ABB SWITZERLAND LTD.

Innovation Management in ABB

IT Innovation designed for Customer Experience

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Management Summary

This Thesis sets out some foundations for the influence of innovation on the Factory Acceptance Test (FAT) of the Generator Circuit Breaker that is manufactured in ABB Schweiz AG in Zürich-Oerlikon, Switzerland. It is an academic study that came out during a traineeship in the project execution department while improving the FAT process from a marketing point of view, applying innovation to increase the experience of the customers.

The Factory Acceptance Test is made by the manufacturer, ABB Switzerland Ltd, at the factory as part of the process of producing the Generator Circuit Breaker. In the most cases, the customer attends this test in order to certify that the design specifications and manufactured product fit with the requirements.

In usual applications, the principal function of the Generator Circuit Breaker is to carry generator rated load current and provide a means for interruption of short-circuit current from the generator as well as from the power system.

This Thesis has the goal to explain how innovation is carried out in ABB, globally and locally. It consists of five different chapters that are structured based on a top-down approach.

The first chapter presents the theoretical basis of innovation and deepens into Strategic Technology and Innovation Management, IT Innovation and Knowledge Management strategies.

To understand better the work environment as well as the innovation processes in ABB Global and ABB Switzerland Ltd., the second chapter is a research on ABB's innovation activities. It focuses on the global organization structure and R&D execution and explains the optimizations done in the production process of the Generator Circuit Breaker and its influence on the FAT process.

Due to the change from a traditional to a Lean based assembly, the FAT process required adapting. These requirements as well as the process flow, the agents and goals are presented in the third chapter. This chapter will set up the object of the study and frame all the later actions, taking into account that it is a process where customers play a main role, as they have to witness and accept the results of the tests.

The fourth chapter focuses on the innovative improvements applied to the FAT. The utilization of the Remote Factory Acceptance Test (RFAT) System and the creation of a Lotus Notes Database Tool are the basis to improve the whole process from a customer oriented point of view. These actions are

explained considering the theory of innovation of the first chapter, the organizational environment of the second one and the FAT process defined in the third chapter.

The last chapter presents the conclusions regarding the impact of the improvements, and evaluates possible reutilization scenarios for both tools.
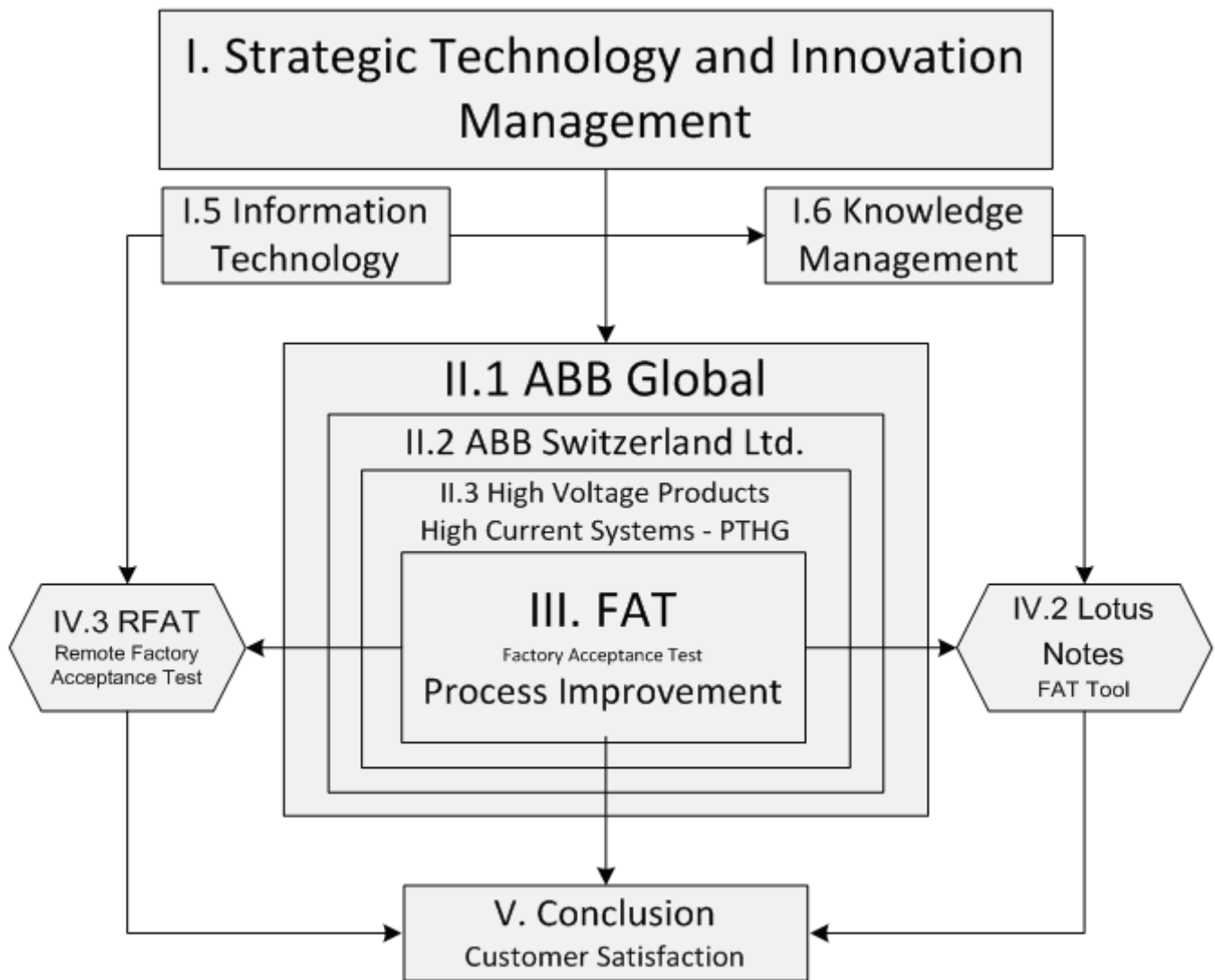
Figure 1. Thesis conceptual structure

Foreword

This Master Thesis has been written in collaboration with ABB Switzerland and "Programa INNOVA UPC". It has been written during an abroad Traineeship in ABB in Zürich as part of the UNITECH International Program.

It has been directed and supervised by Dr. Markus Bachmann, Head Project Execution and Production of ABB PTHG, and Prof. Pere Losantos of the "Universitat Politècnica de Catalunya". I want to specially thank Markus for his commitment and Pere for his counsel.

I want also to thank Ms. Merce Aguila and Ms. Carolina Consolación for the coordination of the project. Special acknowledgement for their help, to my colleagues at ABB, Ms. Sanaz Rahimifar, Head of Project Management as well as all Project Managers, Luciano, Cornelis, Hans, Mike, Pascal, Evdalina and Takaomi.

For their support and contribution to my motivation I want to thank my parents, Antonio and Montserrat, my sister Laura, my girlfriend Verónica and my friends Marc, Miguelo, Toni and Carles.

Spanish Abstract

I. Introducción

La necesidad de innovar para descubrir o generar nuevas necesidades en la sociedad, partiendo del punto de inflexión donde la oferta de productos y servicios supera a la demanda, ha sido objeto de numerosos estudios que han dado lugar a distintas teorías y modelos.

Intento exponer nuevas soluciones al respecto, tomando como referente Asea Brown Boveri (ABB), una empresa multinacional presente en más de 170 países, que gestiona mediante decisiones estratégicas los procesos de innovación en un ámbito tanto global como local. La innovación en ABB es el fundamento de su cultura empresarial; todos los trabajadores tienen la obligación de aportar su contribución, en mayor o menor medida, para mejorar e incrementar esta dimensión de la compañía. Durante más de nueve meses he podido vivir y experimentar la cultura corporativa de ABB, responsabilizándome de la optimización y estandarización del proceso de Aceptación en Fábrica.

La posibilidad de realizar este proyecto surgió de la participación en el Programa Unitech International, creado en el año 2000. Su objetivo es relacionar las universidades europeas más cualificadas con las principales multinacionales del continente para formar ingenieros superiores en el campo de la gestión de empresas. Dicho programa consiste en la realización de estudios de gestión empresarial en una universidad extranjera y la ejecución de un período de prácticas en una de las 20 compañías que esponsorizan esta iniciativa.

La elaboración del presente trabajo es fruto de las sinergias existentes entre los programas Unitech e Innova. El Programa Innova tiene como finalidad contribuir a la valorización de la investigación desarrollada en la Universidad Politécnica de Cataluña y fomentar el impulso de la cultura de la innovación y el espíritu emprendedor, favoreciendo la creación de nuevas empresas e instrumentos de conocimiento.
El resultado final es una monografía sobre la gestión estratégica y la promoción de la innovación en una empresa multinacional, a través de nuevas herramientas basadas en las TIC.

II. Resumen

Presentamos los efectos de la innovación en la Prueba de Aceptación en Fábrica (FAT) del "Interruptor de Generador" diseñado y fabricado en ABB Schweiz AG en Zürich-Oerlikon, Suiza. Se trata de un estudio académico que surgió durante un periodo de prácticas en el Departamento de Ejecución de Proyectos, que tenían por objeto mejorar el proceso FAT desde una perspectiva del marketing, promoviendo la innovación en los inputs que recibe el cliente durante el proceso de aceptación del producto.

La Prueba de Aceptación en Fábrica se realiza por la firma ABB como parte del proceso de producción del Interruptor de Generador. En la mayoría de los casos, el cliente asiste a esta prueba con el fin de certificar que las especificaciones de diseño y los requisitos se ajustan a las del producto fabricado.

En las aplicaciones habituales la principal función del Interruptor de Generador es transferir del generador al transformador de línea la carga nominal, y proporcionar un medio de seguridad para la interrupción de su corriente de cortocircuito en función del comportamiento de la red.
Esta monografía analiza este proceso en cinco capítulos que se estructuran desde un enfoque que parte de lo global hacia lo local. El primer capítulo muestra las bases teóricas de la innovación y profundiza en la Gestión Estratégica de Tecnología e Innovación, presentando diferentes modelos, e introduciendo el uso de las TIC.

Para comprender mejor el entorno de trabajo, así como los procesos de innovación en ABB Group, a nivel mundial, y en ABB Switzerland Ltd., a nivel suizo, el segundo capítulo consiste en un trabajo de investigación sobre las actividades que se realizan para favorecer y organizar la Gestión de la Innovación. Fija las estructuras organizativas y analiza la gestión estratégica de la ejecución del I+D+i a nivel global. En el ámbito local describe las optimizaciones realizadas en el proceso de producción del Interruptor de Generador y su influencia en el proceso FAT. Debido al cambio de una producción artesanal a una producción basada en la filosofía Lean, el proceso FAT, integrado en la línea de producción, ha de ser adaptado.

Los requisitos, así como el diagrama de flujo del proceso, los agentes involucrados y los objetivos a alcanzar se introducen en el tercer capítulo. En éste se define la finalidad del estudio y el marco de acción de las tareas a ejecutar, teniendo en cuenta que es una actividad donde los clientes ocupan un papel fundamental, ya que han de ser testigos y aceptar los resultados de las pruebas realizadas.

