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Analysing monitoring tools for technology development projects in an industrial enterprise

Master Thesis

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Statutory Declaration

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

Graz, March 2013 Heinz Hoesch

Abstract

The industrial enterprise *ACC Austria GmbH* situated in Fuerstenfeld (Austria) aims to integrate a project monitoring tool for its technology development, which is the first phase of the product development process. This thesis shall contribute the following three results: (1) Designing a generic approach for integrating a monitoring tool. (2) Searching for, analysing and evaluating several monitoring tools, which are available on the market. (3) Designing a suitable process for using the monitoring tool.

In the first step of this thesis, a generic process for integrating a monitoring tool is developed for the industrial enterprise. Based on the concept of systems engineering according to Haberfellner et al. (2012) the process is designed. The developed process shall be applicable for prospective intentions.

The developed generic approach contains amongst others a step to analyse and evaluate project monitoring tools. Thereby, monetary and non-monetary aspects are covered. The monetary evaluation is done by applying the total cost of ownership approach developed by Gartner. The non-monetary evaluation is done by applying a value benefit analysis.

The last part of the thesis contains a developed process according to Business Process Model and Notation (BPMN). This process is related to the usage of the tool, especially for planning and controlling technology development projects. All relevant process participants like project leaders, the technology development management, the R&D-management and the monitoring tool itself are integrated.

Kurzfassung

Das Industrieunternehmen *ACC Austria GmbH* mit Sitz in Fürstenfeld (Österreich) beabsichtigt für die Technologieentwicklung, die erste Phase des Produktentwicklungsprozesses, ein Projektmonitoring Instrument zu integrieren. Hierzu soll diese Arbeit die folgenden drei Beiträge leisten: (1) Gestaltung eines allgemeinen Ansatzes zur Integration eines Projektmonitoring Instruments. (2) Erhebung, Analyse und Bewertung verschiedener am Markt existierenden Monitoring Instrumente. (3) Entwicklung eines geeigneten Prozesses für die Verwendung des Instruments.

Im ersten Schritt dieser Arbeit wird für die Technologieentwicklung des Industrieunternehmens ein Prozess für die Integration eines Projektmonitoring Instruments entwickelt. Dabei wird aufbauend auf dem Systems Engineering Ansatz nach Haberfellner et al. (2012) der Prozess gestaltet. Dieser soll ebenso für ähnliche Vorhaben in Zukunft verwendet werden können.

Der entwickelte Ansatz beinhaltet unter anderem die Analyse und Bewertung von Projektmonitoring Instrumenten. Dabei werden monetäre als auch nicht-monetäre Aspekte betrachtet. Die monetäre Bewertung wird durch den Total Cost of Ownership Ansatz nach Garnter realisiert. Die nicht-monetäre Bewertung wird durch eine Nutzwertanalyse behandelt.

Im letzten Schritt der Arbeit wird ein Prozess zur Verwendung des Projektmonitoring Instruments entwickelt. Das Instrument wird für Planung und Controlling verwendet. Die Prozesse werden nach dem Prinzip von Business Process Model and Notation (BPMN) entwickelt. Dabei werden die relevanten Prozessteilnehmer wie Projektleiter, das Technologieentwicklungsmanagement, das R&D-Management sowie das Projektmonitoring Instrument selbst miteinbezogen.

Acknowledgement

On my journey during this master thesis, many lovely people accompanied me and without their support many things would not have been possible and more importantly, who made this time so special to me.

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It is with immense gratitude that I acknowledge the support and help of my line manager Dipl.-Ing. Walter Brabek, who has the attitude and the substance of an outstanding motivational person: he continually and convincingly conveyed a spirit of adventure in regard to the work during this thesis. It is a great pleasure.

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Contents

1 Introduction

In this first chapter entrepreneurial aspects are discussed based on the Porter's generic strategies to draw a bow to the situation and current challenges for the industrial enterprise *ACC Austria GmbH*. For a comprehensive understanding, the company is presented briefly. Information about task, objective and approach of the thesis are given and the structure of this document is exposed.

1.1 ACC Austria GmbH[1]

This master thesis is done in cooperation with ACC, Appliances Components Companies, which was founded in 2002 in Fuerstenfeld. The recent development of the market motivated the company to focus entirely on manufacturing components for refrigerators in the industry of household appliances.

1.1.1 Corporate purpose and market data

The company ACC develops and produces cooling compressors for household appliances on a global scale. In figure 1.1 a current compressor model of ACC is shown. The company operates a production facility and a research & development center in Fuerstenfeld (Austria). Furthermore, ACC holds a production facility in Mel (Italy) and another production facility in Tianjin (China) for the Asian market. The company ACC is part of the ACC Group, whose headquarter is in Pordenone (Italy).

Currently, ACC employs around 850 associates in Fuerstenfeld. Worldwide the company has about 3,000 associates. The annual turnover of ACC Austria GmbH was 167 million euro in 2012. The total annual turnover of ACC Group was 400 million euro in 2012. The

[1] cp. ACC [2011], p 4 ff

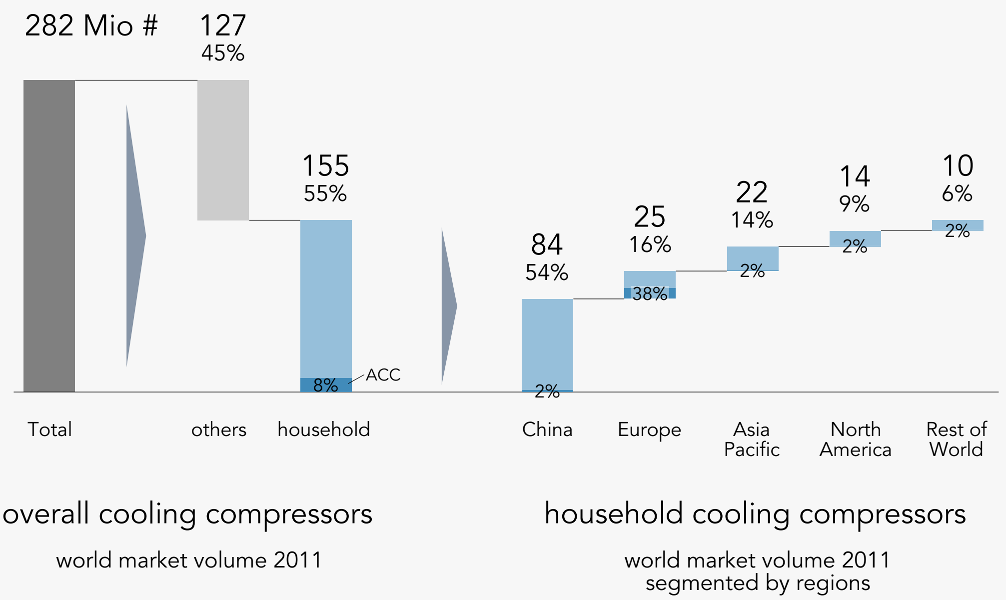
Source: ACC [2011], p 15

Figure 1.1: Current compressor model of ACC

production capacity of ACC Group is in total 12.2 million units, whereby in Fuerstenfeld the company could produce 7.5 million units at best, in Italy 3 and in China 1.7 million.

The annual worldwide cooling compressor demand for household appliances was about 155 million units in 2012, see figure 1.2. The biggest market is China with 54 %, followed by Europe with 16 %, Asia-Pacific with 14 %, North America with 9 %. Worldwide, ACC has about 8 % market share in the industry.

Today, ACC is European market leader in its industry, see figure 1.3. ACC holds about twice as much market share in Europe than the second largest compressor company. Jiaxipera, a Chinese company with production facilities only in China, offers its products all over the world and holds the worldwide position of a cost leader in the industry. This strategic advantage supported them amongst other things to catch up some market shares in the past, more than other companies. The objective of ACC for the future is to expand its market position.



Source: ACC [2011], p 1

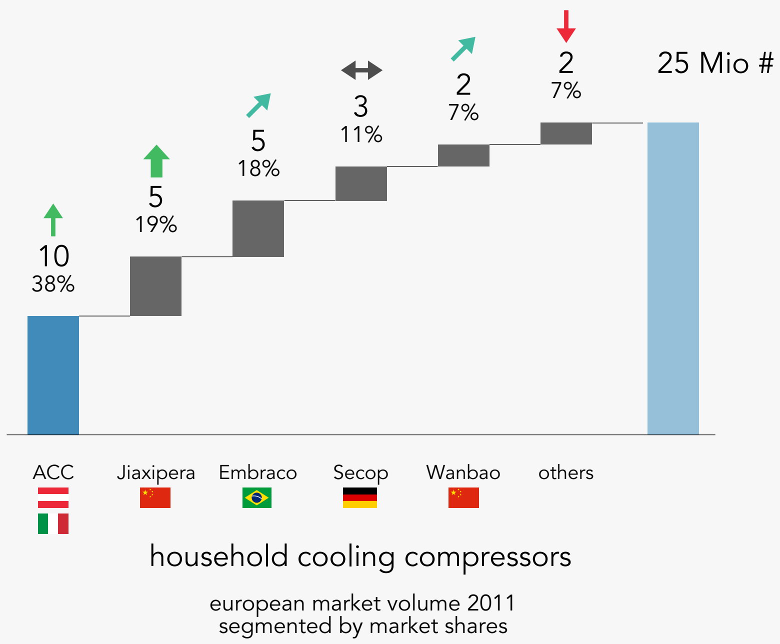
Figure 1.2: Worldwide annual cooling compressor demand

1.1.2 Historical development[2]

In 1982 the company *Verdichter Oe GmbH* was founded by Zanussi Group. Zanussi is an Italian manufacturer of white goods. The basic idea was to have a manufacturing facility in Austria. The first steps were taken by acquiring manufacturing equipment and know-how from Robert Bosch situated in Nuernberg (Germany). Since then, the company has been producing hermetically sealed cooling compressors. Within two years, Verdichter could enlarge its manufacturing from a one shift to a two shift operation by 1984. One year later, Electrolux (a Schwedish manufacturer of white goods) acquired Verdichter from Zanussi. Then, Verdichter was a part of the worldwide largest manufacturer of white goods. The company flourished and a third shift operation was established in 1988.

Verdichter was famous for its high quality products and Electrolux awarded the company

[2]cp. ACC [2011], p 8 ff



Source: ACC [2011], p 1

Figure 1.3: European market shares of cooling compressor companies for household appliances

with the *Electrolux Quality Award* in 1991. The first step towards environmental sustainability was taken in 1992 when starting to use an environment-friendly refrigerant fluid for compressors produced in mass production. In the same year, the company was certified by ISO 9001 and even received the highest decoration by the Styrian provincial government, the *Steirisches Landeswappen*.

Since the beginning, the company has been growing constantly and in 1995 a reorganization took place. Thereafter the characteristics of Verdichter were a lean organisation (three hierarchical levels), a high degree of associate integration in business processes, training courses for associates and implementation of a profit sharing system for all associations of the company. In 1996, Verdichter started its first in-house development project of a cooling compressor called *Kappa*. Three years later, a 50 million investment for the *Kappa* manufacturing equipment was accomplished and Verdichter received the second award from Electrolux: *Electrolux Engineering Award*.

In 2003, Verdichter received the highest decoration by the Austrian government, the *Österreichisches Staatswappen*. The ACC Group situated in Pordenone (Italy) acquired Verdichter and the company's name changed to ACC Austria GmbH.

From 2003 to 2005 ACC Austria doubled its manufacturing capacities and received furthermore several awards: *Austria's leading companies 2004 & 2005*, *Export Award by Austrian Ministry of Economics 2004* and *1st place Top of Styria 2005*.

Over 6 million cooling compressors were produced in 2004 and 7 million units in 2007. In 2010, ACC Austría GmbH launched its second in house developed cooling compressor called *Delta* and won the *Styrian Innovation Award*, the *Austrian Innovation Award* and the *Hidden Champion Contest* in competition with over 800 aspirants. Currently, ACC Austria GmbH employs 850 associates.

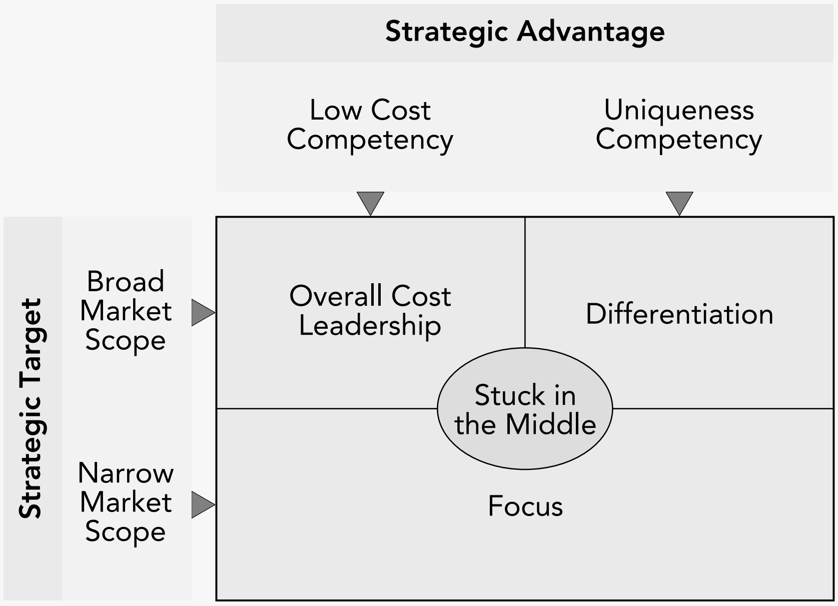
1.2 Motivation

The purpose of this master thesis is to provide a monitoring tool for the company's new integrated early phase of its product development process. The monitoring tool can be either aquired from external software providers or internally developed by the IT department according to the company's IT know how scope. The early phase shall support the idea creation process and, based on these ideas. Furthermore, the early phase shall provide knowledge to various technologies, which are available on the market. The monitoring shall support the management in organizational matters. The origin of the need for a monitoring tool respectively for an early phase of the product development process may be found in the company's strategy and the market conditions. For understanding the company's strategy, a short introduction is presented in this section. Starting with Porter's generic strategies and their application within the company's industry shall point out the need for the monitoring tool.

According to Porter's generic strategies there are mainly three approaches for outperforming other companies in an industry, see figure 1.4: overall cost leadership, differentiation and focus.[3]

Economical profit is a function of the price and the costs. The price is what customers pay for the product or service. The costs arise, when the product or service is brought

[3] cp. Porter [1980], p 35



Source: based on Porter [1999], p 75

Figure 1.4: Porter's generic strategies

to the customers. To enlarge the economical profit, a company needs to either follow the cost leadership strategy or the differentiation strategy. The idea of cost leadership is to provide products or services at a standard level of quality. However, at significantly lower costs compared to costs which are common practice in the same industry. Then, a company can earn above-average profits. The idea of differentiation is to offer *unique* products or services, which are perceived with high appreciation in the eyes of customers (so called: unique selling proposition of product or service). A company can earn high profits by selling them at premium prices and managing the costs at a required level.[4]

In principle, a company may choose between two strategic targets on the market: either to cover the entire market or to focus on a certain field of the market. The idea of a so called broad market scope is to offer a great variety of products or services for several customer segments, in various geographical areas and via different distribution channels. The idea of narrow market scope is to focus on certain customer segments, geographical areas, distribution channels and products or services. The main advantage of a narrow

[4]cp. Porter [1980], p 35 ff

market scope is that products are matched with certain customer segments. Products from companies, who follow a broad market scope strategy, may ignore or only partly fulfill the needs of certain customers.

Michael Porter discussed the idea that following not one, but more than one strategy will lead to a loss of the focus of the enterprise. He names that position *Stuck in the Middle* and says it would be a weak strategic position. On the one side, enterprises may not have enough investments to play a major role in the area of cost competition. On the other side, enterprises may not have enough differentiation to bypass the area of cost competition.[5]

ACC is an industrial enterprise, which operates on a global scale and provides products, mainly automatically produced, to its customers. The company is a TIER 1 supplier and its products are cooling compressors used in household refrigerators. Household refrigerators can be divided into four types where the products of ACC are used: fridge, freezer, wine-cooler and fridge-freezer-combination. The average life time of a cooling compressor is ten to twelve years. This is also the same period of time for an entirely new cooling compressor platform to be launched on the market by ACC. Every three to four years, the platform will be upgraded. Platforms can be differentiated by their cooling capacity range, performance range and coefficient of performance (COP). ACC produces its products in high cost countries. Its competitors mainly produce in low cost countries and those fight for the overall cost leadership position. If the company would compete for the overall cost leadership position, it eventually would find its place stuck in the middle. The company's strategy is to expand its market position through differentiation by being the technology leader in the industry. To fulfill their need for the technology leader, the performance parameters of ACC's next compressor platform shall be increased enormously. ACC set a target of a >20 % COP-increase, instead of a 8 to 12 % COP-increase which is usual in the market.[6]

By now, the company integrated another phase into the development process for ensuring a target of a >20 % COP-increase. The phase is called *technology development* and its target is to generate knowledge about various applicable technologies. The technology development phase differs from the other product development phases in its lean structure, high creative scope for development and its broad, qualitative, defined development

[5] cp. Porter [1980], p 35 ff
[6] cp. ACC [2009], p 7 ff

targets. According to an internal audit, monitoring tools, which are currently used in the company, are unsuitable for the technology development phase.[7] Therefor, a monitoring tool is required to support the controlling of the technology development projects.

1.3 Target

The Target of this thesis is to provide a generic approach for integrating a monitoring tool. This generic approach shall be also applicable for prospective intentions of integrating software tools in ACC. Furthermore, an analysis and evaluation of several monitoring tools shall be done. The third target of the thesis is to develop a process for planning and controlling technology development projects. This process shall be designed according to Business Process Model and Notation (BPMN).

1.4 Approach

Generic process / generic approach for integrating a monitoring tool

At the beginning a literature study is done to gather information about problem solving methods. The literature study shall supply recommendations to develop a generic process. Expert interviews and workshops are done to discuss the findings from the literature study. According to the company's requirements and literature findings, a generic approach for integrating a monitoring tool is developed. The generic approach is discussed and adapted during final workshops.

Evaluation of several tools

A web search is done to gather information about several monitoring tools and to create a list of available monitoring tools. A first selection shall border the relevant monitoring tools for the company. Then, these monitoring tools are evaluated according monetary

[7] cp. ACC [2009], p 8

and non-monetary aspects. For monetary evaluation, a total cost of ownership approach will be determined by doing a literature study. After choosing a total cost of ownership approach, the analysis is done. For non-monetary evaluation, a value benefit analysis will be done for all tools.

Process for using the monitoring tool

For using the tool a process based on BPMN will be developed. Therefore, a literature study regarding BPMN requirements is done. Based on the findings processes for planning and controlling when using the monitoring tools is developed.

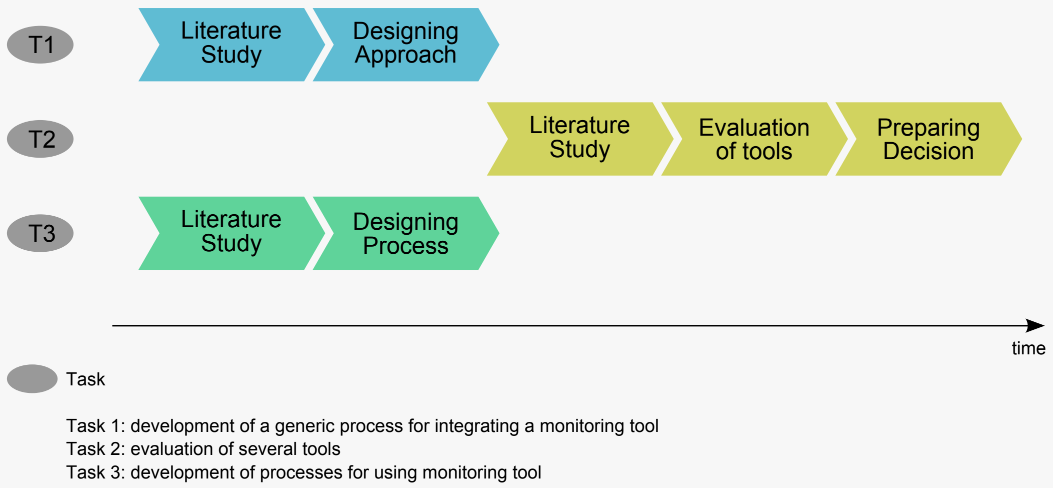


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Figure 1.5: Approach for elaborating master thesis

1.5 Classification regarding St. Galler Management Model

The St. Galler Management-Model consists of 6 basic elements, which combine all dimensions of management, whereby management can be seen as *designing*, *steering* and *developing* of purpose-oriented socio-technical organizations.[8] These 6 elements are:[9]

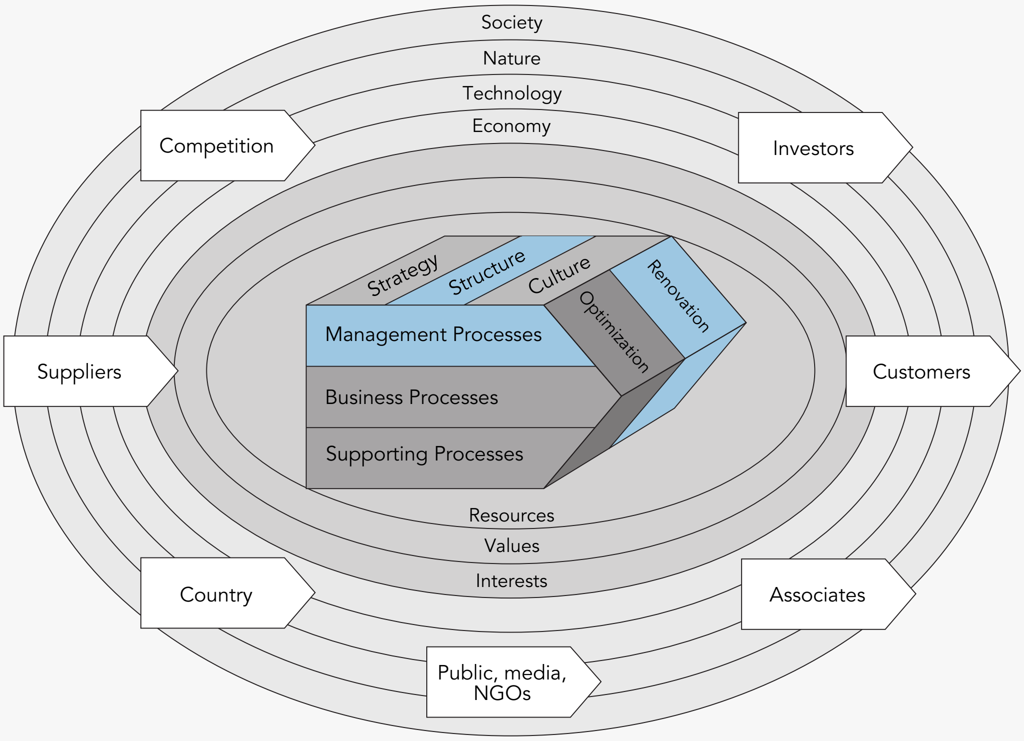
- **environment**: The company is in interaction with various topics in the fields of technology (e.g. biological and genetic engineering, process technology, materials, *energy generation*, ways of transportation etc.), economy (e.g. markets for procurement, for sale, for labor and financing), society (e.g. educational background, willingness to perform of the population, openness to new and unknown things etc.) and nature (e.g. wealth in natural resources like air, water, land area and raw materials etc.). The topics need to be analyized according their trends and changes.
- **stakeholders**: This element contains mainly two parts: stakeholders who define conditions and provide resources and stakeholders who are highly affected by the company's value creation. Stakeholders are all internal and external group of people, who are directly or indirectly affected by the company's activities.[10] Stakeholders secure the right to bring their interests to bear.
- **topics of interaction**: This element contains resources, values and interests. Between an organization and its stakeholders a number of courses of interaction take place. These topics of interaction are, on the one hand, elements with regard to people and their culture and, on the other hand, with regard to objects, the resources.
- **arrangement moments**: For an organization it is essential to provide the following output. First, the **strategy**, a strategic know-how for orientation, which enables the organization to align its targets and activities. It is about the *what to do*. To do the right things. For a long term success, all activities of the organization need to be coherent and need to be fine-tuned, which require a certain coordination. This is about the *How to do*. To do the things right. In other words, the organization needs a **structure**. Each individual of an organization needs some direction to act in particular cases according to the meaning of the whole. This is about the *Why to do* and *What for to do*. The organization would need a common vision and mission, a **culture**.
- **processes**: The fundamental idea of an organization is to acquire orders, so called input, to perform processes for transforming input into a certain kind of output and

[8] cp. Ulrich u. Probst [1995], p 261
[9] cp. Rüegg-Stürm [2004], p 69 ff
[10] cp. Amelingmeyer [2002]

to sell it to its products or services. We distinguish between management processes, business processes and supporting processes.

