudder etc.) and in Independence takes place the seat production, the final assembly and painting of the aircrafts. In the assembly building can be identified two moving assembly lines. In one are produced the Citation Mustang and Citation M2, and in the other one are produced the 4 other models depending on the customer demand, which also shows, that the customer decoupling point is located before the assembly process. This can be justified by the high bounded value of finished aircrafts (e.g. starting sale prices of Citation M2 = $ 4,395,000; Citation Mustang = $ 3,285,000; Corvalis TT = $ 773,950; Stationair = $ 597,000; Skylane = $ 398,100; Skyhawk = $ 289,500).

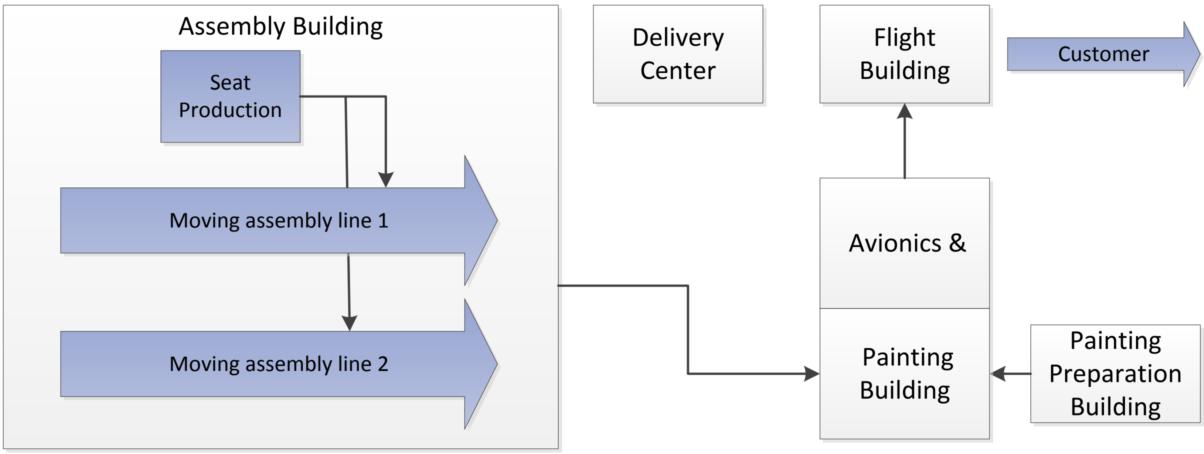

Figure 20: Production Plant in Independence, Kansas

The following paragraphs illustrate the assembly process of the fuselage in detail. The fuselage of the model Citation M2 generally consists of a nose, a cockpit, a cabin fuselage, and aft fuselage.

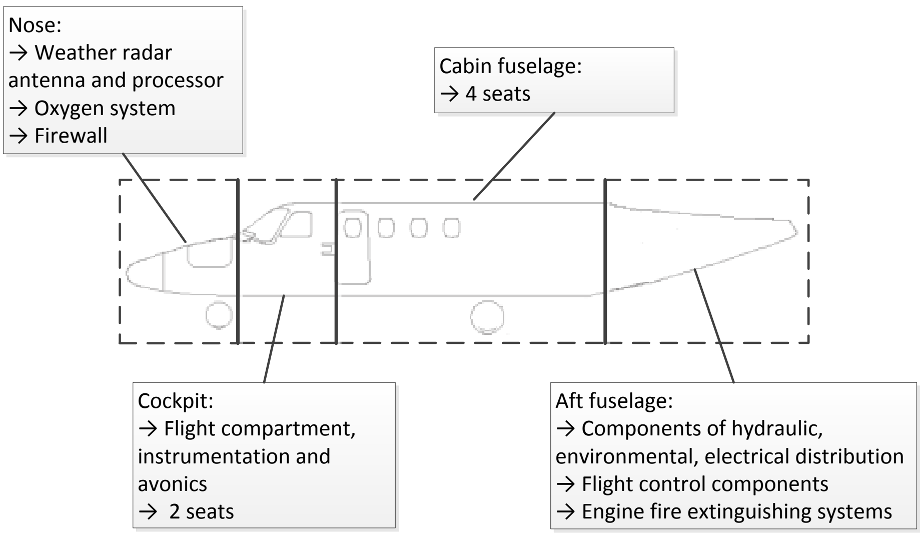

Figure 21: Fuselage of Cessna Citation M2 [39]

In a first step these four segments are produced separately, and subsequently assembled in a second step. For the assembly of the single parts and also the final assembly of the segments are usually used metal rivets.[8] The Citation M2 for example has more than 100,000 metal rivets.

Figure 22: Metal rivets and a Hand Riveting Plier

2.3.5.2 Spirit AeroSystems

Meanwhile, aircraft manufacturers and suppliers also try to integrate robots and other automation system into their production systems. Examples which can be mentioned are the factories of Spirit AeroSystems in Wichita, Tulsa, Kinston, and Prestwick. The majority of the work is still done manually; however, as the American first-tier aero-structures manufacturer only used six robots in 2005, they already apply 30 of them. Main reasons are [40]:

- A simplification of processes,
- An increase in quality due to a higher accuracy,
- Improve safety, ergonomics or the working environment, and
- Cost savings, whereby a robot in average costs between $50,000 and $100,000 plus extra costs for a software system and tooling, which leads to 3 to 10 time's higher final prices, depending on the complexity.

In case of *Spirit AeroSystems* the robots are used for [40]:

- Flame-sprayer (to increase the durability of airplane parts),
- Drilling (especially of aluminum and titanium),
- Testing,
- Fastening, and
- Painting (e.g. to achieve an exact surface, as the paint protects from ultraviolet rays; however, if "the paint is to thick the fuselage won't conduct electricity in the event of a lightning strike")

[8] Nieten

Currently, *Spirit AeroSystems* use their robots mainly behind gates or in separated rooms. For the future the company also plans to integrate their robots into their factory floor completely [40].

2.3.5.3 Boeing

Due to decreasing demand and increasing competition in the 1980s, and 1990s, Boeing started to develop their *Boeing Production System* to improve its efficiency and productivity. This program generally bases on the principles of Lean Manufacturing and Six Sigma (see also 2.3.6: Quality Control and Improvement) and enabled to implement [41]:

- A new Supply Chain concept for its 787 Dreamliner, in which risks are shared across the network and the final assembly, was extremely streamlined.
- A moving assembly line for its 737 jet at the factory in Renton, which only needs one week to be produced.
- Standardized processes e.g. for the production of the 737-800 and its militarized version (P-8A Poseidon), which enables to produce different end-products on the same assembly line.
- Automated guided tuggers to move airplanes from working station to the next working station.
- A strong cooperation between the engineers and operators across the divisions of *Commercial Airplanes* and Military Airplanes (*Integrated Defense Systems)*.
- CATIA other CAD/CAM software's, to allow engineers to work simultaneously on same designs independent from their geographical position.

Figure 23: Moving Assembly Line of the Boeing 787 Dreamliner [42]

2.3.5.4 Diamond Aircraft

Advances in material applications and electronics helped the aircraft industry to achieve huge progresses in the last years. Especially the performance of airframes and engines could be improved with the help of new metallic and non-metallic composite materials. The big advantage of composite materials is that weight can be often reduced, and simulteanously the robustness also rises (e.g. can state-of-the-art alloys resist temperatures up to 3,000 Celsius degrees). Furthermore, developments in electronics (especially the usage of semiconductors) diminished the size of cockpit instruments, and actually much more important, it also enabled huge milestones in communication, navigation, instrumenation, and testing [31: p.99].

The Austrian aircraft manufacturer Diamond Aircraft for example applies three different techniques for the composition of airframes. These are:

- Wet-in-wet laminations,
- Pre-pregnated, and
- Resin infusion

2.3.6 Six Sigma: Quality Control and Improvement

The Six Sigma philosophy primarily seeks to improve process, product and service value with the help of higher quality, reduced waste and capacity alignment [43: p.27]. In this context, the main goals of Six Sigma are [1: p.9]:

- Quality
- Value and,
- Flow

Following figure does not only illustrate ways to achieve *Quality*, *Value* and *Flow*, it additionally shows the relation to a higher operational performance, profit and share-holder-value.

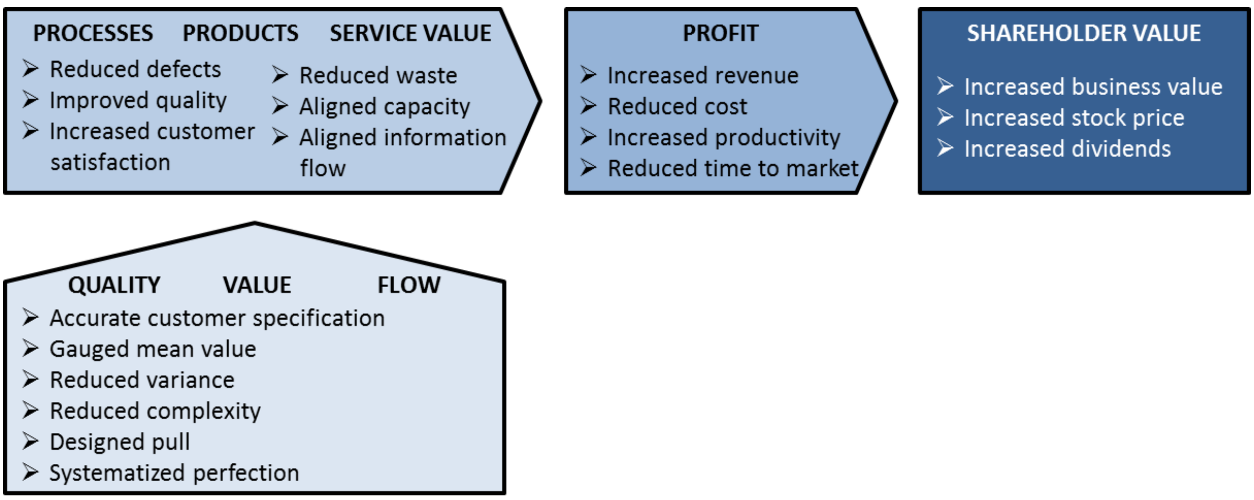

Figure 24: Main Goals of Six Sigma [1: p.9]

Flow gives priority to customers and their actual demand. All information and order processes should be triggered according to the pull-principle, which finally seeks to decrease inventories [5: p.9]. Solid and robust Six Sigma processes consist of a continuous flow (e.g. clocked process steps), capacities that can be easily aligned without causing unnecessary inventories (e.g. flexible wokring hours) and the aim to deliver maximal customer value [44: p.30].

Processes can be generally value-adding, supporting, non-value-adding and value-reducing. *Value* is associated with the elimination of non-value-adding and value-reducing activities, as the customer is not willing to pay for these efforts and can be classified as waste. Figure 25 shows the seven types of waste [1: p.10]:

Table 2: Seven Types of Waste [1: p.10]

7 types of waste	
1	Excess motion ergonomic or physical
2	Excess transportation
3	Waiting time
4	Defects and rework for error correction
5	Overproduction and obsolescence
6	Excess processing, work or inspection
7	Excess inventory

Quality aims to raise „process, product and service value by reducing complexity", to achieve solid and stable processes without big deviations in the output (Statistical Process Management) in combination to meet customer requirements [1: p.10].

A Six Sigma program include following 5 steps (DMAIC) [46: p.2]:

- Define
- Measure
- Analyze
- Improve, and
- Control.

The following two sub-chapters show useful tools, which might be applied in the steps "Measure", "Analyze", "Improve" and "Control."

2.3.6.1 Statistical Process Control

Technically speaking, Six Sigma tries to decrease variance of the produced products, which again leads to higher product and process quality [46: p.207 f.].

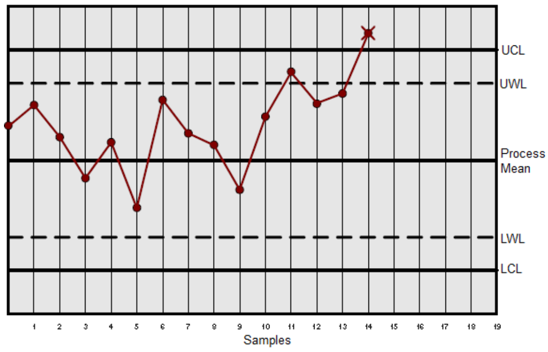

Figure 25: Statistical Process Control Chart

In practice this implies the elicitation of valid measures (e.g. weight, diameter, electrical resistivity etc.) and in the following the calculation of the process means and standard deviations (sigma - σ) [45: p.109 f.]. Once these prerequisites are executed, it is possible to monitor each output on a control chart (see Figure 26) [46: p.295 f.].

As one can see, there are 5 different lines. The *UCL* stands for *Upper Control Limit*, *UWL* stands for *Upper Warning Limit*, *LWL* stands for *Lower Warning Limit* and *LCL* stands for Lower Control Limit. The process mean is calculated as the mean of all samples. The measures are calculated with the help of the mean, the standard deviation (σ) and number of observations per sample (see Figure 27) [46: p.295 f.].

$$UCL = \bar{\bar{x}} + \frac{3\sigma}{\sqrt{n}}$$

$$LCL = \bar{\bar{x}} - \frac{3\sigma}{\sqrt{n}}$$

$$UWL = \bar{\bar{x}} + \frac{2\sigma}{\sqrt{n}}$$

$$LWL = \bar{\bar{x}} - \frac{2\sigma}{\sqrt{n}}$$

UCL	Upper control limt
LCL	Lower control limit
UWL	Upper warning limit
LWL	Lower warning limit
$\bar{\bar{x}}$	Process: mean
σ	Process: standard deviation
n	number of observations per sample

Figure 26: Six Sigma Key Figures

In a final step all collected samples are monitored with reference to certain process control rules. These rules should help to get control of processes [46: p.309].

- No values outside of the control limits,
- Not more than 40 values outside of the warning limits,

- No two consecutive values outside of the same warning limit,
- No trend consisting of five or more values crossing a warning limit,
- Not more than six consecutive values over or below process mean,
- No trend consisting of six or more values.

If one of the rules is broken, the process has to be readjusted and with appropriate measures improved.

2.3.6.2 Quality Improvement

With the help of control charts it is possible to evaluate processes in terms of their stability and capability, whereby a process can be under control or not under control. However, it is also crucial to check if the expectations of the customers are fulfilled. Prerequisites for this step are [46: p.295 ff.]:

- Target values,
- Tolerances (lower & upper specification limit),
- Accuracies and
- Precisions.

Target values can be derived from customer demands, and for instance determined with the help of surveys. Example might be the size of a smartphone, color intensity of products or as well the power of processor (GHz). Product tolerances stay in direct connection to target values and can be defined as customer tolerated deviations from the target value, whereby customers are still willing to pay for a product the same price (→ in practice, the tolerances have to be defined as an optimum of process efforts and customer tolerance). Accuracy is the comparison of the actual process mean and the predefined target value. The highest accuracy is achieved, if a process mean equals the target value. If the range within the samples is observed, a meaningful figure is the precision, which can be expressed either as standard deviation (σ), or as well as variance, which is defined as the square of the standard deviation (σ^2). As lower the standard deviation/variance of process is as higher is its precision. In addition it is necessary to define a target value based on the customer demanded specifications, as they justify the production of products [46: p.295 ff.].

To find out, whether a process in under control or not, the *Process Capability Ratio* (c_{pk}) can be calculated. Depending on the accepted tolerances (number of σ's), this metric has to be above a certain number that a process can be described as capable. If the process mean does not match with the target value, it is necessary to consider only the gap between the process mean and the closer specification limit. In this case, following equation has to be applied [46: p.157 f.]:

Equation 1: Critical Process Capability [46: p.157]

$$c_{pk} = \frac{\Delta_{crit}}{x * \sigma}$$

c_{pk}: Critical Process Capability

Δ_{crit}: Gap between Process Mean and closer Specification Limit

x: Number of considered σ

σ: Standard Deviation

If the process mean corresponds to the target value, the metric is called *Potential Process Capability* and following equation is then used:

Equation 2: Potential Process Capability [46: p.157]

$$c_p = \frac{T}{x * \sigma}$$

c_p: Potential Process Capability

T: Range between Lower and Upper Specification Limit

Following table gives an overview about the *Critical* and *Potential Process Capabilities*, the corresponding tolerances, and the considered and not-considered amounts of samples.