El cuarto capítulo se centra en las innovaciones aplicadas al proceso FAT. La utilización de herramientas basadas en las TIC, como un sistema para la visualización de forma remota (RFAT) del

proceso FAT, y la creación de una base de datos en Lotus Notes, son el medio para mejorar todo el proceso orientado al cliente. Estas acciones se explican teniendo en cuenta la teoría de la innovación, primer capítulo, el entorno laboral, segundo capítulo y la definición del proceso FAT, tercer capítulo.

El quinto y último capítulo presenta las conclusiones basadas en los resultados de las mejoras, y evalúa los posibles escenarios de reutilización para el RFAT y la aplicación en Lotus Notes.

III. Conclusiones

La estrategia de ABB es la de conjugar las necesidades existentes en los mercados "Need Pull" con el desarrollo de tecnologías fundamentadas en las capacidades competitivas de la compañía "Technology Push". Mediante organismos de decisión basados en el conocimiento de los expertos se asignan inversiones para el desarrollo de nuevos productos y la mejora de procesos enfocados a la excelencia operacional.

Los objetivos se fijan para lograr una mejor orientación al cliente y con ello una mayor efectividad en los mercados, a la vez que se mejoran constantemente los procesos operativos para alcanzar la eficiencia y reducir los costes de producción; por supuesto, manteniendo la calidad y confianza en los productos.

La dificultad en la ejecución del proyecto de optimización de la Prueba de Aceptación en Fábrica ha sido la inclusión de las dos tendencias estratégicas: la eficiencia operacional en los procesos de producción y la diferenciación de los productos para una mayor orientación al cliente.

La utilización de herramientas basadas en las TIC ha dado soporte a la mejora del proceso y ha permitido una implementación más rápida y en un más alto grado por parte de los líderes de proyecto. Es importante subrayar, que las herramientas descritas en este documento no han sido el fin, sino el medio para alcanzar los objetivos definidos por la dirección de la empresa. Estas herramientas permiten dar solución a necesidades operativas que han surgido al optimizar todo el proceso de producción, manteniendo el objetivo estratégico de satisfacer las expectativas de los clientes.

Tras la implantación del nuevo proceso, otros departamentos han valorado positivamente el uso de las citadas herramientas, hasta el punto de que se han creado nuevos proyectos en la misma dirección estratégica que requieren la utilización de herramientas similares. El Departamento de Servicio Post Venta, que organiza entrenamientos y demostraciones sobre el producto a nivel internacional, ha mostrado interés en utilizar ambas herramientas aplicadas, en su caso, a la organización y ejecución de cursos. Por un lado, la base de datos, para optimizar la organización y planificación de los cursos que se destinan a los clientes y, por otro lado, la incorporación de sistemas de visualización de forma remota para la tele- enseñanza en el mercado global.

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Key terms and abbreviations

"FAT" means Factory Acceptance Test

"RFAT" means Remote Factory Acceptance Test

"BCG" means Boston Consulting Group

"PM" means Project Manager

"IT" means Information Technology

"MBV" means Market-Based View

"RBV" means Resource-Based View

"TLC" means Technology Life Cycle

"ADL" means Arthur D. Little

"CR" means Corporate Research

"CRC" means Corporate Research Center

"CTO" means Chief Technology Officer

"EC" means Executive Committee

"GF-RD" means Group Function Research and Development

"IPR" means Intellectual Property Rights

"LBU" means local Business Unit

"LN" means Lotus Notes

"NPV" means net present value.

"R&D" means Research and Development

"ROI" means return on investments

"STP" means Strategic Technology Plan

"SWOT" means Strengths, Weaknesses, Opportunities and Threats – Analysis

"JIT" means Just in Time

"CRM" means Customer Relationship Management

"RFID" means Radiofrequency Identification

"CPI" means Continuous Process Improvement

"IDE" means Integrated Development Environment

"OSI" means Open System Interconnection

"PoE" means Power over Ethernet

"IP" means Internet Protocol

"LAN" means Local Area Network

"QoS" means Quality of Service

"DMZ" means Demilitarized Zone

"HTTP" means HyperText Transfer Protocol

"URL" means Uniform Resource Locator

Introduction

The need for innovation to discover or create new needs for society started from the inflection point when the offer of goods and services exceeded the demand. It has been the subject of numerous studies that have led to different theories and models.

I try to present new solutions to them, taking as reference Asea Brown Boveri (ABB), a multinational company present in over 170 countries. ABB manages through strategic decisions the innovation processes, on a global as well as local level. Innovation is the foundation of ABB's corporate culture, all employees are required to contribute to a greater or lesser extent, to improve and increase the innovation activities of the company. For more than nine months I have been able to live and experience ABB's corporate culture, while optimizing and standardizing the Factory Acceptance Process form a customer oriented point of view.

The possibility to do this project arose from the participation in the UNITECH International Program, founded in 2000. UNITECH's goal is to prepare top engineering students for their professional future. Leading corporations and some of Europe's best universities join forces, across borders and cultures, to prepare technical students for tomorrow's business challenges. The program consists of studies in business management at a foreign university and the completion of an internship in one of the 20 companies that sponsor this initiative.

The realization of this Thesis is the result of synergies between the UNITECH Program and INNOVA. INNOVA Program aims to contribute to the promotion of the research developed at the Technical University of Catalonia and promote the drive for a culture of innovation and entrepreneurship, promoting the creation of new knowledge.

The result is a monographic paper on Strategic Technology and Innovation Management and the promotion of innovation in a multinational enterprise, through the use of new tools based on Communication and Information Technologies.

Chapter I. Related literature and theoretical focus on Strategic Technology and Innovation Management

I.1. Innovation

Innovation is the development and introduction of a new idea and transforming that idea into a product, process, object, or service.

Innovation is the act of introducing something new: something newly introduced[1].

The word is derived from the Latin words novus "new" and innovatio "something new uncreated". In common manner of speaking, the term is used in the unspecific sense of new ideas and inventions for their commercial implementation. In the narrow sense, innovations are only resulting from ideas when they are translated into new products, services or processes.

The distinction between "invention" and "innovation" is that invention is the creation of a new idea or concept, and innovation is turning the new concept into commercial success or widespread use.

In economics, the concept was introduced by Joseph Schumpeter in his theory of innovation[2], where it is defined as the establishment of a new production function. Economy and society are changing, as some production factors are combined in a new way. Also in the humanities and the arts, the term innovation is used. The researcher looking for new insights or solutions to artistic and solutions sets curiosity and desire to advance renewal.

The innovation process encompasses the whole process of the emergence of an idea to its widespread application in society. The process begins with the recognition of a problem or finding an idea, extends over the problem-solving and the creation of productive capacity to the introduction of the new product or service on the market.

Sustaining vs. Disruptive Innovation

There are two main types of innovation: the sustaining innovation and the disruptive innovation. Sustaining innovation maintains a steady rate of product improvement. It makes existing products or services better for existing customers. The improvements of performance of existing products is do ne with regard to established performance criteria and focusing on the characteristics that are valued by

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[1] *The American Heritage Dictionary*

[2] *Joseph A. Schumpeter, New York,* Business Cycle. A Theoretical, Historical, and Statistical Analysis of the Capitalist Process, Mc Graw Hil, pag 95

mainstream customers.

Disruptive innovation has new attributes opening entirely new markets. Doing so, performance dimensions for existing customers are often blurred. Disruptive innovation starts with performance disadvantages with regard to established criteria and perform well on criteria valued only by few or new customers.

The concept "Disruptive Innovation" was popularized by *Clayton M. Christensen* in its book "The Innovator's Dilemma" in 1996. Later on different authors[3] suggested that disruptive innovation had the power for broadening and developing new markets and providing new functionality, which turn, disrupt existing market linkages.

The main problem when defining and measuring disruptive innovation is that there are no reliable and valid instruments to measure disruptiveness of innovations. [4] However, despite this main hurdle, in the literature[5] five different characteristics of disruptive innovation are defined:

- Disruptive Innovation underperforms on attributes mainstream values
- New features offered not value by mainstream customers
- Innovation typically simpler and often offered at lower price
- At time of introduction, innovation appeals to a low-end, price-sensitive customer segment, limiting profit potential for incumbents
- Over time, innovation's performance increases on the attributes mainstream customers value; innovation begins to attract more these customers.

The next figure from *Bower and Christensen* describes graphically how Sustaining, Disruptive Innovation and technologies perform throughout the time.

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[3] *Adner (2002), Charitou and Markides (2003), Christensen and Bower (1996), Christensen (1997), Christensen and Raynor (2003), Gilbert (2003), Danneels (2004)*

[4] *V.Govindarajan & P. Kopale 2006, The Usefulness of Measuring Disruptiveness of Innovations*

[5] *Govindarajan & Kopale (2006), Adner (2002), Charitou and Markides (2003,) Christensen and Bower (1996), Christensen (1997), Christensen and Raynor (2003), Gilbert (2003)*
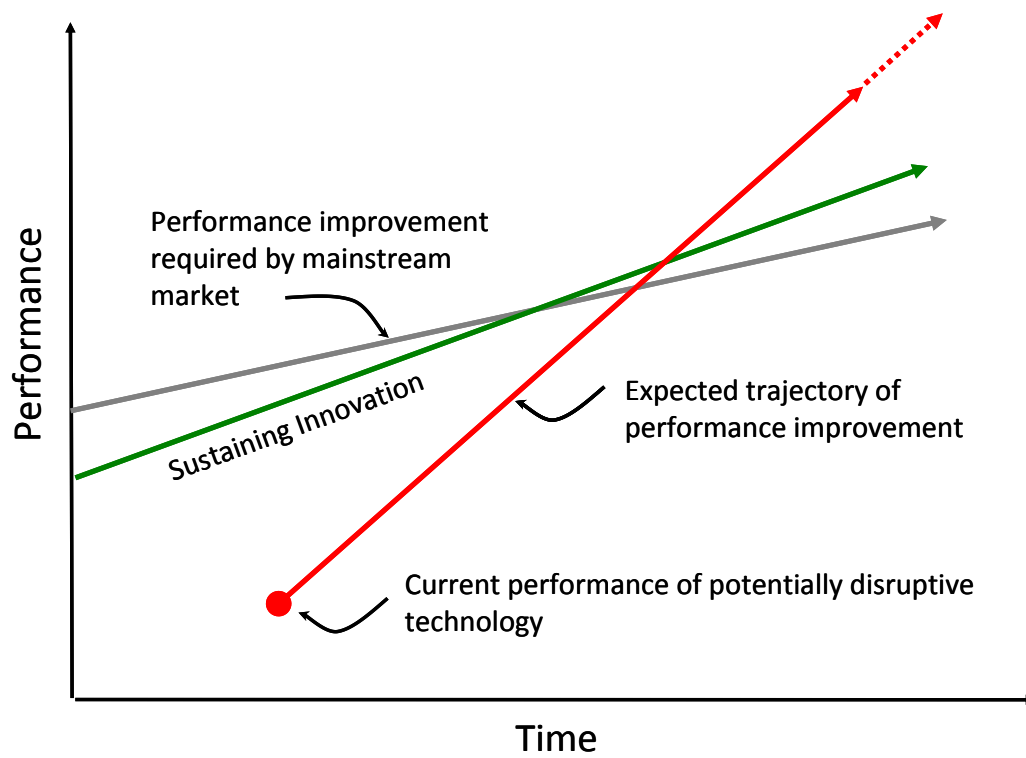
Figure 2. Sustaining Vs. Disruptive Innovation

I.2 Strategic Technology and Innovation Management

I.2.1 Strategy

Why do we need a strategy? This question can be answered from different approaches, but the most significant fact that supports the existence of strategy is the failure of operational excellence practices when creating a sustainable competitive advantage.