- **development mode**: A successful development of an organization is affected by stability and change, by uncertainty and reaffirmation, by appreciation of tradition and fearlessly breaking new ground. Mainly there are two dimensions in organizational change: factual level and relationship level. The factual level is about topics in business processes, in routines, in patterns, in strategy etc. The relationship level is about topics in belonging, in identity, in tenor, in quality and type of relationship, in patterns of interactions etc.

This thesis can be classified within the fields of management processes, structure and renovation, as seen in figure 1.6.



Source: based on Rüegg-Stürm [2004], p 70

Figure 1.6: Classification of Thesis regarding St. Galler Management Model

1.6 Structure

The thesis is structured into five chapters, see figure 1.7.

Chapter 1: Introduction

In the first chapter, a company description including corporate purpose, market data and historical development ist given. The target, the boundary conditions and the approach of the thesis are presented within this chapter.

Chapter 2: Fundamentals

Within the second chapter fundamentals regarding the thesis topics are covered. The used terminology is explained to provide a common understanding. The important controlling parameters, which are required for the monitoring tool, are presented in detail. According to the first task (development of a generic process for integrating a monitoring tool), several approaches for developing a generic process are described and evaluated. Finally, one approach is selected for developing a generic process.

Chapter 3: Generic approach for integrating a monitoring tool

In chapter 3, the development of the generic process is discussed. Based on the selected approach, the main key elements of the generic process are derived. Each phase of the developed generic process is described in detail.

Chapter 4: Applying generic process

In chapter 4, a description of the applied generic process is given. Thereby, for every phase detailed information regarding elaboration is presented. Within this chapter the evaluation of the monitoring tools is covered. This evaluation consists of a monetary and non-monetary evaluation. Furthermore, the developed processes for using the monitoring tool are discussed.

Chapter 5: Summary

Within the last chapter a summary of the entire thesis is given. All relevant findings and elaborations are exposed in a short overview.

Chapter	Short title	Content
1	Introduction	company description motivation and initial situation thesis target and approach for elaboration classification regarding St. Galler Management Model
2	Fundamentals	terminology controlling parameters approaches for developing generic processes
3	Developing generic process	description of the developed generic process
4	Applying generic process	elaboration of each step of generic process main focus: total cost of ownership and value benefit analysis
5	Summary	summarizing elaboration of entire thesis

Source: own representation

Figure 1.7: Structure of thesis

2 Fundamentals project and process management

Within this chapter the fundamentals regarding the thesis topic are discussed. Therefore, at the beginning several terms are clarified. According to the purpose of the monitoring tool, controlling parameters for projects are presented and discussed as well. Finally, several approaches to design a generic process for integrating a monitoring tool into the company are coverd.

2.1 Terminology

Within this section, the terminology, which is relevant for this thesis, is explained.

2.1.1 Project

In DIN – German Institute for Standardization, German: Deutsches Institut für Normung – standard series 69901 basics, processes, process models, methods, data, data models and terms regarding project management are described. The DIN 69901 title in original language is called *DIN 69901 - Projektmanagement : Grundlagen, Prozesse, Prozessmodell, Methoden, Daten, Datenmodell, Begriffe*. According to the DIN 69901 standard, a project is a temporary endeavor undertaken to create a unique product, service, or result. It is characterized by the uniqueness of the conditions in its entity. These can by a deadline, a target, a budget, human resources, cross-divisional teamwork, complexity, etc.[1]

[1]cp. DIN 69901 - Projektmanagement : Grundlagen, Prozesse, Prozessmodell, Methoden, Daten, Datenmodell, Begriffe

In literature you often find a similar definitions of a project. A project is an unique undertaking, starting at a specific date, ending at a specific date and having certain resources at disposal for reaching a specific target at a certain quality level.[2]

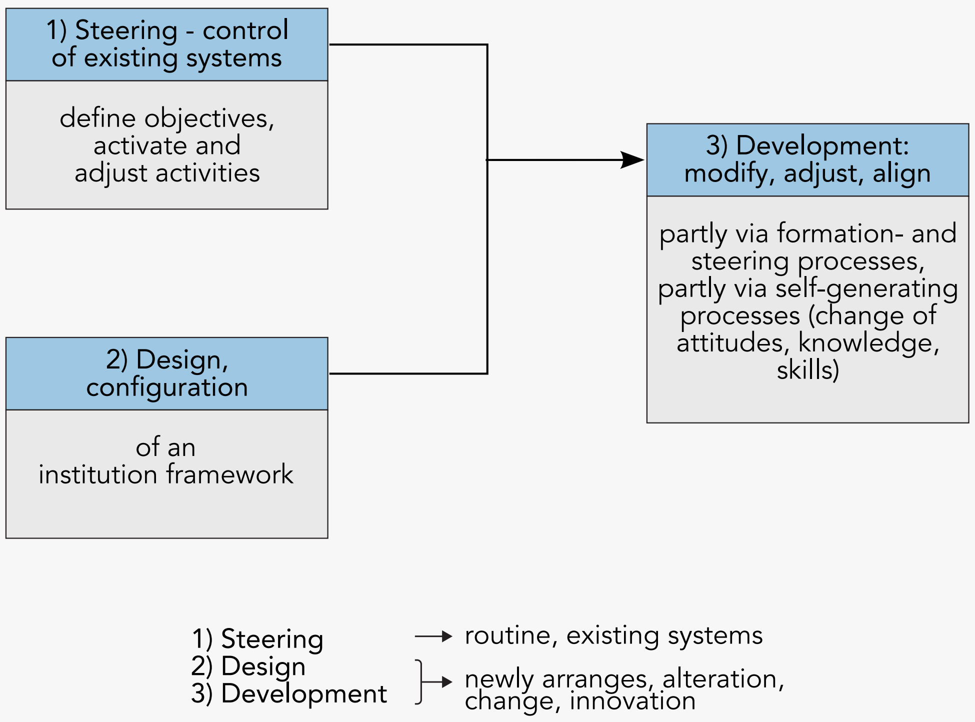
2.1.2 Management

The functions of management, according to Ulrich (1984),[3] are steering, designing and developing an organization, see figure 2.1. Steering is about defining objectives, activating and adjusting activities. Designing is the configuration of an institution framework. Developing is about modifying, adjusting and aligning of organizational topics partly via formation- and steering processes and partly via self-generating processes. Management as a function contains the sub-functions to plan and to think ahead, to decide between various possibilities of actions, to order, to control, to organize and to staff the right people at the the right position. The creation of will is done by planning and deciding. The accomplishment of will is given by ordering and controlling.[4]

2.1.3 Project Management

Project management, according to DIN 69901[5] is a set of management functions, organizational leadership, management techniques and resources for the execution of a project. Project management covers tasks regarding planning, organizing, controlling, steering and leading people of a project. In the execution of project management, it deals with a comprehensive planning, defining targets and supervising the progress of the project. Additionally, staffing, decision for an organizational model and integration of the project into the company hierarchy.[6]

[2]cp. Bea et al. [2011], p 30 f, Litke [2007], p 19 f and Kessler u. Winkelhofer [2004], p 9 f
[3]cp. Ulrich [1984], p 114
[4]cp. Haberfellner [2011], p 19 and Rüegg-Stürm [2003], p 22
[5]cp. DIN 69901 - Projektmanagement : Grundlagen, Prozesse, Prozessmodell, Methoden, Daten, Datenmodell, Begriffe
[6]cp. Litke [2007], p 20 f, Kessler u. Winkelhofer [2004], p 10 f and Haberfellner [2011], p 3-161 f



Source: Haberfellner [2011], p 19

Figure 2.1: Functions of management: directing, creating something new, and changing

Project Planning

A project starts with comprehensive planning. First of all, an analysis of the initial situation regarding the project topic and project environment is done. Targets of the project are defined according to the rule of *SMART*:[7]

- Specific: The goal shall tell a project team what is expected from them, why is the project relevant and important, who is involved in the project team and has influence on the project, where the project takes place and which resources, requirements and constraints it has. A specific goal covers the five *W*-questions.
- Measurable: The idea is to measure the progress and the final results of the project.

[7] cp. Horine [2012], p 53

If a goal is not measurable, it is not possible to know whether you make progress or even reach the desired goal. Measuring shall support the team to stay on the right path, keep deadlines and meet goals. The goal shall tell a project team how much of what needs to be accomplished.

- **A**chievable: A goal shall be on the one side attractive respectively ambitious and on the other side achievable. It shall encourage team members to stay motivated to reach the goal, which is within reach. The goal shall tell the team how to accomplish the goal.
- **R**elevant: This is about defining goals that matter. A goal shall represent an objective you are willing to work towards. If a goal is relevant to the team, the project manager, department manager and organization, the team will get the required support to overcome obstacles and the team will stay motivated.
- **T**ime-based: Time-based goals are about a commitment to a deadline. It is essential for the success that everyone in the team is aware of when the goals have to be accomplished. In best cases a time-based goal is given with numbers of a year, month, day and even a time.

When doing the target definition of the project, the main requirements of the project, the criteria regarding the final target check and dissociations from other projects are described. Threats and obstacles, which may risk the target, are identified. Measures to handle these risks are defined too. This is done in the risk analysis, where probability of occurrence and measures of damages are evaluated. Preventative measures and measures for cases of occurrence are elaborated.[8]

A structural planning will divide the project into its technical aspects, economical aspects and aspects with regard to its tasks parts. The technical aspects are covered through a so called product structure and it contains each component of the product or system, which needs to be developed. Work planning covers all relevant work packages to be done for accomplishment of the project. Work packages and project schedule with milestones go hand in hand. The structured work packages integrated in a project schedule is a basis for a full project planning. An estimation of expenditures and project costing give significant information about financial expenditure for the project. Finally, resource planning completes the project planning. Resource planning is relevant for allocating the

[8] cp. Schelle [2010], p 45 f and Burghardt [2007], p 14

needed staff with certain knowledge and experience and allocating the needed working environment.[9]

Project Realization

A detailed planning of the project is still done during project realization. Work packages are described in detail and the project team members work on their work packages. During the realization, the team expends financial resources, the team consumes parts of the allocated working hours on its way to reach the target. Threats and obstacles may occur and these need to be handled by a risk management. In this phase, project controlling initially comes up. Project controlling is a major part of project realization within project management and is discussed later in this document. As the project goes on, intermediate results as well as final results will be achieved. Communication within the team, towards the project manager and the project environment is essential. Mainly communication is done in meetings and project reports.[10]

Project Closing

At the end of the project, the project manager assures that the targets and results are accomplished at certain agreed quality standards. The project initiator formally approves the actions of the project manager. A final meeting takes place, the course of the project, expierences, findings and suggestions for improvement are discussed. A final calculation gives information about the actual project costs. After the project closing the project organization is closed too.[11]

In the context of project management, project controlling and project monitoring play an essential role. In figure 2.2 the targets and the interactions of project management, project controlling and project monitoring are schematically illustrated. In the next sections, project controlling and project monitoring are discussed.

[9] cp. Burghardt [2007], p 14, Burghardt [2007], p 77 f and Litke [2007], p 83 ff
[10] cp. Burghardt [2007], p 15 and p 158 ff and Litke [2007], p 85 ff
[11] cp. Burghardt [2007], p 257 ff

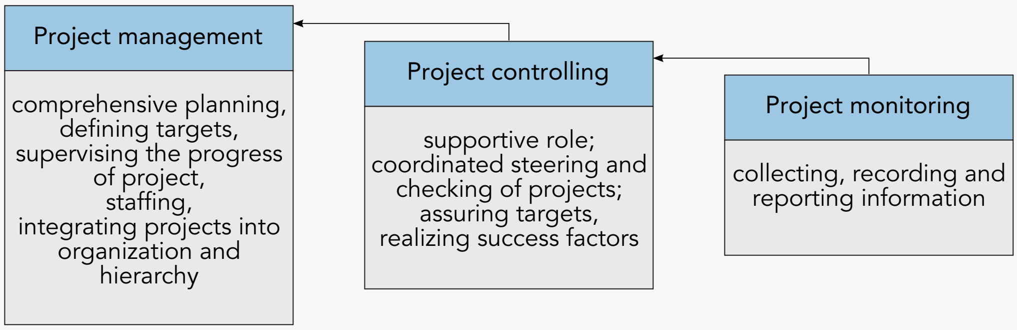


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Figure 2.2: Targets of Project Management, Project Controlling and Project Monitoring

2.1.4 Project Controlling

Project controlling has a supportive role within a project for the project manager and the project team. It is a coordinated steering and checking of the entire project portfolio, of each single project. The aim of project controlling is to assure planned and agreed targets, to realize success factors and to avoid organizational and individual losses. Within its function as steering, controlling supports the operative and strategic management. Within its function as checking, controlling reviews and adjusts aspects with regards to content, finance and form.[12]

The targets of controlling with regards to form are to grant the observance of legal, contractual and in-house rules and agreements. These are e.g. agreements for reporting, documentation and contract design. Furthermore, rules for records, review dates, rights and obligations of the parties, project orders etc. Controlling with regards to content focuses on target achievement, quality assurance, work breakdown structure, work packages, meeting of deadlines and staffing. Controlling with regards to finance covers budgeting, checking and supervision of consumption of resources and investments. Additionally, financial controlling is asked to do feasibility studies, risk analysis and to take preventative measures.[13]

[12] cp. Koreimann [2003], p 18 f and Brecht [2001], p 215
[13] cp. Koreimann [2003], p 19

2.1.5 Project Monitoring

Project monitoring is collecting, recording and reporting information (so called project variables or indicators of projects) concerning project performance that project manager and others wish to know. Project controlling, as discussed above, uses these information and measures are derived to ensure the achievement of targets.[14]

2.2 Controlling parameters[15]

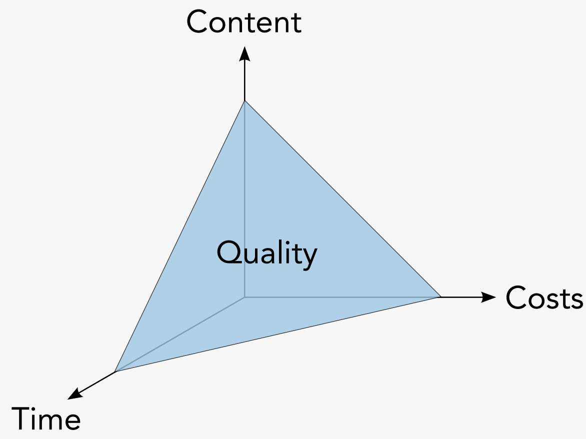
For managing projects, the so called magic triangle characterizes the three main important influencing factors on the quality of the project: content, costs and time, see figure 2.3. These three aspects interact with each other and they need to be balanced. If one of them is being changed, the other two need to be adjusted as well, to keep up a balance. If the project shall be finished more rapidly, higher expenditures (costs) respectively a reduction of the scope (content) needs to done. If the resources are limited, either the duration (time) needs to be elongated respectively the scope (content) needs to be cut. If the results are more ambitious, more resources (costs) and a longer project duration (time) are required.[16]

According to the magic triangle and to Burghardt, in project management mainly four indicators are monitored: time, costs, progress and quality. These four important indicators are discussed in the following sections.

2.2.1 Schedule Review

The schedule has mainly two functions. First, in the planning phase, it shows the full timeline of the project, of each single work package and transparently illustrates all interactions with regard to deadlines. Second, in the project execution phase, the schedule is relevant of the project controlling. Constantly supervising of planned and actual timeline values is the basis for decision making.

[14] cp. Lewis [2006], p 185 f
[15] cp. Burghardt [2007], p 170 ff
[16] cp. Wytrzens [2010], p 25 f



Source: Wytrzens [2010], p 25

Figure 2.3: Magic Triangle in Project Management: Content, Costs, Time, Quality

For a professional project process it is essential, that each team member reports the actual process with regard to deadlines of the tasks. A cycle needs to be set up, within information about the current status of the work packages is reported. This is relevant to determine whether a deadline can be met, the deadline cannot be met or the deadline shall be brought forward.

Considering all status information of all work packages, the project manager will then decide how to proceed with each work package. Usually, the team can deal a single delay of a work package, whereby the entire project deadline is still out of danger. If there are single work package deadlines in danger, the project manager may then decide to allocate new or more personal resources. If all possible options are exhausted, a postponement of the project deadline will be considered. A feedback regarding deadlines shall be designed around the following four aspects. It is essential that everyone is clear about, who reports to whom, feedback cycle (every week, every month etc.), which information to which work packages need to be reported and how are the information treated.

In practice, the feedback giving process (reporting) is done by forms and consists of the following information. A feedback shall cover title of project or sub project, number and title of work package, department and responsible person, date, changes of deadlines, reasons for deadline changes and remaining expenditures. Depending on the work package status, the project manager will decide, whether to allocate additional personal resources, to increase temporarily working hours, to improve application of tools and methods, to optimize work processes and / or to cut targets. Beside these interventions, a project can also be changed regarding its timeline, e.g. start date, duration and end date. A postponement of deadlines is mainly caused by lack of personal resources, qualitative weaknesses of people, unforeseeable difficulties in problem solving processes, estimation of the required effort was unrealistic, new, unnoticed dependencies, or additional requirements of the project.[17]

2.2.2 Expenditure and Cost Control

An overview of expenditures, both personnel, internal (expenditures related to costs for internal development tasks e.g on machines) and financial, is highly relevant. The mentioned types of expenditures have two things in common. First, they are limited and second, they are spent advisedly. A requirement is, that both are recorded regularly and completely. In enterprises, personnel expenditures, mainly consumed person-hours of employees, are recorded via data processing systems. The daily work time recording is often done via a centralized chronology. Spend working hours on projects are often manually recorded via a special software.

The objective of a chronology is to record person-hours (person-hours portray working hours of employees) related to specific work packages. Financial expenditures portray expenditures for materials, consultants, suppliers and other external expenses. A meaningful recording of personnel expenditures shall cover the consumed person-hours of each employee regarding:

- work packages,
- phases of development or milestones and
- type of tasks.

The attendance time of each development engineering of the company ACC is defined with 1,760 person-hours per year[18]. Personnel expenditures are either considered as person-hours or as internal financial costs. The latter is also known as internal hourly

[17] cp. Gido u. Clements [2009], p 388 f
[18] cp. ACC [2012b], p 4

rate and it needs to be calculated even considering costs for the work place. Hourly rates for internal developers include costs regarding:

- personnel,
- vacation money, social insurance contribution etc.
- work place including depreciation for investments, buildings, rooms, machines, equipment etc.
- communication and
- work place related services (maintenance, cleaning etc.)

Expenditures with regard to internal development tasks are e.g. costs for usage of machines, for prototyping, for materials and for other internal services mainly caused by cross-departmental cooperations. During a technical development, several machines are used and the used period of time is often compensated by operating rents. Prototyping is highly cost-intensive and personnel-intensive. Materials, auxiliary material and other internal services (e.g. usage of labs) are also covered via internal costs.

Financial expenditures are related to costs caused by external service providers, institutions or companies who provide expertise, materials, services etc to the enterprise.

2.2.3 Progress Control

There is one major difference between the progress control and the control of costs, expenditures or deadlines: no suitable indicator for progress controll. A progress control may refer to a product progress or to a project progress. In contrast to progress control of a project or a quality assurance, the product progress control relates to the content of the development progress. The possibilities for controlling of the product progress is restricted to the requirements regarding performance, functions and structure of the product. A product progress control is generally a part of the development department.

The major question for a project progress control is the degree of completion of the required development tasks. The degree of completion is a function of the completed volume of work in relation to the total volume of work. An important challenge is to define the completed volume of work. This is most commonly a question with a subjective answer. Shortly before the project will be finished in time, a fulfillment of the planned result is often suggested, whereby the plan has been overran already. That shall mean, the final 10 % of the volume of work requires more than 40 % of the time. Reasons for such misinterpretations are:

- The effort for the work still due is extensively underrated.
- The share of completed volume of work in relation to the total volume of work is overrated.
- Future challenges are either not noticed or played down.
- Failures in meeting deadlines are crowded.
- Statements of developers drift off the reality, due to manager's pushing.

The degree of completion of required development tasks can be calculated in two ways: either to get the relative degree of completion or the get the absolute degree of completion. To calculate the relative degree, it is essential to put the degree of completion of each work package in relation to its volume of work, as demonstrated in table 2.1. To calculate the absolute degree, you need to put the degree of completion of each work package in relation to the entire volume of project work, as demonstrated in table 2.1. When calculating the absolute degree of completion, it is not relevant *how much percent a task is completed*, it is only relevant *if the task is completed*. The binary given question only asks for a *yes* or *no*.

2.2.4 Quality assurance

An important requirement for a development of products is the product's quality assurance over the entire development process. Relevant criteria for product quality are e.g. reliability, fulfillment of functions, ease of use, maintainability, environment-friendliness and efficiency.

Each quality criteria needs at least one parameter and for each parameter target values need to be defined. The criteria *reliability* can be found in e.g. downtime (max. 30 minutes per year), duration for each task (max. 2 seconds) or restart time (max. 30 seconds).

Table 2.1: Relative and absolute degree of completion (Source: Burghardt [2007], p 201)

Example A: relative degree

Tasks	Hours	Completion		
work package 1	1,000	25 %	→	250
work package 2	3,200	60 %	→	1,920
work package 3	2,000	100 %	→	2,000
work package 4	2,800	75 %	→	2,100
Project	9,000	70 %	⇐	6,270

Example B: absolute degree

Tasks	Hours	Completion		
work package 1	1,000	no		
work package 2	3,200	no		
work package 3	2,000	yes	→	22 %
work package 4	2,800	no		
Project	9,000	22 % completed		

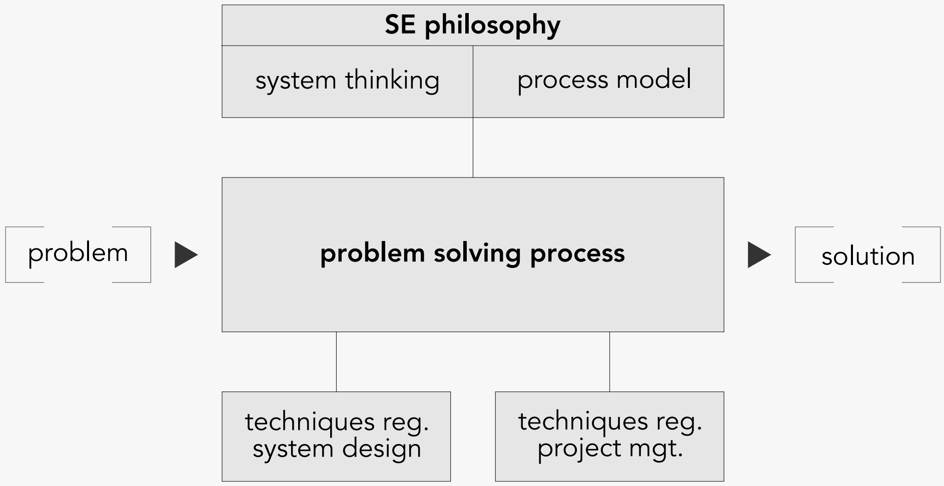
2.3 Approaches for developing generic processes

For developing a generic process, within this section the systems engineering approach according to Haberfellner et al., the Plan-Do-Check-Act-Circle according to Deming and a general problem solving process according to Jakoby are discussed

2.3.1 Systems Engineering[19]

The systems engineering concept consists of two main components: systems engineering (SE) philosophy and problem solving process. The concept of SE is schematically illustrated in figure 2.4. The SE philosophy is a notional framework of SE, whereby SE philosophy is divided into system thinking and process model. The problem solving process is the process to transform the current state of a system into the target state and it can be structured into system designing and project management.