Table 3: Key Figures for Potential and Critical Process Capability [46: p.157 f.]

Potential (c_p) and *Critical Process Capability* (c_{pk})	Corresponding tolerances	Amounts of samples	
		Considered	Not-considered
0.33	1 σ	68 %	32 %
0.67	2 σ	95 %	5 %
1.0	3 σ	99.73 %	0.27 %
1.33	4 σ	99.9937 %	0.0063 %
1.67	5 σ	99.999943 %	0.000057 %
2.0	6 σ	99.9999998 %	0.0000002 %

2.3.6.3 Lockheed Martin

Related to the aircraft industry, there is a big range of implementing the concept of Six Sigma. Lockheed Martin (manufacturer of aeronautical and space systems) for example started a Six Sigma program under the name *LM 21 Best Practices*. The main steps included [47]:

- Value Stream mapping,
- Differentiation of value-added, necessary supporting and non-value-added processes,
- Waste elimination, and
- Improvement measures.

The value stream mapping provided information regarding the customer expectations and wheter they are met or not. If not, possible solutions were then worked out and. For the actual implementation and improvement of the processes is involved the entire organization. In a next step, critical suppliers were integrated into this program, and also had to implement the concept of Six Sigma and Lean Thinking. In the end, more than 5000 improvement projects were conducted, which finally reduced costs by 4 billion dollars [47].

2.3.7 Supply Chain Management

Supply Chain Management is the Management of flows (products, information, and cash) across all steps along a Supply Chain. As aircrafts are produced across companies, countries and actually continents, it is crucial to execute a comprehensive Supply Chain Management.

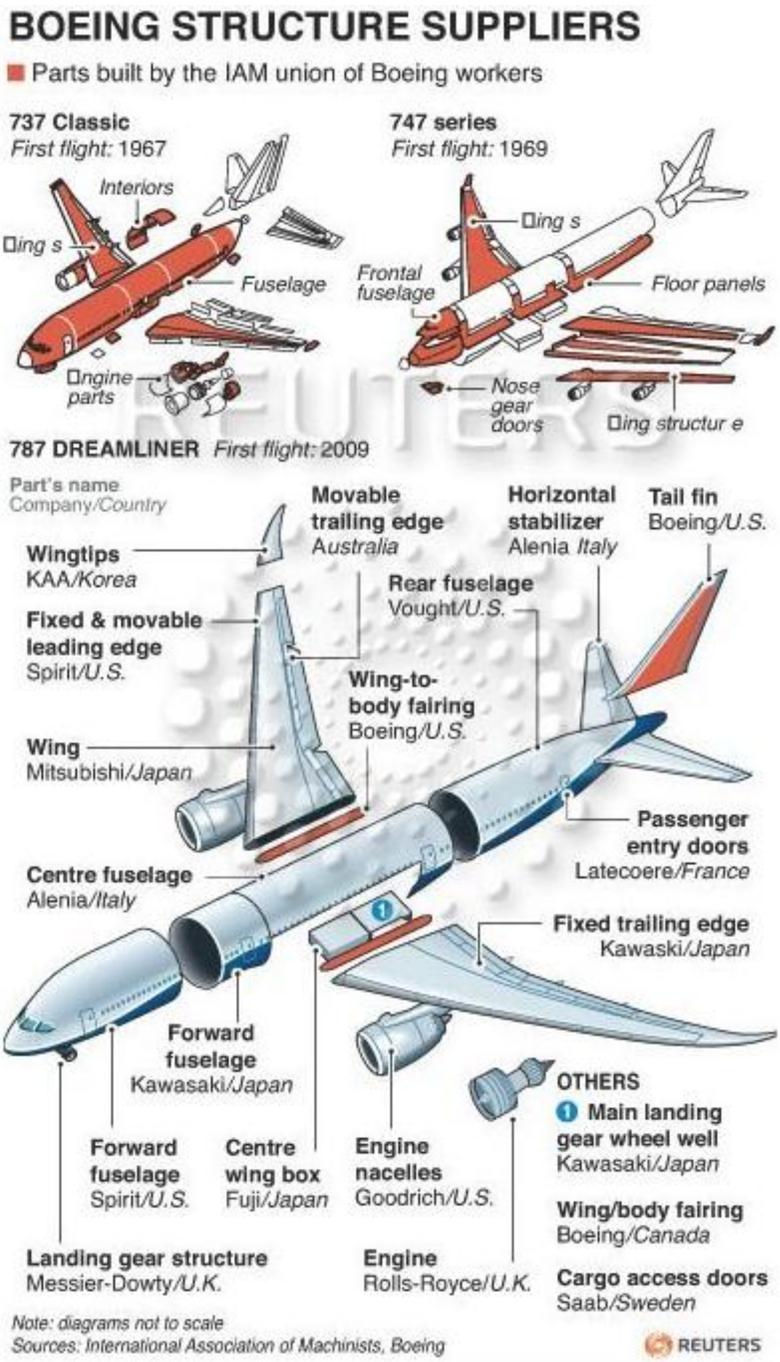

Figure 27: Boeing Structure Suppliers [48]

For the production of the Boeing 777 for example, are involved 12 international companies located in ten countries, and 18 more US-American companies in 12 states. The international suppliers are located in Japan, Britain, Australia, Italy, Korea, Brazil, Singapore, and Ireland [31: p.107]. Figure 29 shows the supplier structure of the Boeing 787 Dreamliner. Nevertheless, if an entire network is completely observed, one may find more than 1000 of domestic and foreign aircraft components manufacturers. This circumstance converts Original Equipment Manufacturers (OEMs) more and more to System Assemblers. This transformation is mainly caused by sharing immense financial risks and the concentration on core competencies. For example the production of jet engines was never a production process of Boeing, or Airbus. This was always a core process of high specialized companies as General Electric, Pratt and Whitney, or also Rolls Royce, which has something to do with the complex and demanding realization (e.g. engine production requires more time than an aircraft production without engines) and huge financial expenses (e.g. equals the value of all jet engines the value of an aircraft without engines) [31: p. 98 f.].

2.3.8 Maintenance

Aircrafts are checked before every flight supferficionally, and inspected in detail every 5 days to meet high safety standards. This high effort can be justified with a 0-defect tolerance, as every incident may cause dramatic consequences [33: p.414]. Breakdown of machinery and equipment in the aircraft production may not have such a big effect on humans and environment, however it may cause exorbitante costs due to delayed deliveries, idled workers or a lower output quality, which in turn could actually again cause a breakdown of an aircraft.

The state-of-the-art is generally the application of Total Productive Maintenance/ Management (TPM). TPM is built by 7 steps, whereby especially the usage of preventive maintenance schedules are common tools in the aircraft industry. This technique considers breakdown probablities of the past, and consequently determines certain maintenance intervals for machine tools and production equipment. If resources still break down, well-defined procedures should help to integrate them as fast as possible again [28: p.14].

For the aircraft industry can be said that a machine should never exceed a breakdown rate of more than 2% of the total available working hours [28: p.14].

2.4 Business Value

There are several reasons to calculate the business value of a company (see Figure 29). The main distinguishing point is whether there is a change of ownership or not. Moreover, there is the difference of dominated and non-dominated situations. The first form describes situations, in which one party is not able to cancel negotiations. Non-dominant situations exist when both parties can break off negotiations and stay in the old situation [49: p.82].

	dominated situation	non-dominated situation
A. Change of ownership stucture		
• Purchasement/Sell-off of a company or shares		x
• Stock market launch		x
• Separation of a shareholder in a joint partnership due to:		
- Cancellation		x
- Sequestration from a shareholder	x	
- Insolvency proceedings of assets of a shareholder	x	
• Cash compensation or share settlement for minority shareholders due to:		
- Profit transfer or domination agreements	x	
- Affiliations because of a majority decision	x	
- Change of legal form because of asset transfer	x	
- Change of legal form	x	
- Squeeze-out procedure	x	
- Merger	x	
B. No change of ownership stucture		
• Distribution of surplus in case of divorce	x	
• Impairments tests		x
• Purchase price allocation		x
• Economic valuation of share holdings		x
• Inheritance dispute		x
• Expropriation or communization	x	
• Reorganisation audits; economic valuations of assets for insolvency proceedings		x
• Value-oriented enterprise controlling		x

Figure 28: Reasons to Calculate the Business Value of a Company [49: p.83]

Depending on the purpose for the calculation of the business value, the appropriate method has to be chosen. The several methods have different names in practice and science of business. However, they can be matched in following way [50: p.102]:

Table 4: Valuation Terms in Science and Practice [50: p.102]

Evaluation purposes of manage-ment economics in science	Evaluation purposes of manage-ment economics in practice
Decision value	Subjective company value
Market value Norm-value (law value) }	Objective company value
Arbitration value	Arbitration value

Decision Value (Subjective Company Value)

The decision value bases on subjective and individual perceptions and preferences (e.g. personal expectations, willingness to take risks, personal tax situation etc.), which also explains the usual name in practice: subjective company value. The goal of this value is to show upper (for buyer) and lower (for seller) price limits (also: marginal price), in which the business position of the potential buyer/seller stays at least the same. For the calculation of the value can be used any input (cash-flow, equity, assets etc.) and any interest rate depending on the personal opinion of the decision maker [50: p.102].

Arbitration Value

An arbitration value is calculated if two parties have to find a fair and appropriate agreement in case of conflicts. Usually, independent parties help to find a consensus, whereby often for each party a decision value is calculated at first, and subsequently a value in between the two decision values is chosen. This procedure is in context of management business very dubious as normative factors influence the fixing of the final value [50: p.103].

Objective Company Value

Especially the German-speaking world often deals with the term of the objective company value (“*objektivierter Unternehmenswert*”), which aims to calculate a person-independent, and consequently an objective company value. The model generally bases on the idea of a future-based profit (in form of cash-flows), which can be expected in a continuation of the company, whereby all market chances and risks, all financial possibilities and all other influences are considered (in form of growth rates and discount factor). The objective company value stays in strong connection to the market and norm value [50: p.103 f.].

Market Value

The goal of calculating a market value is to find a theoretical market price for a company. The market price of a company is generally calculated in terms of an objective company value. In addition, the calculated value is then also related to the values of the other market players and their market shares. However, to execute this model properly, it is necessary to determine assumptions as risk appetite, growth rates etc. on the same basis [50: p.104].

Norm Value

Norm value are also generally calculated ion terms of objective company values, whereby a law or statutory provisions (norms) has to be attended for the calculation of the value (e.g. an appropriate compensation for minority shareholder, or inheritance dispute). As a legal rules influence the calculation, it is possible that final value differs from business principles (especially in comparison with the objective company value) [50: p.104].

2.4.1 Financial Leverage Effect

The financial leverage effect says that return on equity can be increased by borrowing debt capital and using it for investments instead of self-owned equity capital, as long as the return on the total capital is higher than the interest rate on debt capital. However, this is only true under the assumption that interest on debt capital stays constant. Following equation can be then used to calculate the return on the equity (compare: internal rate of return: IRR) [51: p.381]:

Equation 3: Return on Equity

$$r_{EC} = r_{TC} + L * (r_{TC} - r_{DC})$$

r_{EC}:	*Return on equity*
r_{TC}:	*Return on total capital (amount of investment)*
L:[9]	*Debt-to-equity ratio (ratio of debt and equity capital: $\frac{DC}{EC}$)*
r_{DC}:	*Interest on debt capital*

Example 1: A company is able to receive a total income return of 10% (r_{TC}) in case of an investment of $ 1,000, whereby half is funded by equity capital and half is funded

[9] L = Leverage

by debt capital (so each $ 500). The earnings before interest would be $ 100; however, as the company also has to pay interest (assumed: 4% → $ 500 * 0.04 = $ 20), the earnings after interest would be $ 80. Consequently, the return on equity would be 16% ($ 80 / $ 500).

Example 2: The same company now reduces its equity on the investment to $ 300 and increases its debt capital to $ 700, whereby the same return on equity (10%) and interest on debt capital (4%) is assumed. The interest would be now $ 28 ($ 700 * 0.04) and consequently leads to earnings after taxes of $ 72 ($ 100 - $ 28), which was reached with an equity capital of only $ 300. Therefore the return on equity would be now 24% ($ 72 / $ 300). To gain now additional money, the freed-up money of $ 200 has to be used now for other investments, which pay off at least the rate of the interest on debt capital, which is also the profit difference between example 1 and 2 ($ 200 * 0.04 = $ 8). If for example the freed-up money ($ 200) can be invested on a fixed interest rate of 5%, a company would finally make a profit of $ 82 ($ 72 + $ 10 ($200 * 0.05)), and leverage additional $ 2.

Example 3: Let us assume an interest rate of 13%. In combination to example 2 this would mean that the company had to pay $ 91 ($ 700 * 0.13) for interest rates. Therefore the earnings after interest would be only $ 9, which leads to a return on equity of 3% ($ 9 / $ 300), or a return on investment of 0.9 % ($ 9 / $ 1,000), and the freed-up money ($200) has to be invested for 35.5% to achieve at least the same result (+$80) as in example 1.

Return on Investment 1	10%
Interest Rate	4%
Return on Investment 2	5%

Equity Capital	Debt Capital	Total Capital	Income	Payment of Interest	Earnings after Interest	Additional Income	Total Earnings	Return on Equity Capital
1000	0	1000	100	0	100	0	100	10%
900	100	1000	100	4	96	5	101	11%
800	200	1000	100	8	92	10	102	12%
700	300	1000	100	12	88	15	103	13%
600	400	1000	100	16	84	20	104	14%
500	500	1000	100	20	80	25	105	16%
400	600	1000	100	24	76	30	106	19%
300	700	1000	100	28	72	35	107	24%
200	800	1000	100	32	68	40	108	34%
100	900	1000	100	36	64	45	109	64%
0	1000	1000	100	40	60	50	110	#DIV/0!

Figure 29: Comparison of Investments

Concluded can be said that this concept only pays off, if the return on total capital is higher than the interest rate on debt capital. In such cases it is always more beneficial to replace equity capital by debt capital, as long as the freed-up money can be invested also on a higher rate than the interest rate.

2.4.2 Tax Shield

The "financial leverage effect" stays in close relation to the principal of *Tax shields*, as the usage of debt capital implies the payment of interest rates, which in turn reduces the taxable result. The shareholder can now use the disposable equity capital for other investments, which should pay off at least the expenditures for the interest on the debt capital [52: p.464].

If the return on equity is lower than the interest on debt capital, an investment should be generally rejected. It would be more beneficial to invest the equity capital at the same return rate (as the interest rate) for example in stocks. This would result in a higher profit, and furthermore there will not be an implied investment risk [52: p.464].

However, example 3 also shows that the leverage effect is only beneficial, as long as the interest on debt capital is lower than the return on total capital. In case of increasing interest on debt capital or a shrinking return on investment, the leverage effect can therefore easily also have a huge negative impact.