The activities that go into creating, producing, selling, and delivering a product or service are the basic units of competitive advantage. Operational Excellence means performing these activities better. Under better it is understood, that these value added activities are executed faster, or with fewer inputs and defects than rivals or competitors.

The failure of operational excellence when creating a sustainable competitive advantage towards the competitors is explained due to the fact that best practices can be easy emulated.
As all competitors in an industry adopt them, the productivity frontier, the maximum value a company can deliver at a given cost, given the best available technology, skills, and management techniques, shifts outward, lowering costs and improving value at the same time.
Such competition produces absolute improvement in operational effectiveness, but relative improvement for no one.

The more benchmarking companies do the more competitive convergence they have. This means that companies are more indistinguishable from one another.
The need of a strategic position is one of the main theses of *Michael Porter* as it is figured out at the *Hardware Business Review 6 /1996: Modern Porter, What is Strategy?*

Strategy is the creation of a unique and valuable position, involving a different set of activities.
Strategic position emerges from three distinct sources:

- serving few needs of many customers
- serving broad needs of few customers
- serving broad needs of many customers in a narrow market

Strategic positioning attempts to achieve sustainable competitive advantage by preserving what is distinctive about a company. It means performing different activities from rivals, or performing similar activities in different ways.
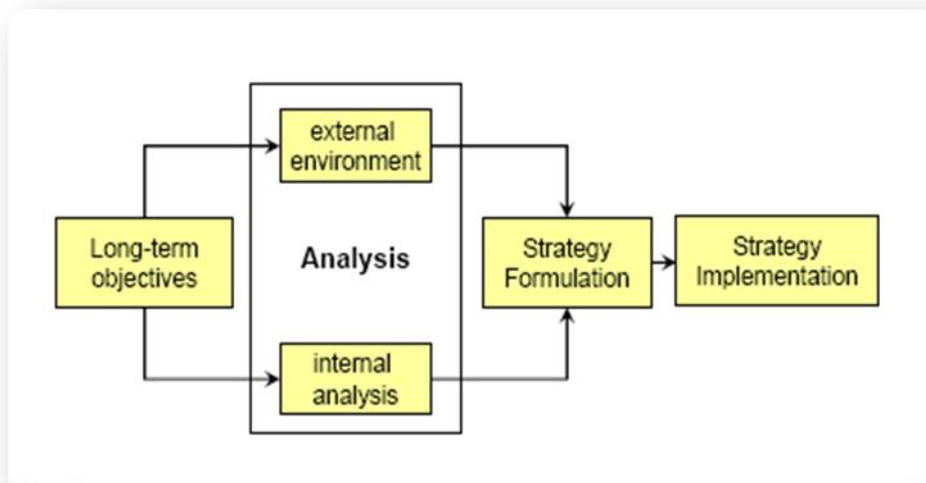
Figure 3. Strategy Process

I.2.2 Analysis

The strategy process has the goal to create a sustainable competitive advantage towards the competition. In order to build up this competitive advantage, long term objectives have to be defined and an internal, as well as an external analysis has to be performed. After the objectives are set and the analysis has been done a strategy can be formulated and implemented.

I.2.2.1 External Analysis

The external analysis of a company is the study of the macro environment and the industry structure of the firm. The general environment of a firm may contain important developments for defining strategic actions.

The macro environment contains aspects related to the economic environment, technological environment, ecological environment, political and legal environment and the societal environment.
In order to define a company's strategic direction all of these environmental aspects have to be analyzed, clarified and understood to define in which fields, the company has to strength its position.
The most known model to identify threats and opportunities in a firm's near environment is the Porter's Five Forces Model.

This model was developed to assess industry attractiveness and is used to analyze firm's external environment. Findings about the desirability to compete in a specific industrial sector and what

factors in the firm's external environment create threats and opportunities for the firm can be answered with Porter's model.

The announced five forces are:

- Bargaining power of suppliers
- Threat of potential entrants
- Bargaining power of buyers
- Threats of substitutes
- Degree of existing rivalry
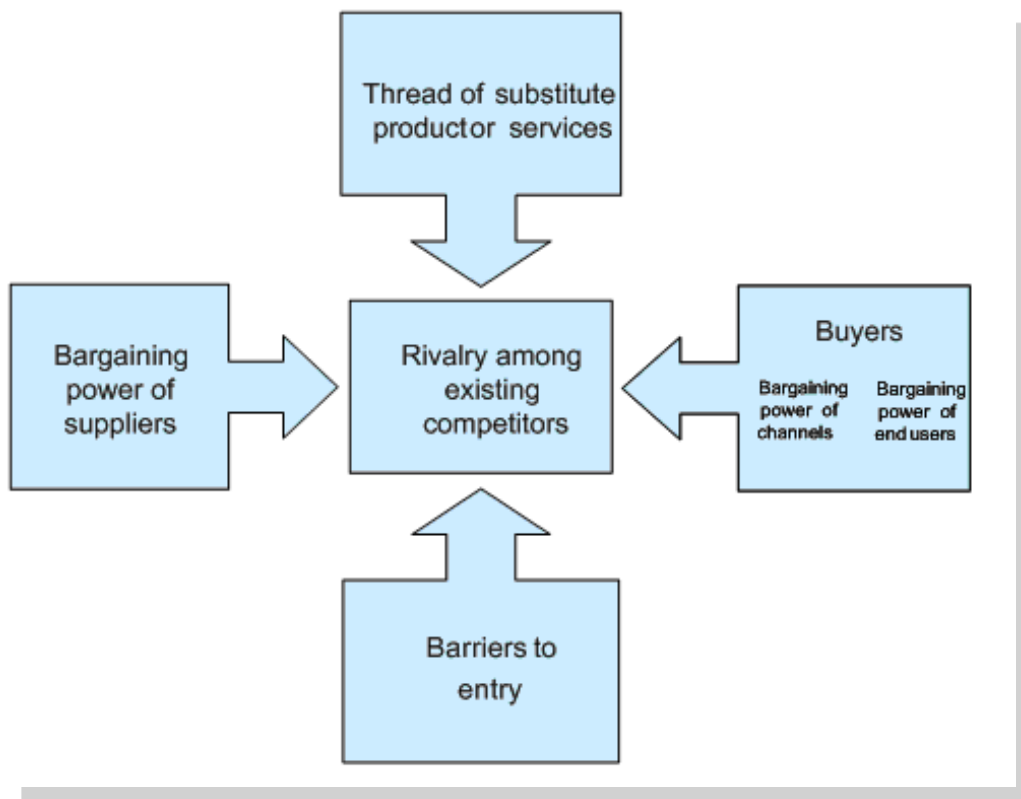
Figure 4. Porter's Five Forces Model

The **degree of rivalry among industry incumbents** is the first factor determining industry attractiveness. It is determined by the amount of similarity of incumbent firms, the degree of concentration, the market growth, the capacity utilization and the exit barriers, i.e. capital investment, emotional and cognitive resistance.

Strong **suppliers** can pose significant strain on companies' opportunities to sustain a profitable position

within the industry. Aspects like the number of existing suppliers and the degree of specialization among them influence their power. Other aspects related to importance of specific inputs to the firm and the availability of substitute inputs determines the power of the suppliers. The amount of firms in the industry relaying on the same supplier and the amount of total supply acquired from one specific supplier are also crucial facts that influence the bargaining power of the suppliers within one industry.

Powerful **buyers** can exert significant influence on what producers offer and to which price. The power of buyers is conditional on the size and concentration of buyers, the number of customers of one firm, the degree of product differentiation and the importance of product offering to the customer.

The **possibility of new entrants** to the industry constitutes a decreasing attractiveness. The likelihood of outside firms entering the industry is determined on one side by the growth and profit outlook for the specific industry and on the other side by the entry barriers a possible entry has to face. Entry barriers exist when the replication of an incumbent firm is difficult or costly for firms considering entry. Some examples of entry barriers are: required capital investment, existing economies of scale, access to input factors, access to distribution channels or customer's brand loyalty and switching costs.

The fifth factor of Porter's five forces model is the thread of **substitutes.** Product offerings from outside the industry can substitute the own industry's products. These substitute products are often not considered direct competition although the offerings perform similar roles or functions for customers. Acknowledging substitution potential must be analyzed from the perspective of value or functionality offered to the customer. The determinants of threat of substitution are for example the relative price performance of substitutes and the degree of similarity, that results from a low degree of own differentiation.

A recent extension to Porter's model is the recognition of the function and role complements play. Complements are products or services that enhance the usefulness of a product or service. These are for example the existence of software to computers.

For the analysis of an industry it is thus important to assess the importance of complementary product offerings, their availability and quality and the market structure of such offerings.

I.2.2.2 Internal Analysis

Assessing a firm's internal environment is the next step in the strategic analysis. The internal analysis aims at identifying strengths and weaknesses with regard to the external situation of the firm. Usually

this happens with identifying a company's value chain.

The value chain structures the activities of the company into two parts: primary activities and supporting activities. It can be designed to match underlying processes, assessed with regard to the importance for the overall value creation potential.

The firm's primary activities are directly contributing to the value creating process, while the firm's support activities are necessary functions without direct value creation potential.

The primary activities of a firm are:

Inbound logistics: receiving, storing and disseminating inputs

Operations: transforming inputs into outputs

Outbound logistics: collecting, storing and distributing outputs

Marketing: informing customers about the product and inducing purchase

Service: after sales service keeping the product work

The support activities are:

The firm infrastructure: accounting, finance, buildings, etc.

The Human Resources management: recruiting, hiring, training, etc.

Technology development: developing and managing equipment, procedures and knowledge with regard to the firms function to transform inputs into outputs.

Procurement: Administrative management of input acquisition processes.

In addition to the value chain analysis stated by *Michael Porter*, another author, *David J. Teece* affirmed that Porter's analytical tools are not sufficient to cover today's dynamics.

"The over-riding problem with (intermediate) industrial economics as an intellectual foundation is that is assumes homogeneity and complete markets when the real world is about heterogeneity of business and incomplete markets."[6]

David J. Teece acknowledged that this intellectual paradigm shift enabled the "Dynamic Capabilities" companies have to develop when analyzing the internal factors.

There are other special instruments and models to include into the internal analysis of a company. Internal analysis principally concerns the analysis of resources and capabilities seeking to establish core competences supporting the resource based view of a company. Later on this Thesis the resourced based view perspective on strategy will be explained. But internal analysis can also take up other perspectives.