[19]cp. Haberfellner et al. [2012], p. 28 ff



Source: Haberfellner et al. [2012], p 57

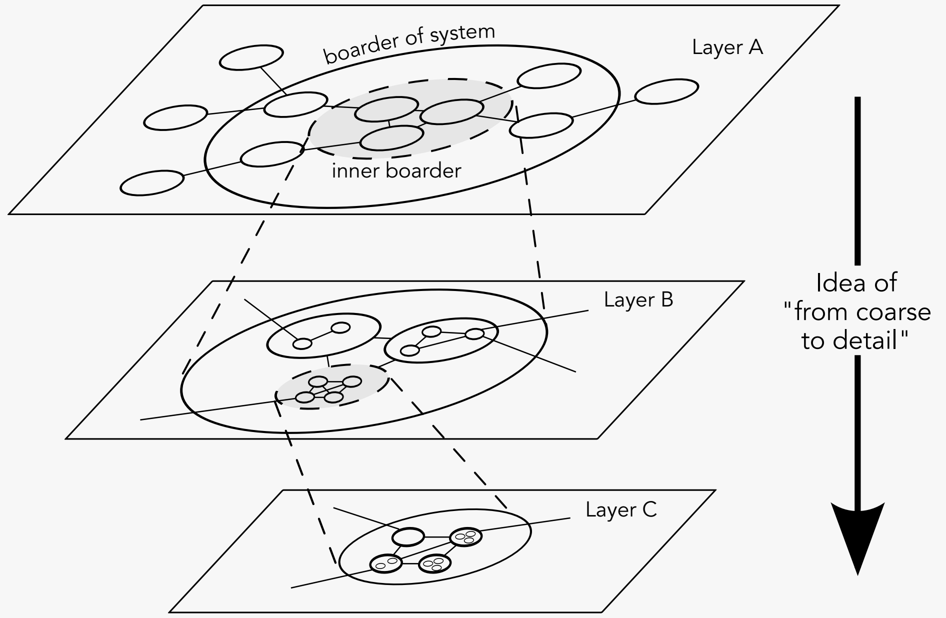
Figure 2.4: Concept of systems engineering

Systems engineering philosophy

Systems engineering philosophy, as mentioned above, consists of system thinking and process model. These two parts are discussed in the following section, starting with system thinking.

System thinking is a way of thinking to support a better understanding and designing of complex phenomena, so called systems. A system consists of building blocks, the elements. In figure 2.5 a schematical illustration of a system is given. Elements have characteristics and specific functions which affect the system. The elements are in relationship with other elements. They may be linked due to material flow relationship, information flow relationship, position relationship etc.

A system is more or less marked off from its environment. In the environment there may be elements, there also may be other systems and peripheral systems. Peripheral systems have influence on the system but also can be influence by the system. A combination of multiple systems within an aera to an overall system is called super-system. There are several ways to view a system: environmental-orientated, input/output-orientated and structural-orientated:



Source: Haberfellner et al. [2012], p 57

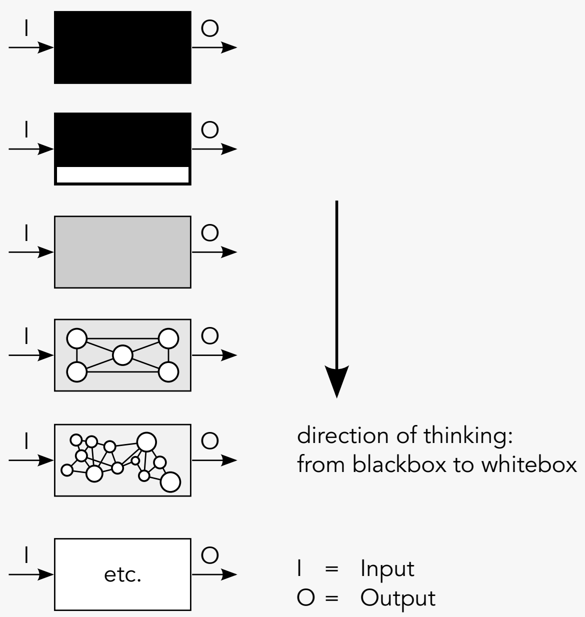
Figure 2.5: Schematical illustration of a system

- An **environmental-orientated view**, considers e.g. customers of an enterprise, competitors on the market, government, society etc.
- An **input/output-orientated view** is about the input, the output and the transformation from input to output. For example it is about material balances, what is brought into the transformation process, how is it transformed and what is the result of the transformation.
- A **structural-orientated view** considers the constitution and the structural correlation within the system. Elements are analyzed regarding their connection to each other, whether the connections are process-related, flow-related etc.

The systems engineering **process model** covers four recommendations, which are discussed in more detail below: *from coarse to detail*, *thinking in variants*, *chronological process* and *problem solving process*.

From coarse to detail

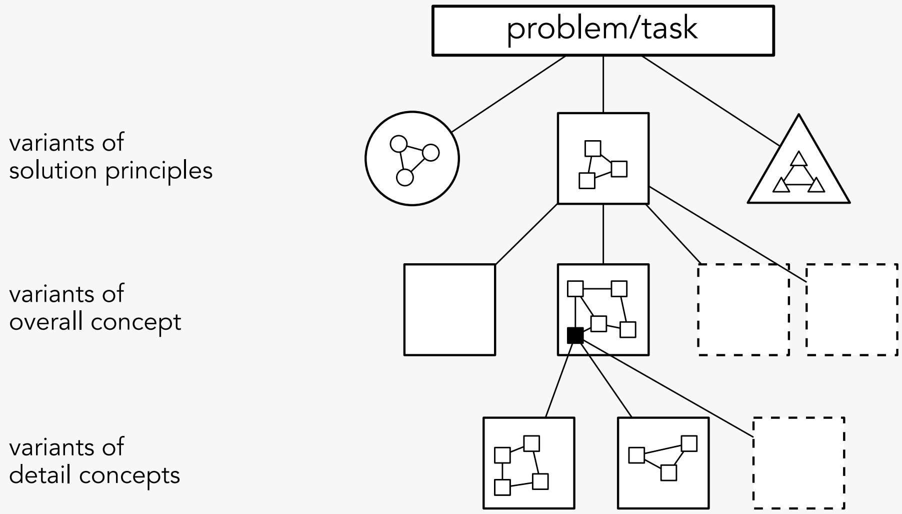
The basic idea of from *coarse to detail* is to start with a black box system and gradually dissolve it to grey and white boxes. Initially, the key aspect of a system is carved out and the system is bordered. In figure 2.6 the basic idea of *from coarse to detail* is shown schematically. The key drivers shall be identified at the beginning and according to systems thinking, the system shall be structured into its elements, supra-system, peripheral system etc. After clearly structuring and carving out the problem, quantitative and qualitative analysis can be done.



Source: Haberfellner et al. [2012], p 58

Figure 2.6: Idea of *from coarse to detail*

Thinking in variants For every assignment of tasks or problems there are multiple ways to solve it. By *thinking in variants* one gets a preferably comprehensive overview of various ways to solve a problem. Thinking in variants is applied to every single hierarchy level, starting with the very top and ending at the very bottom level according to *from coarse to detail*. In figure 2.7 the basic idea of *thinking in variants* is shown schematically. Being able to choose a variant, one shall clearly understand the attributes of each variants and the consequences related with the chosen variant.



Source: Haberfellner et al. [2012], p 62

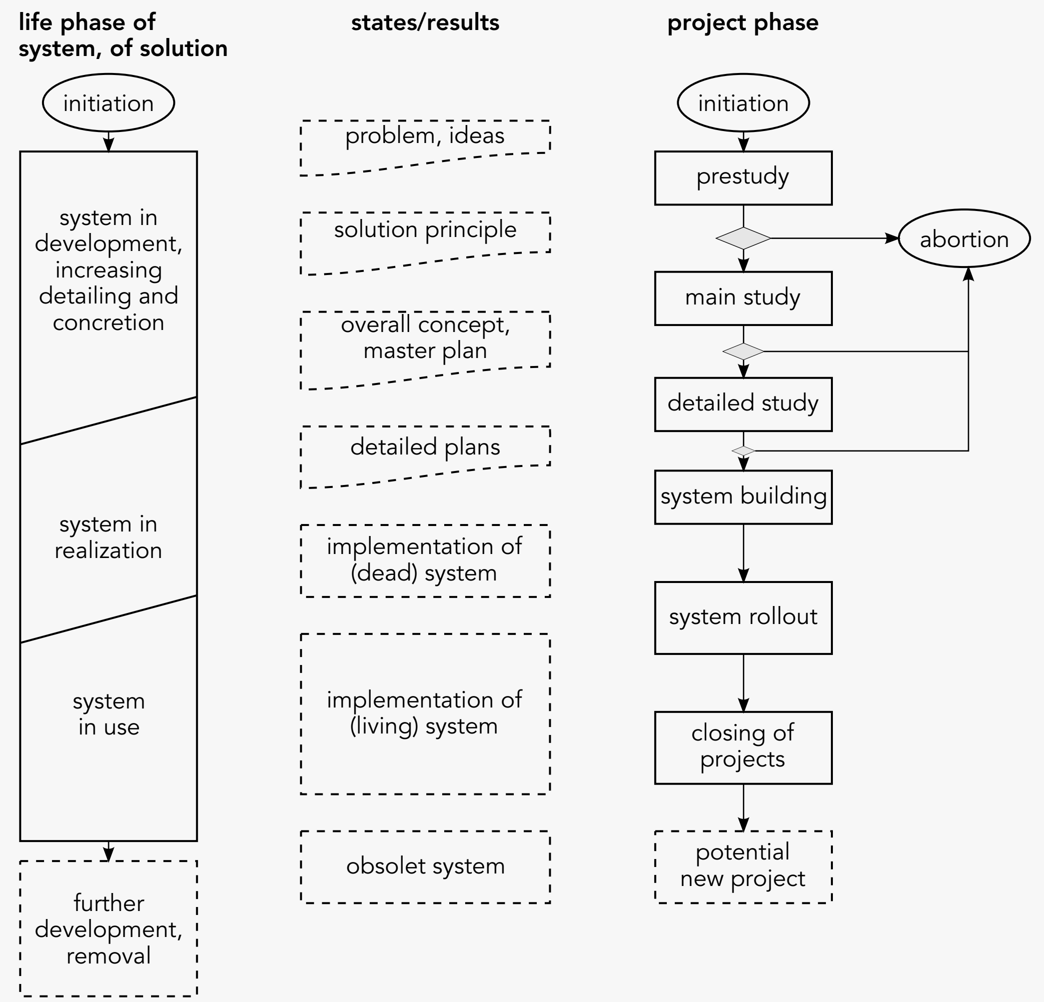
Figure 2.7: Idea of *thinking in variants*

Chronological process

The idea, to develop and realize a solution when structuring the process into single phases, collectively a *chronological process*, is a concretion of *from coarse to detail*. A system, a solution, undergoes the following life phases after initiation: system in development, system in realization and system in use. In figure 2.8 the life phases, their results and the project phases are shown schematically. The project phases are a prestudy, main study, detailed study, system building, system rollout and closing of project.

Initiation

The initiation is the time frame between the first notice of a problem and the decision to take steps agains the problem. The notice of a problem is a discomfort with the current situtation and more or less vague ideas of solution to cover the problem. Highly important to get a prestudy started, is the acceptance of the initiation by the responsible person, whether the initation is set in motion or not. The initiation will be a short phase and ends when the prestudy is launched. During the initiation, adequate personnel and resources are reviewed for availability.



Source: Haberfellner et al. [2012], p 65

Figure 2.8: Idea of *chronological process*

Prestudy

The purpose of the prestudy is to clarify, by investing an arguable effort, how far the scope of analysis is set, which mechanisms occur within the problem field, what the root cause of the problem is, what kind of requirements are underlaid, which principle solutions are thinkable and mainly which concept to follow in the main study.

Main study

During the main study the structure of the entire system is concretized. The purpose is to develop variants of the entire system, which allow a funded evaluation regarding the functionality, convenience and profitability. The result shall be a fully elaborated concept which covers a master plan for the next phases, support decisions for investments, definitions of sub-projects and priorities for executing detailed studies.

Detailed study

The purpose of detailed studies in terms of systems engineering is to elaborate detailed concepts of solutions for sub-systems. Furthermore, to make decisions according to variants of solutions and to concretize solutions in a way so they can be integrated easily.

System building

During system building phase the studies and plans are realized, e.g. raising buildings and equipments, programming code for software including documentation etc. When the entire system is built, the integration takes place and several tests are done.

System rollout

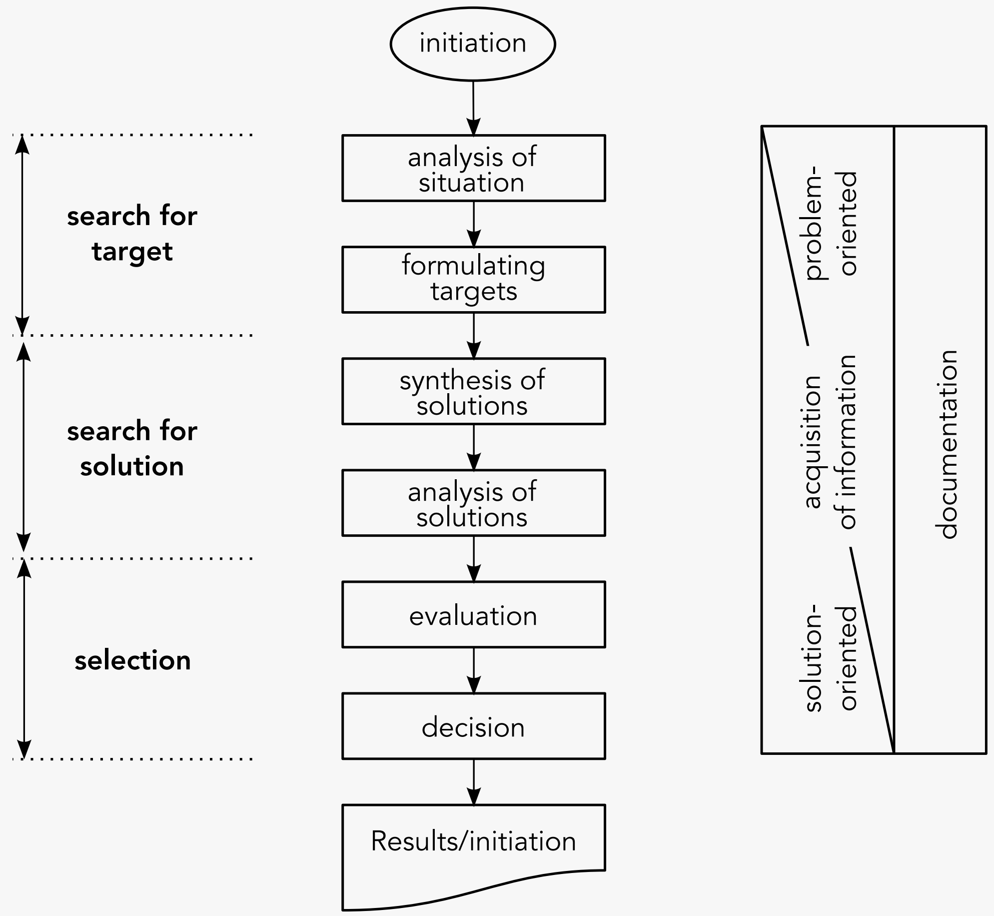
During system rollout, the developed solution is placed into operation and several steps for operating and maintaining the solutions are taken.

Closing of project

After the solution is handed over and into operation, some closing steps need to be executed: final accounting of the project, thinking of lessons learned and disbanding the project team.

Problem solving process

According to Haberfellner, the **problem solving process** may be applied for any kind of problem. The three main aspects of the problem solving process are: target definition, search for solutions and choosing a solution. The steps of the process are: initiation, formulating targets, analysis of situation, synthesis of solutions, analysis of solutions, evaluation, decision and closing. In figure 2.9 the problem solving process is schematically shown. Below the problem solving process according Haberfellner's systems engineering approach is described.



Source: Haberfellner et al. [2012], p 74

Figure 2.9: Idea of *problem solving process*

Analysis of situation

After the initiation, the process starts with an analysis of the situation. The purpose is to get comfortable with the initial position and tasks. Clarifying the boundary conditions for the solutions is essential in this step. During analysis it may be possible that the perception of the target changes.

Formulating targets

The purpose of formulating targets is to summarize the intention for problem solving. It is reasonable that the target formulation shall be neutral to the solution, comprehensive, accurate and realistic. In section 2.2 the main characteristics for formulating targets are discussed. There are three kinds of targets: necessary, desired and requested targets. Necessary targets are essential, desired targets are nice to have and requested targets are not essential but more important than nice to have.

Synthesis of solutions

When thinking creatively and constructively, the step of synthesis of solutions starts. The purpose is to develop several variants of solutions. They may be concepts, drawings, drafts etc. In this step, creativity techniques may be useful.

Analysis of solutions

The analysis of solutions is a crucial, analytical-destructive part. The purpose is to verify, whether a solution meets the requirements or whether it has some weak points. In particular, the task is to check formal criteria, whether necessary targets can be fulfilled, whether significant parts of the solutions are not elaborated as it was required, whether the solution meets safety, handling, maintainability aspects etc.

Evaluation

The main purpose of the evaluation of all solutions is to oppose systematically each solution to each other. Based on the target formulation, the solutions are evaluated. Furthermore, functionality, characteristics etc are evaluated in detail. The result of the evaluation shall be a ranking of solutions regarding their suitability.

Decision

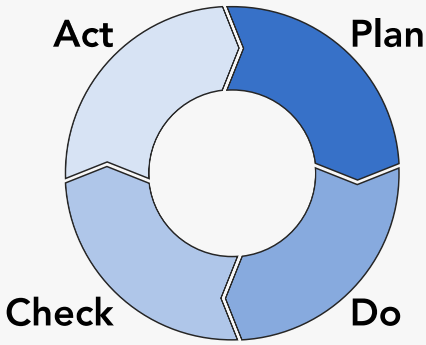
Based on the evaluation a decision needs to be made regarding which solution will be used.

Results, closing and further initiation

Based on the results, the current project will be closed or another project will be started.

2.3.2 Plan-Do-Check-Act circle according to Deming

W. Edwards Deming developed a circle process for problem solving. By designing the problem solving process as a circle, Deming pointed out the importance of a never-ending improvement potential and process within a company. The first step in the problem solving process is a planning phase, where an entire e.g. project needs to be thought through. The second step is the execution phase. The plan is realized, in other words, *it* shall be done. During and after execution it is necessary to check the progress. To check whether the considerations according to the realization, which were done in the planning phase, meet the actual conditions. In the checking phase, the actual values are compared with the target values. Furthermore, it shall reveal discrepancies between actual and desired progress or outcome. Finally, against the discrepancies some measures are required to be done. According to the names of each phase, the problem solving circle is called *PDCA-circle* or *Deming-circle*. In figure 2.10 the Deming-circle is illustrated.[20]



Source: based on Sandrino-Arndt u. Thomas [2012], p 443

Figure 2.10: Deming circle as problem solving process (cirlce)

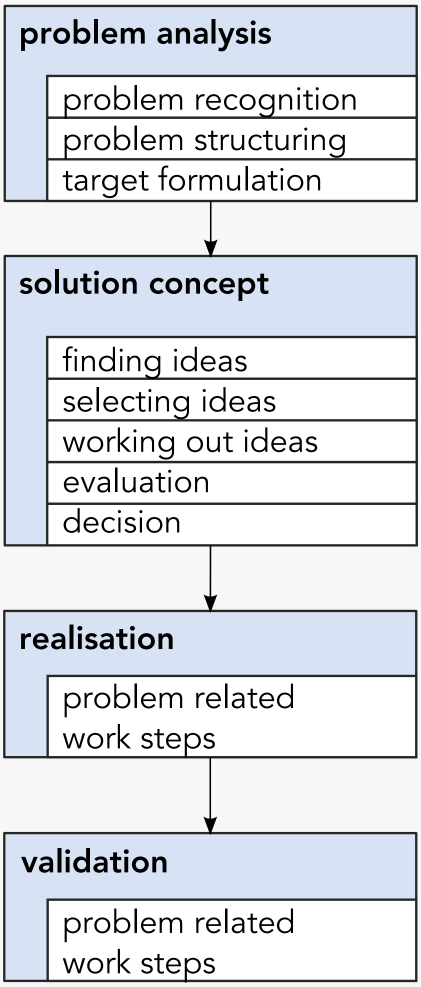
Deming underlines the concept of continuous improvements. The Deming circle shall be also considered as continuous improvement process in quality management. Continuous improvements will inevitably lead to cost reductions, shortening of project respectively production step durations. In total continuous improvements will cause company's success.[21]

2.3.3 General problem solving process according to Jakoby[22]

Jakoby (2013) writes, that in each elaboration of solving a problem, people find similar sequences of work. He defined these similar sequences of work and designed a general problem solving process. In figure 2.11 a general problem solving process according to

[20]cp. Spalding [2007], p 29 f and Sandrino-Arndt u. Thomas [2012], p 443 f
[21]cp. Seghezzi et al. [2007], p 20
[22]cp. Jakoby [2013], p 35 ff

Jakoby is schematically illustrated. The process consists of two planning phases and two execution phases. The planning phases cover problem analysis and a solution concept. Both phases can be further structured into several steps.



Source: based on Jakoby [2013], p 36

Figure 2.11: General problem solving process according to Jakoby

The very first step of the problem analysis is a recognition of the problem, the awareness that a problem exsists. During the next both steps, the structuring and target formulation, the involved people gradually get a clear understanding of the problem. The final result of the problem analysis phase is a thorough and precise formulation of the problem. In the next planning phase, the solution concept phase, the target is to elaborate proper solutions. By doing that, finding several suitable ideas is relevant. These ideas need to be roughly evaluated and furthermore, selected. The selected ideas will then be worked out in detail. The final evaluation is based on detailed facts about the ideas, which shall allow a proper decision making. The planning phases end, after deciding with which solution shall be further continued.

The realization phases cover both realization itself and validation. During the realization, the solution shall be elaborated. After removing the problem by implementing a solution, a validation shall give information whether the problem was solved properly or not. Furthermore, during the validation the problem solving process shall be analyzed and evaluated. Thereby, questions regarding mistakes made, experiences gained and insights obtained shall be answered. These answers will help to improve problem solving processes in the future.

2.3.4 Concluding Comment

An approach for developing a generic process is required to be defined. The three discussed approaches within this section are commented afterwards based on the literature study and evaluated regarding their suitability. The evaluation is based on the following three criteria: content, structure and practicability. The evaluation was done during a workshop with the management of the company.

- **Structure**: How good is the approach structured? How much effort is required to apply the approach's structure?
- **Content**: Does the approach support a clear understanding of how a generic process shall be developed? Does the approach provide comprehensive and detailed information or are the information merely from a bird's eye view?
- **Practicability**: How good does the approach fit to the company's needs, wishes and requirements for developing a generic process?

General problem solving process according to Jakoby

The general problem solving process's structure is comprehensible. The tasks of each phase are constitutivly designed to the previous phase. All four phases together form a collectively exhaustive process. It is remarkable that the process ends with a validation of the solution and lessons learned. Although the structure of the approach is exemplary, the content of the approach is less comprehensive in comparison with the systems engineering approach. The working steps of each phase are coherent and self-explanatory. However, an extensively deep and broad scope of each step is not given in comparison with systems engineering. Secondly, a framework for e.g. analysing a problem is not provided. The frameworks shall support the design of the generic process and later the application of the generic process.

Deming circle

The structure of the Deming circle is comprehensible. The process starts with the planning phase and ends with an validation and measures for re-aligning the execution to the plan or adapting the plan to the given circumstances. The last phase of the Deming circle, the *Act*-phase, symbolically stands for a continuous improvement process. The approach's content is fordable. Although, the structure is exemplary, the content allows many ways of interpretation. This could be very disadvantageous, because during process designing a designer could drift off the path. Additionally, a second level path (working steps, as it is given in the general problem solving process according to Jakoby) is not given at all. The practicability of the Deming circle might be highly given for quality problems, as it is said in Seghezzi et al. (2007).[23]. The practicability for designing a generic process might be less common.