2.4.3 Discounted Cash Flow Method

The DCF methods generally base on the *Net Present Value* method (NPV), which means that the same assumptions and premises are applicable [50: p.120]. Some of them are [53]:

- Economically rational behavior,
- Deterministic data structure,
- Imputed interest rate are constant over all periods,
- Liquidity is always secured,
- Full market transparency, and
- Unlimited monetary access for buyers and sellers

It is generally possible to distinguish between the *Entity Approach* and the *Equity Approach*, whereby the three different methods generally differ in the handling of tax shields [50: p.120].[10]

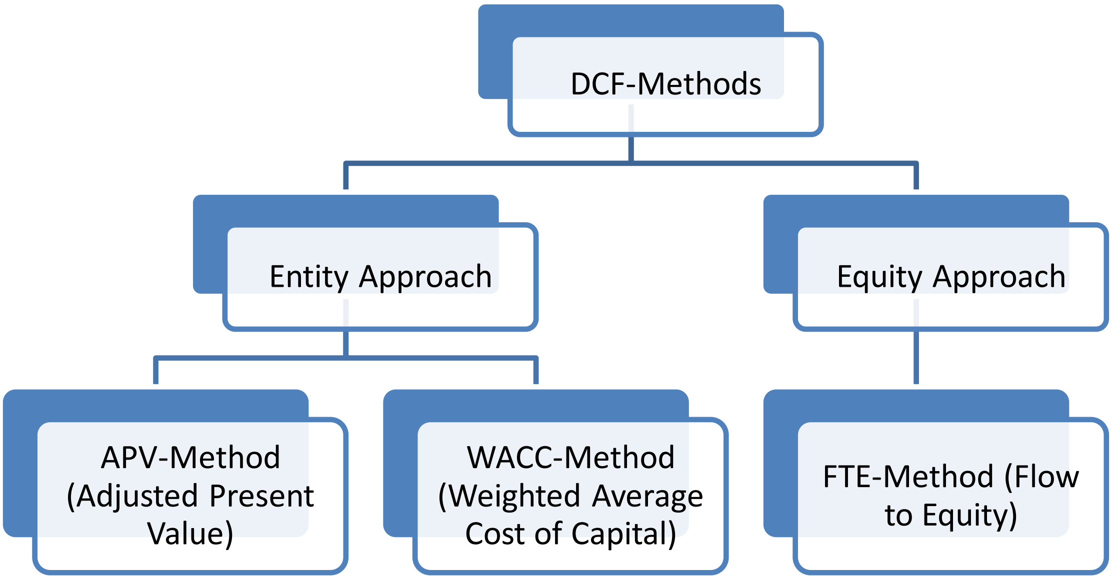

Figure 30: Types of DCF Methods [50: p.120]

All methods aim to calculate an objective business value of companies and of their equity. The entity methods calculate at first a value of the complete company (debt and equity capital), and in a second step the value of the debt capital is subtracted, which enables a conclusion regarding the value of the equity capital. In the equity approach, the value of the equity capital is calculated directly [50: p.121].

The different methods can be generally linked by analytical equivalent transformations, which would also lead to same results. However, the different methods also require a different financial strategy, which in turn has an influence on the final values of the company and equity [50: p.121].

2.4.3.1 Adjusted-Present-Value Method

The calculation of the company and equity value is conducted in 3 steps. The relevant cash flows are [50: p.122]:

---

[10] Replacing equity capital by debt capital does not only increase expenses on interest, it also decreases corporate tax on profit. The not used equity capital should be then used for other investments, which hopefully pay off higher returns as the expenses for the additional interest on debt (see also chapter 2.4.1. Tax shield)

1. Free cash flows from the day-to-day operations
2. Tax effects due to debt financing ("tax shield")
3. Value of the debt capital.

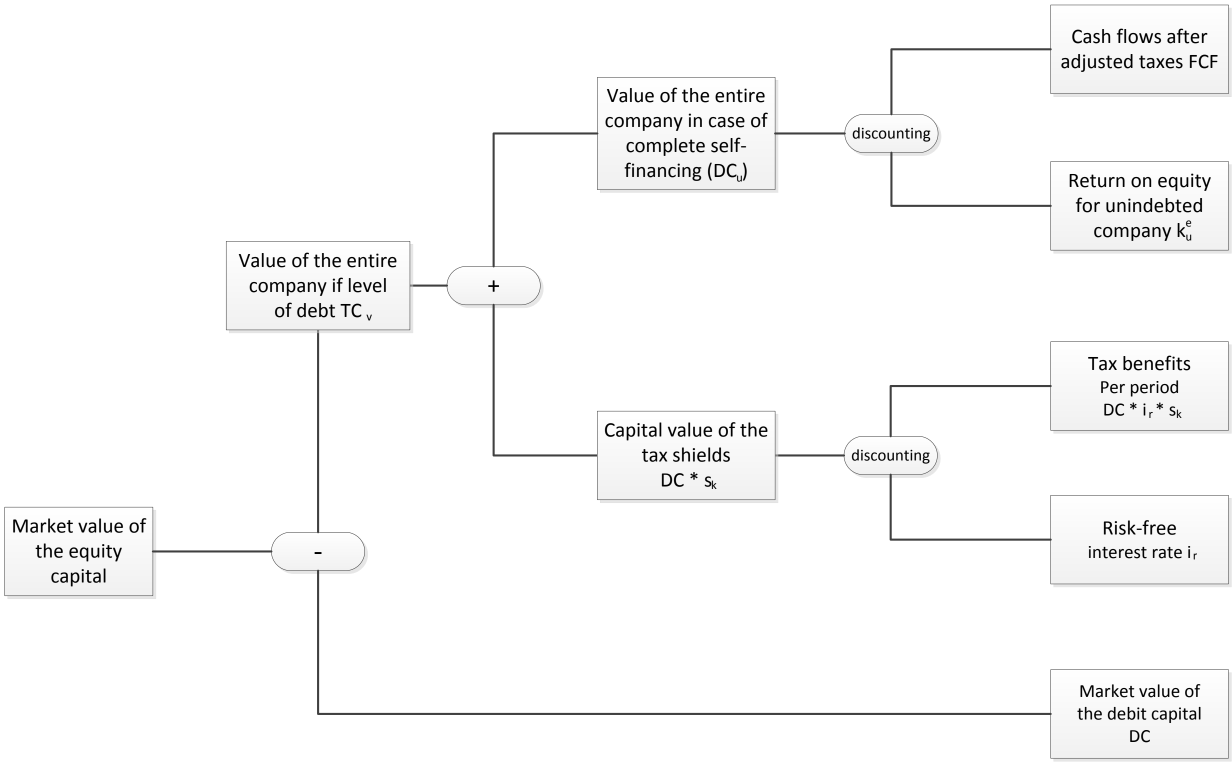

Figure 31: Relations in the APV Method [50: p.122]

In the first step it is assumed that the company is complete self-financed. All cash flows under this assumption are the so-called *Free Cash Flows (FCF)*[11], which theoretically only come from the ordinary activities and are not influenced by financial activities (financial neutrality). Therefore all cash flows to the providers of debts (e.g. interests, clearance and paying off debts) and tax benefits due to debt financing are not into account [50: p.122].

A calculation of *Free Cash Flows* has following appearance:

---

[11] The *Free Cash Flow by operating activities* has to be distinguished from the *Cash Flow from operations/to the firm*. The FCF from operations is generally defined as provided net cash by operating activities less capital expenditures (investments in buildings, factories, equipment etc.).

Table 5: Steps of a Free Cash Flow Calculation [50: p.122 f.]

Net income (profit or loss)	
+	Interest on debt capital
-	Tax benefits due to the deductibility of interest on debt capital
Net operating profit less adjusted taxes (NOPLAT)	
+	Depreciations of fixed assets
-	Appreciations of fixed assets
-/+	Earnings/loss from the disposal of tangible, intangible & financial assets
+/-	Increase/decrease of long-term provisions
	= Cash earnings
-/+	Increase/decrease of stock-in-trade
-/+	Increase/decrease of accounts receivable
-/+	Increase/decrease of other assets (if matching to ordinary activity)
-/+	Increase/decrease of prepaid expenses and deferred charges (ARAP)
+/-	Increase/decrease of short-term provisions
+/-	Increase/decrease of accounts payable
+/-	Increase/decrease of other liabilities (if matching to ordinary activity)
+/-	Increase/decrease of deferred credits to income (PRA)
=	Cash Flow by operating activities
-	Investments in tangible, intangible & financial assets (longer than 3 months)
-	Capitalized self-constructed assets
+	Book value of disposed asset

+/-	Earnings/losses of disposed tangible, intangible & financial assets
-/+	Increase/decrease of financial loans between associated or affiliated companies (shareholding relationship)
=	Cash Flow by investing activities
Cash Flow by operating activities + Cash Flow by investing activities = Free Cash Flow from operations	
+	Inflows from shareholder (capital reserves, increase in share capital)
-	Outflow to shareholder
+/-	Increase/repayment of financial credits and bonds
=	Cash Flow by financing activities
Cash Flow by investing activities + Cash Flow by operating activities + Cash Flow by financing activities = Change in the financial funds	

The discounting of the FCF is done due to a required rate of return from the equity capital provider for a debt-free company. As a complete self-financing is assumed, the calculated market value can be therefore described as an operating value [50: p.123].

Equation 4: APV - Step 1 [50: p.123]

$$TC_u = \sum_{t=1}^{T} \frac{FCF_t}{(1+k_u^e)^t} + \frac{FCF_{T+1}}{k_u^e(1+k_u^e)^T}$$

TC_u:	Total capital value; assumed under complete self-financing
FCF:	FCF in the periods
k_u^e:	Required rate of return of the equity

In a second step, the capital structure is considered, which means that all positive tax benefits due to the external financing are added to the before calculated company value, which assumes complete self-financing. The value of the so-called tax shield is calculated by discounting the probable tax savings in the future with a risk equivalent interest rate. For the *Adjusted Present Value* method, the risk equivalent interest rate equals the risk-free interest rate, because it is assumed that the debt capital of the future remains constant at the time of t_o. The determination of the total amount of debt capital for the future is done independently from other factors, and can be therefore called an autonomous financing strategy. The sum of step 1 and 2 results in following total company value [50: p.124]:

Equation 5: APV - Step 2 [50: p.124]

$$TC_v = TC_u + s_k * DC$$

TC_v:	Total capital value; risk equivalent interest rate is considered
s_k:	Tax rate
DC:	Total debt capital

In the last step, the value of the equity is calculated by subtracting the amount of the debt capital:

Equation 6: APV - Step 3 [50: p.124]

$$EC = TC_v - DC$$

EC:	Market value of the equity capital

Finally, it is retrospectively possible to calculate the required rate of return of the company for the equity providers, whereby this time the debt capital is considered:

Equation 7: Required Rate of Return (Indebted Company) [50: p.124]

$$k_v^e = k_u^e + (k_u^e - i_r) * (1 - s_k) * \frac{DC}{EC}$$

i_r:	Average cost of external debt capital

Summarized can be said the APV method consists of following steps:

Table 6: Steps of a Free Cash Flow Calculation (APV Method) [50: p.124]

Present value of Free Cash Flows in case of a capitalization of k_u^e	
+	Market value of non-operating assets
=	Market value of debt-free company
+	Increase in market value due to external financing (tax shield)

=	Market value of the total capital of the indebted company (company value)
-	Market value of debt capital
=	Market value of the equity (shareholder value)

When comparing the APV method to other methods, one main advantage is its clarity. The benefit of external financing is added separately, which makes it more comprehensive and easier to understand [50: p.124].

2.4.3.2 Weighted Average Cost of Capital Method

The WACC method calculates the company value by discounting the FCF with a weighted average cost of capital (k^{WACC}) and subtracting the market value of the debt capital. The WACC represents the target rate of return of equity and debt capital and is used to discount Free Cash Flows of the future. The weighted average cost of capital is defined as [50: p.126]:

Equation 8: Calculation of the Weighted Average Cost of Capital [50: p.127]

$$\text{WACC} = r_{DC} * (1 - s_k) * \frac{DC_M}{TC_M} + r_{EC(v)} * \frac{EC_M}{TC_M}$$

r_{DC}:	Interest rate of return on debt capital
s_k:	Tax rate
DC_M:	Debt capital in balance sheet in period t_0
TC_M:	Total capital in balance sheet in period t_0
$r_{EC(v)}$:	Expected rate of return on equity capital of the indebted company
EC_M:	Equity capital in balance sheet in period t_0

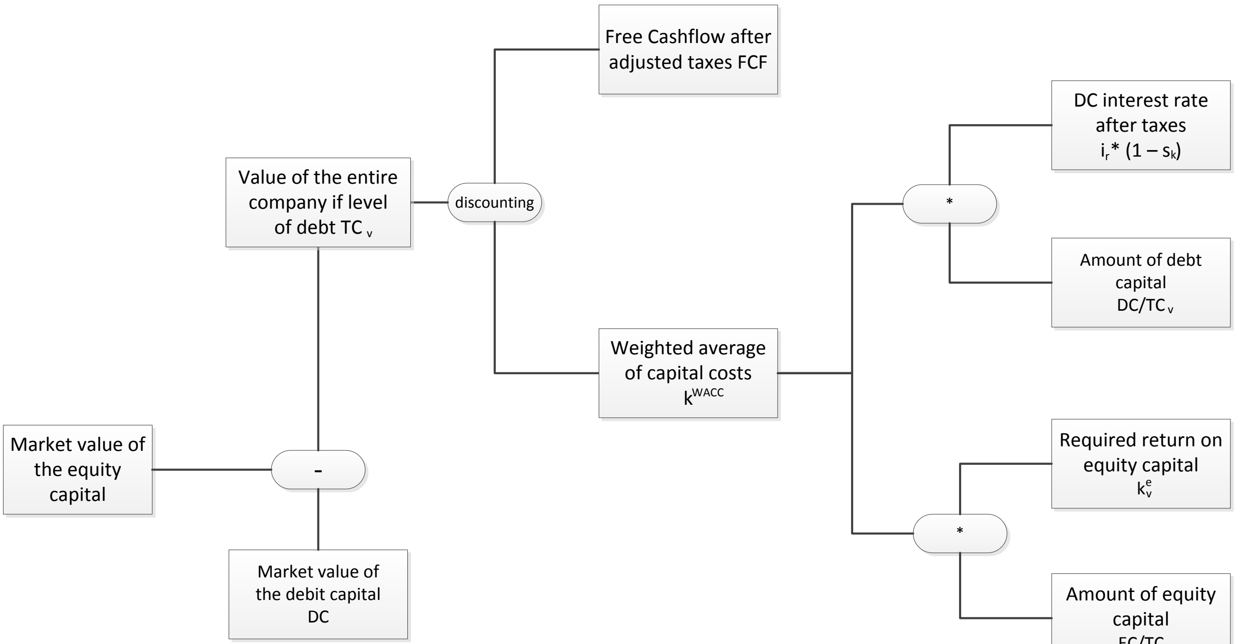

Figure 32: Relations in the WACC Method [50: p.127]

The principle of the WACC method is generally the same as in the APV method, which means that the same *Free Cash Flows* are discounted. However, the WACC method only reflects the value effects of external financing in the discounting equation:

Equation 9: Market Value of Total Capital [50: p.127]

$$TC_v = \sum_{t=1}^{T} \frac{FCF_t}{(1 + k^{WACC})^t} + \frac{FCF_{T+1}}{k^{WACC} * (1 + k^{WACC})^T}$$

The cost of capital weights the expected required rate of return of the equity provider (based on the market value of the equity) in relation to the tax-adjusted interest rates of debt capital (based on the market value of the debt capital).

Equation 10: WACC (Modiglani/Miller) [50: p.127]

$$k_{MM}^{WACC} = k_v^e * \frac{EC}{TC_v} + i_r * (1 - s_k) * \frac{DC}{TC_v}$$

k_{MM}^{WACC}: Market-based weighted average cost of capital

k_v^e: Required rate of return of the equity

EC: Market value of the equity capital

TC_v: Market value of the total capital

i_r: Average cost of external debt capital

s_k: Tax rate

DC: Market value of debt capital

It can be noticed that the final results (the market values of equity and debt capital) are already necessary (see Equation 8: E/TC_v & DC/TC_v) for the calculation of k_{MM}^{WACC}. Furthermore, the calculated market value of the total capital interdepends with the required rate of return of the equity, which can be seen in following equation [50: p.128]:

Equation 11: Required Return of Equity [50: p.128]

$$k_v^e = k_u^e + (k_u^e - i_r) * (1 - s_k) * \frac{DC}{EC}$$

These circumstances generally necessitate using the final results of the APV method. However, it would be also possible to solve these interdependences by approximating through iteration or determining the debt ratio (so-called: targeted capital structures). The second option would imply to fix the ratio of the market value of the debt capital in relation to the value of the market value of the total capital. This would also mean that the amount of debt capital depends on the market value of the total capital. An increasing(!) or decreasing(!!) market value of the total capital consequently also causes an increase(!) or redemption(!!) of finance loans (debt capital). Therefore it is also known as value-oriented financing strategy, which is generally assumed in terms of the WACC method [50: p.128].