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[6] *David J. Teece, 2008*

The analysis of the product life cycle shows the position and potential of a product offering and lens insight to which actions a firm must take. The product life cycle has several implications for product & innovation management. It sets up a framework in which sales are expressed as a function of time and defines four stages of the life cycle of a product.

The introduction stage encloses the product marketing for achieving quick adoption and market share. The product introduction period is characterized for high costs and negative or low profits.

The growth stage defines the period when companies have to sustain marketing efforts and market share growth and start to watch competitor's actions and products.

During the maturity stage, efforts have to be realized to maintain the position. This stage is characterized for reap profits and engage in differentiation of product offering. The development of successor products is one of the actions to take to assure a sustainable position of the company in the market.

The decline stage starts when the number of sales decreases. During this stage the company has to relaunch the product and try to extend the life cycle or clear the product portfolio and substitute for a mature product.

A second analysis complementing the product life cycle is the cost experience curve. The basic tenet of this curve is that with higher cumulated output, costs per unit will decrease. Empirical studies show a 20% - 30% reduction of the direct costs per unit each time the number of produced units is doubled. These results arise due to two main effects. On one side the learning effects, and on the other side the quantity effects.

The learning effects consist of a higher efficiency because of standardization, an improved product design and changes of the inputs used to produce a unit.

The quantity effects appear due to the fact that increased quantity allows realizing economies of scale. The strategic implications of the cost experience curve, setting the maximization of the market share as the primary goal of a company, is to focus on business where the company can realize this effects: learning effects and quantity effects. For this purpose markets have to be entered early. It is very important to attain high market shares and adapt pricing and product offerings towards this goal.

The experience curve effects don't realize automatically but need management. The main problems arise because of two main reasons. The first tread-off to manage is the cost reduction versus the product differentiation. Focusing only on cost reduction and attaining quickly high market share has to be balanced with a resulting lower differentiation potential of the product offerings. Second, focus on

routinization and standardization of internal processes can derive in a rigid reaction ability of the company to new technologies and processes.

The BCG portfolio matrix was developed by the Boston Consulting Group (BCG) and is intended to illustrate the relationship between the product life cycle and the cost experience curve. It can be organized into a matrix and is often expressed graphically as scatter / bubble diagram.

The real future market growth that derives from the product life cycle is set on the ordinate of the matrix. This is supposed to represent the environmental dimension.

The relative market share based on the experience curve concept is placed on the abscissa. It embodies the business dimension and should take into account the idea that a company gains experience due to higher sales, compared to what the competition means. This additional experience leads mainly to cost-of scale and to reduce market risk.

The relative market share is derived from the ratio of its market share to that of the strongest competitor's.

Dividing lines must be found for allocating the portfolio. The separation line for market growth results from the future average growth of the industry, or from the gross national product. For the market share is usually assumed a value of 1.0, a different level is not possible. The diameters of the circles represent the turnover of the respective products.

The products or business of a company are now assigned based on their values of one of the four areas. Each section embodies a so-called standard strategy. It aims to give a good recommendation for further action. The life of a typical product goes from the Question Mark through the Star and Cash Cow to the Poor Dog. There are also products, which do not follow this ideal path. Many products flop and not even reach the Star area. Imitating, on the other hand, a product may skip the area of Question Marks. Each position in the portfolio matrix has embedded a best practice standard strategy. These are the standard strategies based on the different positions:

The **Question Marks** are the young newcomer among the products. They have a high growth potential, but only limited market share. The management is faced with the decision whether to invest or dispatch the product. In the case of an investment, the product requires a lot of cash, which it can not generate itself. Then an offensive selection strategy is recommended.

The **Stars** are the absolute starlets of the company. They do not only have a high market share, but also a high market growth. The enormous investments requirements resulting from the high market growth can be however satisfied by they own cash flow. The strategy advice is investment.

The **Cash Cows** have broad market, but a low market growth. They produce stable high cash flows and can be "milked" without further investment. A levy strategy is appropriate.

The **Poor Dogs** are the run-out products in the company. They have a low market growth and sometimes even a market decline and a small market share. In addition, the danger of establishing as loss sources takes place. Due to that fact, the portfolio should be adjusted and a disinvestment strategy is recommended.

It is not only important to evaluate each product based on the standard strategies, but also to inspect the entire portfolio. It is important to put special attention to the static financial equalization. The products in the portfolio should be able to support each other and their financing. A Question Mark can expand only if i.e. a Cash Cow funds the expansion. For future developments the products should be equally represented in each area. A company without new growing products has little chance of coming in the future market.

I.2.2.3 SWOT: Integration of External and Internal analysis

As introduced before, the structure of the Strategy Process starts defining the long term objectives. Once these objectives are set, an internal and external analysis is required for the formulation of an appropriate strategy.

It is necessary to integrate the internal and external analysis to derive valuable conclusions. For these purpose the SWOT framework can be used. Integrating the two perspectives via the SWOT framework allows clear insights in a firm's situation.

The SWOT framework is the confrontation of the strengths, weaknesses, opportunities and threads for a company, as it is shown below.

Relation between SWOT, MBV and RBV

Internal analysis

Strengths

Weaknesses

External analysis

Opportunities

Threads

Resource-based view approach

Market-based view approach to sustainable competitive advantage
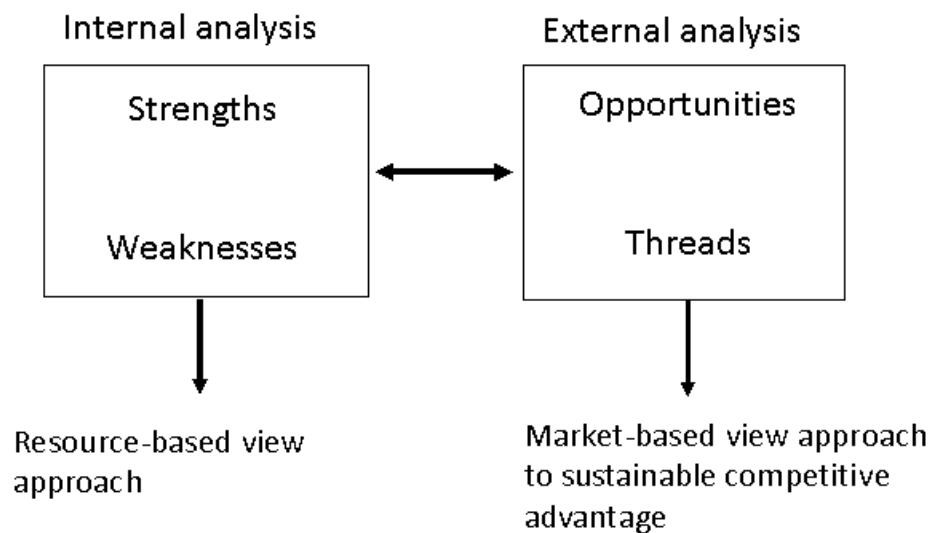
Figure 5. Relation between SWOT, MBV and RBV

I.3. Strategy Formulation

I.3.1 Objectives of Strategic Management

As it has been mentioned before, the primary goal of Strategic Management is creating sustaining competitive advantages. These result from sustainably doing things better than competitors and offering superior value to customers in areas customers recognize and consider the offered value important to them.

Therefore companies can adopt different perspectives on strategy. However, corporate strategy constitutes the beginning for strategic considerations of technology and innovation.

I.3.2 Perspectives on Strategy

Strategic management has two central perspectives explaining a company's performance. These perspectives are the Market-based view and the Resource–based view.

The **Market-Based View (MBV)** proposes positioning to be the driver of company performance. Strategy making in this view means choosing an attractive industry with high rent potential and identify an attractive position within that industry. For this purpose, business conduct has to be aligned accordingly, i.e. by choosing the right strategy: cost leadership or differentiation. Another important

necessity to achieve this strategic position is to defend the own company's position by building barriers to entry and to substitution.

Strategy is about positioning a company in favorable business environments or market positions and influencing industry structure and competitor's conduct.

The **Resource-Based View (RBV)** alters emphasis and sheds light on intra-industry differences in profitability. Strategy making in this view means leveraging resources and capabilities in the market environment. This perspective asserts that differences in companies' profitability stem from distinct resources and capabilities and not only from strategically superior positioning. Resources are meant to be tangible or intangible resources. The tangible ones are i.e. raw materials, production facilities or machines. The intangible resources are i.e. the company's brand, the intellectual property or the knowledge. The capabilities of a company are a combination of assets, people and processes forming distinct routines like for example technology sourcing capability, market capability or product planning capability. The RBV considers differences in a company's resources and capabilities as the source of competitive advantage.

Jay Barney, "father" of the RBV has still another yet similar set of dimensions to assess value. The so called '**VRIO**', **V**alue – **R**areness – **I**mitability – **O**rganization, concept defines the characteristics for the determination of a resource's value. Resources are not inherently valuable but only due to interplay between company and market conditions along three dimensions. These dimensions are: the scarcity, rare or inimitable; the appropriability or value capture control; and the demand, value creation for customers. The intersection of the fulfillment of these three dimensions defines the value creation zone of a firm.
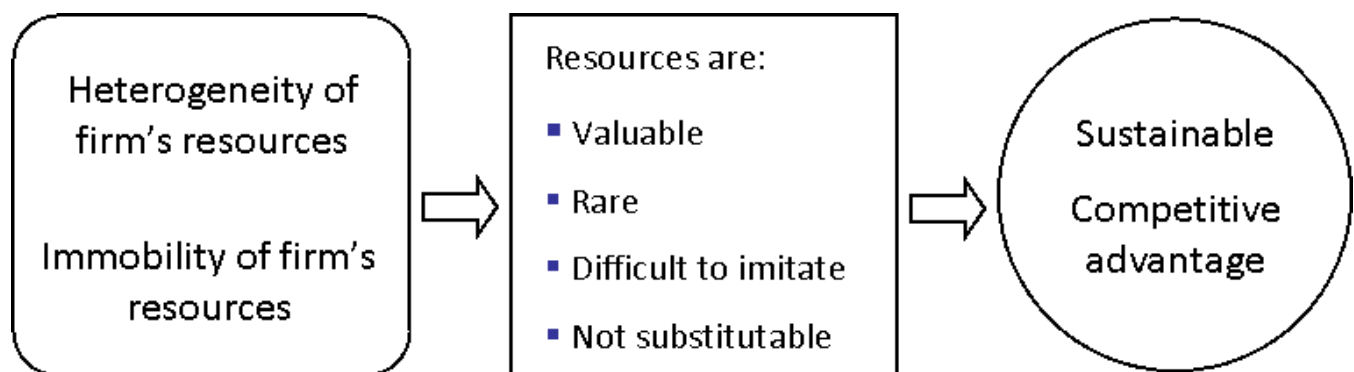
Figure 6. Sources for Sustainable Competitive Advantage

Resources and capabilities lay the foundation for firm's core competencies. Core competencies are distinct clusters of capabilities and resources forming the basis of companies' product offerings while differentiating these offers form competitive offerings and creating value for customers. Core competencies have to be valuable for customers and differentiating form competitors. They have to be difficult to imitate or substitute and able to be used in several areas or functions in different products or markets of the company. Core competencies can take various forms. They can take the form of core products, core processes or core skills.