Systems Engineering according to Haberfellner et al.

Comparing to the other approaches, systems engineering is the most comprehensive approach. Systems engineering provides a proper first level path (phases) and defines several working steps. The approach starts with an initiation and ends even with an validation respectively a launch of a new project. The content of the systems engineering concept is coherent and self-explanatory. Furthermore, an extensively deep and broad scope of each framework (e.g. the four recommendations) is given. The frameworks support the designer to think of several possibilities on the path and off the path. The approach provides a systematical course of action for problem solving which can be properly used

[23]cp. Seghezzi et al. [2007], p 20

to design an own problem solving process. The systems engineering approach has been used in the company for several years. Based on the experience with systems engineering, the practicability for designing a generic process is highly given.

Results of qualitative evaluation of approaches

Having gathered and discussed the information given above, a qualitative evaluation was done by the management. The results of this qualitative evaluation are illustrated in figure 2.12. The results lead to the conclusion that the systems engineering approach will be used for designing a generic process for integrating a monitoring tool.

	structure	**content**	**practicability**
Systems engineering by Haberfellner et al.	●	●	●
Plan-Do-Check-Act circle by Deming	●	○	–
General problem solving process by Jakoby	●	○	○

● entire fulfillment
○ part fulfillment
– no fulfillment

Source: own representation

Figure 2.12: Results of qualitative evaluation of approaches

3 Generic approach for integrating a monitoring tool

After having discussed the fundamentals regarding the thesis topic and having defined an approach for developing a generic process, this chapter covers the development of a generic process. The main purpose of the generic approach is to provide a direction select for finally having a monitoring tool integrated into the company. Therefore, it shall support a guidance about what phases need to be run through and what tasks are required to be done.

The realization of the four recommendations according to systems engineering for the generic approach is covered as discussed below:

- *from coarse to detail*: The idea of *form coarse to detail* is transformed into a first rough evaluation to filter relevant monitoring tools and to a second, detailed evaluation based on a comprehensive tool analysis
- *thinking in variants*: The idea of *thinking in variants* is transformed according to ways of analysis the current situation, evaluating several tools and later according to a make-or-buy decision for the tool.
- *chronological process*: The idea of *chronological process* is transformed by structuring the generic approach into single phases. The first part is an analysis and development of the *system*, in this case of the tool. The second part is a realisation and the third part is the use of the tool.
- *problem solving process*: The idea of *problem solving process* is nearly identically transformed into the generic approach.

The developed generic approach consists of eight phases and is illustrated at the end of this chapter, see figure 3.2.:

1. *Situation analysis*: After the initiation, an analysis of the situation is required according to the idea of *problem solving process*. The situation analysis shall provide information about available tools on the market. Furthermore, by doing the situation analysis, basic information regarding the tools shall be gathered. Within this phase, the target formulation shall take place. In other words, at the end it shall be clear, which requirements the tools need to fulfill in order to be acquired.

2. *Check for must have functions*: The found tools will be roughly filtered according to several requirements they definitely need to fulfill.

3. *Evaluation of the tools*: Those tools which pass the previous check will be evaluated regarding 2 dimenions. Firstly, the evaluation is done according to monetary aspects. Secondly, the evaluation is done according to non-monetary aspects. Monetary aspects are e.g. cost, which arise by installing and using the tool. Non-monetary aspects are e.g. quantitative ratings according to the functionality of the tool or the licensing concept.

4. *Classification according to specific parameters*: The evaluation shall deliver results, so a classification according to the evaluation's dimensions can be done. The classification shall support the decision making process by grouping the tools. Having arranged the tools in group, it shall be more supportive to distinguish between suitable and not suitable tools.

5. *Decision based on evaluation*: When decision making is done, the results of the evaluation and the classification shall be beared in mind.

6. *Tool realization*: Based on the decision, a certain tool will be bought from external suppliers or an in-house development team will create the tool.

7. *Integration*: After the tool was acquired internally or externally, the tool is going to be integrated into the software and also into the hardware environment of the company.

8. *Implementation & Closing*: The final step is to implement processes for using the tool into the process environment of the company.

3.1 Initiation

A first hint to launch the process is given, when people sense a problem, a discomfort with the current situation, a speculation of a chance and / or an emergence of vague problem solutions regarding a need for a tool to monitor technology development projects. This entire process starts, when people are aware of a demand for a tool and a decision for applying the process is made. In the best case, the demand is noticed by people with power of decision. These people could be the management of the product development or of the technology development. At the beginning of initiation the following three aspects shall be defined according to the idea *from coarse to detail*:

- *strategic input*: According to systems engineering *structural point of view*[1] for analysing a situation, the strategic input shall provide information regarding company's and stakeholder's needs and requirements.
- *organizational matters*: Based on a common project process (cp. section Project Management), one major part is to define a project team, allocate financial and personal resources, define the target and purpose of the project and develop a proper schedule and deadlines. The project target is in this case e.g. to implement a tool into the company's process. Therefore the purpose of the tool needs to be defined too.
- *tool requirements*: According to the project target, restrictions and requirements need to be identified. For implementing a tool it is essential to define the tool's function which the tool needs to have in any case. If a tool would not meet the requirements for must-have functions, it would not be suitable for the company. The tool requirements are a set of filter for tools.

The initiation of this process shall guarantee a common collective understanding of the reason why the tool is required and what the purpose of the tool is. A general project framework for elaborating the upcoming project shall be defined.

[1] cp. Haberfellner et al. [2012], p 43

3.2 Analysis

When the decision for starting the undertaking was made, a detailed analysis of the situation according to systems engineering shall be conducted. By applying the idea of *thinink in variants* a broad analysis can be realized by integrating experts' opinions, literature study and web search. The analysis serves two purposes:

- *Detailed definition of tool requirements*: Besides must-have functions, the requirements for the functions shall be expanded to nice-to-have functions. Secondly, characteristics of the tool shall be set. These characteristics cover those, which shall be desired and which shall be avoided. Furthermore, a list of criteria for evaluating the tools shall be generated.
- *List of tools*: A comprehensive seach for tools according to the tool requirements shall be done. The result of the search is a list of possible applicable tools.

By defining necessary functions and other must-have criteria, a filter is created which shall support the first tool selection. Furthermore, a list of pros and cons is elaborated which support defining criteria for evaluating the tools. Based on the findings a search for tools shall be done and a list of possible tools is the outcome of this step.

3.3 Check for must-have functions

According to the defined must-have functions and necessary characteristics, the tools are filtered. These tools, which fulfill the criteria, will pass this check. Those tools, which do not fulfill the defined criteria will not be considered in the next steps of the process.

During the initiation and analysis phase, the company defined three must-have functions of the tools. These function are related to the magic triangle:

- *Cost control*: The functions for a monitoring the costs shall be available in the tool in two ways: (a) Sum of all expenditures caused by external suppliers for services or products and (b) number of consumed and available person-hours of employees.
- *Progress control*: The monitoring regarding the technology development project's progress shall be done by getting information about the number of completed and ongoing work packages respectivley a degree of progress.

- *Schedule Review*: In the planning phase, the schedule shall show the timeline of the project. Thereby, it shall give information, which workpackage needs to be completed at a certain date and how much expenditures are allowed for a certain period of time.

Although, the functions of many tools exceed these three functions and provide an enormous variety of functions. One of the key characteristics of the tool is, that the tool shall be simple and easy to use. Any additional function will devalue the tools.

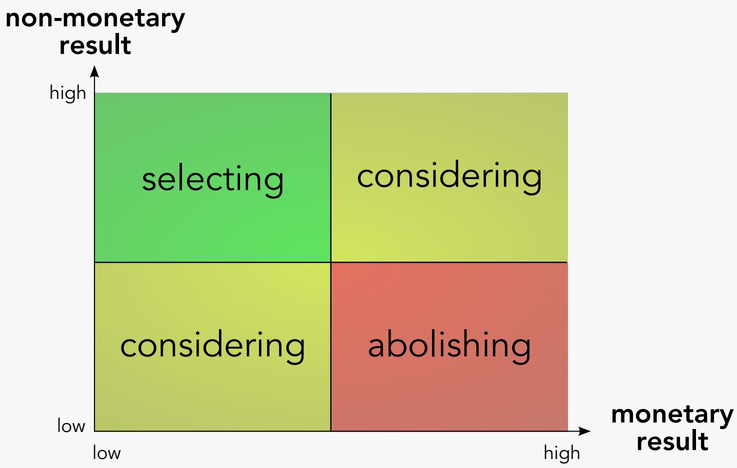
3.4 Evaluation

Software is evaluated by a cost calculation. However, a cost calculation does not covers the software's utility.[2] According to Bruegge (2004) a total cost of ownership calculation cover the overall costs of a software. A value benefit analysis shall evaluate the software's utility. According to the company's requirements, the total cost of ownership calculation conforms to the desired monetary evaluation and the value benefit analysis conforms to the desired non-monetary evaluation. The evaluation of the tools shall be done by consulting experts regarding tools, management regarding supervision and operative task force regarding appliance of the tools. The theory of both total cost of ownership calculation and value benefit analysis are covered in the next chapter *Applying generic process*.

3.5 Classification

The purpose of classification is to support the decision making process. Therefore, the evaluated tools are categorized in a 2x2-matrix. The results of the monetary evaluation are put on the axis of abscissa and the results of the non-monetary evaluation are put on the axis of ordinates. Within this thesis the the total cost of ownership results are put on the axis of abscissa and the value benefit results are put on the axis of ordinates. In figure 3.1 the 2x2-matrix is schematically shown. The upper left rectangle contains tools which are suitable and shall be selected. The lower right rectangle contains tools which are unsuitable and shall be abolished. The lower left and upper right rectangles contain tools which can be considered for usage too.

[2]cp. Brügge et al. [2004], p 117



Source: own representation

Figure 3.1: 2x2 matrix regarding tool classificiation

3.6 Decision

During the previous phases, the company gets an overview as well as detailed considerations regarding the tools. Furthermore, the company will ponder whether the tools, which are available on the market, fulfill their requirements. A tool which fulfills all functional requirements, but its functional range is too extensive, might not be suitable in the company's opinion. If non of the tools is suitable according to the management's considerations, an in-house tool development might be launched to develop a tool which fulfills the specific requirements. Based on the considerations about functional suitability, evaluation and the classification a decision needs to be made. The next steps of the process strongly depend on the decision which tool will be used.

3.7 Tool realization

Depending on the decision made, a tool either is bought from a software provider and then adapted to the enterprise specific needs or the tool is developed by the company's IT work force itself. When acquiring a tool externally, a purchasing process needs to be started. This involves several departments of the company. At the beginning, IT department needs to communicate the company's demands and requirements for the tool. The software supplier usually provides a technical support during the purchasing. In many cases a software will be adapted to the enterprise specific requirements. When the scope of supply and services is finalized, the contract negotiations start. The purchasing department will get involved to conduct negotiations. Legal department needs to prove the contract and finally, internal approval processes will confirm the acquisition.

When acquiring a tool internally as an in-house development the sub-processes are completely different. The main two departments, which are involved, are the IT department and the R&D department. The tool is designed according to the defined requirements. An advantage is, that during the development, both IT and R&D deparment can compare notes with each other to improve the development of the tool.

3.8 Implementation

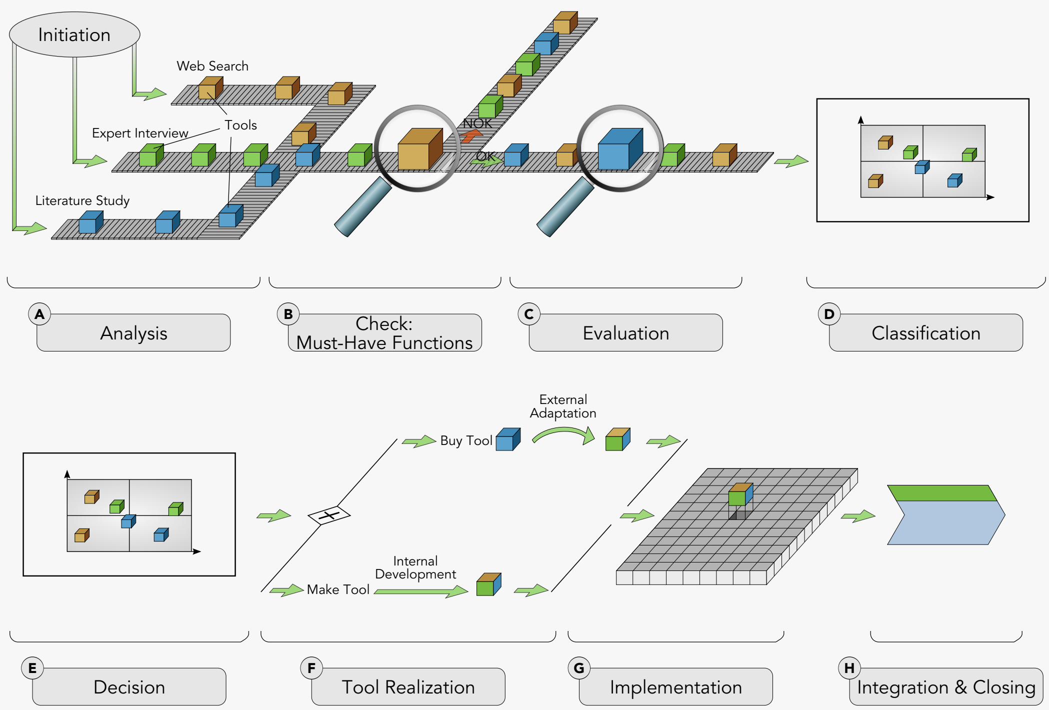
The sub-processes for the implementation are different for a tool which was externally acquired and for a tool which was internally acquired. However, the implementation contains two major tasks:

- implementing the tool into the software and hardware environment and
- trainings for the end-users.

The main part is to implement the tool into the software and hardware environment of the enterprise. By doing this, training for the IT work force as well as for the end-users shall be planned and done. Possible adaptions of the software can be done too. When implementing a tool which was externally acquired, technical support from the software provider would help during the implementation. Furthermore, external trainers would do the training for IT department as well as for the R&D department. When implementing a tool which was internally acquired, the IT department executes the implementation and the training. An advantage is, that when asking the IT work force for support, the response would be immediately, whereby response by external technical support could take longer.

3.9 Integration & Closing

According to a procedure the tool shall be integrated into the company's process environment. Thereby, two procedures are required to be developed: (1) a procedure for planning technology development project and (2) a procedure for monitoring technology development projects. Finally, the undertaking shall be reviewed regarding fulfillment of criteria, keeping the project frameworks and eventually disbanding the project team. To improve future undertakings for prospective intentions of integrating software tools into the company, thinking of lessons learned shall be the final step to finalize the process.



Source: own representation

Figure 3.2: Generic process for integrating a tool

4 Applying generic process

In this chapter the generic process for integrating a monitoring tool is discussed. Therefore, each step of the process is handled separately.

4.1 Initiation

The integration of the technology development process into the company's process environment forced the company to think about several ways for controlling and monitoring projects within the process. The management decided to initiate this process.

- *strategic input*: According to the strategic considerations, the company asks for a monitoring tool which shall be used for the technology development phase. Furthermore, the current company's Enterprise-Resource-Planning (ERP) software is developed by Oracle. A monitoring tool e.g. developed by SAP or any other ERP software provider might only be suitable after replacing the current ERP system to a compatible ERP system. This is less advisable. However, the analysis and evaluation shall cover also such monitoring tools.
- *organizational matters*: For this undertaking a project team was formed and resources were assigned. The team constantly consisted of a project manager, an IT expert and two advisors from the R&D department. The duration for executing the approach was set for seven months. The project had interim deadlines too. The decision phase had to be finalized within 3 months after project initiation. The tool realization and the implementation had to be finalized within 3 months. The integration and closing had to be finalized within 1 month after implementation. The project target was to implement and integrate a monitoring tool into the company's process. In total 900 person-hours were assigned for this project. A rough project plan showing the duration and project team of this undertaking is schematically illustrated in figure 4.1.

Source: own representation

Figure 4.1: Schematical illustration of project plan for applying generic approach

- *tool requirements*: Based on the requirements, which were given by the management, the tool should be able to perform the following functions (cp. section 3.3:
  - *Cost control*: The functions for monitoring the costs shall be available in the tool in two ways: (a) Sum of all expenditures caused by external suppliers for services or products and (b) number of consumed and available person-hours of employees.
  - *Progress control*: The monitoring regarding the technology development project's progress shall be done by getting information about the number of completed and ongoing work packages respectivley a degree of progress.

- *Schedule Review*: In the planning phase, the schedule shall show the timeline of the project. Thereby, it shall give information, which workpackage needs to be completed at a certain date and how much expenditures are allowed for a certain period of time.

4.2 Analysis

In this phase, two main tasks were accomplished. Firstly, a further definition of requirements regarding the tools and secondly, the search for suitable tools.

The further definition of the requirements was about the characteristics of the monitoring tool. The characteristics of the monitoring tool shall be suitable for the technology development phase. The characteristics of the technology development phase are:[1]

formal	with regards to content
→ focus on very early phase of innovation process → thoughtful use of financial and personnel resources → little but sufficient structure	→ generating of know-how and creating of concepts → technical and economic aspects of technologies → high degree of freedom in development

According to the mentioned characteristics, the most relevant aspects of the monitoring tool are functional and non-functional aspects. The management of company and experts in the field of project management came to the following conclusion for most relevant aspects of the tool, see table 4.1. The functional aspect's are mentioned above. Regarding non-functional aspects, the tools' ease of use needs to be high. Thereby, peole shall need very little effort in training and the tool's handling shall be self-explanatory. Furthermore, the security needs to meet the standard of the company. Finally, the company plans to cultivate a long-term business relationship with the software provider.[2]

[1]cp. ACC [2009], p 10
[2]cp. ACC [2012b], p 5

Functional	
planning, data collecting and reporting of	financial expenses, person-hours, project progress
Non-Functional	
ease of use	high: little training effort, tool shall be self-explanatory
security	high: same security level as currently given in ACC
provider availability	long: ACC plans to cultivate a long-term business relationship

Table 4.1: Main Characteristics of Monitoring Tool

It takes some effort to get an overview of which tools are currently available on the market.

- **web search**: Firstly, *every* software provider presents its company and its products via a webpages, which provide a great market overview of available monitoring tools. Thirdly, you will find also webpages, which provide field reports and user ratings regarding software tools.
- **expert interview**: Two great advantages of an expert interview over a web search or literature study are the access to implicit knowledge which are not covered in written sources and the information given by the experts refer to customized questions.
- **literature study**: The third way for searching monitoring tools is by doing a literature study. You may use information out of books, articles or papers etc. to get an idea of tools, which proved of value in the past.

The search delivered a huge amount of monitoring tools available on the market. Over 250 tools were found, by web search, expert interviews and literature study. According to the non-functional requirements, the number of found tools was reduced to 35.

4.3 Check regarding must-have functions

The remaining 35 tools were checked according to their functional aspects. This task was done by consulting IT experts. The list of 35 tools was further reduced to six tools. Additionally, as mentioned in the previous chapter, an in-house developed tool by the company will be considered as well.

In this section, the seven tools, which are considered, are briefly described below:

- PSI Projectmanagement,
- Oracle Primavera,
- Sciforma Projectmanagement,
- SAP Projektsystem,
- Microsoft Project,
- Projectplace and
- ACC Self-Developed Tool.

4.3.1 PSI Projectmanagement

PSI PM is a server-based multiproject- and multiresourcemanagement software for planning and controlling of projects particularly of deadlines, resources and costs. The functions of the software are suitable for projects which run parallelly and sequentially. The software is able to cover interdependences between various processes and resources. The software is capable to run with the PSI Enterprise-Resource-Planning (ERP) system through a common standard interface.[3]

[3]cp. webpage `http://www.psi.de/`, called on January 10th, 2013

Source: *http://www.psi.de/*

Figure 4.2: PSI Projectmanagement logo

4.3.2 Oracle Primavera

Oracle Primavera is suitable for enterprises when a system for the entire project portfolio life cycle and various projects independently of their duration and size is required. The software covers portfolio management, scheduling, project controlling and risk management. Additionally, Oracle Primavera provides functions regarding work flow management and data management. Oracle Primavera is a server-based software with an interface to the Oracle ERM system.[4]

Source: *http://www.oracle.com/*

Figure 4.3: Oracle Primavera logo

4.3.3 Sciforma Projectmanagement

Sciforma Projectmanagement is a multifunctional project- and project portfolio management web-based solution. The functions of the web-solution cover additionally, project- and resource planning and collecting data regarding person-hours. Changes in the hierarchy or structure of the enterprise can be adjusted in Sciforma. Every change in the

[4] cp. webpage `http://www.oracle.com/`, called on January 10th, 2013

project is recorded by a specific tool and the changes can be read later. A graphical reporting system shall provide required information at short notice.[5]

Source: *http://www.sciforma.com/*

Figure 4.4: Sciforma Projectmanagement logo

4.3.4 SAP Projektsystem

SAP Projectsystem is a server-based software for project management. The software allows a work breakdown structure, precendence diagrams in combination and separate and provides an interface to SAP R/3. Using SAP Projektsystem with various SAP R/3 modules like controlling (CO), financing (FI), distribution (SD) or materials management (MM) etc, the entire value chain is mapped.[6]

Source: *http://www.sap.com/*

Figure 4.5: SAP Projektsystem logo

4.3.5 Microsoft Project

Microsoft Project is a part of the entire Microsoft Office. The software is available to run as a server-based or client-based solution. Using Microsoft Project the client is able

[5] cp. webpage `http://www.sciforma.com/`, called on January 10th, 2013
[6] cp. webpage `http://www.sap.com/`, called on January 10th, 2013

to plan and control work flow and time schedule of projects, personnel and operating resources, budget and actual costs. An important part of the software is precedence diagram method and the software provides a Gantt chart. As part of the Microsoft Office, Microsoft Project is able to integrate e.g Microsoft Word and Microsoft Excel.[7]

Source: http://www.microsoft.com/

Figure 4.6: Microsoft logo

4.3.6 Projectplace

Projectplace is a web-based solution for project management. The uptime rate of the software is according to the provider at 99,97 %, which means, the software is down max. 3 hour per year. Projectplace modules include management of documents, release management, planning and tracking, management of meetings and resource management.[8]

Source: http://www.projectplace.de/

Figure 4.7: Projectplace logo

[7] cp. webpage `http://www.microsoft.com/`, called on January 10th, 2013
[8] cp. webpage `https://www.projectplace.de/`, called on January 10th, 2013

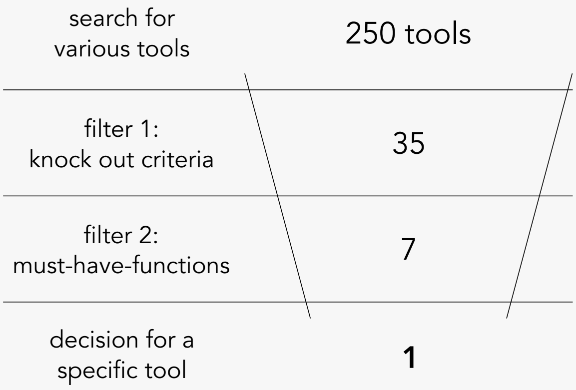
4.3.7 ACC SDT

ACC self-developed tool (ACC SDT) would be an in-house development of the tool, customized to the exact needs and requirements of the enterprise. According to the in-house IT competences, the tool would be designed to fulfill the requirements at highest level.

Source: ACC [2011], p 1

Figure 4.8: ACC logo

Summarized, the the search delivered a number of over 250 tools, see figure 4.9. According to the non-functional requirements (1^{st} filter), the number of found tools was reduced to 35. The remaining 35 tools were checked according to their functional aspects (2^{nd} filter) and the list was further reduced to seven tools. A decision will be made, to select one tool.



Source: own representation

Figure 4.9: Schematical illustration of first applied filter when searching for monitoring tools

4.4 Evaluation

The described tools fulfill the defined must-have functions. In this step the tools are evaluated regarding total cost of ownership and their value benefit. Within this section, the theoretical background regarding the evaluation model is given and the evaluation is presented.