As the external financing depends on the market value of the company, the debt capacity and consequently interest rates payments and tax shields are insecure for the future. As insecure tax shields are less worth than secure tax shields, the value-oriented financing strategy has a negative impact on the market value of the company. Modiglani/Miller did not respect that fact at all. Miles/Ezzel assumes that the tax shields are known for the first period, as the amount of debt capital is known to the beginning of the period [50: p.128]:

Equation 12: WACC (Miles/Ezzel) [50: p.128]

$$k_{ME}^{WACC} = k_v^e - s_k * i_r \frac{DC}{TC_v} * \left(\frac{(1 + k_u^e)}{(1 + i_r)}\right)$$

However, Harris/Pringle offer a spimplifaction, and assume that the tax shields are insecure for all periods. As a result, the last part of the WACC equation of Miles/Ezzel is taken away [50: p.129]:

Equation 13: WACC (Harris/Pringle) [50: p.129]

$$k_{HP}^{WACC} = k_v^e - s_k * i_r \frac{DC}{TC_v} * \left(\frac{(1 + k_u^e)}{(1 + i_r)} \right)$$

The procedure of the WACC method can be concluded to:

Table 7: Steps of a Free Cash Flow Calculation (WACC approach) [50: p.129]

Present value of the Free Cash Flows in case of a capitalization of k^{WACC}	
+	Market value of non-operating assets
=	Market value of the total capital of the debted company (company value)
-	Market value of the debt capital at the time of t_0
=	Market value of the equity capital (shareholder value)

The WACC method is based on the principals of Modiglani/Miller and is characterized by its easy understanding and applicability. Therefore, it is the most common method in practice [50: p.129].

2.4.3.3 Flow to Equity Method

The *Flow to Equity* method calculates the market value of the equity capital directly (→equity approach). This is done by considering only the cash flows that are really going to the providers of the equity capital [50: p.131].

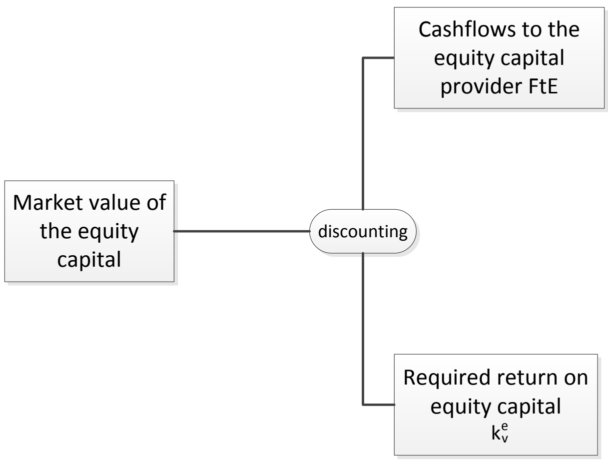

Figure 33: Relations in the FtE Method [50: p.131]

The Flow to Equity can be calculated according to following steps:

Table 8: Steps of a Flow to Equity [50: p.131]

Earnings before interests and taxes (EBIT)	
-	Interest on borrowed capital
-	Business taxes
=	Earnings after interest and taxes
+/-	Expenses / income from asset disposals
+/-	Depreciations / appreciations
+/-	Dissolution / creation of long term reserves and other non-cash transaction
-/+	Increase / decrease of net working capital (without short term interest-bearing liabilities)
-/+	Cash flow from investments / disinvestments
+/-	Increase / redemption of interest-bearing debt capital
=	Flow to Equity (FtE)

The *Flow to Equity* can be also derived from the Free Cash Flow. It is only necessary to add the tax benefits (tax shield) due to external financing, and subtract the cash flow to the providers of debt (*Flow to Debt*) [50: p.132]:

Table 9: Steps of a Flow to Equity Calculation [50: p.132]

Free Cash Flow (FCF)	
+	Tax benefits due to external financing (tax shield)
=	Total Cash Flow
-	Interest on debt capital
+/-	Increase / redemption of interest-bearing debt capital
=	Flow to Equity (FtE)

As above mentioned, the Flows to Equity are a net amount, whereby all cash flows regarding external financing (flow to debt, adjustment of taxes) are considered. Furthermore, the FtE are discounted with a required rate of return (k_v^e) of the indebted company [50: p.132]:

Equation 14: Flow to Equity Equation [50: p.132]

$$EC = \sum_{t=0}^{T} \frac{FtE_t}{(1 + k_v^e)^t} + \frac{FtE_{T+1}}{k_v^e * (1 + k_v^e)^T}$$

EC:	Market value of the equity capital
FtE:	Flow to equity in period
k_v^e:	Required rate of return

The required rate of return depends on the selected financing strategy (either autonomous, or value-oriented). In case of an autonomous financing strategy and debt capital that stays *constant*, it is necessary to use the equation of Modigliani/Miller to calculate the required return on equity [50: p.132]:

Equation 15: Required Return of Equity (Autonomous Financing Strategy & Constant Debt Capital) [50: p.132]

$$k_v^e = k_u^e + (k_u^e - i_r) * (1 - s_k) * \frac{DC}{EC}$$

In case of an autonomous financing strategy and debt capital that *changes*, it is necessary to use equation 13. In comparison to equation 12, the term *(1 - s_k) * DC* (rearranged as *(DC - DC * s_k)*) is replaced by *(DC - TaxShield)*. The *TaxShield* represents the absolute amount of secure tax shields [50: p.133].

Equation 16: Required Return of Equity (Autonomous Financing Strategy & Changing Debt Capital) [50: p.133]

$$k_{v,t}^e = k_u^e + (k_u^e - i_r) * \frac{DC_{t-1} - TaxShield_{t-1}}{EC_{t-1}}$$

In case of a value-oriented financing strategy, it is possible to use the return on equity equation by *Harris/Pringle*. This equation generally bases on the Modigliani/Miller Equation (Equation 12). However, as the tax shield is always insecure in value-oriented financing strategies, the value-adding term *(1 - s_k)* has to be taken out, which leads to following return on equity equation [50: p.133]:

Equation 17: Required Return of Equity (Value-Oriented Financing Strategy) [50: p.133]

$$k_v^e = k_u^e + (k_u^e - i_r) * \frac{DC}{EC}$$

The FtE method also contains a vicious cycle. In case of an autonomous financing strategy, it is necessary to have the market value of the equity to calculate the required return on equity, which in turn makes it necessary to use the calculated numbers of the APV method. However, the value-oriented financing strategy (the capital structure is fixed) also calls for the WCAA method, when the amount of debt capital has to be calculated. Thus, the FtE method is not a stand-alone solution, and can be only conducted in comparison with another method (APV or WACC method) [50: p.133].

2.5 Technology Balance Sheet

Company valuation primarily bases on key figures from finances and accounting. Normally, they are regularly extrapolated from balance sheet analysis in the past and incomes and cash flows are estimated under high uncertainties for the future. However, these metrics do not really consider the technological ability and potential of a company in the present and future, which strongly influence revenues and profitability in the future [54: p.8 ff.].

This lack can be overcome by using a so-called *Technology Balance Sheet*. By this, decision-makers get, in addition to a financial perspective, a technological perspective to manage and control a company. Thus, it is possible to create a 2-dimensional matrix, in which companies can be evaluated in terms of their financial and technological performance (see Figure 34) [55: p.308].

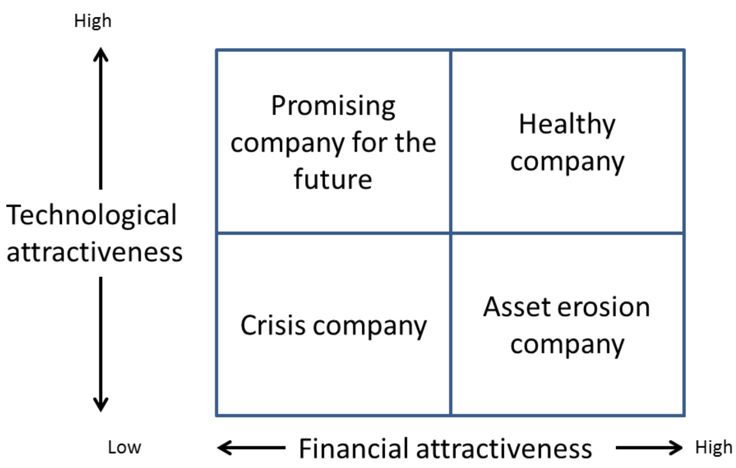

Figure 34: Technology-Finance-Portfolio [55: p.308]

A technological balance sheet is similarly structured as a financial balance sheet. It is a logical system of numbers, referred to a certain point of time and also consists of assets and liabilities, which can be connected and related by calculations. The assets are built by processes and products. The liabilities are technologies, which are either mastered by the observed company or by suppliers and other partners in the Supply Chain. The values of the processes and products result from the determined values of the technologies. Therefore, the right side of technology balance sheet also shows the source of funds, and the left side can be related to the application of the funds. In a financial balance sheet are for example a liability and bank deposits linked with each other [55: p.310 ff.].

Financial Balance Sheet

A. Fixed Assets	A. Equity Capital
B. Fluid Assets	B. Debt Capital Annual Profit/Loss
Total assets	Total assets

Financial attractiveness

Financial Balance Sheet

A. Processes	A. Company Owned Technologies
B. Products	B. Debt Capital Annual Technology Surplus/Minus
Total assets	Total assets

Technological Attractiveness

Figure 35: Structure of a Financial and Technological Balance Sheet [55: p.311]

One of the main goals is the evaluation of the technological potential of a company. In slow-changing branches it might be possible to hear the warning bells with the help of financial metrics (revenue, cash flows, profitability etc.). However, in case of fast-changing branches, where technologies develop rapidly and change promptly, it might be too late for appropriate counter-measures [55: p.311 f.].

For the creation of a technology balance sheet, it is also necessary to do the inventory of products, processes and technologies, to evaluate them (on a scale from 0 to 4) and position them properly in the structure of the technology balance sheet [55: p.312].

2.5.1 Technologies

In this context, technologies are defined as knowledge that is used in methods to solve functional problems. Therefore can be said that technologies are not understood as structural know how that provides information concerning the composition of finished-products. The second understanding of technologies could be related for example to bills of material (BOM), component diagrams, or as well Gozinthograph [55: p.310].

The applied technologies of a company and its suppliers build the liability side of a technology balance sheet, and can be described as the *"source of funds"*. In relation to a financial balance sheet, mastered technologies by the observed company could be compared to the equity capital, and mastered technologies by suppliers could be compared to the debt capital of the observed company. Therefore is can be said that the liability side of a technology balance sheet also represents the capital (Know How) of a company [55: p.311].

After matching the technologies in terms of the possessors, they are then distinguished in terms of knowledge types. Generally, following 4 types can be found [55: p.312]:

- Principal knowledge
- Observational knowledge
- Skill knowledge
- Systems knowledge

Principal knowledge can be described as theoretical-scientific knowledge that is necessary to execute a method in terms of natural and physical laws. Observational knowledge is needed understand cause and effect principals in the applied methods (e.g. a worker knows that metals can be for example connected by friction). Skill knowledge includes all kinds of technical knowledge (e.g. abilities and limitations of equipment and machines). Systems knowledge expresses the ability to apply the three before mentioned knowledge's in combination [55: p.312].

2.5.2 Processes and Products

As before mentioned the assets side of a technology balance sheet is built by processes and products, and can be described as the *"application of funds."* In this context, processes are defined as distinguishable production and engineering methods, which apply companies' technologies and produce a predefined output; therefore products are defined as the output from processes, which apply the companies' technologies. In comparison to a financial balance sheet, the processes, in a technology balance sheet, could be matched with machines and other permanent assets; products in the technology balance sheet equal fluid assets. Similar to the technologies, the products and processes are also structured on a second level. They are divided due to their life-cycles, which are built by phases of [55: p.311]:

- Development and introduction (on the scout),
- Growth,
- Maturity, and
- Decline.

In a further step the different knowledge's regarding the technologies are evaluated on a scale from 0-4, depending on their attractiveness [55: p.315].

		High Technological Attractiveness
		4
Trendsetter Technology	- Early stage of development - Huge impact on the competitiveness, huge potential predictable - Only one or few companies are capable of the technology - Implementation of technology in products/processes already started	3
Key Technology	- Significant impact on competitiveness - Critical to success, capable to be a distinctive feature - Only a few companies are capable of the technology - Implemented in several products/processes	2
Basic Technology	- Low earning and/or cost impact - Hardly a distinctive feature - All competitors are capable of the technology - Implemented in almost all products/processes → no usage in new products/processes possible	1
		0
		Low Technological Attractiveness

Figure 36: Attractiveness of Technologies [55: p.315]

The different scores of the technologies build the value of the products/processes, whereby it is obvious that for the production of products and the execution of processes regularly more than one technology is used. This principle is also the before mentioned connection between the assets side and liabilities side of the technology balance sheet. The development of a technology balance sheet is generally done in 6 steps [55: p.313]:

1. Elicitation and distinction of single technologies
2. Elicitation and distinction of products and processes

3. Evaluation of the single technologies on a scale from 0 (low) to 4 (high)
4. Matching of technologies and products/processes
5. Calculation of technological surplus and minus
6. (Analysis of numbers and metrics)

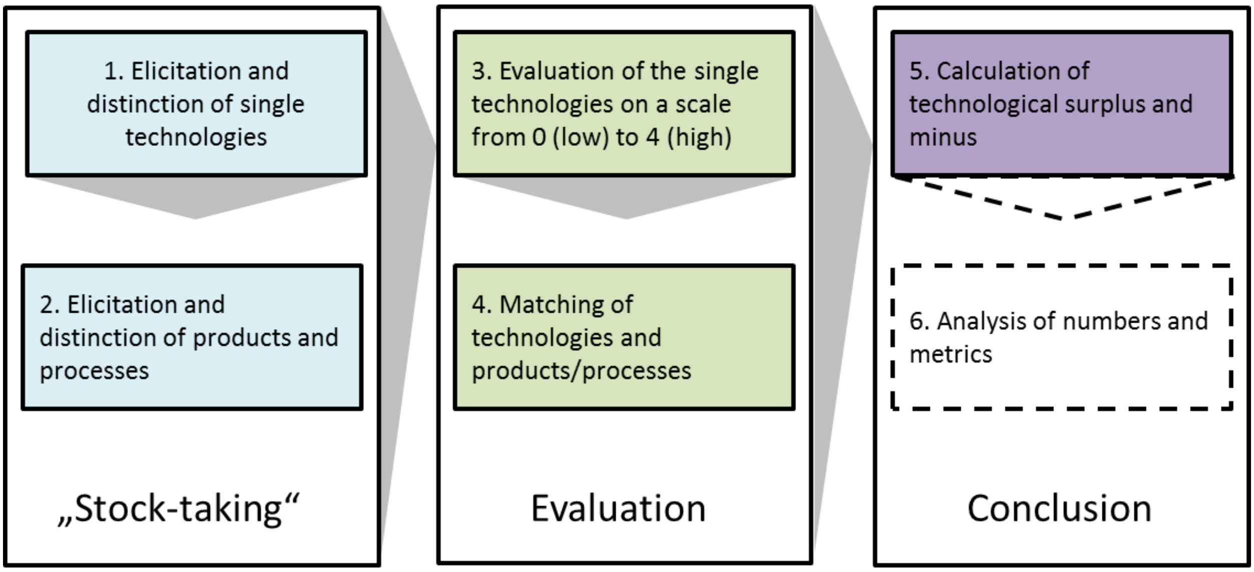

Figure 37: Steps of Developing a Technology Balance Sheet [55: p.313]

The development of a technology balance sheet is described in chapter 4.2 in detail.