However, there is an associated risk to this perspective. Core capabilities are central to companies' superior performance but may also be reason for failure. Core capabilities stem from distinctive combinations of technical systems, skills, managerial systems, and values and are best defined as "a set of differentiated skills, complementary assets, and routines that provide the basis for firm's competitive capacities and sustainable advantage in a particular business"[7].

Core capabilities are interdependent knowledge systems which are cumulated over time and institutionalized through constant interaction of the people and projects. They represent the basis for sustained success but paradoxically bread failure when change is needed.

Core capabilities become core rigidities when new products or processes deviate from previous ones in a way that renders existing capabilities inappropriate or at least insufficient and change of capabilities is not easy.[8] This paradox is the starting point for the **Dynamic Capabilities** approach.

Dynamic capabilities integrate the dynamics of marketplaces and the need to adapt core competencies and competitive advantages. This approach addresses the question how firms can sustain competitive advantage given rapid technological and market change.

"Even when firms have strong IP and are well positioned with complementary assets, competitive advantage will be ephemeral unless undergirded by dynamic capabilities. The reason is that shifts in the external environment require (entrepreneurial) management to "orchestrate" co-specialized assets so that the enterprise continues to deliver value to the customer and capture some for itself."[9] Dynamic capabilities are mostly managerial skills used to create new or reconfigured sets of

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[7] *Teece et al., 1997*

[8] *Leonard-Barton, D (1992). Core capabilities and core rigidities: A paradox in managing new product developement, in SMJ, Vol 13, p. 111-125 (1992)*

[9] *Teece, Pisano and Shuen, SMJ, 1997*

competences, capabilities and resources. There are three classes of dynamic capabilities:

Sensing: Exploring technological opportunities, probing markets and listening to customers. This involves understanding latent demand and requires predicting likely competitive responses to changing markets and technologies.

Seizing: The execution of this capability requires business models that capture value, proficient investment protocols and access to capital, leadership and commitment.

Transforming: Develop standard operating procedures and deeper hierarchies. Core rigidities can hinder an enterprise's ability to reconfigure when the environment shifts.[10]

I.3.3 Generic Strategies

Generic strategies are the fundamental options for firms to compete in markets. Firms can decide whether to compete on price with commodity offerings or on unique value propositions with differentiated offerings. These generic strategies are known as Cost/price strategy or Differentiation strategy.

The cost/price strategy requires effective operations management and tight cost management. Potential to achieve cost leadership can derive from an appropriate product design, the utilization of efficient-scale facilities and the utilization of experience curve effects. In addition, a tight cost and overhead control, throughout the value chain is required as well as adequate pricing and marketing to attain quickly high market share. It is necessary to focus on all value chain activities and integrate them efficiently and effectively.

This generic strategy focused on cost leadership is not without pitfalls. Over-emphasis on cost reduction leads to below parity offerings, i.e. the value for money is worse than competitors'. Customer adaptation to low prices increases the need to maintain or lower prices although the company is vulnerable to input price increases. Focusing only on cost will derive to a low differentiation and leaves room for imitation or substitution by competitors' products or services.

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[10] *INTANGIBLE (KNOWLEDGE) ASSETS AND DYNAMIC CAPABILITIES New Paradigms for Analyzing Competitive Advantage, Keynotes by David J. Teece, University of California, Berkeley, at the SMS Conference 2008.*

The Differentiation strategy, on the contrary, focuses on offering unique value propositions to customers. Potential for differentiation can derive from the brand image of the company, Technology know how or a well established innovation culture. Differentiation is also valued by customers related to product features and functionalities, product quality, the after sales service and the distribution channels. Summing up, all value creation activities can equally act as starting point for developing a differentiation strategy.

Similar to the other generic strategy, the Differentiation strategy is not without pitfalls. It is crucial to differentiate on the right thing, to the right extend, to the right price and in a sustainable way. Customers must value the differentiated offer and it is important to keep in mind that customer have a finite willingness to pay.

A third alternative is focusing on niches or small market segments. In this case a cost leadership or differentiation strategy can be applied, but concentrated in a narrow market. The definition of the market can be done my segmenting it related to geography, demography or social aspects.

Michael Porter claims that generic strategies are mutually exclusive. Companies can only compete on either cost or differentiation. Following Porter, companies have to decide which way to go. Companies that pursue both strategies (hybrid strategy) are called "stuck in the middle". Pursuing both strategies at a time, the company does not possess any competitive advantage, as both cost leader and differentiator have a better competitive position in their respective fields of action. Hence, this is the recipe for a mediocre strategic and below average performance.

I.3.4 Linking Corporate strategy and R&D Innovation

As it has been mentioned before, technology and innovation strategy are determined by the corporate strategy. Business strategy defines where and how to compete. Therefore, in line with the goals set by business strategy, the functional strategies are determined.

As a particular functional strategy, technology strategy has to answer questions like for example which technologies to employ, which budgets are needed or how should technology be acquired in order to develop and maintain the technology base of the company.
It is necessary to analyze which technological developments have impact on the business and which potential prospective technologies should be developed or acquired to be exploited or commercialized.

The functional strategy aligns corporate functions with the business strategy. For this purpose, Technology Push and Market Pull are two approaches that contribute to support corporate strategy with technology & innovation management.

The Technology Push approach focuses on inventing new technologies without having a market need identified, while the Market Pull approach focuses on solving a customer need without having identified the required technology.

Technological companies apply the Technology Push model when they decide that their technology will lead to new market needs and demand.

The flow of activities in the Technology Push Model starts with finding a technical issue or problem. Ones defined, the internal or external scientific and technical knowledge is selected to find out a technical solution. Finally, these solutions are brought to market in order to try to satisfy the market needs.
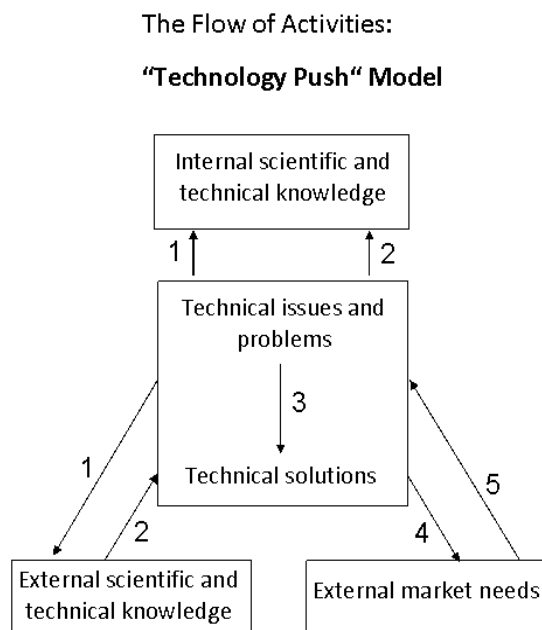
Figure 7. Flow activities for Technology Push   *Figure 8. Flow activities for Market Pull*
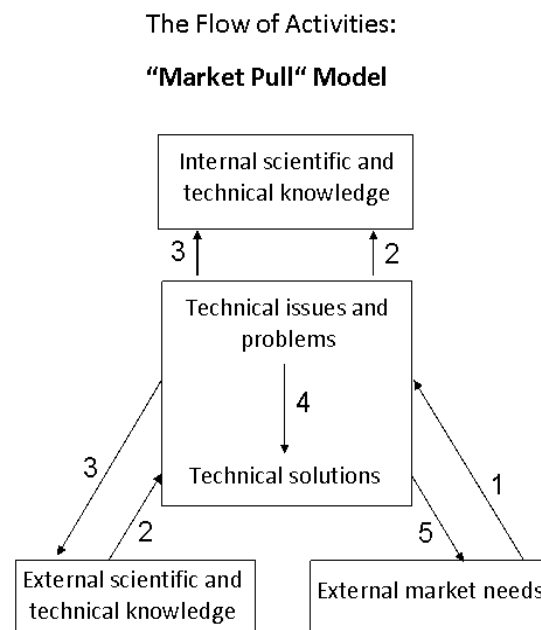
The opposite approach is applied by those technological companies that think that the market should dictate their course of action regarding to the incorporation of a new technology.

The Market / Need Pull Model begin identifying and verifying a market need. Then the technical issues and problems are analyzed. Ones defined, the internal or external scientific and technical knowledge

are selected or acquired in order to achieve the required solution. Finally the developed product or service is commercialized.

Linking Technology Push and Market Pull promises to be the most successful. There are three elements requiring Linkage: relevant problems, technology sources and market demand.[11]

Relevant problems are defined by top management's professed interests, problems of operating divisions and new opportunities created by external events.

Technology sources come from researcher's personal interests, existing corporate expertise and new technological developments.

Market demand derives from marketer's personal search, areas of customer dissatisfaction and potential for new need satisfaction.

The next figure describes conceptually this double linkage.
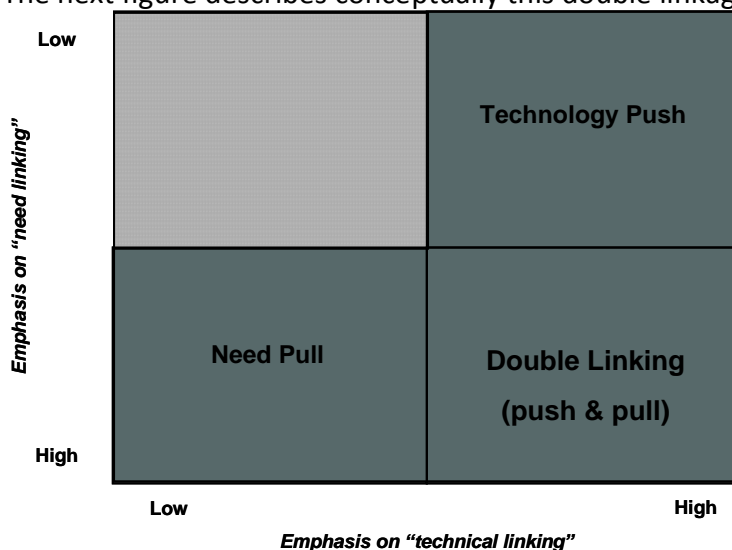
Figure 9. Double linkage: Need Pull and Technology Push

Corporate strategy requires foresight and integration of different time perspectives. To sustain growth, developing new products has to be faster than the decline of older products. "Three horizons of growth" depict the pipeline for new products as horizons. Continuous growth is the core objective.