4.4.1 Total Cost of Ownership

The Total Cost of Ownership (TCO) calculation was invented by the IT consulting company Gartner Group in 1987. Gartner Group presented a model to capture costs, which accrue for an IT-infrastructure. Back in 1987, the calculation was originally developed for personal computer. At this time, costs for IT-infrastructure became minor attention, but this idea found continuously more and more popularity.[9] Gradually, many relevant participants in the IT industry spent time on this topic: Consultants Forrester Research, Fraunhofer-IAO, Giga Information Group, GSM Software Management AG, International Data Corporation and META Group. Although a standard model was claimed but a single model never came out on top and a consensus between the models could not be found. The only consensus is that such costs were seen as costs caused by the usage of an IT-infrastructure, which result out of an ownership or usage over the time of the investment. The need to capture all costs systematically and considering a broad scope can be backed by the following four advantages:[10]

- **Increased transparency**: Traditional concept of capturing costs of an IT-infrastructure only covered direct costs and *ignored* indirect costs which were caused by internal cost allocation. As the total cost of ownership calculation does consider direct and indirect costs, an awareness for all costs shall be created.
- **Intra-industry benchmarks possible**: Calculating all costs systematically and considering a broad scope, enterprises have the possibility to compare their costs with competitors within their industry sector. The company is able to identify its cost position regarding its IT-infrastructure.

[9] cp. Wild u. Herges [2000], p 3 ff
[10] cp. Wild u. Herges [2000], p 5 ff

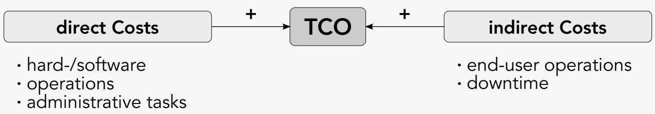
- **Fundamental based decisions**: Gradually, decisions regarding an IT-infrastructure are made by the upper management of enterprises. The idea is to cover company-wide consequences. Covering direct and indirect costs, the management is able to realize all costs by an IT-infrastructure which the company needs to pay for.
- **Systematic approach**: Enterprises face difficulties and challenges when calculating costs for IT-infrastructure. Having the total cost of ownership approach in the enterprise's method portfolio, the following difficulties can be systematically identified and handled:
  - full investigation of all data regarding costs,
  - gathering relevant data and
  - proper determination of expenditures.

In literature,[11] mainly three TCO-models are described: TCO model by Gartner Group, Consultants Forrester Research and META Group. In 2005, Gartner Group acquired amongst others META Group, a direct competitor to Gartner Group[12]. In the next part of this section the three TCO-models are described and one model for the calculation is chosen.

TCO-model by Gartner Group

The first TCO-model originally developed by Gartner Group is basically structured into direct and indirect costs for an IT-infrastructure, see figure 4.10. The aim is to determine costs caused by asset accumulation through parts for IT-infrastructure, through technical support, through IT-related administrative tasks, through operations by end-users and downtime. Gartner Group's first model was designed for personal computer and then they developed TCO-models for local area networks, handheld-calculators, mainframes, servers, notebooks, printers, telecommunication systems etc. Gartner Group referred costs caused by hardware, software, operations and administrative tasks to direct costs. Costs caused by end-user operations and downtime were referred to indirect costs.[13]

[11] cp. Wild u. Herges [2000], p 7 f, Biedermann [2008], p 2 and Schwickert [2004], p 5
[12] cp. webpage `http://www.gartner.com/`, called on January 10th, 2013
[13] cp. Wild u. Herges [2000], p 9 and Riepl [1998], p 8



Source: own representation based on Wild u. Herges (2000), p 15

Figure 4.10: Main Structure of Gartner Group's TCO-Model

Direct costs of an IT-infrastructure contain budgetable expenditures, which are caused by the IT-department for provision of services. These can be the following costs: acquisition costs, process costs through procurement, expenditures for trainings, maintenance and support, depreciations, leasing costs etc. One can determine direct costs with high accuracy, as these are traceable by invoices, payroll etc. As mentioned above, Gartner Group divided direct costs into three categories:[14]

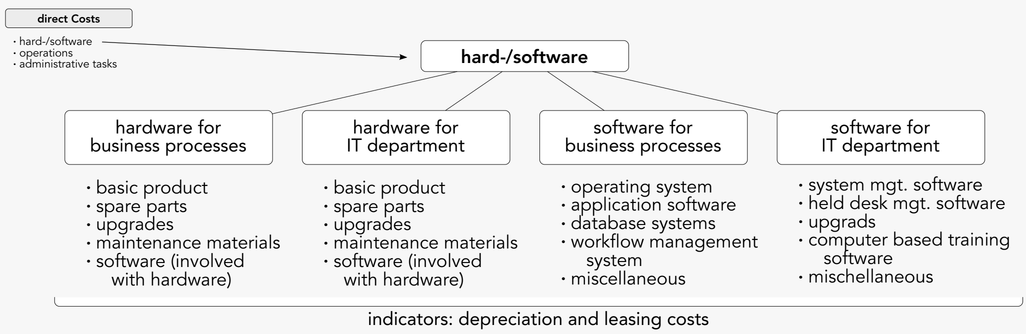
- hard-/software,
- operations and
- administrative tasks.

On the following pages these three types of direct costs are briefly described and schematically illustrated.

- **hard-/software**: These are costs related to expenditures, caused by procurement and usage of on the one hand hardware: basic product, upgrades, spare parts, maintenance materials and software which is involved with hardware. On the other hand, the costs are caused by software: operating system, application software, database systems, workflow management system, help desk management software, training software and other software costs, see figure 4.11.[15] Furthermore, hardware and software is structured into costs caused by business processes and costs caused by IT department. Costs caused by IT department arise through procurement and usage at the IT department's side (e.g. software and hardware infrastructure), so the tool is ready for

[14]cp. Wild u. Herges [2000], p 10 f
[15]cp. Wild u. Herges [2000], p 15 and Schwickert [2004], p 4

installation. Costs caused by business processes arise through procurement and usage at the end-user's side, so the end-user can operate the tool.

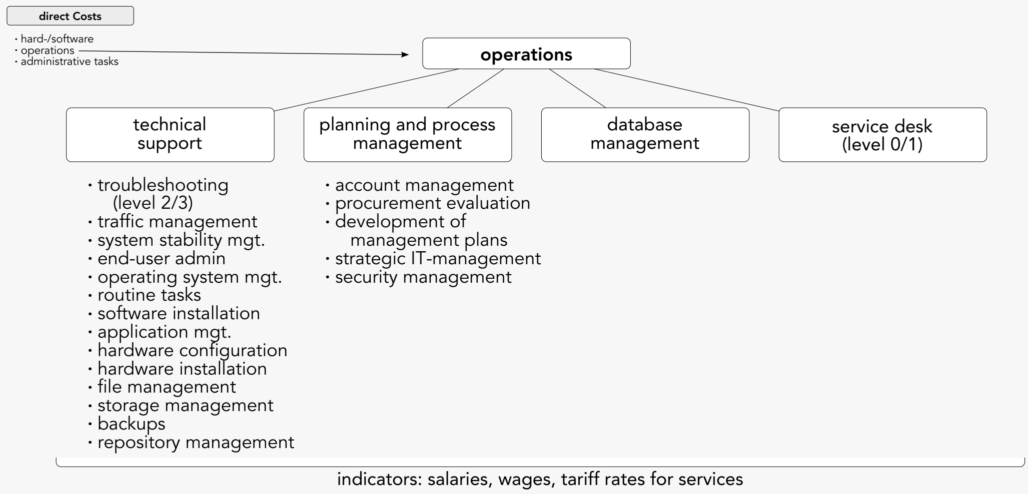


Source: own representation based on Wild u. Herges (2000), p 15

Figure 4.11: Structure of Hard-/Software

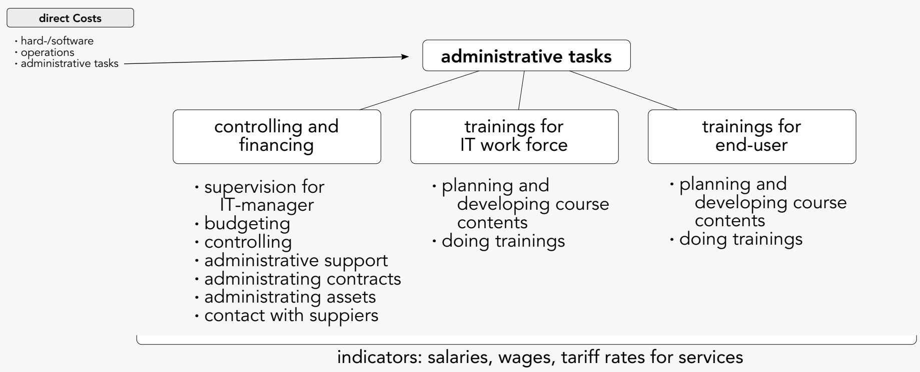
- **operations**: Costs within this sections are costs caused by the payments for employees (internal as well as external). These are directly related to the IT-infrastructure, see figure 4.12. Operational costs are costs for a) technical support: troubleshooting, traffic management, system stability management, end-user administration, operating system management, routine tasks, software installation, application management, hardware configuration, hardware installation, file management, storage management, backups and repository management; costs for b) planning and process management: account management, procurement evaluation, development of management plans, strategic IT-management and security management; costs for c) database management and costs for d) service desk.[16]

- **administrative tasks**: These costs are caused by administrating and organizing the IT-department. These are mainly driven by salaries and wages, see figure 4.13. These Costs can be divided into a) costs for controlling and finance: supervision for IT-managers, budgeting, controlling, administrative support, administrating contracts and assets and contact with suppliers; b) costs for trainings for IT work force and c) costs for trainings for end-users: both consisting of planning and developing course contents and doing the trainings.[17]



Source: own representation based on Wild u. Herges (2000), p 15

Figure 4.12: Structure of Operations



Source: own representation based on Wild u. Herges (2000), p 15

Figure 4.13: Structure of Administrative Tasks

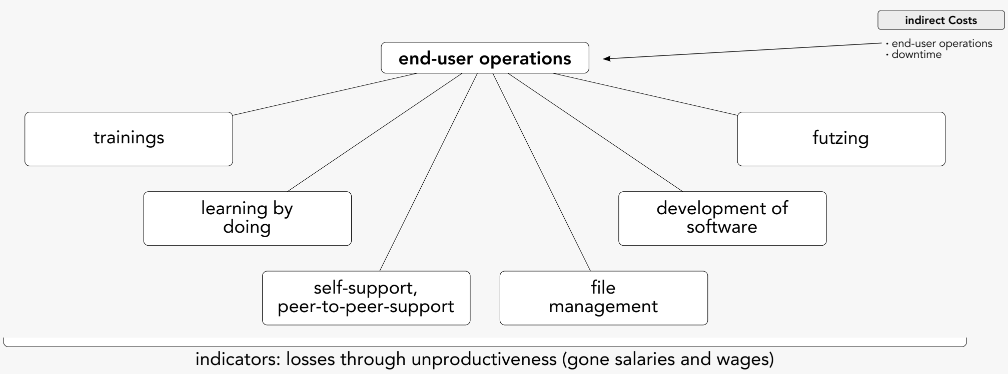
Indirect costs of an IT-infrastructure accrue according to Gartner Group from inefficient processes when using an IT-infrastructure. One can think of the period of time, in which

[16]cp. Wild u. Herges [2000], p 15 and Schwickert [2004], p 5
[17]cp. Wild u. Herges [2000], p 15 and Schwickert [2004], p 6

employees spend unproductive at their working place, due to an unavailable operating system or software, so called downtime. Furthermore, indirect costs may refer to end-user-operations also due to unproductiveness. Summarizing, indirect costs consist of the following categories:[18]

- end-user operations and
- downtime.

- **end-user operations**: Costs within this category include expenditures caused by periods of time, when employees need to take specific trainings organized by the IT-department, see figure 4.14. Furthermore, they also include labor costs due to daily learning by doing, self-support and peer-to-peer support, file management the end-user needs to keep in mind, development of software by end-user as well as by IT-experts and finally, futzing. Latter is a waste of time through the employees when playing games during working hours our privately surfing through the web.[19]



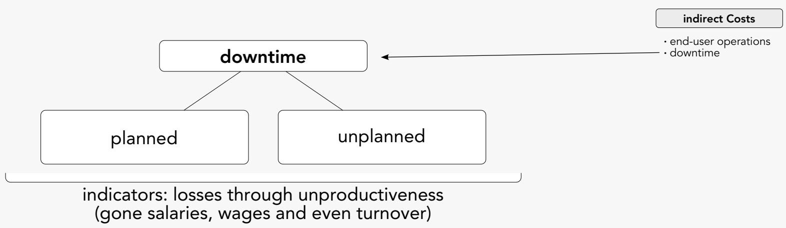
Source: own representation based on Wild u. Herges (2000), p 15

Figure 4.14: Structure of End-User Operations

- **downtime**: When the entire or even only a part of an IT-infrastructure is not available over a certain or uncertain period of time, then the originating costs are categorized into a planned and an unplanned downtime, see figure 4.15. When downtime occurs

[18] cp. Wild u. Herges [2000], p 15 and Schwickert [2004], p 7
[19] cp. Wild u. Herges [2000], p 15 and Schwickert [2004], p 7

on purpose at a certain period of time, it is a planned downtime. When downtime occurs surprisingly to the enterprise and its employees, it is an unplanned downtime.[20]



Source: own representation based on Wild u. Herges (2000), p 15

Figure 4.15: Structure of Downtime

Gartner Group's TCO-model has another advantage: Beside capturing costs caused by procurement and usage of an IT-infrastructure, costs are also considered, which are caused by substandard or inadequate hard- or software as well as by IT-system change. Furthermore, the Gartner Group's TCO-model covers risks which are linked to the usage of an IT-infrastructure too.[21]

TCO-model by Consultants Forrester Research

According to the detailed description of the TCO-model by Gartner Group, the reader would have now a proper understanding of the various cost positions for purchasing and using of an IT-infrastructure. On this basis and due to the fact, that one hardly finds informations regarding the TCO-model by Consultants Forrester Research, we cover this on a more broad perspective.[22]

The TCO-model by Consultants Forrester Research captures the following cost factors:[23]

[20]cp. Wild u. Herges [2000], p 15 and Schwickert [2004], p 7
[21]cp. Wild u. Herges [2000], p 16, Schwickert [2004], p 8 f and Riepl [1998], p 9
[22]cp. Wild u. Herges [2000], p 16
[23]cp. Wild u. Herges [2000], p 16 and N.N. [1998], p 87

- constitutive hard- and software of the IT-infrastructure in terms of assets of IT-infrastructure parts,
- maintenance contracts in regard to the IT-infrastructure,
- management of the IT-infrastructure,
- support services regarding the IT-infrastructure (e.g. help desk),
- indirectly resulting tasks from the usage of the IT-infrastructure,
- periods of time, when part of the IT-infrastructure is not available including the from the downtime resulting effects on the enterprise's turnover and
- tasks for disaster prevention including disaster recovery plans as well as, when a disaster occurred, a disaster recovery

Though, there may exist some differences in detail between the TCO-model by Garter Group and the TCO-model by Consultants Forrester Research, both models do have some main cost factors in common, see the following table 4.2:[24]

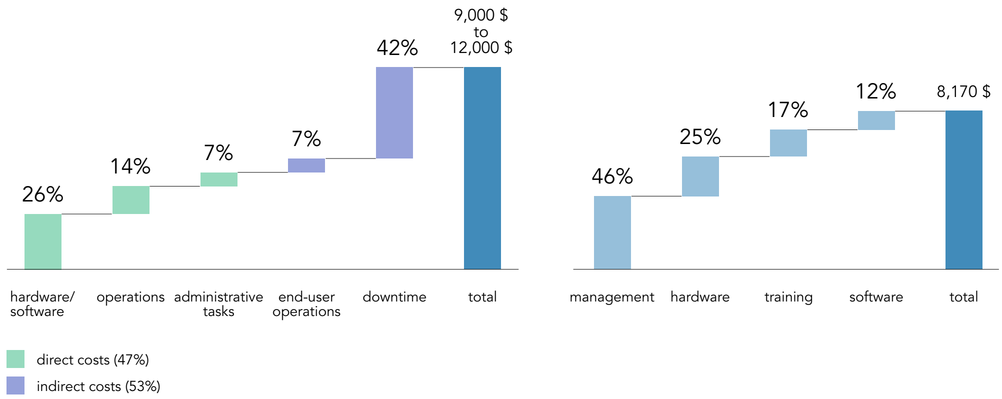
Consultants Forrester Research (cost factors)	**Gartner Group** (cost categories interpreted as cost factors)
constitutive hard- and software of the IT-infrastructure	category *hard-/software*
maintenance contracts	categories *operations and administrative tasks*
management of the IT-infrastructure	categories *operations and administrative tasks*
support services	category *operations*
indirectly resulting tasks from the usage of the IT-infrastructure	categories *administrative tasks and end-user operations*
periods of time, when part of the IT-infrastructure is not available	category *downtime*
tasks for disaster prevention and disaster recovery	categories *operations and end-user operations*

Table 4.2: Comparison of Cost Positions between TCO-model by Consultants Forrester Research and by Gartner Group *(Source: based on Wild u. Herges [2000], p 17)*

[24]cp. Wild u. Herges [2000], p 17 and Schwickert [2004], p 10

As we could find correlations between these two TCO-models, there is one major difference in capturing cost positions in the TCO-model by Consultants Forrester Research: These are financial losses through unproductiveness caused by end-user operations. With reference to Gartner Group's TCO-model, these are futzing, self-support, peer-to-peer-support and mostly learning by doing.[25]

Schwickert presented a quantitative comparison between the TCO-model by Gartner Group and by Consultants Forrester Research and he shows the total cost of ownership for a desktop computer for a year. The total cost of ownership according to the TCO-model by Gartner Group were 9,000 to 12,000 $ per year, see figure 4.16(a). The total cost of ownership according to the TCO-model by Consultants Forrester Research were 8,170 $ per year, see figure 4.16(b). The differences could be found in costs through unproductiveness caused by end-user operations, which are not covered in the TCO-model by Consultants Forrester Research.[26]



(a) approach by Gartner Group

(b) approach by Consultants Forrester Research

Figure 4.16: TCO analysis for a desktop computer using approaches from Gartner Group and Consultants Forrester Research *(Source: based on Wild u. Herges [2000], p 15)*

[25]cp. Wild u. Herges [2000], p 17 and Schwickert [2004], p 10
[26]cp. Schwickert [2004], p 8 f

TCO-model by META Group

The TCO-model by META Group captures 5 blocks of different cost positions:[27]

- basic usage costs, e.g. salaries and wages for employees according to their IT know-how, procurement and usage of hard- and software, depreciations and lease costs etc.,
- costs caused by operating an Enterprise Resource Planning System (ERP-system),
- costs caused by maintaining the IT-infrastructure,
- migration costs and
- costs caused by maintaining legacy-systems.

Although, META Group indicates additional costs caused by unproductiveness, but does not capture these costs in the approach. The key aspect of the TCO-model by META Group is to cover costs which are traceable by invoices, receipts etc.[28]

Choosing a Model for TCO-analysis

In the previous subsections the TCO-models by Gartner Group, by Consultants Forrester Research and META Group as well as their differences were discussed. Given these information of the various models, the IT-experts of the enterprise *ACC Austria GmbH* decided to go on with the TCO-model by Gartner Group. The simple two reasons for excluding the other TCO-models were:

- TCO-model by Consultants Forrester Research does not capture costs caused by futzing, self-support, peer-to-peer-support and mostly learning by doing, and
- TCO-model by META Group does not capture costs caused by unproductiveness.

Especially in the first phase, when implementing a new software there are times for the end-user to ask for support, to learn handling the software etc. Even for the IT work force, they might improve their software during the first weeks or months, as the end-users report improvement feedback etc.

[27]cp. Wild u. Herges [2000], p 17
[28]cp. Wild u. Herges [2000], p 18

TCO-Analysis for the Tools

In the following part of this section we discuss the results of the TCO analysis for the seven monitoring tools: PSI Projectmanagement, Oracle Primavera, Sciforma Project-management, SAP Projektsystem, Microsoft Project, Projectplace and ACC SDT. The IT-experts of the enterprise ACC did a study regarding the required expenditures for each tool solution. The TCO calculation was done considering a usage period of 3 years, whereby the tools would be operated by 10 end-users.

For the case calculation a rate of simultaneous tool usage was defined with 1/3 of the end-users. That would mean, the TCO calculation represents costs caused by 10 end-users using the software for 3 years, maximum 30 % of end-users at the same time. The hourly wage rate for internal work force is 40 € (opportunity costs not covered) and for external work force 150 €. Costs for hardware, software and other positions are determined by receiving quotations free of cost to the enterprise ACC and without any commitment on the part of the enterprise ACC.

Within this section the results of the TCO calculation are presented in several figures, using the color green representing direct costs and the color purple representing indirect costs. All considerations regarding any acquisition are based on the enterprise's available software, hardware and know-how. Summarizing, in table 4.3 the relevant information are given structured.[29]

usage period	3 years
number of end-users	10
simultaneous tool usage	1/3 of end-users
internal hourly wage rate	40 €
external hourly wage rate	150 €

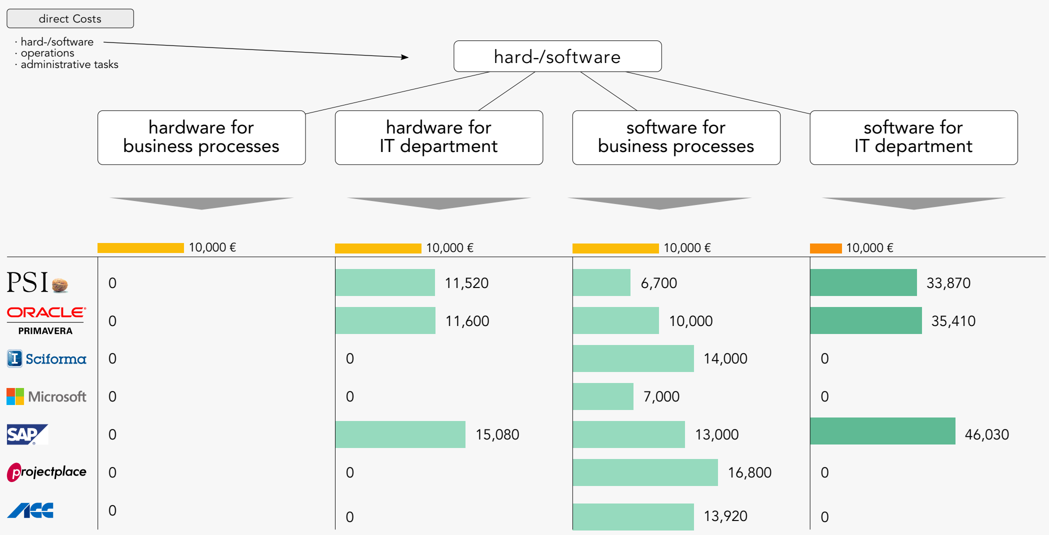
Table 4.3: Basic Information regarding TCO Analysis for the Tools

[29] cp. ACC [2012b], p 2 ff

Costs for Hard-/Software

The category *hard-/software*, part of direct costs, is structured into 4 sections: hardware for business processes and for IT department, software for business processes and for IT department. As shown in figure 4.17, one would see for none of the six tools accrue costs in the section hardware for business processes. The current end-user's equipment fulfills the requirements of each tool for operating the software properly. Thus, any equipment acquisitions of upgrades would not be necessary.

Hardware would only be required for the IT department, when deciding to go with one of the server-based solutions: PSI Projectmanagement, Oracle Primavera or SAP Projektsystem. For all three server-based solutions servers for the application, job service and database are required. The cost differences between each tool are caused by different hardware requirements from the software-providers. The hardware upgrades are calculated based on the enterprise's experiences with 15 % of the acquisition costs per year for each server.