2.6 Review of Literature

The following table reviews the sourced literature in terms of their research questions, issues, hypothesis and applied methods.

Related Topic	Author, name of book & year	Research questions, issues and hypothesis	Methods
Production and Operations Management	[3] Khanna R B: Production and Operations Management 2007	➢ Why is production and operations management necessary? ➢ How should be products and services designed? ➢ What is high product quality? ➢ How should be processes designed? ➢ Which location should be chosen? How should the layout look like? Which capacities should be provided? ➢ How is production planning and control done? ➢ Which personnel should be employed?	Teaching book. Analysis of the multidimensional aspects of production and operations management through: ➢ Illustration of state-of-the art theory and scientific consensus, ➢ Practical applications
Production and Operations Management	[4] Chary S N: Production & Operations Management 2009	Extensive discussion of: ➢ Forecasting, ➢ Location and Layout of facilities, ➢ Inventory control, ➢ Purchasing,	Teaching book. Explanation and enhancement of theory and concepts. ➢ Solving of 225 practice-related problems,

	2009	➢ Purchasing, ➢ Materials requirement planning, ➢ Project management, ➢ Maintenance management, ➢ Quality Management.	problems, ➢ 120 self-study problems, ➢ Description of several real life problems and their solution.
Production and Operations Management	[6] Virender S P: Production And Operations Management 2010	➢ What are the main impacts of operations decisions on a firm? What are the cross-functional impacts on other departments? ➢ How does globalization and internationalization influence the today's operation and production management? ➢ How should be the integration of industrial countries and emerging countries (e.g. India, China) managed?	Teaching book. ➢ Explanation of fundamental concepts and techniques, ➢ Theory and practice of production and operations management, ➢ Illustration of theory with the help of a sufficient number of examples, ➢ Considers new research results.
Operational Value drivers	[1] Hahn V G: Creating Sustainable Shareholder Value with Lean Six Sigma 2011	➢ Approach of combining the concepts of Lean Six Sigma and Shareholder Value. ➢ Which financial effects do Lean Six Sigma projects have? ➢ How can Lean Six Sigma projects have a sustainable positive effect on financial results? ➢ What are effects of Lean Six Sigma projects on earnings (EBIT), cash flow (CF) and Shareholder	This book is on the one hand thought for directors, controllers, Lean Six Sigma Master Black Belts, and on the other hand also predestined for students and lectures. ➢ Detailed description of theoretical background, ➢ Realization of Lean Six Sigma

		Value (SV)? ➢ What is the positive impact of Lean Six Sigma projects on non-financial evaluation as Balance-Scorecard (BSC)?	projects (e.g. projects starting with different types of wastages and quality costs, which showing subsequently improvements), and ➢ Financial and non-financial evaluation of Lean Six Sigma projects.
Operational Value drivers	[43] Naumann E: Customer Centered Six Sigma 2001	➢ Discussion of customer involvement and alignment with the organization's processes and culture, ➢ Continues innovations and process improvements to meet constantly rising customer expectations, ➢ Increasing customer satisfaction by implementing the concept of Six Sigma in processes.	➢ Theoretical high-level review of the principal of Six Sigma, ➢ Explanation of Six Sigma tools for gathering customer requirements, conducting customer satisfaction surveys, and managing organizational processes and opportunities based upon customer input, ➢ Case studies support the understanding of the theoretical principals.
Operational Value drivers	[44] George M O: The Lean Six Sigma Guide to Doing More	➢ Fully integrating of Lean Six Sigma initiatives to reduce costs and improve speed, quality and also shareholder value. ➢ What are the financial impacts of Lean Six Sigma	A retired consultant recalls his experiences and conclusions of implementing process improvements and business transformations over the

	With Less 2010	projects (ROIC, business profit) ➢ How can Lean Six Sigma projects achieve real business benefits? ➢ What are the best practices Lean Six Sigma projects? ➢ How are costs managed in terms of Lean Six Sigma, and what are usual pitfalls and lessons learned of Lean Six Sigma projects?	last 20 years. ➢ The theoretical principals are supplemented by case studies to deliver a better practical understanding. ➢ Best practices of Lean Six Sigma projects are outlined.
Operational Excellence in the Aircraft Industry	[8] Lakshman S, Majid A K: Challenges in Production Line for TOT Projects of Aircraft Optoelectronics Avionics Systems in India October 2012	This scientific paper discusses the challenges of transfer of technology (TOT) from industrial countries to emerging countries (in this paper: India) in the aircraft industry. Some of them are: ➢ Licenser support, ➢ Production facility setup, ➢ Training for the project, ➢ Testing bench and its calibration-related issues, and ➢ Material supply. One of the main goals was to meet international quality standards of TOT projects of aviation.	This scientific paper shows the results of a single case-study. ➢ Analyses of existing production line problems for TOT projects. ➢ Ideas and recommendations for an effective TOT are given. ➢ Statistical methods, Baye's theorem of probability and a chi² test were executed to find the root cause for the high failure rate of optoelectronics avionics systems.

Operational Excellence in the Aircraft Industry	[11] Rasheed A, Manarvi I A. A Framework of Technology Diffusion in Aircraft Manufacturing Industry Environment 2008	This scientific paper also deals with the challenges of technology and knowledge transfer. It was aimed to establish a generic framework to allocate technology and knowledge optimally. Nowadays, some of the core elements of a state-of-the-art technology and knowledge transfer are: ➢ Computing Systems and Software's, ➢ Materials Management, ➢ Management techniques, ➢ Supply Chain Management ➢ Communication Management, and ➢ Make-or-Buy Decisions.	This scientific paper can be described as theoretical field study that bases on descriptive researches in the aircraft industry. With the help of process mapping was developed an integrated model for the diffusion of technology and knowledge in the aircraft manufacturing. Some of the key findings are: ➢ The aircraft industry applies high-complex technologies, ➢ Methods of other industries can be applied in the aircraft industry, ➢ The advancement of technologies moves on much faster than in other technologies, ➢ The social, organizational culture, work environment and communication are main factors in the diffusion of knowledge and technology.

Production and Operations Management	[12] Altfeld H H: Commercial Aircraft Projects: Managing the Development of Highly Complex Products 2010	Highly complex projects also need perfectly adapted management skills. This is also applicable for the production of aircrafts. This practice-related book seeks to show that it is even in highly complex projects possible to achieve cost reductions by applying management disciplines as: ➢ Systems Engineering, ➢ Life-Cycle Costing, ➢ Rapid Development, ➢ Project Management, ➢ Total Quality Management, and ➢ Multi-Cultural Management.	This book seeks to have a big practical relation and not only a conceptual discussion of managing complex processes in the aircraft industry. It interlinks processes, products and resources data from past projects. This holistic approach makes it possible to achieve efficiency and effectiveness in the management of real commercial aircraft development projects.
Operational Excellence in the Aircraft Industry	[13] Kroll N, Fassbender J K: MEGAFLOW - Numerical Flow Simulation for Aircraft Design Results of the second phase of the German	The aerospace industry more and more applies advanced numerical simulation tools in the early design phase. This book shows recent results of the German Computational Fluid Dynamics (CFD) program MEGAFLOW which combines many of the pioneer developments from the German Aerospace Center (DLR), German universities and companies from the	This book has mainly an informative purpose and wants to outline the recent improvements and enhancements of the MEGAFLOW software system (→ descriptive). For example following topics are discussed: ➢ Improvements of numerical

	CFD initiative MEGAFLOW 2005	aircraft industry.	algorithms and physical modeling capabilities, and ➢ Evaluation of viscous flows around complex configurations that are used for the design of new aircrafts.
Operational Excellence in the Aircraft Industry	[16] Donaldson B K: Analysis of Aircraft Structures 2008	The main focus is on fundamental concepts of structural analysis, which are for example used in aircrafts, automobiles and ships.	The book can be described as theoretical and descriptive. However, several examples and tasks help to understand the concepts of structural analysis.
Production and Operations Management	[23] Buzacott J A, Corsten H, Gössinger R, Schneider H M: Production Planning and Control 2013	Following Production Planning and Control systems are discussed: ➢ MRP II, ➢ Kanban, ➢ ConWiP, ➢ Input-Output-Control, ➢ Workload Control.	This textbook explains the concepts and basics of Production Planning and Control systems. However, this book also tries to clarify the different concepts by offering several examples from practice.
Operational Excellence in the Aircraft	[24] Klenger F: Operatives	The book can understand as holistic introduction to the topic of operational controlling. Some of the	This textbook is thought for students and lectures. It was consciously decided to explain the idea of operational

Industry	Controlling 2000	topics are: ➢ Integrated operational planning, ➢ Profit and loss accounts, ➢ Financial Accounting, ➢ Investment calculations, and for example ➢ Deviation analysis.	controlling with help of illustrations, calculations and examples, and not with endless discussions.
Operational Excellence in the Aircraft Industry	[29] Neelankavil J P, Rai A. Basics of International Business 2009	This book delivers an extensive overview about dynamics, complexity and challenges in international management. For this Master Thesis especially chapter 8 and 9 have been very helpful: ➢ International Production and Operations Management and Supply Chain Management ➢ Global Outsourcing or Offshoring.	This book primarily serves as literature for students and lectures; however it is also thought for managers and strategic decision-maker. The concepts, theories and techniques base on collective experiences of professors who have been teaching international business courses over decades. It is a product of several persons (professors, assistances, volunteers) and also considers revisions and data from practice.
Operational Excellence in the Aircraft Industry	[31] Kerzner H. Project Management: Case Studies	Project management techniques have become vital for any businesses and companies. The main process of Project Management can divided into:	This book is one the most comprehensive collection of project management case studies all over the world. More than 100 of them from real companies illustrate current challenges,

	2013	➢ Planning, ➢ Scheduling, and ➢ Controlling.	corresponding successful and also poor implementations.
Operational Excellence in the Aircraft Industry	[27] Flouris T G, Lock D: Aviation Project Management 2008	This book gives an extensive insight to all perspectives of project management in the aircraft industry. Some of the discussed topics are: ➢ Strategic decisions, ➢ Estimating project costs, ➢ Evaluating an aviation investment, ➢ Project organization, ➢ Work breakdowns and coding, ➢ Critical path network analysis, and also ➢ Resource Scheduling.	This book shows successful managed businesses in the aircraft industry by identifying and applying valid project management techniques. Beside the definition of theoretical concepts, also a lot of applications, examples, illustrations and case examples show the value of consequent project management.
Operational Excellence in the Aircraft Industry	[28] Prakash Reddy: Production Planning and Control 2009	This Paper concentrates on the general execution of production planning and control in the aircraft industry. Some topics are: ➢ Organization, ➢ Facility layout, ➢ Aggregate production plan, ➢ Scheduling, ➢ Plant Maintenance, and also	This scientific paper can be described as field study that shows a generic organization of Production Planning and Scheduling in an aircraft company. The paper contains 14 chapters reaching over 18 pages and provides a good introducing overview.

		➢ Management information systems.	
Operational Excellence in the Aircraft Industry	[25] Chung C H: Aggregate plan and master production schedule linkage 2000	This chapter is part of the Encyclopedia of Production and Manufacturing Management. It consists of about 1000 pages and gives excellent insight and understanding. The observed chapter deals with production planning and control, and can be probably named as of one the leading collections regarding definitions and explanations. One of the main topics is Manufacturing Resource Planning (MRP II), which is generally built by Aggregate planning (AP) and Master Production Scheduling (MPS).	The focus is on practical issues such as forecast horizons, planning horizons, planning time buckets and the re-planning frequencies for both AP and MPS. Furthermore are described: ➢ 2 methods for coordinating the 2 planning activities ➢ Real examples, and ➢ Practical applications
Operational Excellence in the Aircraft Industry	[33] Baker A, Dutton S, Kelly D: Composite Materials for Aircraft Structures 2004	This book provides an introduction to technologies of compositing materials, which are very often used in the production of aircraft parts.	The book can be classified as nomological book, as the authors discuss important physical differences between various composite technologies regarding metals. Furthermore, advantages and disadvantages of the different methods are mentioned in terms of the actual manufacturing, handling, and also in-

			service performance.
Business Valuation	[50] Aschauer E, Purtscher V: Einführung in die Unternehmens-bewertung 2011	The authors see business valuation as investment calculation, which generally bases on the net present value method. This implies the determination of discount/interest rates/interest and the consideration of risks in the future. DCF methods and for example the corresponding topic of calculating the BETA-factor are discussed in detail. Thus the focus is on the APV, WACC and FTE approaches.	This book is dedicated to students and practitioners. It offers an introduction to all kinds of business valuations, but at the same time business values of selected companies are calculated. Furthermore, also several small examples seek to illustrate the idea and application of business valuation. In addition, this book also includes expert reports as the KFS/BW 1 and current suggestions for business valuations by the Austrian Chamber of Chartered Public Accountants. Both authors are Austrians and also have their main place of residence there. Dr. Ewald Aschauer is university assistant at the Vienna University of Business and Business Administration. Dr. Victor Purtscher is area manager of

			the division valuation services at Deloitte Financial Advisory.
Business Valuation	[49] Drukarczyk J, Schüler A: Unternehmens-bewertung 2009	This book has its main focuses on: ➢ Risky and risk-free investment decisions, ➢ Tax regulations, ➢ Principles of business valuation, ➢ DCF method, ➢ Leasing, ➢ Provisions and their effects on the business value, ➢ Valuation in case of loss, need for capital and financial recovery, and ➢ Value-oriented controlling.	This book does not only discus the theoretical principals of business valuations; it also gives a lot of practice examples too clearer understanding.
Business Valuation	Wolly C: der objektivierte Unternehmens-wert 2010	The author assumes that the relevance of business valuations increase more and more, and therefore wants to increase the recognition of those with his practical book. The title "objective business valuation" mediates that the book wants to illustrate replicable and reasonable methods to calculate the monetary value of a company (e.g. DCF approaches).	Although theoretical principals are also discussed, the main focus is on several examples that should show the application of valuations methods in practice. The author Wolly is CEO of a chartered accountants and tax consultants company and primarily wants to improve the understanding of valuations methods of practitioners.

			The book is structured due to the steps of an entire business valuation and also includes current judicatures in Germany (e.g. IDW S.1 i. d. F. 2008).
Technology Balance Sheet	[54] Hartmann M: Technologie Bilanzierung 1996	This dissertation is one of the first elaborated papers concerning Technology Balance Sheets.	This doctoral dissertation discusses various perspectives of the Technology Balance Sheets and can be understood as a pioneer in this topic. As this dissertation is thought to give an idea of Technology Balance Sheets in general, it primarily deals with its theoretical principals.
Technology Balance Sheet	[55] Hartmann M: Technologie Bilanzierung 2008	The author Hartmann revitalizes the idea of Technology Balance Sheets.	This scientific paper generally bases on the dissertation from 1996; however, the messages and key-points are streamlined and much more understandable especially for newcomers. Furthermore, an example illustrates very well how the concept of TBS can be applied in practice.

In retrospect can be said that most of the literature discusses theoretical principals, but at the same time also tries to proof and apply those regarding practice.

From a philosophical point of view this kind of approach can be described as deductive method, which means that general hypothesis are formulated, and subsequently verified preliminary or falsified with the help of practical examples. If the assumed hypothesis are rejected, new and other hypothesis have to be formulated. In case of preliminary verifications, the assumed assumptions can be accepted as long as they are not falsified. If hypothesis are accepted by scientists over a longer time of period, they might be named thesis in the subsequent. And if they are accepted on a long-term basis, they might be finally called theories [Sir Karl Popper: critical rationalism].

3. Methods

This chapter gives an overview of the research objectives, the used data, the study design and the research methodology.