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[11] *R.Burgelman & L. Sayles: Transforming Invention into Innovation, in: Strategic Magmt. of Techn. & Innovation, 2004*
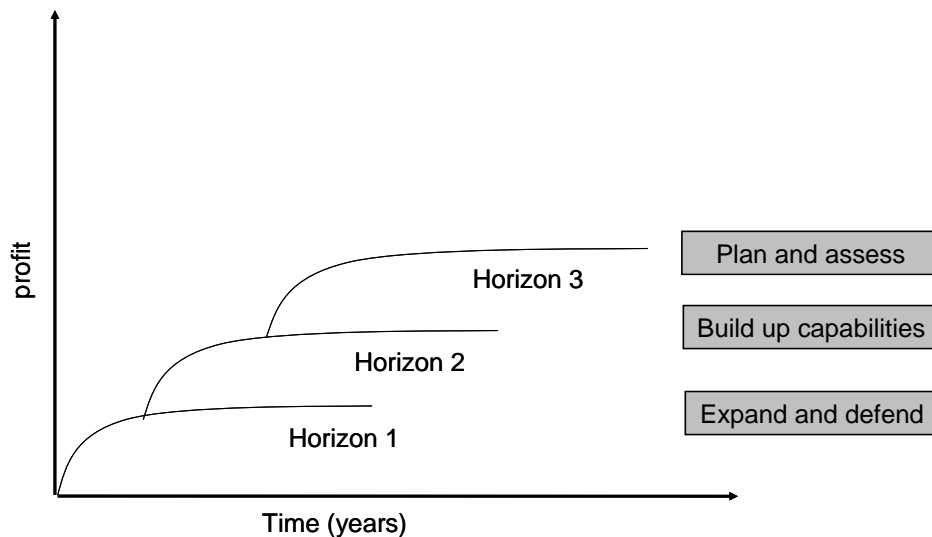
Figure 10. Three horizons of growth

The before shown horizons can be defined as follows:

The **Horizon 1** is meant to be the core business. This enclose the current core business and products and prop up the efficiently use of the remaining potential for incremental development.

The **Horizon 2** is the "emerging stars". These define the emerging and strongly growing businesses that will substitute the current Horizon 1. For the development of new skills and resources in the second horizon, high investments of time and money may be needed to build up the required capabilities.

The last one, the **Horizon 3** is the "Options for tomorrow". This horizon describes the need for develop concrete business ideas and the commitment of resources in order to support future business options.

Achieving sustainable growth requires the simultaneous management of the horizons. All three horizons have to be taken into account simultaneously. Neglecting one leads to gaps in the future development of the firm.[12]

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[12] *Baghai, Coley, White 1999: Wachstum über drei Horizonte*

I.4 Developing Technology and Innovation Strategy

In analogy to corporate strategy formulation, technology and innovation strategy starts with strategic analysis.

An analysis of the external environment has to be done for the identification of opportunity-threat profiles with regard to technology fields and developments.

The analysis of the internal environment can support the identification of internal strengths and weaknesses with regard to technology and innovation fields.

I.4.1 External Technology Analysis

There are different possibilities to execute an external analysis and extract all the significant information for defining a Technology and Innovation Strategy.

There are some fundamental questions which have to be answered by this external analysis. Have the current technologies potential to develop? Where are the limits of the current technologies? Which are the substitution relations of the existing or future technologies? How are the technological discontinuities? And, when are new technologies emerging?

In order to enable firms to base decisions regarding technology, an option is to try to interpret the *weak* signals in companies' environment. The identification and interpretation of these signals can be defined as **Technology Scanning** and **Monitoring**.

It is important to differentiate the scanning concept that is related to future technologies from the monitoring concept that is related to the current technologies.

For scanning it is necessary to disconnect from the current firm's technology base in order to discover future technologies. Then an identification of threats and opportunities has to be done.

Monitoring is observing and interpreting the developments around the current technology base and core technologies of the company.

The next framework depicts the formal and informal nature of the Technology scanning and

monitoring and breaks it down into directed and undirected search.

	Undirected search	Directed search	
Informal	Looking for weak signals **outside** *the domain of the company* **without fixed topic.**	Looking for weak signals **inside** *the domain of the company* **without fixed topic.**	**Scanning**
Formal	Looking for weak signals **outside** *the domain of the company* **with fixed topic.**	Looking for weak signals **inside** *the domain of the company* **with fixed topic.**	**Scanning**
Formal	Monitoring / in depth search for information **outside** *the domain of the company* **with particular consideration of an identified signal.**	Monitoring / in depth search for information **inside** *the domain of the company* **with particular consideration of an identified signal.**	**Monitoring**

Figure 11. Technology Scanning and Monitoring

Potential sources for Scanning and Monitoring technology are Innovative customers, leading users, innovative suppliers, leading edge research institutions; patent analysis and publicly accessible technical literature like for example technical standards.

A systematic patent analysis consists of quantitative examination of relevant patent statistics based on key figures of patenting activities. Figures of patenting quantity as well as quality must be analyzed in order to find out the amount of inventions applied for a patent and the amount of patent citations and patent applications in different countries.

Systematic patent analysis is a good tool to identify emerging and fading technologies.

Based on observations of current developments of technological fields the future needs to be predicted in order to evaluate the respective impact potential. Therefore forecasts are necessary and aim at identifying the availability and applicability of technology and are used as indicators of performance development and market acceptance. It is important to mention that good forecasts require a lot of investment and it is impossible to cover every topic. Forecasting has to be in line with core competencies and targeted markets and the goals must be formulated precisely. For these purposes, all relevant criteria have to be integrated creating an interactive forecast instead of an isolated one. Technology prognosis has to be logical and systematic using different methods.

The quantitative forecast can be described with trend extrapolation, multiple regression analysis, model simulation and with a cost benefit analysis.

The qualitative forecast can be done by analyzing scenarios and trends and by doing a cross impact analysis.

Due to the complexity of forecasts given a multitude of relevant variables to be taken into account, models based on single variable have been developed. The models that use time as declaratory factor are called endogenous, while the models that use activity variables such as R&D spending are called exogenous.

The technology life cycle forecast development paths based on a single variable are based on the assumption of the existence of a strong relationship between these variables and the development of a given technology. For describing these development paths there are other basic assumptions to be considered: [13]

- Each technology reaches over time a performance frontier
- New technologies initially show slow performance increases
- Performance increases decrease over the development cycle
- Reaching performance frontiers of technologies increases the likelihood of new emerging technologies

There are two ideal representation models of the Technology Life Cycle (TLC). One represented with a bell curve with time as a direct factor and one represented as an S-curve with time as an indirect factor. Utilizing these ideal representation models, there are three interpretation models of the Technology Life Cycle.

The TLC model by *Ford / Ryan* may help pointing out the general development of technology within the company. This model uses time as a direct factor and evaluates the penetration of a technology. This model defines six different stages: the technology development, technology application, application launch, application growth, technology maturity and the degraded technology. Some of the criticism on this model is that there is no clear discrimination of the core criteria for the separation of different phases and there is no empirical foundation for the curve and no joint technology development implemented.

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[13] *Specht 2002, Technologielebenszyklen als Konzept zur Erfassung der Technologiedynamik*
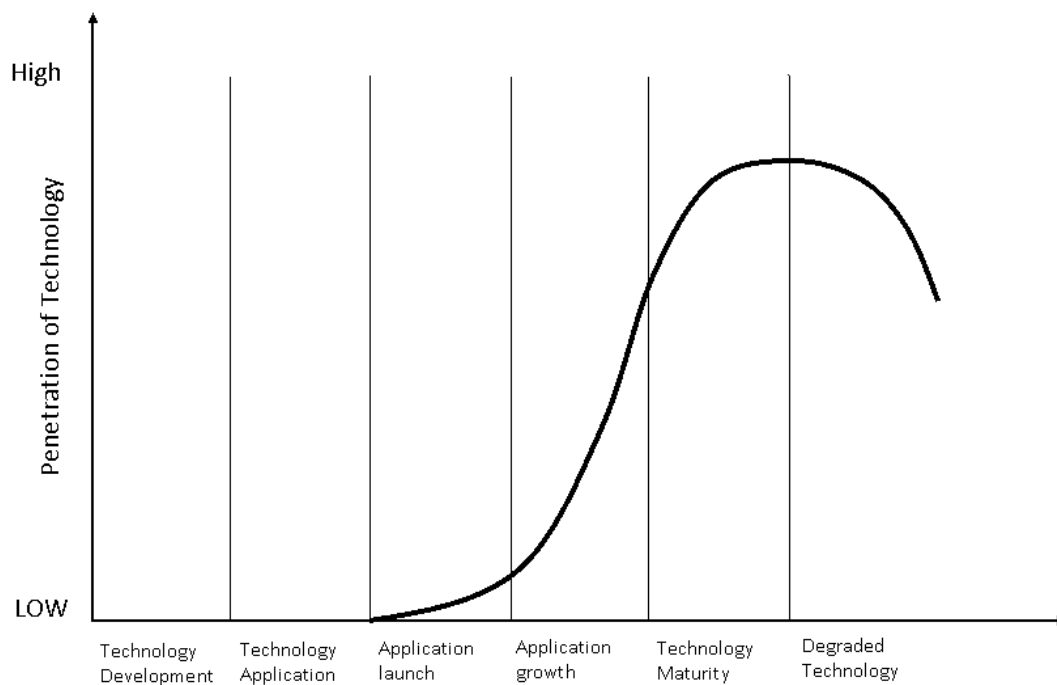
Figure 12. Technology Life Cycle by Ford / Ryan[14]

The technology life cycle by *Arthur D. Little* (ADL) is based on an ideal type of technology development. It points out correlation between the position of technology on its life cycle and its competitive potential. There are four stages defined by this model: the emergence / development, growth, maturity and decline.[15]

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[14] *Ford, D. and Ryan, C. 1981, Taking technology to market, Harvard Business Review, March- April*

[15] *Arthur D. Little, pages 24-25*

Indicators	Embryonic	Growth	Mature	Aging
Uncertainty over technological efficiency	High	Medium	Low	Very Low
Number of applications	Unknown	Increasing	Stable	Decreasing
Investments in technology development	Medium (Bases)	High (Application)	Low (cost reduction)	Very Low
Impact on cost/performance ratio for products & processes	Secondary	Maximum	Marginally	Marginally
Number of patent applications	Increasing, Very High	Very High	Decreasing, Low	Decreasing, Very Low
Type of patents	Design patents	Product patents	Process patents	----
Entry barriers	F&E capabilities	Workforce	Licenses	Application Know-how

Figure 13.Technology Life Cycle by Arthur D. Little

The main statement of Arthur D. Little's model is that the potential of technology differs according to its position in the TLC.

Technology in the **emergence stage** is characterized as risky and uncertain but expected to have high potential. Technology is considered to have very fast development and because of that it is called a "pace maker technology".

During the **growth stage** a reduction of the risk turns out due to the fact that technology based applications exist. Technology in this stage is characterized for being up to date and starts to be considered as a "key technology".

In the **maturity stage** the technology is fundamental to an industry, but has low further potential. It has developed to a base technology of the company.

The last stage of ADL's the Technology Life Cycle is the **decline stage**. In this stage technology has no further development and remains an even base technology.

This model provides a classification of different development stage and respective strategic relevance. It points out strategic activities and provides managers with qualitative criteria to ascertain the different stages and the position of their technology.

The third model of technology life cycle is the S-curve[16] by McKinsey. There is no major difference to the previous concepts, except that the activity factor or cumulative R&D effort is in this model the determined factor. In this case technology potential is expressed depending on the cumulated expenses for technology development. It emphasizes the perspective on R&D productivity and the existence of technological discontinuities and the possibility of technology substitution.