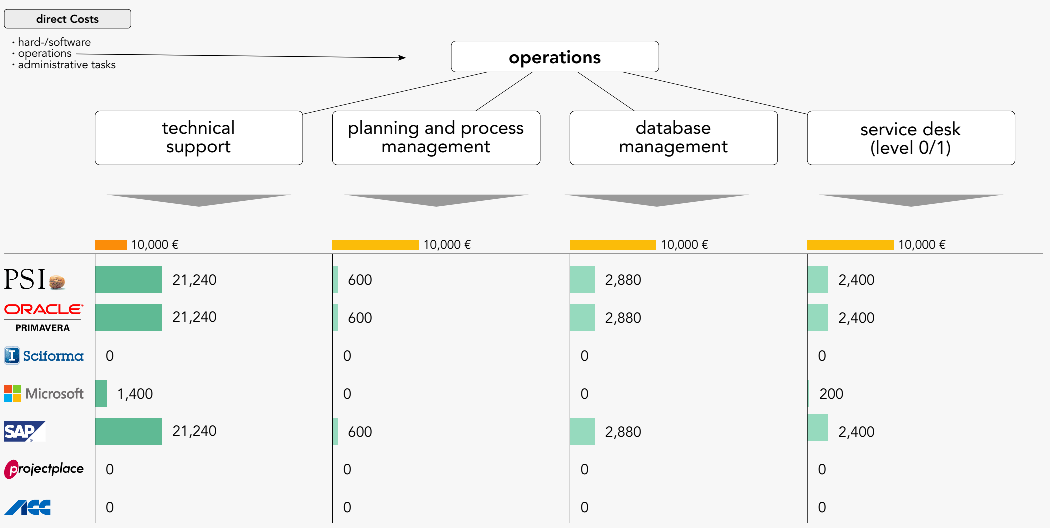
Source: own representation

Figure 4.17: Costs for Hard-/Software

Software costs would arise from business processes and IT department. Business process software costs are due to licensing fees, calculated for a time period of 3 years and 30 % of 10 end-users simultaneously using the tool. Microsoft Project is the most competitive regarding licensing fees, whereby the web-based tools are the most cost-intensive tools. The expenditures for licensing fees range from 6,000 to 16,800 €. ACC self-developed tool would cost 13,920 €. Additionally, the IT department requires operating systems, application software and database systems to run the server-based solutions. These expenditures range from 33,870 up to 46,030 €.

Costs for Operations

The next cost category is *operations*, which is structured into the sections technical support, planning and process management, database management and service desk, see figure 4.18. The lion's share within this category is contributed by technical support. As Projectplace and Sciforma are web-based tools, one would not require any hardware and software configuration and installation. Furthermore, file management, storage management, backups and end-user administrator are neither necessary. The required support for these two solutions is covered with the licensing fees and done by the software providers at their places.



Source: own representation

Figure 4.18: Costs for Operations

For PSI Projectmanagement, Oracle Primavera and SAP Projektsystem costs arise mainly through software configuration and installation by external IT experts delegated by the respecitve software provider. The configuration and installation would take five working days each eight hours having three experts delegated. The rest of the expenditures come from hardware configuration, installation, end-user administration and backups as well as storage management, which would be done by internal IT work force. As Microsoft Project would be operated as a client-based solution, the technical support would be insignificant compared to the server-based solutions. The web-based solutions do not need any technical support, which is ordered by the enterprise.

Within the section planning and process management, a security management software is needed for certain tools: for the server-based and client-based solutions. For Microsoft Project, the security management is already available in the enterprise and therefore, no additional acquisition of a virus protection software is required. The section database management is necessary for PSI Projectmanagement, Oracle Primavera and SAP Projektsystem and would cost for each tool 2,880 €, which would arise from internal IT work force. Addtionally, a service desk for the mentioned tools is required and the costs would also arise from internal IT work force.

Costs for Administrative Tasks

Administrative tasks are tasks regarding controlling and financing, trainings for IT work forces as well as for the end-users. The costs in this category are on a low level compared to other categories, see figure 4.19. Costs regarding controlling and financing are mainly caused by doing the budgeting, administrating contracts, contact with suppliers and controlling the procurement process. A planning for various training sessions for the IT work force and for the end-users would cost a bagatelle.

Costs for End-User Operations

Expenditures related to end-user operations, see figures 4.20 and 4.21, are internal work force hours spent by the end-users whether for training, learning by doing, support or file management and futzing. The main part in this category is caused by trainings. Training expenditures would mainly arise from external training personnel and the internal IT work force as well as end-users.

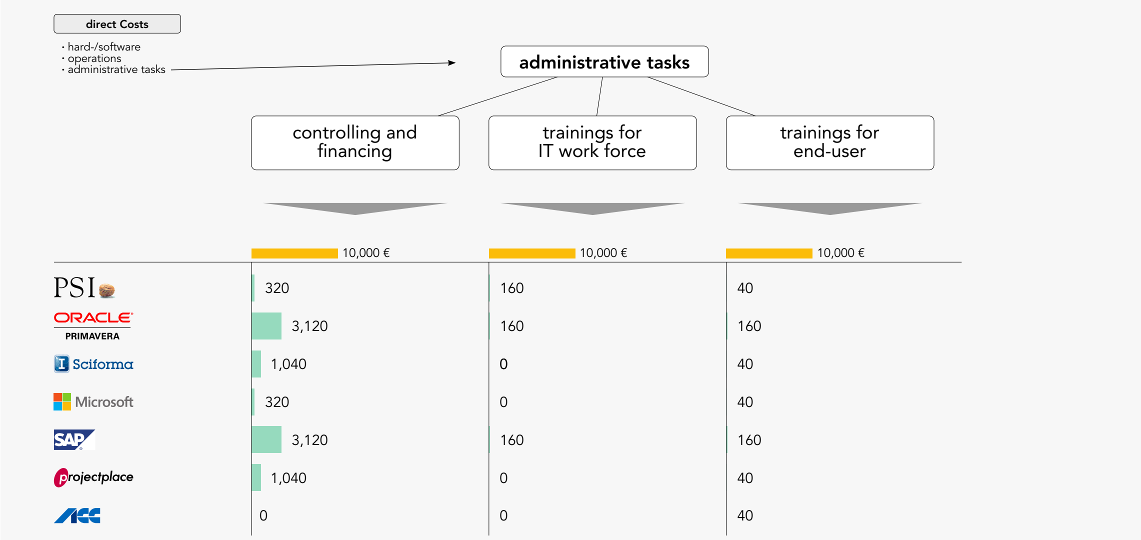


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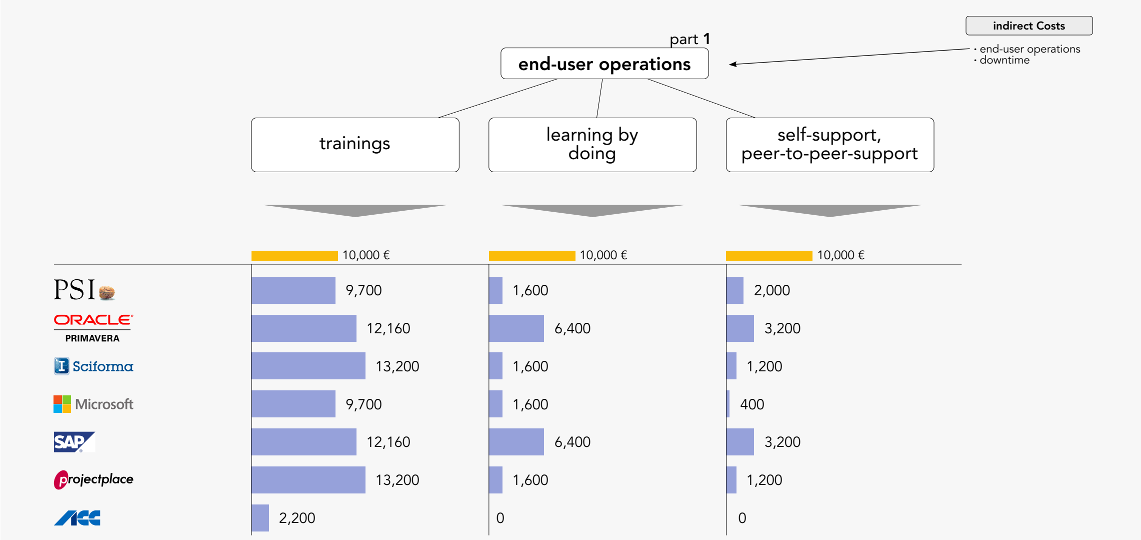
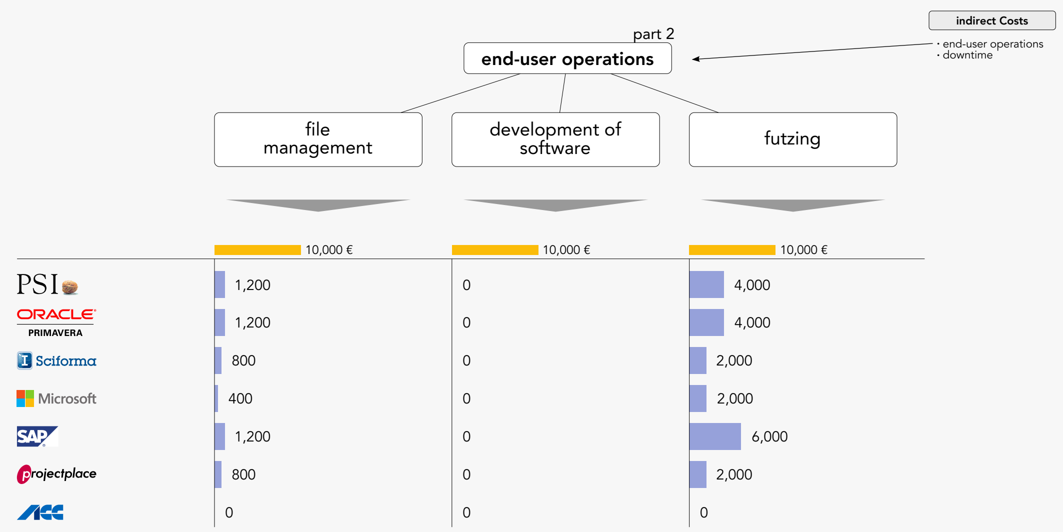
Figure 4.19: Costs for Administrative Tasks



Source: own representation

Figure 4.20: Costs for End-User Operations (Part 1)

The costs in the other sections are proportional to the complexity of the tool. The more complex a tool is (e.g. SAP Projektmanagent, PSI Projectmanagement and Oracle Projectmanaget) the more time is spent on the different tasks when the end-users are learning by doing. The less complex a tool is, the less time is spent on the tasks. Oracle Primavera, PSI Projectmanagement and SAP Projectmanagement would require a more intensive support than the web-based tools and mainly than Microsoft Project. Laters is already better know in handling by the end-users in the enterprise.



Source: own representation

Figure 4.21: Costs for End-User Operations (Part 2)

Getting used to the procedure for storing the files properly and managing the file consume certain efforts. The costs in the section file management are caused by internal end-users. As each of the tools is developed directly by the software provider a potential further development of the software is a) already considered in the licensing fees and b) not intended during the usage period. Finally, in this category a main cost part is futzing. The IT experts would state the hypothesis, that the higher the scope of the tool, in other words the range of functions, the higher is the likelihood that the end-users would explore the software and would waste time.

Costs for Downtime

The final category downtime consists of two sections: planned downtime and unplanned downtime, see figure 4.22. Aside from Sciforma and Projectplace (both web-based solutions) a planned downtime occur for all tools. The expenditures arise through the internal IT work force, when doing maintenance tasks. The two web-based tools would not have a planned downtime during working days according to their provider.

However, these tools might cause intensive unplanned downtime costs. The costs would arise from unused working time by the end-users, defining three hours per end-user for each year. Sciforma and Projectplace have a high risk for unplanned downtime, defining ten hours per end-user for each year.

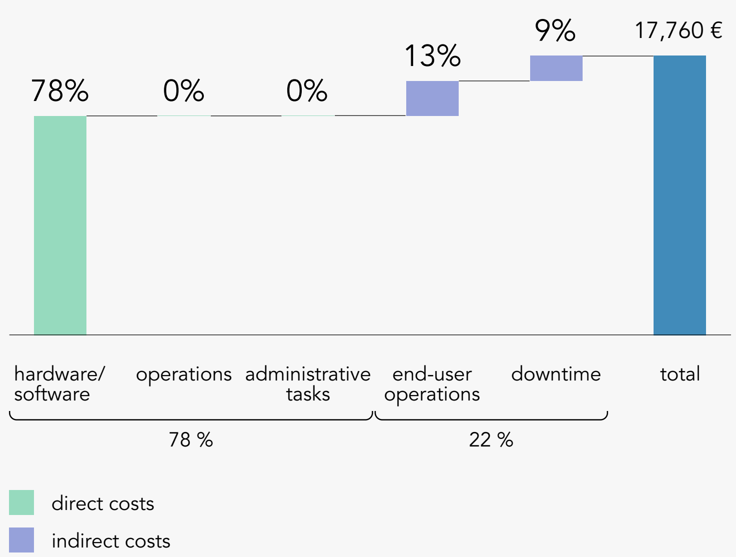
Source: own representation

Figure 4.22: Costs for Downtime

Comparing TCO of all Tools

In figure 4.23 the results of the most reasonable tool in terms of costs is shown, which is ACC SDT. A main cost block of the self-developed tool is caused by the internal IT work force for developing the tool. As there needs to be done some training, costs occur in the section of end-user operations. Although the tool shall fulfill the highest standards, an unplanned downtime was covered as well.

In figure 4.24 the results of the total cost of ownership calculation and all cost categories for the six analyzed tools are illustrated. Every single tool has considerable high indirect costs. The major cost categories are hard-software and end-user operations. Both web-based tools, Sciforma and Projectplace, are about twice as cost-intensive as Microsoft Project or ACC SDT.



Source: own representation

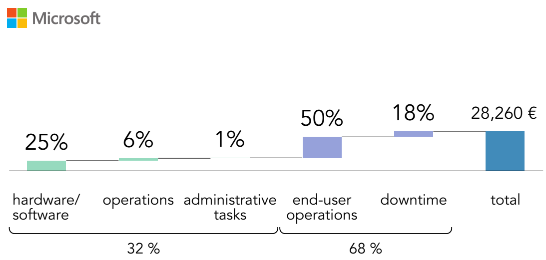
Figure 4.23: TCO of ACC self-developed tool

PSI Projectmanagement, Oracle Primavera and SAP Projektsystem have the highest total cost of ownership, about four times higher than Microsoft Project. The huge difference is found in the hardware and software acquisitions for the IT department, the needed technical support and operations related tasks. For the web-based tools, the category downtime plays a significant role in total cost of ownership. As the enterprise is not able to influence the duration of an unplanned downtime, this cost block conceals an important risk factor.

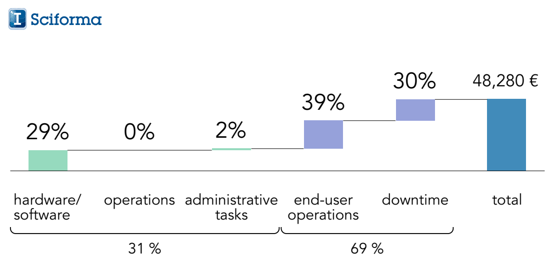
In table 4.4 the results of the total cost of ownership calculations are presented. The results are ranked according to the costs of the tools. The relevant information for doing the TCO calculations were a usage period of 3 years, 10 end-users, 1/3 of all end-users simultaneously use the tool, internal hourly rate of 40 € and external hourly rate of 150 €.

1.	ACC SDT	17, 760 €
2.	Microsoft Project	28, 260 €
3.	Sciforma Projectmanagement	48, 280 €
4.	Projectplace	51, 120 €
5.	PSI Projectmanagement	103, 430 €
6.	Oracle Primavera	119, 730 €
7.	SAP Projektsystem	138, 830 €

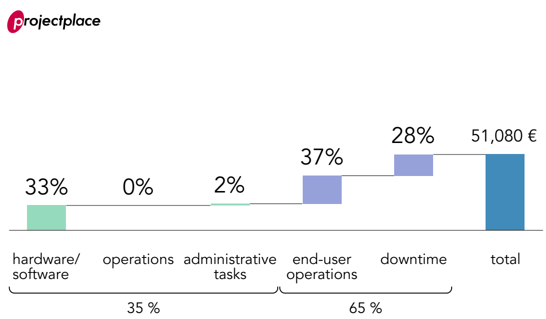
Table 4.4: Results of total cost of ownership calcuation



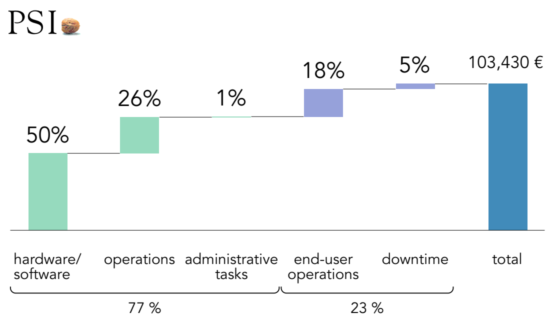
(a) TCO of Microsoft Project



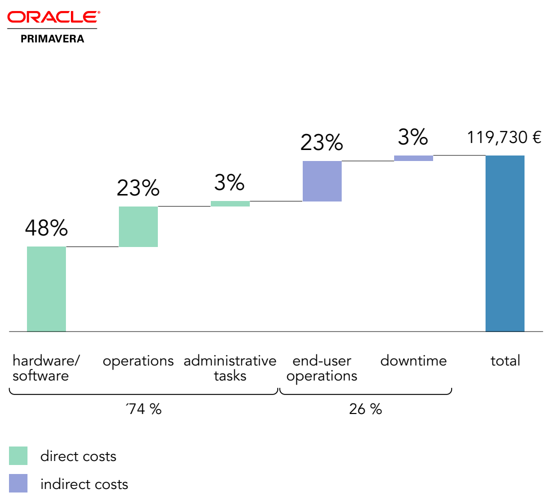
(b) TCO of Sciforma Projectmanagement



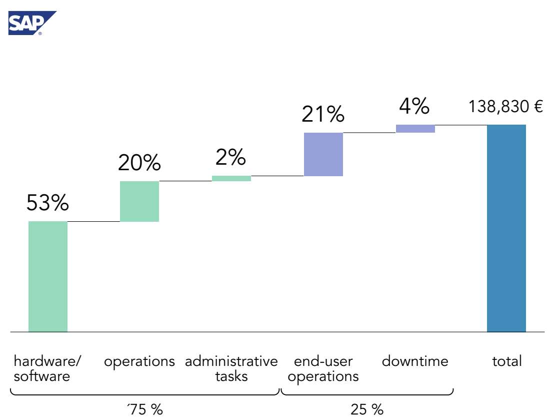
(c) TCO of Projectplace



(d) TCO of PSI Projectmanagement



(e) TCO of Oracle Primavera



(f) TCO of SAP Projektsystem

Figure 4.24: TCO Analysis of all Tools

4.4.2 Value Benefit Analysis

In the first part of this chapter, the monetary evaluation of the tools was discussed. A decision of a specific investment also needs to factor non-monetary influences in. These non-monetary influencing factors could be up-to-date technology of the tools, dependence on and long-term availability of software provider, security of software and hardware against *hacker* attacks and several other factors.

A method to systematically compare alternatives on a non-monetary level is the so called **Value Benefit Analysis**. Considering both monetary and non-monetary aspects of the tools will provide a comprehensive basis for the decision making process. In the following part of this section, we address the fundamentals of the value benefit analysis and later on, the calculations of the value benefit for each tool is given.

Fundamentals Value Benefit Analysis

The value benefit analysis is a method to evaluate alternatives for decision making processes, whereby multiple evaluation criteria are considered. These criteria do compete among each other. This method allows to consider quantitative as well as qualitative consequences.[30]

The value benefit analysis, often known as utility analysis, was originally developed in the United States. In the German-speaking regions the approach was designed by Zangemeister in the beginning of 1970s. The idea of the value benefit analysis is to express the fitness for purpose of alternatives by a number, a so called *value benefit*. This value benefit is a dimensionless factor, which is tied to the target- and evaluation system of the alternatives. The approach to calculate the value benefit is the following:[31]

1. Define target: Formulating evaluation criteria and structuring them in a hierarchy.
2. Weight sub targets: Expressing the importance of each target criteria to each other by numbers. Either it is a knot weight or a hierarchy weight. A hierarchy weight of a sub target is the result of multiplying the knot weight of the sub target by the hierarchy weight of the supra target.

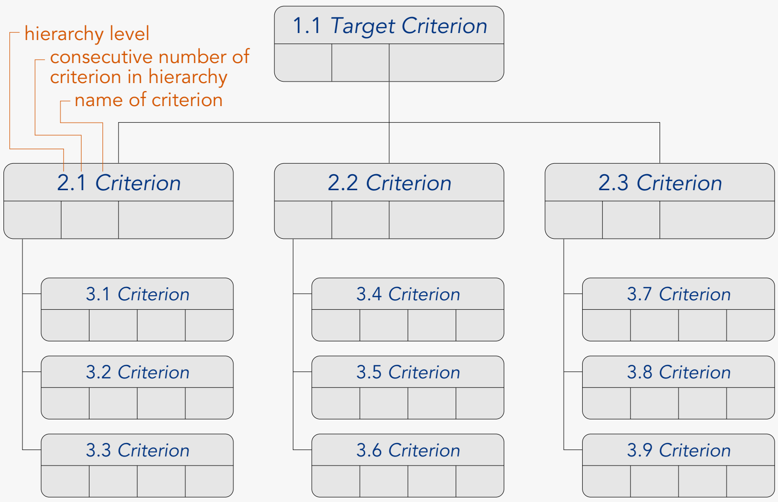
[30]cp. Preißner [2010], p 84 f and Rüegg-Stürm u. Sander [2009], p 209 f
[31]cp. Hoffmeister [2007], p 280 and Zangemeister [1971], p 45

3. Evaluate alternatives regarding their sub target fulfillment: Both ordinal and metric scales are suitable. An **ordinal** scale gives information about the hierarchy of the evaluated criteria: a is *bigger* than b, c is *weaker* than b, so a $>$ b $>$ c etc. The ordinal scale is e.g. used for grading. The grade 1 is better then 2 etc. However, one does not know, whether the difference between grade 1 and grade 2 is the same than between grade 3 and grade 4. In other words, one would know, that grade 2 is better than grade 4, but grade 2 is not (necessarily) two times better than grade 4. A **metric** scale gives information about the difference between two values. Using a similar example, to receive grade 2, one would need to achieve 82 points out of maximum 100 point and to received grade 4, one would need 50 points. If candidate A has 100 points (therefore grade 1) and candidate B as 50 points (therefore grade 4), that would give information about the difference between these two values. In this case, 50 points difference and candidate A is twice as good as candidate B.
4. Determine sub value benefit: Multiplying the hierarchy weight of the lows hierarchy level by the defined rating.
5. Determine overall value benefit: Adding all sub value benefits of one hierarchy level for each alternative

In figures 4.25, 4.26, 4.28, 4.29 and 4.30 all five steps to calculate the value benefit are schematically illustrated. Firstly, the target criterion and the sub target criteria are defined. As illustrated in figure 4.25, the result is a *hierarchy tree*. The main target criterion is on top of this tree and it can be structured into, in this case, 3 criteria on the second level. Each criterion in the second level may consist also of sub criteria. The number of criteria may vary highly depending on the topic and executing person.