3.1 Definition of Problem

The main questions of this Master Thesis are:

1. What is *Operational Excellence* in the aircraft industry?
2. What are state-of-the-art processes and technologies in the aircraft industry?
3. How can a production department influence the business value positively?
4. Which value driver (process and production measure) is currently the most promising in the aircraft production?

Based on this main question, further questions are:

5. Which production and process measures can be implemented to increase a companies' business value?
6. Is the *Discounted-Cash-Flow-Method (WACC approach)* an appropriate method to evaluate the performance of company*?*

Furthermore, the author proceeds on the assumption, that financial perspectives and key figures express too little about a companies' production performance, the current technology situation and the competitiveness in general. This problem might be solved by the use of a technology balance sheet. For this topic, questions are:

7. What is a technology balance sheet?
8. How is a technology balance sheet created and implemented?
9. What are the advantages and core statements of a technology balance sheet?

In the following, a fictive balance sheet is created, which contains products, processes and technologies of companies of the aircraft industry.

3.2 Data Structure

For the calculation of the business values are used either the annual reports of the years from 2007 to 2011, or from 2008 to 2012, depending on the availability.

The development of the technology balance sheet bases on the products, processes and technologies that are produced and applied at the plant of Cessna Aircraft Corporation in Independence, Kansas.

3.3 Study Design

The study design can be seen in following figure:

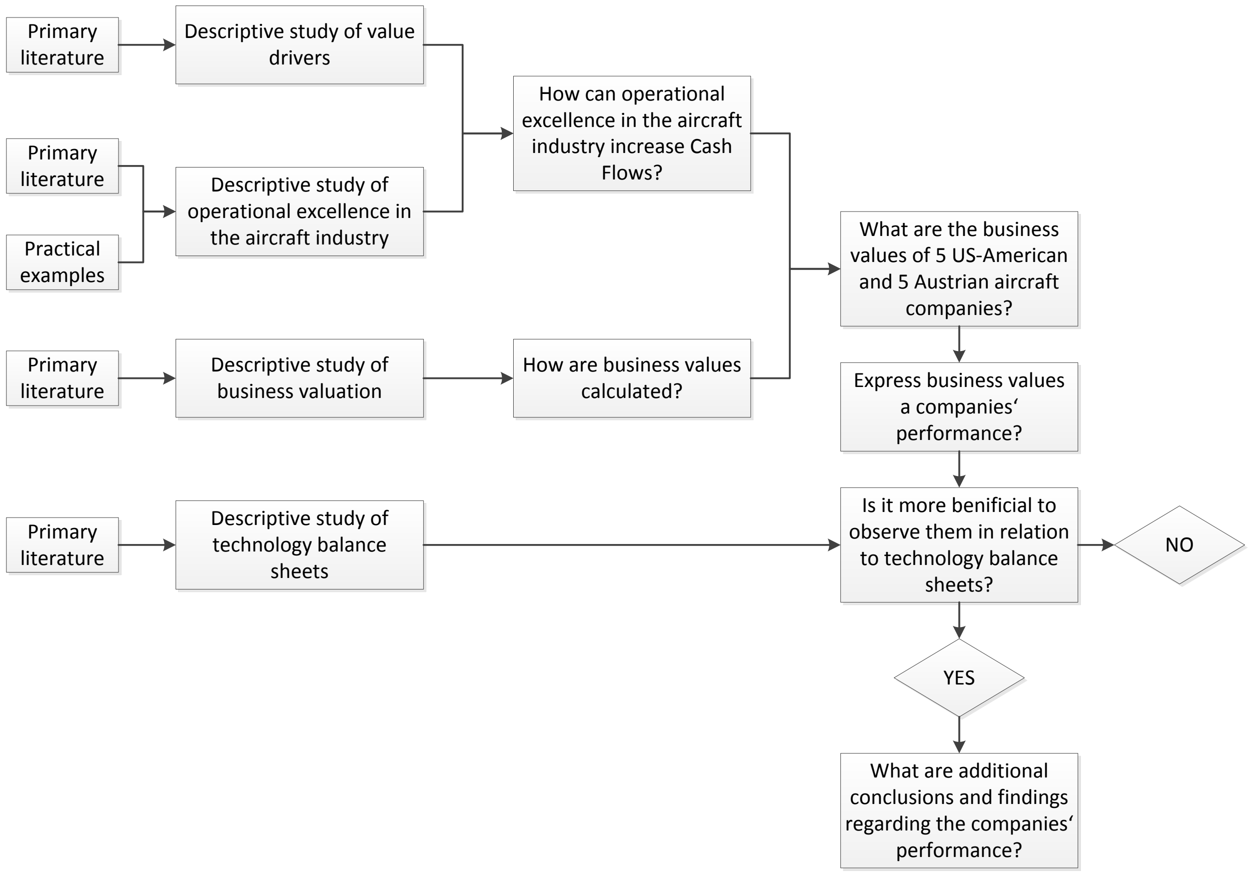

Figure 38: Study Design

3.4 Research Methodology

In general it is aimed to adhere to scientific principles, as:

- Use objective approaches and working methods,
- Do not use subjective and metaphysical terms as beautiful, god, bad etc.,
- Work out a well-structured thesis, which is comprehensible for third parties.

This Master Thesis can be generally described as descriptive field study that bases on relevant literature from following subject areas:

- *Production and Operations Management*,
- *Operational Excellence* in the aircraft industry,
- *Business Value* of a company by using *Discounted Cash Flow* approaches, and
- *Technology Balance Sheets*.

In detail, following methods are thought to answer the research questions of this Master Thesis:

- Qualitative and explorative study of *Operational Excellence* in the aircraft industry based on primary literature, examples in practice and interviews,
  - 7 experts, who all have a practical relation to the aircraft industry, have been interviewed to confirm and proof theoretical principals of *Operational Excellence* in the aircraft industry.
- Business valuation of 5 US-American and 5 Austrian companies,
- Development of a technology balance sheet for the Cessna Aircraft Corporation in Independence, Kansas.

4. Results

The following two chapters are the empirical parts of this Master Thesis. 4.1 shows the business values of selected companies. 4.2 shows the development of a *Technology Balance Sheet* of the Cessna Aircraft Corporation in Independence, Kansas. Regarding 4.1 can be already said that the size of the American and Austrian companies differs tremendously, which can be seen in the unit size: the key figures of the Austrian companies are expressed in kEURO (thousand Euros); the ones of the American companies in Mio. US$ (million US Dollar).

4.1 Calculation of Business Values

For the valuation of the different business values should be considered following assumptions:

- The DCF method is applied with the WACC approach,
- The Free Cash Flows of 5 years are considered + perpetuity of the last FCF,
- If reliable FCF estimations of 2013 can be found, the period under observation is from 2009 to 2013; otherwise the period is restricted from 2008 to 2012
- The values are discounted for the first year of observation (so either 2008, or 2009), and are afterwards compounded to 2012,
    - In case of a reliable FCF estimation for 2013 the periods are: t_0 = 2009, t_1 = 2010, t_2 = 2011, t_3 = 2012, t_4 = 2013,
    - In case of no FCF estimation for 2013 the periods are: t_0 = 2008, t_1 = 2009, t_2 = 2010, t_3 = 2011, t_4 = 2012,
- The growth rates (g) are determined as 2% based on market analysis [56],
- If the WACC cannot be determined based on reliable sources, it is assumed with 10%,
- For the calculation of the perpetuity (residual value) is following equation used:

Equation 18: Calculation of the Residual Value (perpetuity)

$$V_n = \frac{FCF_{n+1}}{(WACC - g)} = \left[\frac{(1+g)}{(WACC - g)}\right] * FCF$$

4.1.1 Austrian Companies

For the calculation of the business value are chosen following 5 Austrian companies:

- FACC AG,
- AMAG,
- Diamond Aircraft,
- International JET Management,
- Isovolta AG.

4.1.1.1 FACC AG

The calculation of the *Free Cash Flows* of the FACC AG is based on the annual reports from 2008 to 2012. The FCF calculation bases on the one hand on metrics from annual balance sheets and on the other hand on metrics from annual profit & loss statements. In the following figure one can see the balance sheets of FACC AG from 2008 to 2012. Generally can be said that a tool in MS-Excel was created, which enables an automatic calculation of the business value, if one imports the metrics of the balance sheets and profit & loss statements.

in kEURO	BS 2008	Difference	BS 2009	Difference	BS 2010	Difference	BS 2011	Difference	BS 2012
Assets									
A. Fixed assets									
I. Intangible assets	15.865	-2.554	13.311	-2.069	11.242	8.089	19.331	847	20.178
II. Tangible assets	94.365	-3.594	90.771	-8.467	82.304	-8.098	74.206	-2.171	72.035
III. Financial assets	1.045	-86	959	118	1.077	179	1.256	243	1.499
B. Current assets									
I. Inventories	42.943	-16	42.959	10.287	32.672	-10.958	43.630	-13.037	56.667
II.Receivables									
i. Accounts receviables	36.683	-16.025	52.708	11.227	41.481	-14.603	56.084	-19.738	75.822
ii. Accounts receviables arising from	732	-124	856	6	850	7	843	-7.257	8.100
iii. Other Receivables	4.492	1.398	3.094	701	2.393	-3.205	5.598	-6.555	12.153
III. cash on hand, checks, deposits with financial institutions	13.316	-3.742	9.574	13.185	22.759	-4.712	18.047	567	18.614
C. Prepaid expenses and deferred charges (ARAP)	576	116	460	-55	515	-179	694	-247	941
	210.017		214.692		195.293		219.689		266.009
Liabilities									
A. Equity									
I. Nominal share capital	30.000	10.000	40.000	40.000	80.000	0	80.000	0	80.000
II. Capital reserves	3.000	0	3.000	0	3.000	0	3.000	0	3.000
III. Retained earnings	8.733	0	8.733	0	8.733	584	9.317	597	9.914
IV. Balance sheet profit/loss	-11.127		-9.266		-8.381		11.096		22.458
B. Untaxed reserves	78	0	78	0	78	0	78	0	78
C. Public subsidies	4.849	3.749	8.598	-745	7.853	-745	7.108	-730	6.378
D. Provisions									
1. Long-term provisions	4.081	160	4.241	665	4.906	104	5.010	2.731	7.741
2. Short-term provisions	10.034	393	10.427	1.634	12.061	258	12.319	6.713	19.032
E. Liabilities									
1. Bonds	75.000	0	75.000	-40.000	35.000	0	35.000	-15.000	20.000
2. Liabilities to financial institutions	49.365	-2.246	47.119	-20.517	26.602	-1.656	24.946	28.245	53.191
3. Advances received	0	0	0	2.565	2.565	-2.565	0	1.952	1.952
4 Accounts payables	28.490	-9.421	19.069	-1.404	17.665	6.868	24.533	9.280	33.813
5. Accounts payables arising from affiliated or associated companies	326	196	522	-169	353	122	475	-167	308
6 Other liabilities	6.485	137	6.622	-1.966	4.656	1.993	6.649	1.364	8.013
F. Deferred credits to income (PRA)	703	-154	549	-347	202	-44	158	-27	131
	210.017		214.692		195.293		219.689		266.009

Figure 39: Balance Sheets - FACC AG - 2008-2012

Most of the metrics of the columns "*difference*" (e.g. change of inventories, accounts receivable, prepaid expenses & deferred charges, bonds etc.) go into the FCF calculation, which can be seen in the next figure. The balance sheets are primarily needed as a basis to calculate the changes between the years. However, for the business value calculations are also considered the total capital debt of 2008 (basic year), as they are subtracted to calculate the market value of the equity capital.

in kEuro	2008	2009	2010	2011	2012
Earnings/loss from ordinary activity less corporate income tax	-19163	1.886	1026	21129	11964
+ Depreciations of fixed assets	15607	15.866	15458	13186	12672
- Appreciations of fixed assets	0	0	0	0	0
-/+ Earnings/loss from the disposal of tangible, intangible & financial assets	-465	-9	-13	0	-10
- Release of public subsidies	-352	-745	-745	-745	-730
+/- Increase/decrease of long-term provisions	2060	160	665	104	2.731
= Cash earnings	-2.313	17.158	16.391	33.674	26.627
-/+ Increase/decrease of stock-in-trade	-19037	-16	10.287	-10.958	-13.037
-/+ Increase/decrease of accounts receivable		-16.025	11.227	-14.603	-19.738
-/+ Increase/decrease of other assets (if allocatable to ordinary activity)	0	0	0	0	0
-/+ Increase/decrease of prepaid expenses and deferred charges (ARAP)	-10	116	-55	-179	-247
+/- Increase/decrease of short-term provisions	0	393	1.634	258	6.713
+/- Increase/decrease of accounts payable	4981	-9.421	-1.404	6.868	9.280
+/- Increase/decrease of other liabilities (if allocatable to ordinary activity)	0	0	2.565	-2.565	1.952
+/- Increase/decrease of deferred credits to income (PRA)	480	-154	-347	-44	-27
= Cash Flow by operating activities	-15.899	-7.949	40.298	12.451	11.523
- Investments in tangible, intangible & financial assets (owned longer than 3 months)	-25303	-9.875	-5420	-13375	-13602
- Capitalized self-constructed assets	-110	-89	-104	-43	-295
+ Book value of disposed asset	4589	454	816	875	6135
+ granted public subsidies	5201	0	0	0	0
+/- Earnings/losses of disposed tangible, intangible & financial assets	465	9	13	0	10
-/+ Increase/decrease of financial loans between associated or affiliated companies (shareholding relationship)	9	72	-163	129	-7.424
= Cash Flow by investing activities	-15.149	-9.429	-4.858	-12.414	-15.176
= Free Cash Flow from operations	-31.048	-17.378	35.440	37	-3.653
+ Inflows from shareholder (capital reserves, increase in share capital)	40.000	10.000	40.000	0	0
- Outflow to shareholder	0	0	0	0	0
+/- Increase/repayment of financial credits and bonds	-5.013	-2.246	-20.517	-1.656	28.245
= Cash Flow by financing activities	34.987	7.754	19.483	-1.656	28.245
= Change in the financial funds	3.939	-9.624	54.923	-1.619	24.592

Figure 40: Free Cash Flows - FACC AG 2008-2012

The *Free Cash Flow* calculation illustrates very well the difference between "*Cash Flow by operating activities*" and "*Free Cash Flow from operations*". As before mentioned, the second metric also includes investments and disinvestments (also: capital expenditures). For the sake of completeness is also the *Cash Flow from financing activities* shown, which is irrelevant for the calculation of business values.

Finally, the *Free Cash Flows from operations* are used for the calculation of the business value of FACC AG.

in kEuro	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	-€ 31.048,00	-€ 17.378,00	€ 35.440,00	€ 37,00	-€ 3.653,00	-€ 46.575,75
DC FCF	-€ 31.048,00	-€ 15.798,18	€ 29.289,26	€ 27,80	-€ 2.495,05	-€ 31.811,86

WACC	10,00%
Growth rate	2,00%

Market value of total company (T_0 = 2008)	-€ 51.836,04
Minus: Liabilities (2008)	-€ 174.484,00
Market value of equity capital/SHV (T_0 = 2008)	-€ 226.320,04
Market value of equity capital/SHV (T_0 = 2012)	-€ 331.355,17

Figure 41: Business Value - FACC AG

The first impression of the market value of the equity capital is not the best. This can be especially explained by the fact that the FCF in 2012 (basis for the perpetuity) and 3 other FCF are negative. However, it is possible to see a positive trend, which gives hope for a better business value in the future.