The TLC by *McKinsey* provides management with foundations for decisions concerning resource allocation and technology switch. It tries to clarify if further investments in existing technology make sense due to remaining potential or R&D productivity, or on the contrary, the company should direct invest to the new technology. This model can be useful to decide between choosing a sustaining technology innovation or on the contrary decide for a disruptive innovation due to technology discontinuities. [17]

The conclusions of life cycle concepts mainly contribute to raising the awareness of the management. The awareness understood as generally restricted performance potential and non linear performance development. It focuses on clarifying different strategic and operational activities with regard to development stages and focuses on the necessity to observe technological developments to develop successor technologies and appropriate competencies avoiding the finiteness of competitive advantages based on certain technologies.

The main problems concerning the technology life cycle model is the definition of adequate parameters and shape characteristics and the proper discrimination of the technology phases. The analysis of the influencing factors on the curve is also a difficult task that can be challenging.

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[16] R. Foster, "The S-Curve: A New Forecasting Tool" in Innovation: The Attacker's Advantage, New York: Summit Books. 1986. pp. 87-111

[17] R. Foster, "The S-Curve: A New Forecasting Tool" in Innovation: The Attacker's Advantage, New York: Summit Books. 1986. pp. 87-111

I.4.2 Internal Technology Analysis

Internal technology analysis intends to examine technology and innovation positions of the firm. The goal is the evaluation of the technological performance of a company with regard to past results and activity patterns, and resources and capabilities.

The key questions to be answered are: Which internal technology resource and external technology sources are available to the company? How innovative has the company been previously? How strong is the "fit" between a company's current market strategies and its internal technology and innovation capabilities?

With the internal technology analysis and evaluation the technology position as well as the innovation position may be defined.

The analysis of technology position concerns availability and performance of firm's technological resources and capabilities. There are mainly four steps of analysis:

The first step is the definition of relevant technologies and organization entities. This helps to analyze currently used and potentially interesting technologies with regard to their potential for the performance of a respective BU.

The second step is the specification of the benchmark team. A strategic planning unit has to be defined and supported by an ad hoc audit team, staffed with qualified employees from throughout the company.

The third step consists of the creation of an inventory of the technological resources, activities and performance. The main challenge is to find out the different innovation inputs, processes and outcomes that are dispersed within the company.

The fourth step is the analysis of the collected data for the identified technologies. The determination of a strength weakness profile for each technology relative to internal benchmarks and industry average or competitive environment's requirements should be done for the assessment of the technological position of the BU.

The analysis of the innovation position of the firm or BU concerns factors regarding transfer of technological inventions into innovations, bringing them to the market.

The transformation of technologies into products or services requires the implementation skills of

employees and a general ability and willingness of the employees. These factors are hard to measure due to complexity, uncertainty and risk associated with innovation endeavors and organizations' capabilities.

Another approach for defining the innovation position of a firm or BU is via the company's culture, also called organizational culture. It is formally defined by *E. H. Schein* as a "*A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems*"[18] The objective is to define to which degree the culture of a company or BU raises the awareness for innovation, facilitates and enables it.

Corporate cultures can be grouped into two types: mechanistic cultures or organic cultures.
Mechanistic cultures are characterized for centralized decision making, vertical communication, a deep and elaborated hierarchy and extensive and formalized cooperation rules.

On the contrary organic cultures are characterized for decentralized decision making, mostly horizontal communication, a flat hierarchy and few cooperation rules inside the company.[19]

There are different researches[20] that affirm that organic systems rather facilitate innovation and mechanistic systems on the contrary rather hind innovation inside a company.

A different approach to innovation position analysis is the identification of aspects that hinder innovation. There are some Syndromes that put hurdles to achieve a well performed innovation position. The "Not-invented-here Syndrome" for example defines the rejection and mistrust of innovation or technologies that come from outside the respective BU or company. The "Status-Quo-Syndrome" expresses the general rejection of any change or development inside the organizational culture. The overestimation of one's capabilities can appear due to a systematic biased overestimation of a manager's past achievements and can hind new developments or improvements, reducing the opportunities for innovation activities.

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[18] *Edgar H Schein, Organizational Culture & Leadership, 1992, p. 12*

[19] *Tom Burns and G.M. Stalker, Theory of Mechanistic and Organic Systems, 1961*

[20] *Hofstede, G. (1991).* Culture and organizations: Software of the mind. *London: McGraw-Hill;*

O ̈Reilly, C., Chatman, J., & Caldwell, D. (1991). *People and organizational culture: A profile comparison approach to assessing person-organization fit.* Academy of Management Journal, *34:487-516*

I.4.3 Evaluation of external and internal technology and innovation

Once the external technological environment is defined and the internal position of the company is determined, the development of the technology and innovation strategy has to be done. Portfolio models can be used for the evaluation and planning of a technology and innovation strategy. Portfolios combine the external analysis results with the internal position or potential of the company.

The technology portfolio analysis is a tool for strategic technology management. It is used for the systematic evaluation of technologies and provides the basis of strategic investment decisions in favor of economically promising technologies. The technology portfolio analysis was developed in the late 1970s by *Werner Pfeiffer* and employees of the research group on innovation and technology forecasting headed by him. This technology portfolio reflects the assessment of a technology with respect to two key variables: the technology attractiveness and the resource strength.

The two variables of the technology portfolio, technology attractiveness and resource strength, set each, high aggregate evaluation result in terms of underlying individual factors. *Pfeiffer and Dögl* propose three indicators to determine the technology attractiveness:[21]

Potential for further development: To what extent is a technical advancement, and thus increase performance and / or cost reduction possible?
Estimate applications: What are the number of possible applications of the technology and the quantities in each application area?
Compatibility: What is the expected negative or positive impact regarding users and other systems?

The resource strength expresses a measure of the technical and economic strength or weakness of a company regarding technology relative to its competitors.
Pfeiffer and Dögl propose again three indicators to determine the resource strength:

Degree of technical and quality control: How can we assess technology-specific know-how in relation to the competition, is there a development lead or an excess?
Potential: To what extent are financial, human and material resources available to exploit in order to further develop the existing potential of the technology?

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[21] *Pfeiffer, W. & Dögl, R., Das Technologie-Portfolio-Konzept zur Beherrschung der Schnittstelle Technik und Unternehmensstrategie, page 154*

(Re-) Action Speed: How quickly can the company be assessed in comparison to the competition to exploit the development potential of the technology?

The evaluation of Pfeiffer's Technology Portfolio establishes four different strategic actions that can be taken regarding technology: Investment, disinvestment, selection of technologies or selection of resources.
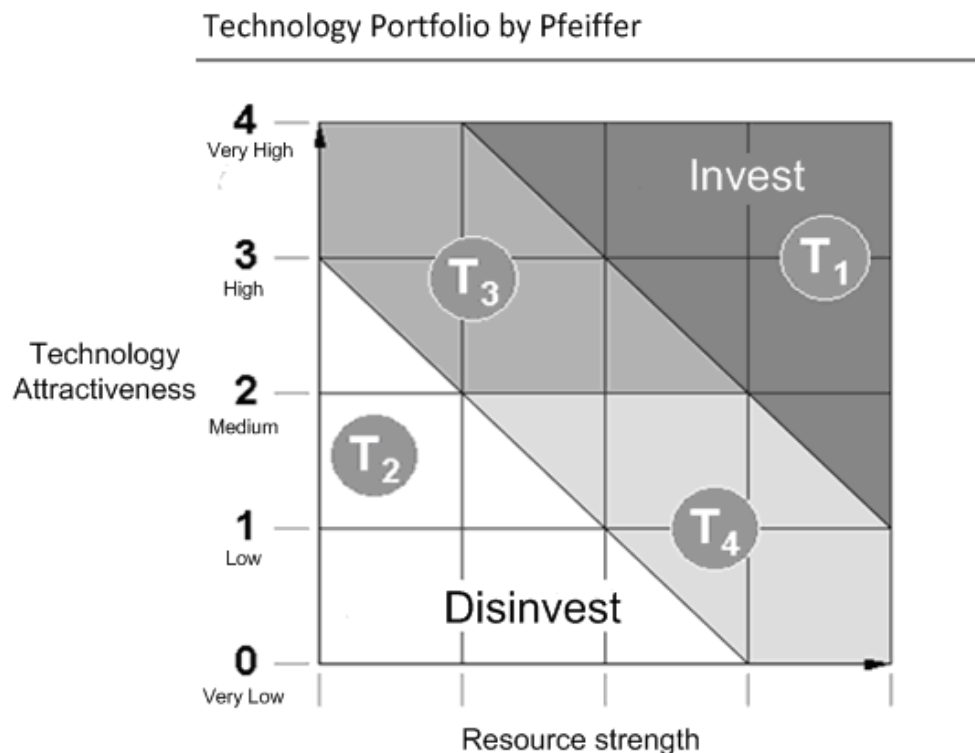
Figure 14. Technology portfolio by Pfeiffer

Investment (T1): A technology with high attractiveness combined with high resource strength (top right box) should be encouraged. Financial resources for further investments in these technologies should be granted to strengthen the good competitive position in its own economically attractive applications.

Disinvestment (T2): On the contrary, when a combination of low-tech application and low resource strength (box at the bottom left), investments are discouraged and a disinvesting strategy is recommended. Companies that were previously unattractive on these technology areas were not active and should not try to entry.

Selection of technology (T3): In a position with high technology attractiveness, but lower resource intensity (upper left box), there are two general alternatives. On one hand, exit due to the weak strength of its own resources or one the other hand expand in the technology with massive

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investments in order to bridge the existing development gap.

Selection of resources (T4): A position with high resource strength, but low technology attractiveness (bottom right box) carries the risk of misdirection of funds and human resources. The development of technologies that are currently still the basis of numerous products and provide low improvements for a high inflow of resources, often binds a large proportion of R & D budgets while the knowledge-building in new fields of technology is reduced.

The next paragraphs will present and describe two portfolio models to identify and develop a proper innovation strategy.

The main purpose of the use of portfolios is to obtain transparency about the product lines. They give a basis for resource allocation and cash transfers between business segments. Portfolios support decision making on finance value-creating growth projects and balance between revenue assurance for the present and the future. They contribute to take depoliticize decisions, based on objectivity and business Logic and focus management attention. Portfolios are always used to promote the strategic discourse.

The portfolio founded by McKinsey is characterized by the fusion of technology and market portfolio in an integrated technology-market portfolio. This approach seeks to ensure that strategic R & D decisions are not only taken based on market attractiveness, but also based on technology attractiveness.

First the technology portfolio has to be developed with the identification of core technologies using an S-curve analysis and identifying the key technologies for the company. The second step consists of classifying the relevant technologies according to the attractiveness and relative technology positions in the technology portfolio of the company.