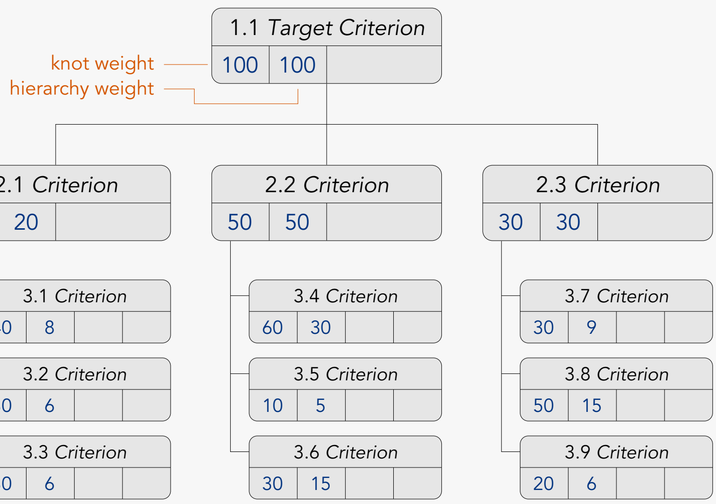
Secondly, the knot weight for each criteria, independently on which hierarchy level it is situated, is evaluated, see figure 4.26. The hierarchy weight of a specific criterion is deduced by the knot weight of this certain criterion multiplied by the knot weight of the criterion one hierarchy level above and then divided by 100. For example, the hierarchy weight of the item *3.2 Criterion* is calculated the following: $30 \cdot 20/100 = 6$. The first number, 30, represents the knot weight of the item *3.2*, the second number, 20, represents the knot weight of the item *2.1*

The common understanding to do the weighting is comparing each criterion in pairs, a so called *pairwise comparison*. The aim is to directly compare each criterion with the others



Source: own representation based on Schulte [2001], p 240

Figure 4.25: Value Benefit Analysis: 1. Step: define target criteria



Source: own representation based on Schulte [2001], p 240

Figure 4.26: Value Benefit Analysis: 2. Step: weight sub targets

and get a final ranking based on the importance. Each criterion is put in a matrix, firstly column by column and secondly row by row. The result is a 2x2-matrix, see figure 4.27. Then, the criterion in one line is compared with all other criteria in the columns, except its own criterion. This comparison can be done by defining e.g. three comparison levels: better, equal or worse. In this case, *Criterion A* is better than *Criterion B*. Finally the total of each row is built and summed up. The weighting of *Criterion A* is calculated by the dividing the row-sum of *Criterion A* by the total sum.[32]

	Criterion A	Criterion B	Criterion C	Criterion D	Criterion E		
Criterion A		2	2	1	2	7	35%
Criterion B	0		1	2	0	3	15%
Criterion C	0	1		0	2	3	15%
Criterion D	1	0	2		2	5	25%
Criterion E	0	2	0	0		2	10%
						20	100%

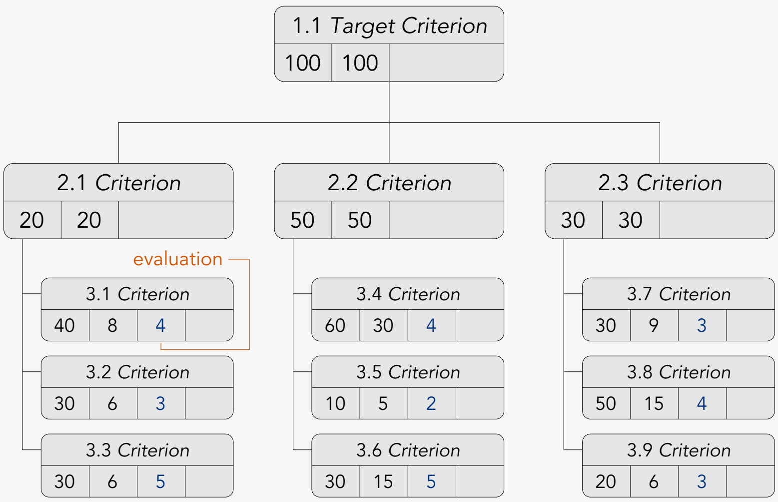
Source: own representation based on Schulte [2001], p 240

Figure 4.27: Schematical Illustration of a pairwise comparison

The third step is about evaluating each criterion, see figure 4.28. In this case, the criteria were evaluated on an ordinal scale from 1 to 5, whereby 5 represents the best fulfillment of the analyzed alternative for this criterion and 1 the worst fulfillment. The evaluation was done for all criteria on the lowest hierarchy level.

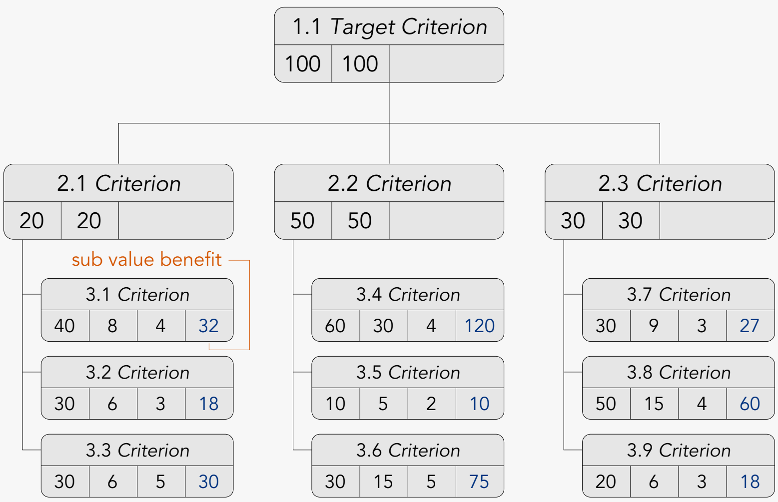
Fourthly, the sub value benefit is determined, see figure 4.29. The formula for doing it, is multiplying the hierarchy weight by the defined rating. In the case of item *3.2 Criterion* it is $6 \cdot 3 = 18$. In step 4 one need to do that for all criteria on the lowest hierarchy level.

[32]cp. Lindemann [2009], p 289



Source: own representation based on Schulte [2001], p 240

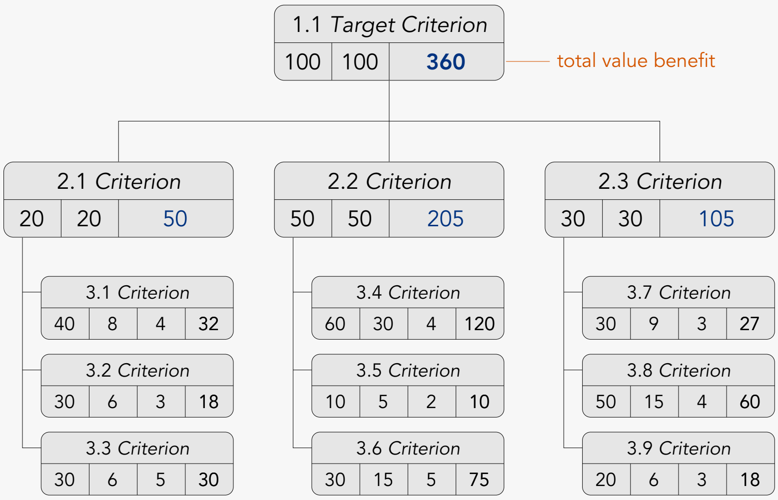
Figure 4.28: Value Benefit Analysis: 3. Step: evaluate regarding their sub target fulfillment



Source: own representation based on Schulte [2001], p 240

Figure 4.29: Value Benefit Analysis: 4. Step: determine sub value benefit

Finally, the total value benefit is determined, see figure 4.30. At first, the value benefit for all criteria on the second hierarchy level is calculated by adding up all sub value benefits of their sub criteria. In the case of item *2.1 Criterion* it is the sum of the sub value benefits of item *3.1*, *3.2* and *3.3*. Having done this, the last task is to add up all value benefit of the second hierarchy level. This is the total value benefit of the analyzed alternative. In this case it is 360, whereby the maximum, using a ordinal scale up to 5, is 500. The minimum total value benefit in this case would be 100, as the scale starts at 1.



Source: own representation based on Schulte [2001], p 240

Figure 4.30: Value Benefit Analysis: 5. Step: determine overall value benefit of the analyzed alternative

VB-Analysis of the Tools

For caluclating the value benefit of the tools, interviews with ACC's IT experts, end-users and the management on the one hand and interviews with IT experts participating in the CIO-Event organized by Capgemini Consulting on the other hand were held to gather, to structure and to describe the criteria for the value benefit analysis, see figure 4.31. Thereafter, the evaluation with all attending IT experts was done in collaboration. The outcome of the interview were five different criteria groups, which were seen as relevant by the interviewees:

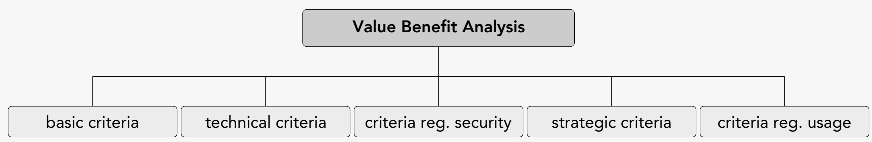
(A) basic criteria,

(B) technical criteria,

(C) criteria regarding security,

(D) strategic criteria and

(E) criteria regarding usage.



Source: own representation

Figure 4.31: Structure of Value Benefit Analysis Criteria

In the following tables 4.5 and 4.6, detailed information regarding the weighting and the value benefit calculation are given. The tool with the highest value benefit is Microsoft Project with 387 points, which is an overall fulfillment of 77 %.

criterion	*weighting*		PSI		ORACLE PRIMAVERA		Sciforma	
	knot	*hier.*	*rat.*	***VB***	*rat.*	***VB***	*rat.*	***VB***
A. basic criteria	**10**							
A.1 references	30	3.00	2	6.00	4	12.00	1	3.00
A.2 advisory activity	25	2.50	4	10.00	3	7.50	3	7.50
A.3 support	45	4.50	4	18.00	3	13.50	4	18.00
B. technical criteria	**25**							
B.1 technology	10	2.50	4	10.00	3	7.50	5	12.50
B.2 data interface	15	3.75	3	11.25	3	11.25	3	11.25
B.3 licensing concept	15	3.75	4	15.00	3	11.25	3	11.25
B.4 simpleness of software realization	10	2.50	4	10.00	4	10.00	3	7.50
B.5 functionality	20	5.00	4	20.00	4	20.00	4	20.00
B.6 simpleness of hardware installation	15	3.75	2	7.50	2	7.50	5	18.75
B.7 simpleness of software installation	15	3.75	2	7.50	2	7.50	5	18.75
C. criteria regarding security	**25**							
C.1 security against software virus	65	16.25	4	65.00	4	65.00	2	32.50
C.2 security against hardware damages	35	8.75	4	35.00	4	35.00	2	17.50
D. strategic criteria	**25**							
D.1 dependency on software provider	30	7.50	3	22.50	2	15.00	3	22.50
D.2 availability of software provider on the long run	70	17.50	3	52.50	4	70.00	3	52.50
E. criteria regarding usage	**15**							
E.1 easy training	20	3.00	3	9.00	2	6.00	3	9.00
E.2 ease of use	50	7.50	3	22.50	3	22.50	3	22.50
E.3 plausibility checks	30	4.50	4	18.00	4	18.00	4	18.00
				339.75		**339.50**		**303.00**

Table 4.5: Value Benefit Analysis for PSI Projectmanagement, Oracle Primavera and Sciforma

criterion	weighting		Microsoft		SAP		Projectplace	
	knot	*hier.*	*rat.*	***VB***	*rat.*	***VB***	*rat.*	***VB***
A. basic criteria	**10**							
A.1 references	30	3.00	4	12.00	4	12.00	1	3.00
A.2 advisory activity	25	2.50	3	7.50	3	7.50	3	7.50
A.3 support	45	4.50	3	13.50	3	13.50	4	18.00
B. technical criteria	**25**							
B.1 technology	10	2.50	4	10.00	4	10.00	5	12.50
B.2 data interface	15	3.75	3	11.25	3	11.25	3	11.25
B.3 licensing concept	15	3.75	4	15.00	3	11.25	3	11.25
B.4 simpleness of software realization	10	2.50	5	12.50	3	7.50	3	7.50
B.5 functionality	20	5.00	3	15.00	2	10.00	2	10.00
B.6 simpleness of hardware installation	15	3.75	4	15.00	2	7.50	5	18.75
B.7 simpleness of software installation	15	3.75	3	11.25	2	7.50	5	18.75
C. criteria regarding security	**25**							
C.1 security against software virus	65	16.25	4	65.00	4	65.00	2	32.50
C.2 security against hardware damages	35	8.75	5	43.75	4	35.00	2	17.50
D. strategic criteria	**25**							
D.1 dependency on software provider	30	7.50	3	22.50	2	15.00	3	22.50
D.2 availability of software provider on the long run	70	17.50	5	87.50	4	70.00	3	52.50
E. criteria regarding usage	**15**							
E.1 easy training	20	3.00	3	9.00	2	6.00	3	9.00
E.2 ease of use	50	7.50	3	22.50	2	15.00	4	30.00
E.3 plausibility checks	30	4.50	3	13.50	4	18.00	4	18.00
				386.75		**322.00**		**300.50**

Table 4.6: Value Benefit Analysis for Microsoft Project, SAP Projektsystem and Projectplace

In table 4.7 the results of the value benefit analysis are presented. The results are ranked according to the value benefit of the tools.

1.	Microsoft Project	387	(77 %)
2.	PSI Projectmanagement	340	(68 %)
3.	Oracle Primavera	339	(68 %)
4.	SAP Projektsystem	322	(64 %)
5.	Sciforma Projectmanagement	303	(61 %)
6.	Projectplace	300	(60 %)

Table 4.7: Results of value benefit analysis

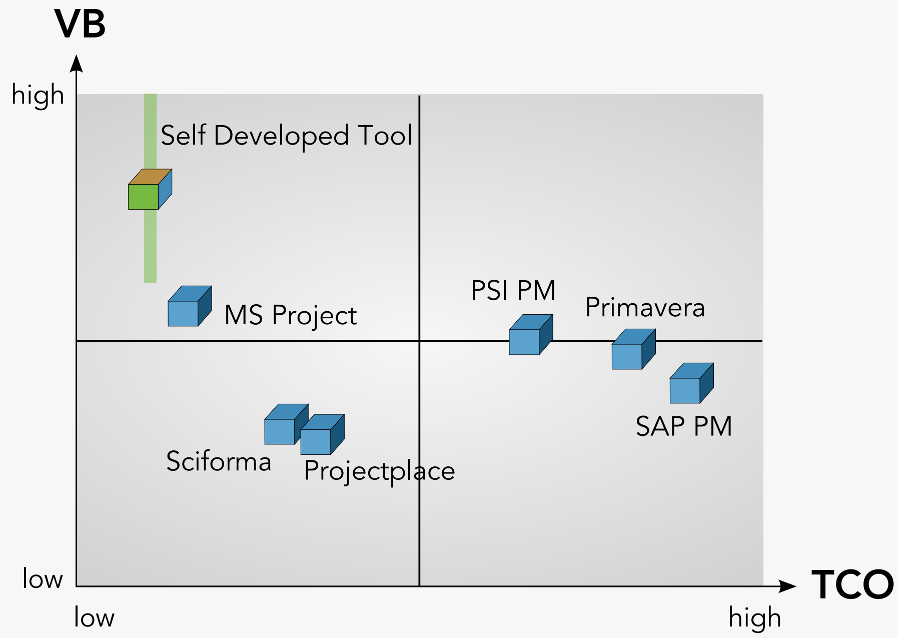
4.5 Classification

For choosing a tool, a classification of the tools regarding their value benefit and their total cost of ownership shall be supported. Being able to classify them into a 2x2 matrix, some statistical calculations are done to define the maximum scale values and the minimum scale values for the abscissa and the ordinate. Therefore, arithmetic average, minimum and maximum values of the sample as well as standard deviation are calculated and used for determining maximum scale values and minimum scale values.

Having done the classification of the tools into the 2x2 matrix, we are now able to categorize the tools into three groups:

- selecting: high VB at low TCO
- considering: high VB at high TCO or low VB at low TCO
- abolishing: low VB at high TCO

In figure 4.32, the categorized tools are schematically illustrated in the 2x2 matrix. SAP Projektsystem and Oracle Primavera are according to the categorization worst suitable. Sciforma Projectmangement and Projectplace are categorized as selectively suited. PSI Projectmanagent is at the boarder between worst suited and selectively suitable. Well suitable tools are MS Project and in the case that the value benefit of ACC's self-developed tool is above the average it is also well suitable.



Source: own representation

Figure 4.32: Classification of all Tools

4.6 Decision and Tool realization

Microsoft Project and ACC's self-developed tool are categorized in the area of suitable tools, see figure 4.32. According to all findings the enterprise's IT experts were consulted. The aim was to gather information for supporting the decision making process whether to internally develop the tool or to externally buy the tool. The internally developed tool would be ACC self-developed tool (ACC SDT) and the externally bought tool would be Microsoft Project. Based on the total cost of ownership of Microsoft Project would be 28,260 € and the total cost of ownership of ACC SDT would be 17,760 €, the IT experts pointed out five highly important aspects, when developing the tool internally:

- exactly designing the tool according to the enterprise's expectations,
- the tool would be fully customizable, even when already integrated,

- fully independent from a software supplier respectively software provider,
- know-how to develop a tool is available in the enterprise and
- resources are available to develop, implement and upgrade the tool.

The main aspect, when developing the tool internally, is to design the tool in a way, that its value benefit would be higher than Microsoft Project's value benefit. As determining a certain value benefit of a tool in advance would not be possible, this constitutes a certain risk. According to the in-house competences regarding software development, the tool is going to be developed by the IT department.

4.7 Implementation and Integration

According to the requirement for designing a process based on Business Process Model and Notation (BPMN), at the begining of this chapter BPMN is described briefly and later the designed processes are discussed.

4.7.1 Business Process Model and Notation

Within this section, the reasons for the need for a notation is discussed. Furthermore, a brief overview of the development of the notation is and several types of notations are given.

The need for a notation

Business processes consist of value defining, value creating, management and support processes. The aim of all these different kind of processes is to contribute a certain part for transforming a specific input into a specific output.[33] To manage the processes, it is essential to describe and to document the processes.[34]

To describe the processes, one needs to consider all relevant aspects, e.g. occuring events, branch rules, participating organisational parties, flow of information, root for initiating

[33] cp. Haberfellner [2011], p 3-117
[34] cp. Allweyer [2009], p 8

the process etc. A notation is a graphical way of modeling business processes and it creates a common understanding of how each element of the notation may be used, how each element may be linked with another and most importantly what each element does actually mean. Business Process Model and Notation (BPMN) is a standard for business process modeling.[35]

Development of BPMN

BPMN was initially published by Business Process Management Initiative (BPMI) in 2004. BPMI is an organisation, which consists of representatives of software enterprises and it defined a standard for modeling business processes. Since 2005, BPMN has been managed by the organisation Object Management Group (OMG) and BPMI merged with OMG. In 2006, the BPMN Version 1.0 was officially published and since that two updates of the first versions were made in 2008 and 2009.[36]

Specific information regarding the adaptions from version 1 to version 1.1 and to version 1.2 can be found in Object Management Group (2009).[37] Since January 2011 the latest version of BPMN, version 2.0, is available.[38]

Description of notations of BPMN

The BPMN covers a great variety and extensive number of elements. A description of the elements is given below. According to the elements used in the planning process and controlling process, only those are described in this section

In figure 4.33 the relevant elements, which were used for designing the process, are illustrated. The elements are described below. According to BPMN there are five basic categories of elements: flow objects, data, connecting objects, swimlanes and artifacts.[39]

- **Flow objects** are the main elements to define the behavior of the business process. Within flow objects one may differ between events, activities and gateways. *Events* occur during the course of a process. They affect the flow of the process, and

[35] cp. Allweyer [2009], p 8
[36] cp. Allweyer [2009], p 10 and Müller [2011], p 11
[37] cp. Allweyer [2009], p 10
[38] cp. Object Management Group (2011), p 1 ff
[39] cp. Object Management Group (2011), p 20 ff

therefore the flow of the model, and generally have a cause (trigger) or an impact (result). The symbol of an event is a circle with open centers. Depending on when they affect the flow, they have different internal markers for start, intermediate and end.

Activities are a basic term for work that needs to be done during the process. Within activities one may differ between sub-processes and tasks. The symbol of an activity is a rounded rectangle.

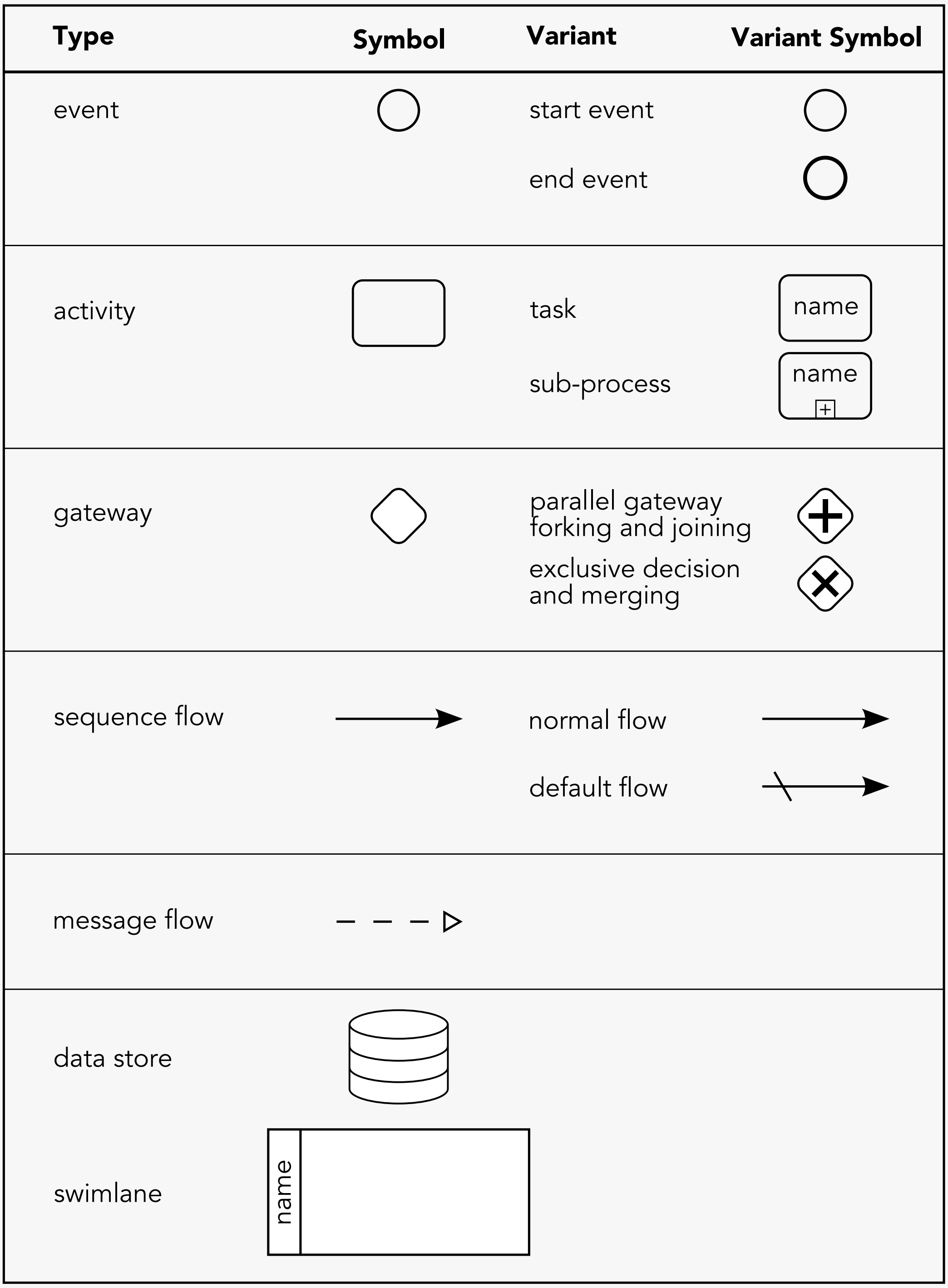
Gateways are used to control divergences and convergences of flows in a process. There are different types of gateways with certain impacts, e.g. branching, forking, merging and joining of paths. The symbol of a gateway is a rhombus, having four equally sized angles.

- **Data** is represented by data objects, data inputs, data outputs and data stores. *Data objects* provide informations about activities, which are necessary to be done. *Data input* and *data output* provide the same information for the process. *Data stores* manage the storing of data.

- **Connecting objects** are ways to create a link between elements. These can be sequence flows, message flows, associations or data associations. Main important connecting objects are in this thesis sequence flows and message flows.
  Sequence flows are used to link two elements in a certain order. A normal flow is a simple connection between two elements and it defines the execution flow of activities. A default flow is the default branch to be chosen if all other conditions evaluate to false. *Message flows* are used to show the flow of information between two participants.

- **Swimlanes** are either pools or lanes used for structuring a process model.
  A *pool* is a representation of a participant. A *lane* is a sub-participant within a pool. These elements are used to organize and categorize activities.