4.1.1.2 AMAG

in kEURO	BS 2007	Difference	BS 2008	Difference	BS 2009	Difference	BS 2010	Difference	BS 2011
Assets									
A. Fixed assets									
I. Intangible assets	31	-10	21	-6	15	8	23	56	79
II. Tangible assets	80.410	25.228	55.182	-6.452	48.730	8.873	57.603	13.756	71.359
III. Financial assets	300	-25	325	0	325	0	325	0	325
B. Current assets									
I. Inventories	95.516	75.405	20.111	-8.208	28.319	1.189	27.130	-6.694	33.824
II.Receivables									
i. Accounts receiviables	50.796	13.265	37.531	8.255	29.276	-10.460	39.736	-6.546	46.282
ii. Accounts receiviables arising from affiliated or associated companies	19.830	4.639	15.191	-2.557	17.748	-677	18.425	989	17.436
iii. Other Receivables	3.772	1.536	2.236	-3.510	5.746	1.105	4.641	550	4.091
III. cash on hand, checks, deposits with financial institutions	349	-13	336	455	791	-635	156	279	435
C. Prepaid expenses and deferred charges (ARAP)	16	-18	34	27	7	6	1	-135	136
	251.020		130.967		130.957		148.040		173.967
Liabilities									
A. Equity									
I. Nominal share capital	12.000	0	12.000	0	12.000	0	12.000	0	12.000
II. Capital reserves	18.400	15	18.415	0	18.415	0	18.415	-270	18.145
III. Retained earnings	2.798	0	2.798	0	2.798	0	2.798	0	2.798
IV. Balance sheet profit/loss	0	0	0	10.954	10.954	25.223	36.177	8.234	44.411
B. Public subsidies	2.447	-641	1.806	-279	1.527	594	2.121	-801	1.320
C. Provisions									
1. Long-term provisions	25.952	-1.916	24.036	-2.043	21.993	-37	21.956	-126	21.830
2. Short-term provisions	13.350	1.760	15.110	-541	14.569	-938	13.631	4.168	17.799
D. Liabilities									
1. Bonds	0	0	0	0	0	0	0	0	0
2. Liabilities to financial institutions	21.334	-1.917	19.417	-7.078	12.339	-5.019	7.320	9.061	16.381
3. Advances received	108	-88	20	-20	0	645	645	-615	30
4. Accounts payables	6.687	-3.192	3.495	-1.220	2.275	1.839	4.114	2.622	6.736
5. Accounts payables arising from affiliated or associated companies	142.900	-113.213	29.687	860	30.547	-5.633	24.914	2.442	27.356
6 Other liabilities	5.044	-861	4.183	-649	3.534	405	3.939	952	4.891
F. Deferred credits to income (PRA)	0	0	0	6	6	4	10	-10	0
	251.020		130.967		130.957		148.040		173.697

Figure 42: Balance Sheets - AMAG 2008-2012

in kEuro	2008	2009	2010	2011
Earnings/loss from ordinary activity less corporate income tax	28.098	13.848	33994	43964
+ Depreciations of fixed assets	12.394	11.256	9997	10696
- Appreciations of fixed assets	0	0	0	0
-/+ Earnings/loss from the disposal of tangible, intangible & financial assets	-1	-16	-9	-32
- Release of public subsidies	-641	-279	0	-801
+/- Increase/decrease of long-term provisions	-1.916	-2.043	-37	-126
= Cash earnings	37.934	22.766	43.945	53.701
-/+ Increase/decrease of stock-in-trade	75.405	-8.208	1.189	-6.694
-/+ Increase/decrease of accounts receivable	13.265	8.255	-10.460	-6.546
-/+ Increase/decrease of other assets (if allocatable to ordinary activity)	0	0	0	0
-/+ Increase/decrease of prepaid expenses and deferred charges (ARAP)	-18	27	6	-135
+/- Increase/decrease of short-term provisions	1.760	-541	-938	4.168
+/- Increase/decrease of accounts payable	-3.192	-1.220	1.839	2.622
+/- Increase/decrease of other liabilities (if allocatable to ordinary activity)	-88	-20	645	-615
+/- Increase/decrease of deferred credits to income (PRA)	0	6	4	-10
= Cash Flow by operating activities	125.066	21.065	36.230	46.491
- Investments in tangible, intangible & financial assets (owned longer than 3 months)	-6.862	-4.913	-19071	-24581
- Capitalized self-constructed assets	-90	-108	-373	-444
+ Book value of disposed asset	412	1.257	1870	4147
+ granted public subsidies	2.447	0	594	0
+/- Earnings/losses of disposed tangible, intangible & financial assets	1	16	9	32
-/+ Increase/decrease of financial loans between associated or affiliated companies (shareholding relationship)	-108.574	-1.697	-6.310	3.431
= Cash Flow by investing activities	-112.666	-5.445	-23.281	-17.415
= Free Cash Flow from operations	12.400	15.620	12.949	29.076
+ Inflows from shareholder (capital reserves, increase in share capital)	0	0	0	0
- Outflow to shareholder	0	0	0	0
+/- Increase/repayment of financial credits and bonds	-1.917	-7.078	-5.019	9.061
= Cash Flow by financing activities	-1.917	-7.078	-5.019	9.061
= Change in the financial funds	10.483	8.542	7.930	38.137

Figure 43: Free Cash Flows - AMAG 2008-2012

in kEuro	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	€ 12.400,00	€ 15.620,00	€ 12.949,00	€ 29.076,00	€ 17.861,48	€ 227.733,81
DC FCF	€ 12.400,00	€ 14.200,00	€ 10.701,65	€ 21.845,23	€ 12.199,63	€ 155.545,25

WACC	10,00%
Growth rate	2,00%

Market value of total company (T_0 = 2008)	€ 226.891,76
Minus: Liabilities (2008)	-€ 215.375,00
Market value of equity capital/SHV (T_0 = 2008)	€ 11.516,76
Market value of equity capital/SHV (T_0 = 2012)	€ 16.861,69

Figure 44: Business Value - AMAG

4.1.1.3 Diamond Aircraft

in kEURO	BS 2007	Difference	BS 2008	Difference	BS 2009	Difference	BS 2010	Difference	BS 2011
Assets									
A. Fixed assets									
I. Intangible assets	14.472	-13.747	725	-173	552	-197	355	-136	219
II. Tangible assets	10.146	-4.533	14.679	585	15.264	1.660	16.924	-3.614	13.310
III. Financial assets	5.724	3.821	1.903	-107	1.796	0	1.796	-1.583	213
B. Current assets									
I. Inventories	38.448	-21.089	59.537	-1.329	60.866	8.281	52.585	7.378	45.207
II.Receivables									
i. Accounts receiviables	2.745	-3.810	6.555	2.971	3.584	-13.126	16.710	13.115	3.595
ii. Accounts receiviables arising from affiliated or associated companies	65.438	-40.779	106.217	69.140	37.077	20.903	16.174	1.120	15.054
iii. Other Receivables	18.852	9.044	9.808	3.203	6.605	5.066	1.539	15	1.524
III. cash on hand, checks, deposits with financial institutions	1.077	5.715	6.792	6.084	708	405	303	-1.915	2.218
C. Prepaid expenses and deferred charges (ARAP)	153	-19	172	-13	185	-98	283	47	236
	157.055		206.388		126.637		106.669		81.576
Liabilities									
A. Equity									
I. Nominal share capital	37	0	37	0	37	0	37	0	37
II. Capital reserves	20.152	-20.152	0	0	0	0	0	0	0
III. Retained earnings		0		0	0	0	0	0	0
IV. Balance sheet profit/loss	-2.056	-23.133	-25.189	-34.436	-59.625	51.027	-8.598	-5.102	-13.700
B. Untaxed reserves	10	-10	0	0	0	0	0	0	0
C. Subordinated loan	0	129.480	129.480	28.932	158.412	-102.993	55.419	400	55.819
D. Provisions									
1. Long-term provisions	1.196	59	1.255	346	1.601	243	1.844	-833	1.011
2. Short-term provisions	4.498	223	4.721	1.302	6.023	912	6.935	-3.130	3.805
E. Liabilities									
1. Liabilities to financial institutions	109.218	-38.783	70.435	-63.834	6.601	-528	6.073	-2.683	3.390
2. Advances received	9.508	-1.150	8.358	-5.851	2.507	7.309	9.816	-5.971	3.845
3. Accounts payables	7.012	2.564	9.576	-5.566	4.010	7.248	11.258	8.594	19.852
4. Accounts payables arising from affiliated or associated companies	488	406	894	811	1.705	-1.041	664	1.467	2.131
5. Other liabilities	6.991	-170	6.821	-2.058	4.763	18.217	22.980	-17.594	5.386
F. Deferred credits to income (PRA)	0	0	0	603	603	-362	241	-241	0
	157.054		206.388		126.637		106.669		81.576

Figure 45: Balance Sheets Diamond Aircraft - 2008-2012

in kEuro	2008	2009	2010	2011
Earnings/loss from ordinary activity less corporate income tax	-29.460	-33.301	52935	-5376
+ Depreciations of fixed assets	7.624	8.537	2578	2367
- Appreciations of fixed assets	0	0	0	0
-/+ Earnings/loss from the disposal of tangible, intangible & financial assets	0	-641	-1558	387
+/- Increase/decrease of long-term provisions	59	346	243	-833
= Cash earnings	-21.777	-25.059	54.198	-3.455
-/+ Increase/decrease of stock-in-trade	-21.089	-1.329	8.281	7.378
-/+ Increase/decrease of accounts receivable	-3.810	2.971	-13.126	13.115
-/+ Increase/decrease of other assets (if allocatable to ordinary activity)	0	0	0	0
-/+ Increase/decrease of prepaid expenses and deferred charges (ARAP)	-19	-13	-98	47
+/- Increase/decrease of short-term provisions	223	1.302	912	-3.130
+/- Increase/decrease of accounts payable	2.564	-5.566	7.248	8.594
+/- Increase/decrease of other liabilities (if allocatable to ordinary activity)	-1.150	-5.851	7.309	-5.971
+/- Increase/decrease of deferred credits to income (PRA)	0	603	-362	-241
= Cash Flow by operating activities	-45.058	-32.942	64.362	16.337
- Investments in tangible, intangible & financial assets (owned longer than 3 months)	-6.898	-3.983	-5210	-1405
- Capitalized self-constructed assets	-104	-2.083	-575	-665
+ Book value of disposed asset	18.692	721	1417	2756
+/- Earnings/losses of disposed tangible, intangible & financial assets	0	641	1.558	-387
-/+ Increase/decrease of financial loans between associated or affiliated companies (shareholding relationship)	-40.373	69.951	19.862	2.587
= Cash Flow by investing activities	-28.683	65.247	17.052	2.886
= Free Cash Flow from operations	-73.741	32.305	81.414	19.223
+ Inflows/outflows equity (capital reserves, increase in share capital)	-20.152	0	0	0
- Outflow to shareholder	0	0	0	0
+/- Increase/repayment of financial credits and bonds	90.697	-34.902	-103.521	-2.283
= Cash Flow by financing activities	70.545	-34.902	-103.521	-2.283
= Change in the financial funds	-3.196	-2.597	-22.107	16.940

Figure 46: Free Cash Flows - Diamond Aircraft 2008-2012

in kEuro	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	-€ 73.741,00	€ 32.305,00	€ 81.414,00	€ 19.223,00	€ 15.096,26	€ 192.477,25
DC FCF	-€ 73.741,00	€ 29.368,18	€ 67.284,30	€ 14.442,52	€ 10.310,95	€ 131.464,55

WACC	10,00%
Growth rate	2,00%

Market value of total company (T_0 = 2008)	€ 179.129,50
Minus: Liabilities (2008)	-€ 138.911,00
Market value of equity capital/SHV (T_0 = 2008)	€ 40.218,50
Market value of equity capital/SHV (T_0 = 2012)	€ 58.883,91

Figure 47: Business Value - Diamond Aircraft

4.1.1.4 International JET Management

in kEURO	BS 2007	Difference	BS 2008	Difference	BS 2009	Difference	BS 2010	Difference	BS 2011
Assets									
A. Fixed assets									
I. Intangible assets	23	-2	21	1	20	10	10	6	4
II. Tangible assets	200	-73	127	49	78	23	55	6	49
B. Current assets									
I.Receivables									
i. Accounts receviables	8.499	-651	9.150	1.538	7.612	-386	7.998	62	7.936
ii. Other Receivables	715	55	660	232	428	136	292	-202	494
II. Cash on hand, checks, deposits with financial institutions	1.431	-994	437	-49	388	658	1.046	-623	423
C. Other Prepaid expenses and deferred charges (ARAP)	11	6	5	-2	7	2	5	1	4
	10.879		10.400		8.533		9.406		8.910
Liabilities									
A. Equity									
I. Nominal share capital	400	0	400	0	400	0	400	0	400
II. Balance sheet profit/loss	-841	-1.733	-2.574	534	-2.040	683	-1.357	361	-996
B. Atypical dormant holding	0	0	0	0	0	1.743	1.743	177	1.920
C. Provisions									
1. Long-term provisions	24	3	27	17	44	46	90	-30	60
2. Short-term provisions	92	10	102	5	107	114	221	-75	146
D. Liabilities									
1. Liabilities to financial institutions	1.082	1.483	2.565	-364	2.201	-1.368	833	229	1.062
2. Accounts payables	6.247	505	6.752	-1.420	5.332	-1.116	4.216	-326	3.890
3. Accounts payables arising from affiliated or associated companies	5	-5	0	0	0	0	0	0	
4 Other liabilities	3.870	-742	3.128	-639	2.489	771	3.260	-832	2.428
	10.879		10.400		8.533		9.406		8.910

Figure 48: Balance Sheets - International JET Management 2008-2012

in kEuro	2008	2009	2010	2011
Earnings/loss from ordinary activity less corporate income tax	-1.730	574	826	706
+ Depreciations of fixed assets	1.075	64	42	39
- Appreciations of fixed assets	0	0	0	0
-/+ Earnings/loss from the disposal of tangible, intangible & financial assets	0	0	0	0
+/- Increase/decrease of long-term provisions	3	17	46	-30
= Cash earnings	-652	655	914	715
-/+ Increase/decrease of stock-in-trade	0	0	0	0
-/+ Increase/decrease of accounts receivable	-651	1.538	-386	62
-/+ Increase/decrease of other assets (if allocatable to ordinary activity)	0	0	0	0
-/+ Increase/decrease of prepaid expenses and deferred charges (ARAP)	6	-2	2	1
+/- Increase/decrease of short-term provisions	10	5	114	-75
+/- Increase/decrease of accounts payable	505	-1.420	-1.116	-326
+/- Increase/decrease of other liabilities (if allocatable to ordinary activity)	-742	-639	771	-832
+/- Increase/decrease of deferred credits to income (PRA)	0	0	0	0
= Cash Flow by operating activities	-1.524	137	299	-455
- Investments in tangible, intangible & financial assets (owned longer than 3 months)	-47	-14	-9	-27
- Capitalized self-constructed assets	0	0	0	0
+ Book value of disposed asset	77	0	0	0
+/- Earnings/losses of disposed tangible, intangible & financial assets	0	0	0	0
-/+ Increase/decrease of financial loans between associated or affiliated companies (shareholding relationship)	0	0	0	0
= Cash Flow by investing activities	30	-14	-9	-27
= Free Cash Flow from operations	-1.494	123	290	-482
+ Inflows from shareholder (capital reserves, increase in share capital)	0	0	1.743	177
- Outflow to shareholder	0	0	0	0
+/- Increase/repayment of financial credits and bonds	1.483	-364	-1.368	229
= Cash Flow by financing activities	1.483	-364	375	406
= Change in the financial funds	-11	-241	665	-76

Figure 49: Free Cash Flows - International JET Management 2008-2012

in kEuro	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	-€ 1.494,00	€ 123,00	€ 290,00	-€ 482,00	-€ 398,57	-€ 5.081,70
DC FCF	-€ 1.494,00	€ 111,82	€ 239,67	-€ 362,13	-€ 272,23	-€ 3.470,87

WACC	10,00%
Growth rate	2,00%

Market value of total company (T_0 = 2008)	-€ 5.247,74
Minus: Liabilities (2008)	-€ 11.320,00
Market value of equity capital/SHV (T_0 = 2008)	-€ 16.567,74
Market value of equity capital/SHV (T_0 = 2012)	-€ 24.256,83

Figure 50: Business Value - International JET Management

4.1.1.5 Isovolta AG

As the Isovolta AG explicitly mentioned their operating Free Cash Flows in their annual reports, it was not necessary to reinsert the key figures into the self-developed Excel-tool.

in kEuro	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	-€ 9.328,00	€ 55.934,00	-€ 1.847,00	-€ 56.253,00	-€ 2.930,97	-€ 37.369,87
DC FCF	-€ 9.328,00	€ 50.849,09	-€ 1.526,45	-€ 42.263,71	-€ 2.001,89	-€ 25.524,12
		Market value of total company (T_0 = 2008)				-€ 29.795,08
WACC	10,00%	Minus: Liabilities (2008)				-€ 114.584,00
Growth rate	2,00%	Market value of equity capital/SHV (T_0 = 2008)				-€ 144.379,08
		Market value of equity capital/SHV (T_0 = 2012)				-€ 211.385,41

Figure 51: Business Value - Isovolta AG

4.1.1.6 Overview Austria

Following figure shows the business value of the observed Austrian companies in ascending order:

	Market value of equity capital/ SHV (T0 = 2012) in kEuro
Diamond	€ 58.883
AMAG	€ 16.861
Jet Mgmt	-€ 24.256
Isovolta	-€ 211.385
FACC	-€ 331.355

Figure 52: Overview of Business Values: Austria

4.1.2 US-American Companies

For the calculation of the business value are chosen 5 of the 10 biggest aerospace companies on the US market. These are [57]:

- The Boeing Company
- United Technologies Corporation
- Lockheed Martin
- General Dynamics, and
- Northrop Grumman

4.1.2.1 The Boeing Company

For the calculation of the business value of the Boeing Company are considered the FCF of the past from 2009 to 2012, and the estimated FCF of 2013 [58]. The WACC is assumed as 9.1% [59]. The long-term debts and provisions are taken from the Balance Sheet of 2009 [60].

in Mio. US$	2009	2010	2011	2012	est. 2013	Perpetuity
FCF to the Firm	$4.417,00	$1.827,00	$2.310,00	$5.805,00	$4.100,00	$58.901,41
DC FCF	$4.417,00	$1.674,61	$1.940,72	$4.470,21	$2.893,91	$41.574,47

WACC	9,10%
Growth rate	2,00%

Market value of total company (T_0 = 2009)	$56.970,91
Minus: Liabilities (2009)	-$59.828,00
Market value of equity capital/SHV (T_0 = 2009)	-$2.857,09
Market value of equity capital/SHV (T_0 = 2012)	-$3.710,20

Figure 53: Business Value - Boeing Company

4.1.2.2 United Technologies Corporation

For the calculation of the business value of United the Technologies Corporation are considered the FCF of the past from 2009 to 2012, and the estimated FCF of 2013 [61: p.11]. The WACC is assumed as 10.38% [62]. The long-term liabilities and provisions are taken from the Balance Sheet of 2009 [63].

in Mio. US$	2009	2010	2011	2012	est. 2013	Perpetuity
FCF to the Firm	$4.310,00	$4.882,00	$5.531,00	$5.216,00	$5.600,00	$68.162,29
DC FCF	$4.310,00	$4.422,90	$4.539,66	$3.878,52	$3.772,48	$45.917,96

WACC	10,38%
Growth rate	2,00%

Market value of total company (T_0 = 2009)	$66.841,52
Minus: Liabilities (2009)	-$39.910,00
Market value of equity capital/SHV (T_0 = 2009)	$26.931,52
Market value of equity capital/SHV (T_0 = 2012)	$36.218,63

Figure 54: Business Value - United Technologies Corporation

4.1.2.3 Lockheed Martin

For the calculation of the business value of Lockheed Martin are only considered the FCF of the past from 2008 to 2012, as the corporate governance "is unable to reasonably estimate the cost and cash flow" of 2013 [64: p.24]. The WACC is assumed as 9.1% [65]. The long-term liabilities and provisions are taken from the Balance Sheet of 2008 [66]. As the cash flows are only available as operating cash flows, an auxiliary calculation has to be done [64: p.24]:

	2008	2009	2010	2011	2012
CF by operating activities	$4.724,00	$3.487,00	$3.801,00	$4.253,00	$1.561,00
-Capital expenditures	-$1.210,00	-$1.832,00	-$573,00	-$813,00	-$1.222,00
FCF to the Firm	$3.514,00	$1.655,00	$3.228,00	$3.440,00	$339,00

Figure 55: Calculating FCF from Operating CF

in Mio. US$	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	$3.514,00	$1.655,00	$3.228,00	$3.440,00	$339,00	$4.870,14
DC FCF	$3.514,00	$1.516,96	$2.711,96	$2.649,01	$239,28	$3.437,50

		Market value of total company (T_0 = 2009)	$14.068,71
WACC	9,10%	Minus: Liabilities (2009)	-$30.570,00
Growth rate	2,00%	Market value of equity capital/SHV (T_0 = 2009)	-$16.501,29
		Market value of equity capital/SHV (T_0 = 2012)	-$23.378,51

Figure 56: Business Value - Lockheed Martin

For the company size of Lockheed Martin can be noticed that especially accrued pension liabilities (part of Provisions/Reserves) have a big negative impact on the business value. In 2008, they amounted $ 12,004 Mio.

4.1.2.4 General Dynamics

For the calculation of the business value of General Dynamics are only considered the FCF of the past from 2008 to 2012, since no reliable FCF estimations for 2013 can be found [67, 68: p.17]. The long-term liabilities and provisions are taken from the Balance Sheet of 2008 [69: p.32]. The WACC is assumed as 9.6% [70].

in Mio. US$	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	$2.634,00	$2.470,00	$2.616,00	$2.780,00	$2.237,00	$30.022,89
DC FCF	$2.634,00	$2.253,65	$2.177,79	$2.111,61	$1.550,33	$20.807,04

		Market value of total company (T_0 = 2009)	$31.534,42
WACC	9,60%	Minus: Liabilities (2009)	-$18.320,00
Growth rate	2,00%	Market value of equity capital/SHV (T_0 = 2009)	$13.214,42
		Market value of equity capital/SHV (T_0 = 2012)	$19.067,35

Figure 57: Business Value - General Dynamics

4.1.2.5 Northrop Grumman

For the calculation of the business value of Northrop Grumman are only considered the FCF of the past from 2008 to 2012, since no reliable FCF estimations for 2013 can be found [71: p.34, 72: p.25]. The long-term liabilities and provisions are taken from the Balance Sheet of 2008 [73: p.54]. The WACC is assumed as 9.3% [74].

in Mio. US$	2008	2009	2010	2011	2012	Perpetuity
FCF to the Firm	$2.420,00	$1.411,00	$1.471,00	$1.855,00	$2.309,00	$32.262,74
DC FCF	$2.420,00	$1.290,94	$1.231,32	$1.420,64	$1.617,87	$22.605,84

WACC	9,30%
Growth rate	2,00%

Total market value of company (T_0 = 2008)	$30.586,61
Minus: Provisions/Reserves (2008)	-$18.280,00
Market value of equity capital value (T_0 = 2008)	$12.306,61
Market value of equity capital (T_0 = 2012)	$17.563,82

Figure 58: Business Value - Northrop Grumman

4.1.2.6 Overview USA

Following figure shows the business values of the US-American companies in ascending order:

	Market value of equity capital/ SHV (T0 = 2012) in Mio. US$
United Technologies	$36.219
General Dynamics	$19.067
Northrop Gumman	$17.564
Boeing	-$3.710
Lockheed	-$23.379

Figure 59: Overview of Business Values: USA

4.2 Development of a Technology Balance Sheet

As source for the development of the technology balance sheet serves the plant of Cessna Aircraft in Independence, Kansas. The processes, products and technologies in the following figure can be related to Chapter 2.3.5.1 (Cessna Aircraft Corporation), which delivers a good overview of the plant.

Technology Balance Sheet							
Application of funds		Sum		Source of funds		Sum	
A. Processes				A. Internal technologies			
I. Development & introduction		0		I. Systems knowledge			
II. Growth				● Moving assembly line	4		
● Assembly of single parts	18			● Clocking	2		
● Final assembly	16	34		● Six Sigma/Lean Management	3		
III. Maturity				● Total Productive Management	3	12	
● Painting	5			II. Skill knowledge			
● Painting Preperation	2			● Riveting[1]	1		
● Implementation of Avionics	8			● Sewing	1		
● Product presentation	2	17		● Coating (paint)	2		
IV. Decline				● Drying	1		
● Seat production	7	7	**58**	● Polishing	2		
B. Products				● Marketing and Sales	2	9	
I. Development & introduction		0		III. Observational knowledge			
II. Growth				● Riveting[2]	3	3	
● Citation Mustang	20			IV. Principal knowledge			
● Citation M2	20	40		● Thermosetting	2	2	**26**
III. Maturity				B. External technologies			
● Stationair	20			I. Systems knowledge			
● Corvalis TT	20	40		● Assembly of Avionics Systems	4	4	
IV. Decline				II. Skill knowledge			
● Skyhawk	20			● Surface preparation[1]	4	4	
● Skylane	20	40		III. Observational knowledge			
				● Surface preparation[2]	4	4	
				IV. Principal knowledge			
				● Compositing materials	4		
			120	● Avionics	4	8	**20**
				C. Technology surplus		**132**	
TOTAL SUM			**178**	TOTAL SUM			**46**

Figure 60: Technology Balance Sheet

Concluded can be said that the plant in Independence has a technology surplus of 132 points.

4.3 Technology-Finance-Portfolio

A Technology- Finance-Portfolio enables an evaluation and a comparison of companies regarding their technological and financial performance.

This chapter bases only partly on real data (business value) and primarily has an illustrating function as the technology surpluses/deficiencies are not indeed calculated for each company. Generally should be noticed that the technological evaluation for the following companies are randomly chosen, and the financial evaluation bases on the before calculated business values. Therefore, following figures should not be taken seriously.

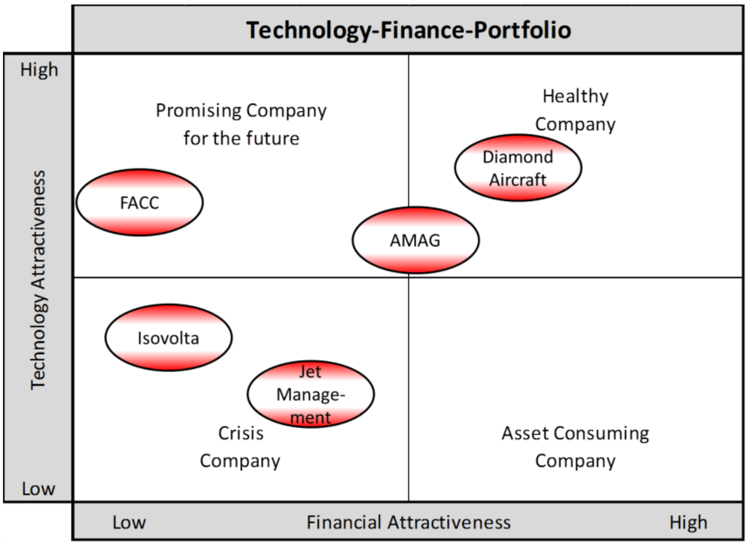

Figure 61: Technology-Finance-Evaluation of 5 Austrian Aircraft Companies

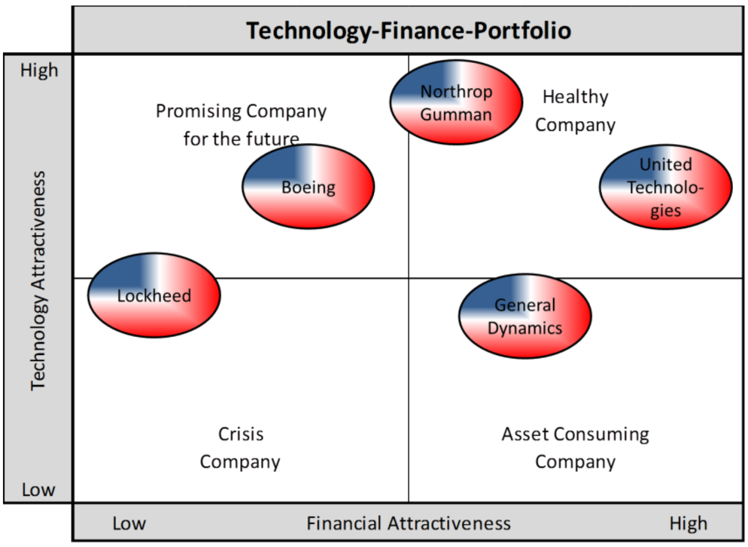

Figure 62: Technology-Finance-Evaluation of 5 US-American Aircraft Companies

4.4 Research Questions

In this chapter it is tried to answer the research questions based on the theoretical principals and results that have been worked out.

1. What is *Operational Excellence* in the aircraft industry?

Operational Excellence in the aircraft industry consists of multiple components. It can be for example achieved by designing aircrafts, conducting feasibility studies, executing production planning and control, making make-or-buy decisions, assembling and producing aircrafts, assuring and improving product and process quality, managing supply chains, maintaining equipment and plants, managing information systems, managing human resources, and meeting military, civil or federal aviation standards effectively and efficiently. By reaching these goals additional Cash Flows can be evoked and consequently also lead to higher business values in case of calculating with DCF-methods.

2. What are state-of-the-art processes and technologies in the aircraft industry?

State of the art-processes and technologies can be reviewed in the chapters from 2.3.1 to 2.3.8.

3. How can a production department influence the business value positively?

A production department can influence the business value positively by evoking additional Cash Flows. This can be achieved for example by applying more efficient processes and saving costs or producing a higher quality of products, which in turn hopefully leads to higher sale prices.

4. Which value driver (process and production measure) is currently the most promising in the production of aircrafts?

Currently one of the most promising value drivers in the aircraft production is the implementation of moving assembly lines, since cycle times and inventories can be reduced drastically, which for example reduces lead times and a faster fulfillment of payments and also improves liquidity of a company.

5. Which production and process measures can be implemented to increase a companies' business value?

The chapters from 2.3.1 to 2.3.8. show useful references (processes, technologies etc.) to increase the operational and consequently financial performance of a company.

6. Is the *Discounted-Cash-Flow-Method (WACC approach)* an appropriate method to evaluate the performance of company?

Although the DCF-method has its weaknesses (negative business value, because of negative Cash Flows) it is a very common approach in practice and generally simple method.

7. What is a technology balance sheet?

A technology balance sheet can be compared to a financial balance sheet. It also consists of assets (products & processes) and liabilities and enables the evaluation of a company in 2 perspectives; a financial and technological one.

8. How is a technology balance sheet created and implemented?

Chapters 2.5.1, 4.2 and 4.3 illustrate very well how technology balance sheets are created and implemented.

9. What are the advantages and core statements of a technology balance sheet?

A technology balance sheet evaluates the actual technological performance of a company. It generally relates available technologies (understood as knowledge) in a company with produced products and applied processes. A high technological surplus can be related to a high efficiency due to the fact that the available technologies are used for a lot of products and processes.

5. Discussion

A company evaluation that bases only on financial key figures might be fallacious and might not express the future prospect of a company. Therefore, it might be useful to develop and implement a technology balance sheet in addition, which represents the actual technological situation and technological future prospect of a company in detail. Although, it can be questioned that the creation of technological balance sheets might be mandatory for each company one day, it can be still said that it delivers useful information regarding the technological performance of a company and consequently helps to manage and control a company, especially on medium to long-term.

6. Outlook

This Mater Thesis gives a good overview of common operations in the aircraft industry, the practical application of the DCF-method (WACC-approach) and the development of technology balance sheets. To enable an entire benchmarking of companies within an industry, it might be possible to develop for several different companies a technology balance sheet, and compare them not only in a financial, but also in a technological perspective based on real-life data from their plants and operations.

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5	Didier Morreti	Bombardier Aerospace	Design Engineer
6	Jeff Glimpse	B/E AEROSPACE	Senior Recruiter
7	Shawna Biggars	Exacta Aerospace	Director of Human Resource

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