- **Artifacts** are used to provide additional information regarding the process. An artifact may be seen as a *group* or as a *text annotation*



Source: own representation based on Object Management Group (2011), p 20 ff

Figure 4.33: Illustration of elements used for designing the processes

4.7.2 Planning process

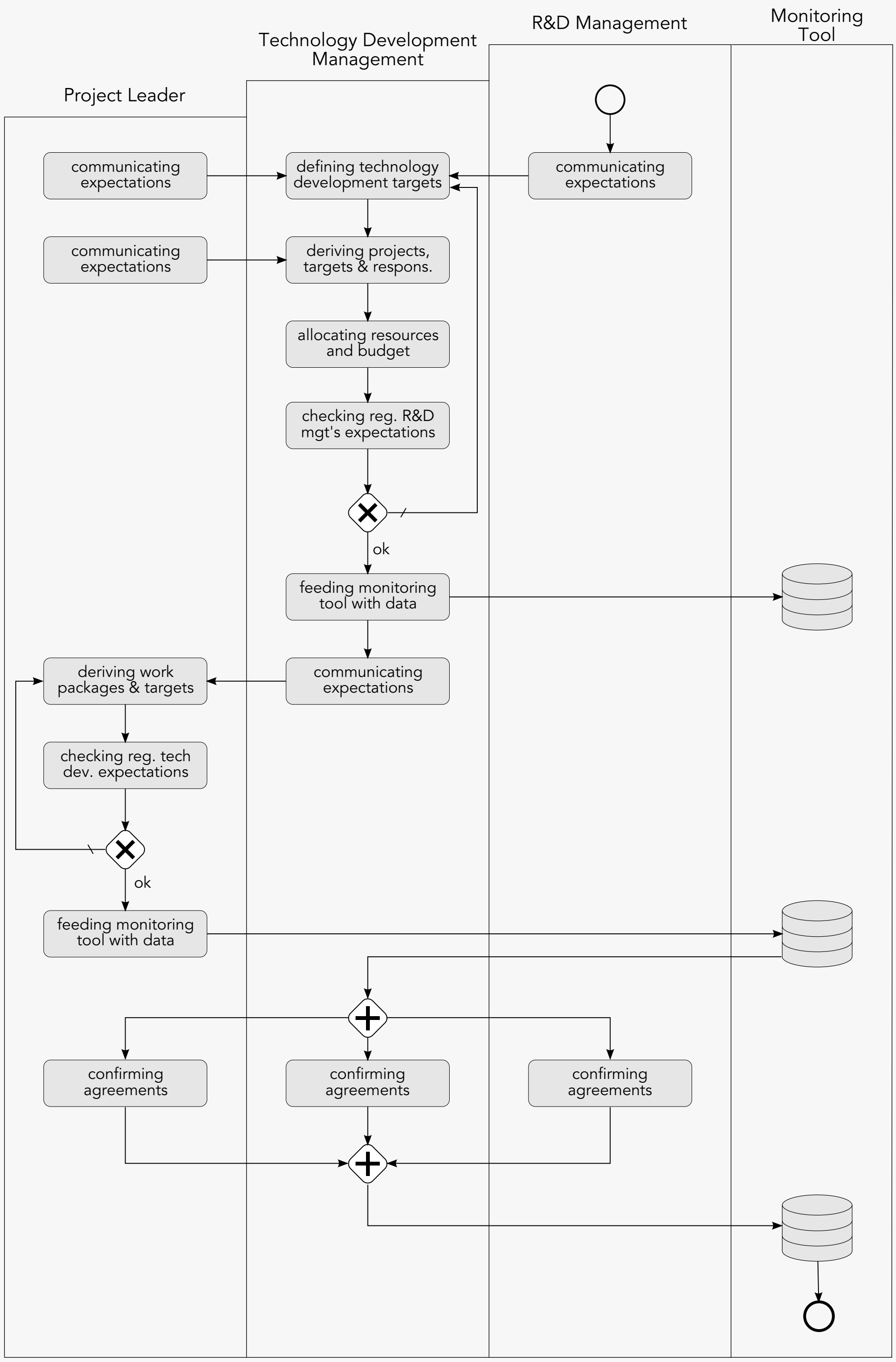
For planning technology development projects, the following tasks are required to be done:[40]

- defining technology development targets,
- deriving projects and their targets,
- allocating responsibilities for each project,
- allocating resources and budget for each project,
- deriving work packages and their targets,
- feeding monitoring tool with data and
- confirming the agreements.

The planning process shall be designed according to the principle *keep it short and simple*. Along the planning process the R&D management, technology development management and all project leaders are participating. The technology development management shall be responsible for defining targets, whether for the entire technology development or each projects. The R&D management will have mainly a guiding role. After the planning is done, the agreements shall be confirmed by all participants. During the process, the monitoring tool shall be feeded with relevant data. In figure 4.34 the process for planning technology development projects is schematically illustrated according to BPMN.

The BPMN defines, that each participant of the process is represented in a certain swimlane. Participants may be companies, departments, teams, single persons or virtual participants (e.g. servers, androids). The participants of the planning as well as of the controlling process are the monitoring tool itself, the R&D management, technology development management and project leaders. Each participant is assigned to one swimlane. The planning process is initiated by the R&D management. The process is closed after confirming the agreements by all participating management levels (R&D management, technology development management and project leaders).

[40] cp. ACC [2012b], p 6



Source: own representation

Figure 4.34: Process for Technology Development Project Planning

The main responsible person within this process is the person who represents the technology development management. By integrating both R&D management and project leaders into defining the technology development targets, expectations of all participants are considered. Based on the technology development targets, projects are derived. According to the projects, project targets are defined and responsibilities are assigned to projects. This is done by the technology development management. An interim check procedure shall ensure that the expectations of the R&D management are fulfilled. If the projects are defined, the monitoring tool will be feeded with the relevant data. These relevant data are project name, project description, responsibilites, important deadlines, allocated budget, person-hours and priorities.

Based on the project assignments, each project leader will derive work packages and work package targets considering budget and personal resources. A final check regarding technology development expectations shall ensure that each project manager is in line with the overall requirements. After feeding the monitoring tool with the data, each participant needs to confirm the agreement via the monitoring tool. Thereafter the planning process is finished.

4.7.3 Controlling process

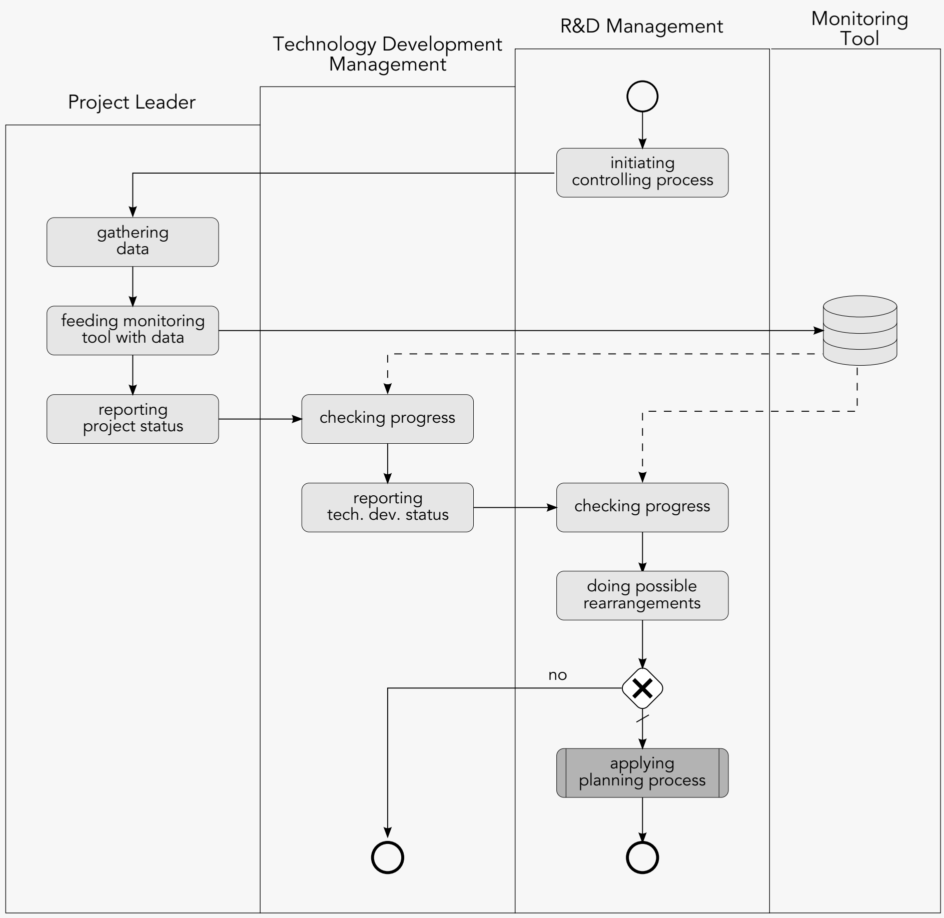
For controlling technology development projects, the following tasks are required to be done:[41]

- verbal reporting according to bottom-up principle,
- information shall be prepared using the monitoring tool and
- possible rearrangements regarding targets etc. may be done.

Also the controlling process shall be designed according to the principle *keep it short and simple*. Along the controlling process the R&D management, technology development and all project leaders are participating. The main role is assigned to the R&D management and the technology development management shall do a pre-checking regarding progress. Any decision causing rearrangements needs to be done by the R&D management. In figure 4.35 the process for controlling technology development projects is schematically illustrated according to BPMN.

[41] cp. ACC [2012b], p 6

The controlling process is initiated by the R&D management. According to the bottom-up principle, each project leader will then gather all relevant data regarding the specific project. After feeding the monitoring tool with the required data, the tool will then automatically report the project status to the technology development management and R&D management. The project leaders will verbally report the project status to the technology development management. They will discuss the progress and develop possible rearrangements.



Source: own representation

Figure 4.35: Process for Technology Development Project Controlling

In the next step, the technology development management will report the technology development progress to the R&D management. Based on the development progress they will work out possible rearrangements. If the progress of a project will fulfill the requirements, the controlling process is finised. If any rearrangements need to be done, the planning process will then be initiated for those projects which do not meet the progress requirements. Thereafter, the controlling process is finished. Based on the internal controlling cycle, the controlling process will be started again after a certain period of time.

5 Summary

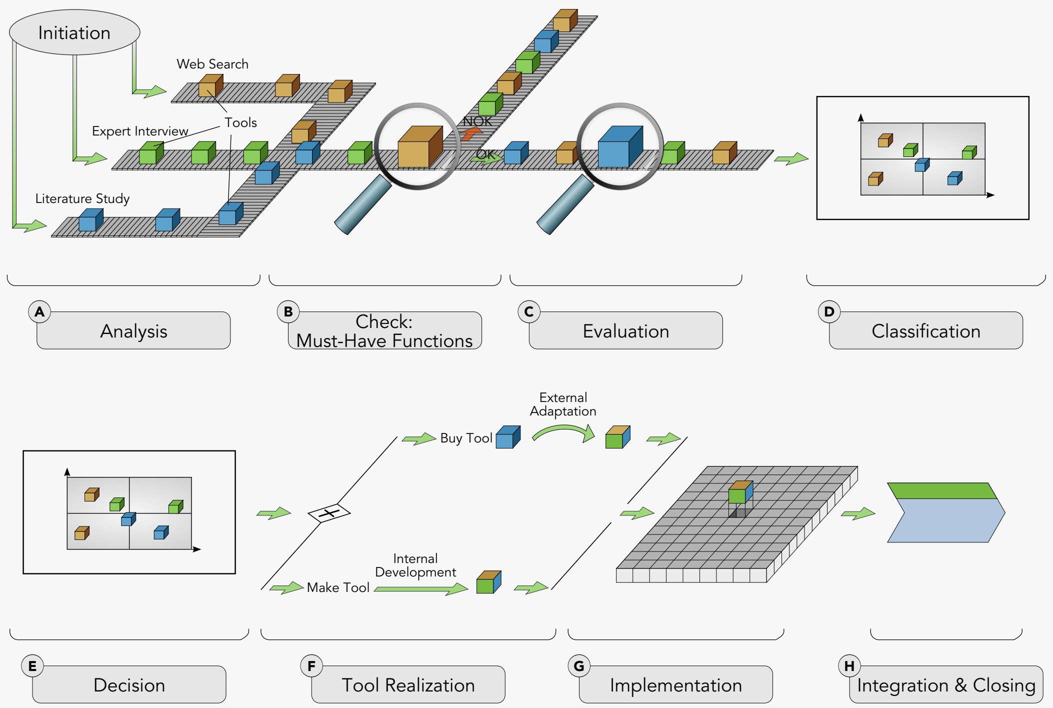
Summarized, within this thesis three tasks were accomplished. At first, a generic approach for integrating a monitoring tool according to systems engineering requirements was designed. Secondly, an analysis and evaluation regarding monetary and non-monetary aspects of several monitoring tools was done. Finally, a process for using the tool according to Business Process Model and Notation was designed.

For developing the generic approach, a literature study was done to gather information about several approaches for designing a generic process. Therefore, the systems engineering approach by Haberfellner et al., Plan-Do-Check-Act circle by Deming and a general problem solving process by Jakoby were analysed and evaluated. According to the evaluation, systems engineering approach was used to design the generic process for integrating a monitoring tool. Starting with an initiation, the process contains 8 steps. The process is schematically illustrated in figure 3.2.

The process follows the recommendations according to systems engineering:

- from coarse to detail,
- thinking in variants,
- chronological process and
- problem solving process.

During the analysis, over 250 monitoring tools were found. According to the defined requirements, the number of tools was reduced to 35. Furthermore, after the regarding must-have functions, the list contained only 7 monitoring tools. The monitoring tools were PSI Projectmanagement, Oracle Primavera, Sciforma Projectmanagement, Microsoft Project, SAP Projektsystem, Projectplace and the ACC in-house developed tool. The evaluation was done for monetary and non-monetary aspects. For monetary aspects the total cost of ownership approach developed by Gartner Group was used. The



Source: own representation

Figure 5.1: Generic process for integrating a tool

self-developed tool by ACC and Microsoft Project were the most reasonable tools according to total cost of ownership. Server-based tools, such as Oracle Primavera, PSI Projectmanagement and SAP Projektsystem have the highest costs. Web-based tools, such as Sciforma and Projectplace, are between the most reasonable tools and the most expensive tools.

Non-monetary aspects were evaluated by a value benefit analysis. The value benefit analysis covered basic criteria, technical criteria, criteria reg. security, strategic criteria and criteria reg. usage. The most suitable tools regarding the value benefit analysis is Microsoft Project. The company decided to put the tool development in hand of the IT department and to start an in-house development. Five highly important aspects were pointed out for this decision:

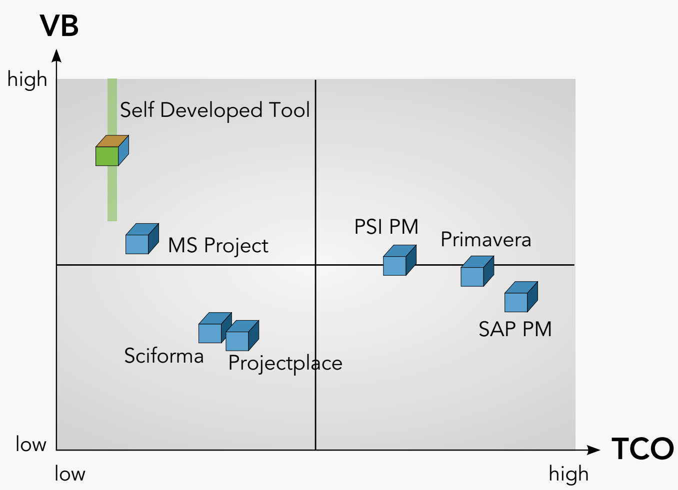
- exactly designing the tool according to the enterprise's expectations,
- the tool would be fully customizable, even when already integrated,

- fully independent from a software supplier respectively software producer,
- know-how to develop a tool is available in the enterprise and
- resources are available to develop, implement and upgrade the tool.

The results of the evaluation are shown in table 5.1 and the classification of the tools is given in figure 4.32.

	TCO (abscissa)	VB (ordinate)
Samples		
PSI Projectmanagement	103, 430 €	340
Oracle Primavera	119, 730 €	339
Sciforma Projectmanagement	48, 280 €	303
Microsoft Project	28, 260 €	387
SAP Projektsystem	138, 830 €	322
Projectplace	51, 120 €	300
ACC Self-Developed Tool	17, 760 €	–

Table 5.1: Results of evaluation



Source: own representation

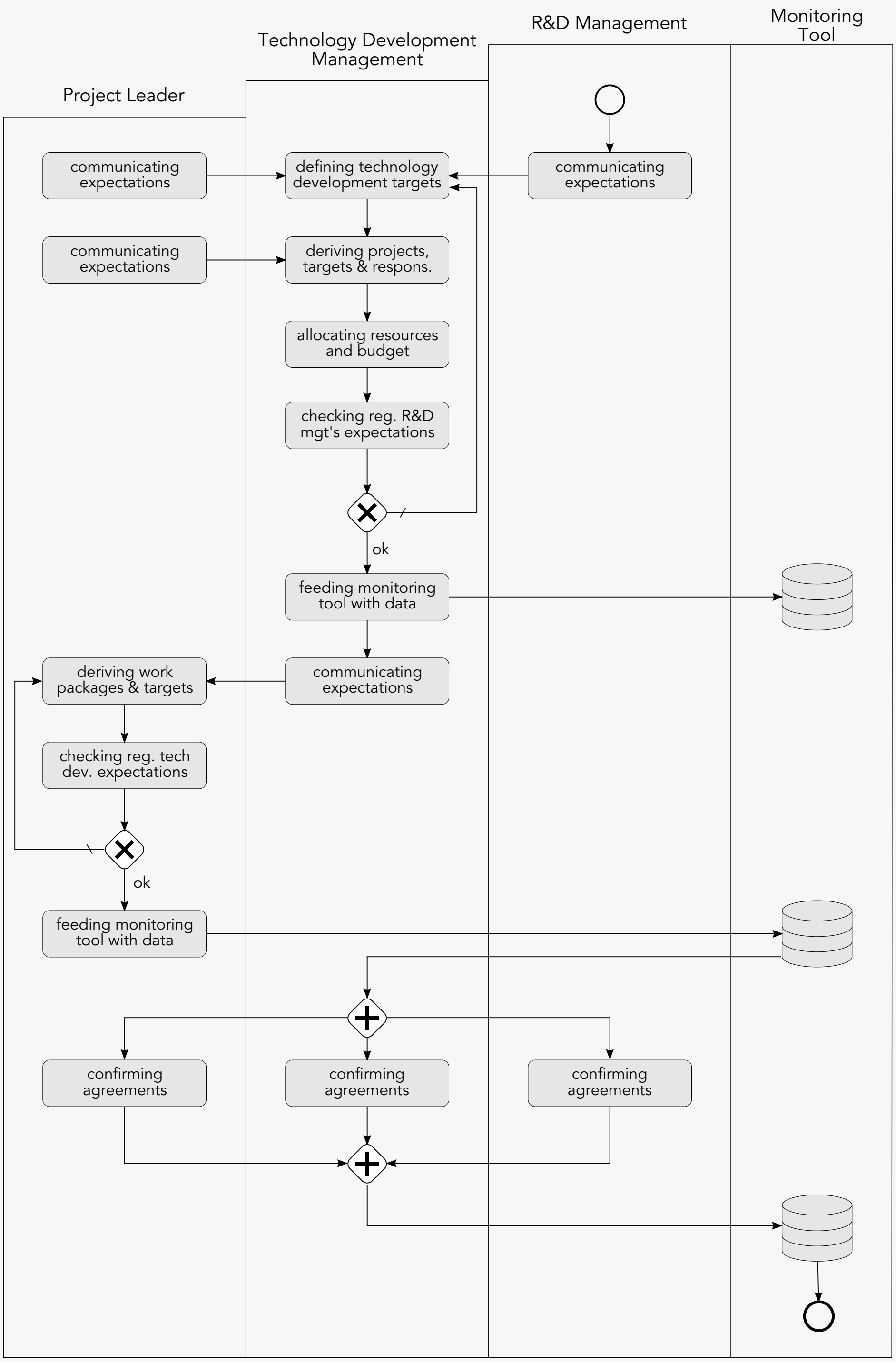
Figure 5.2: Classification of all tools

Finally, processes for using the tool according to BPMN were designed. For using the tool for planning technology development projects, the process is schematically shown in figure 4.34, whereby the following tasks were identified in advance:

- defining technology development targets,
- deriving projects and their targets,
- allocating responsibilities for each project,
- allocating resources and budget for each project,
- deriving work packages and their targets,
- feeding monitoring tool with data and
- confirming the agreements.

For using the tool for monitoring technology development projects, the process is schematically shown in figure 4.35, whereby the following tasks were identified in advance:

- gathering data,
- feeding monitoring tool with data,
- checking progress,
- reporting progress,
- doing possible rearrangements and
- in case of applying rearrangements: applying planning process.



Source: own representation

Figure 5.3: Process for Technology Development Project Planning

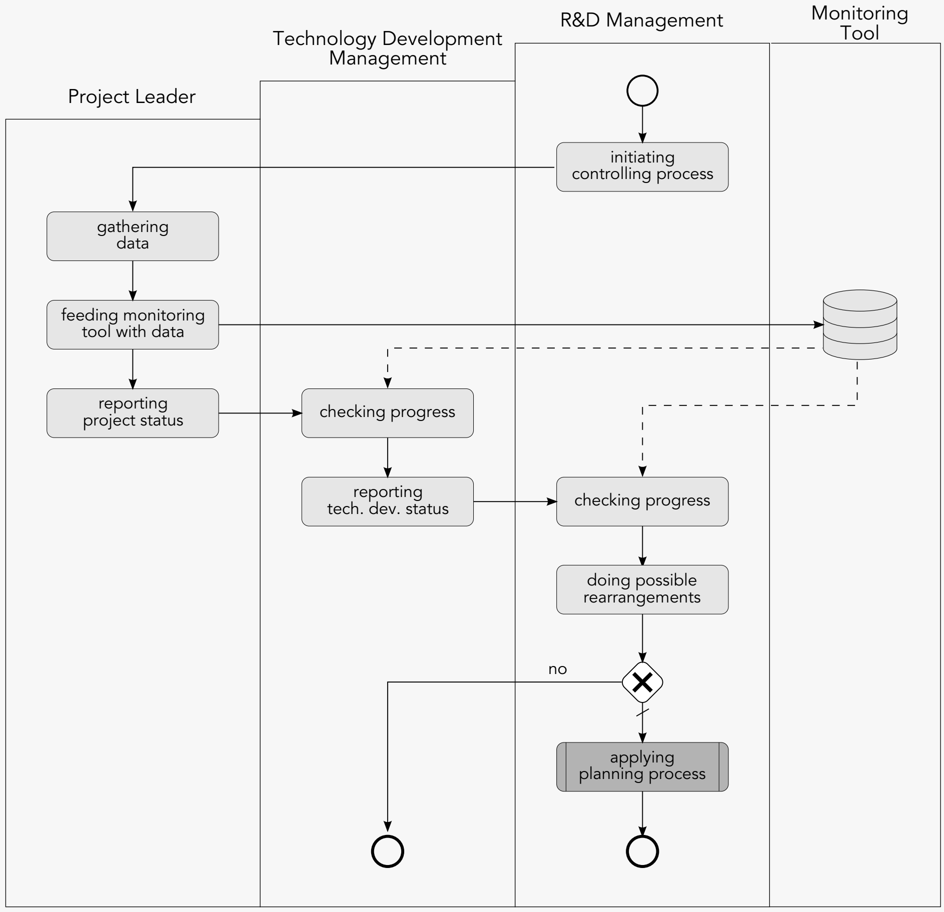


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Figure 5.4: Process for Technology Development Project Controlling

A Appendix

Source: own representation

Figure A.1: Details regarding weighting of value benefit criteria (part 1)

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Figure A.2: Details regarding weighting of value benefit criteria (part 2)

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List of Abbreviations

ACC	Appliances Components Companies
BPMN	Business Process Model and Notation
COP	Coefficient of performance
etc.	latin: et cetera, english: and so on / and so forth
IT	Information technology
OMG	Object Management Group
R-D	Research and Development
TCO	Total cost of ownership
VB	Value benefit
VBA	Value benefit analysis