Once technology factors are determined, the third step is to define the market portfolio. This portfolio is determined depending on market attractiveness and relative market positions of the company.
In the fourth step the two portfolios are combined into an integrated whole portfolio. Depending on the location of R & D-derived recommendations, strategic actions can be selected.
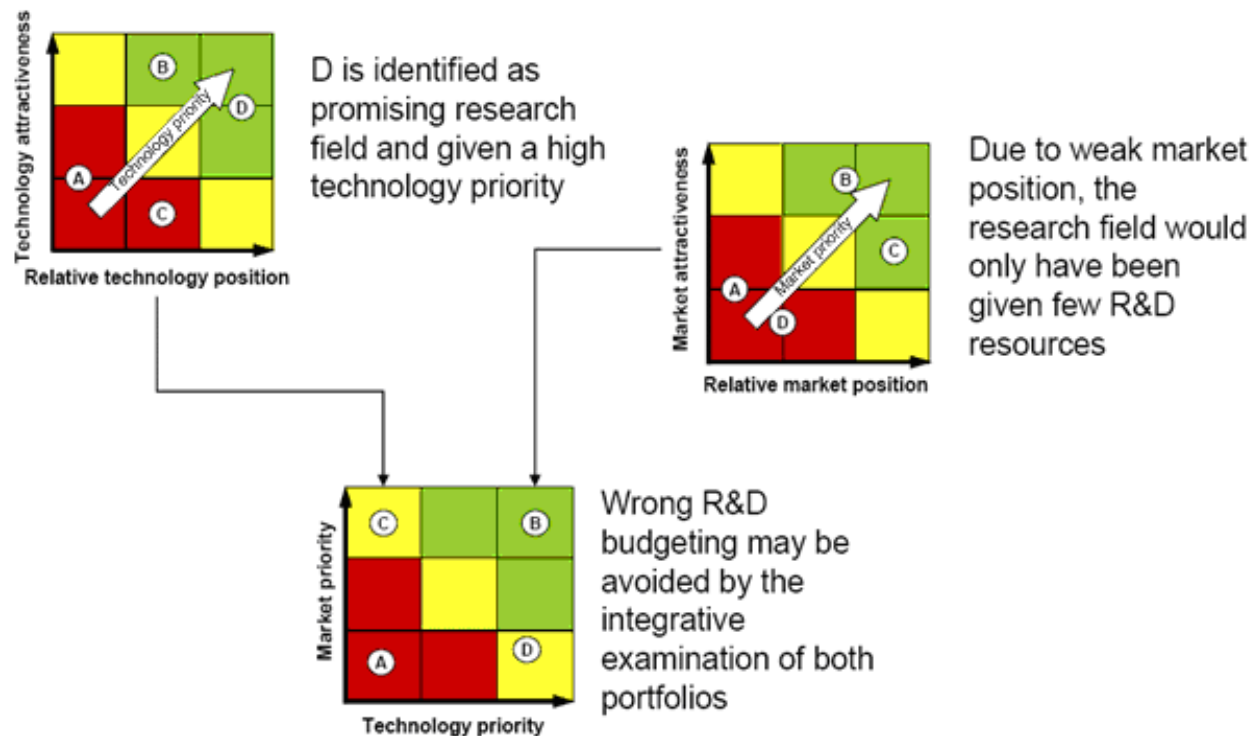
Figure 15. Technology-Market portfolio by McKinsey

Summarizing, the four steps to develop the technology-market portfolio are:[22]

- Identification of important technologies
- Classification of the technologies in the technology portfolio
- Classification of business segments in the market portfolio
- Merge into an overall portfolio and the disposal of R & D priorities

The aim of the portfolio approach by Arthur D. Little is to derive technology strategies that serve as basis for decisions. It consists of two main analyses:

- Analysis of the technological and competitive position of the strategic business
- Analysis of the life cycles of technologies and their industry

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[22] *Eversheim, W. & Schuh, G., Betriebshütte: Produktion und Management, 1996, page 4-48*

Combination of market and technology portfolio to the 4-fields scheme by A. D. Little
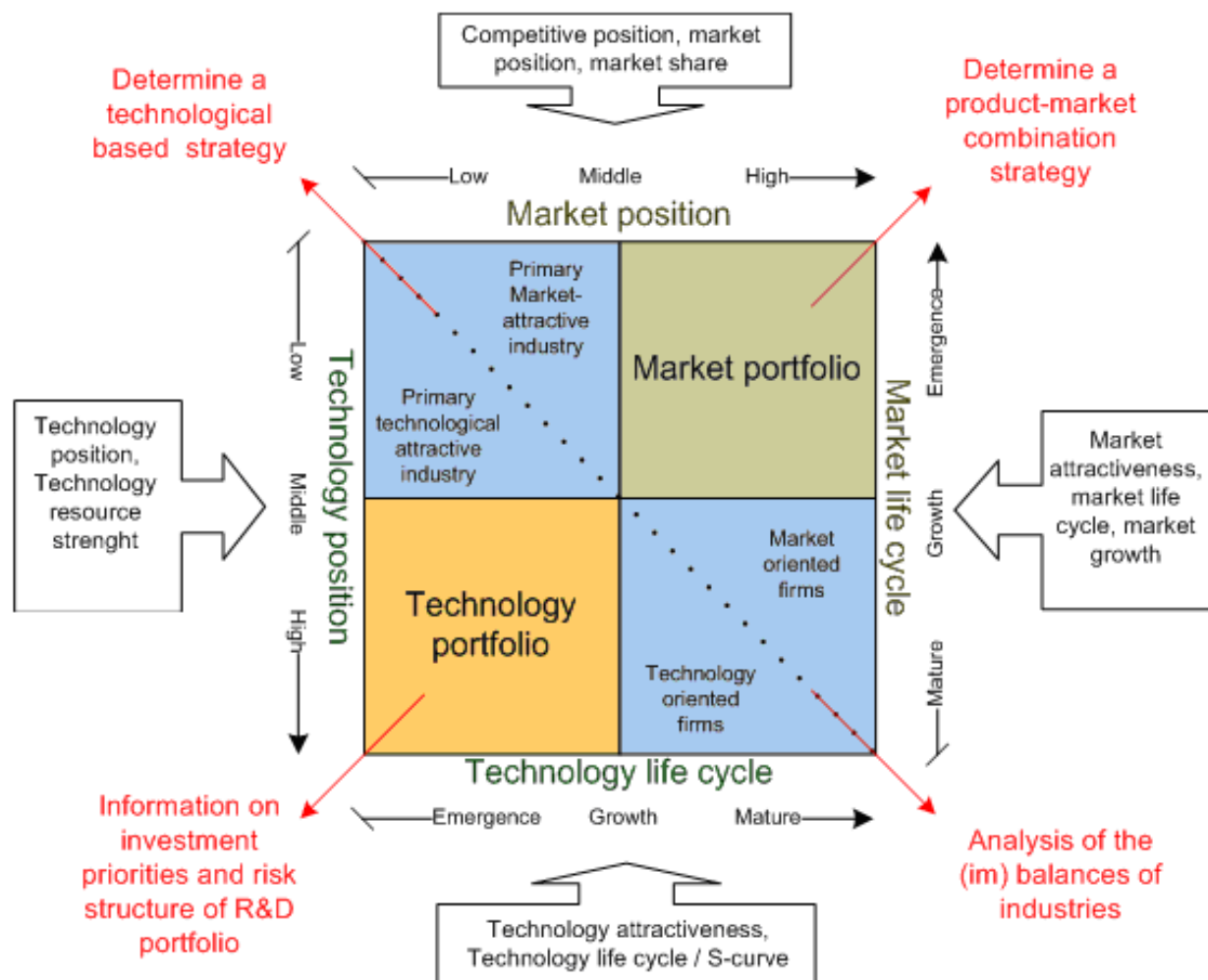
Figure 16. 4-field Scheme by Arthur D.Little

Based on the description of *W. Eversheim*, the analysis consists of six steps:

The first step is to classify business' relevant technologies into key, pacing and emerging technologies, according to their position in the technology life cycle.

In the second step, a benchmark of the technological position of the company or strategic business area is determined in relation to its competitors.

The third step is the positioning of the relevant technologies in the portfolio. The parameters are the relative technological position as a measure of attractiveness and the life cycle phase as a measure of the relevance of competition.

In step four, R & D priorities and risks are derived from the positioning of technology.

The next step is to compare the market and technology positions in those strategic business units for

which the technology has proven to be relevant. These opportunities and risks that may arise should be disclosed to generate a strategic competitive position for the business unit.

The last step is the combination of market and technology portfolio positions. Explicit strategic recommendations should derive into strategic actions for a specific technology field.

I.5. IT for Business improvement

A revolution is now underway. Most innovation occurs first in software.[23] And software is the primary element in all aspects of innovation from basic research through product introduction:

Software provides the critical mechanism through which managers can lower the costs, compress the time cycles, and increase the value of innovations. It is also the heart of the learning and knowledge processes that give innovations their highest payoffs.

In many cases, software is the core element in process innovations or in creating the functionalities that make products valuable to customers. In others, software is the "product" or "service" the customer actually receives.

Software provides the central vehicle enabling the inventor-user interactions, rapid distribution of products, and market feedback that add most value to innovations. Consequently, customers—and the software itself—make many inventions the company's technologists, acting alone, could not conceive.

All this demands a basic shift in the way managers approach innovation from strategic to detailed operational levels. Some portions of the innovation process may still require traditional physical manipulation, but leading companies have already shifted many steps to software. And those who do not will suffer.

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[23] *James Brian Quinn, Jordan J. Baruch, and Karen Anne Zien, Software-based innovation, Sloan Management Review, November 1996*

I.6. Knowledge Management

Knowledge management is a practice that tells how knowledge is distributed inside an organization. In business world with the help of knowledge management, an employee knows, in which way he or she should pass the information to a colleague on the other side of the world, for example. Also when a worker saves his work document to a common company database he is doing his part of company's knowledge management. By utilizing knowledge management, the company doesn't need to invent the wheel time after time again.

However, the term of "Knowledge Management" isn't so easy to define precisely. Knowledge management includes various aspects and activities, and the functions may vary between two different organizations. Knowledge management gives instructions how to store, organize and access the knowledge that exists inside the firm, for example. It also helps a company to decide how to get or create new knowledge. Barclay & Murray define knowledge management in their article "*What is knowledge management?*" the following way:

"Knowledge management often encompasses identifying and mapping intellectual assets within the organization, generating new knowledge for competitive advantage within the organization, making vast amounts of corporate information accessible, sharing of best practices, and technology that enables all of the above — including groupware and intranets."(Barclay & Murray, 1997)[24]

I.6.1 Knowledge

To be able to manage knowledge efficiently, it should first be defined what knowledge actually is. There are two different dimensions of knowledge, *explicit knowledge* and *tacit knowledge*, which are explained below.

Explicit knowledge

Explicit knowledge is the type of knowledge that can be articulated, stored and disseminated via databases. Explicit knowledge is often expressed or documented in a formal, systematic way - frequently in words and numbers. Examples of explicit knowledge are i.e. different manuals,

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[24] *Rebecca O. Barclay, Philip C. Murray, What is knowledge management?, Knowledge Management Associates, 1997*

documents, management directives and reference guides.

Tacit knowledge

Tacit knowledge is the knowledge that is ingrained in the brains of the organization's members[25]. Tacit knowledge is rooted in individual experience and intuition and it involves individual's personal belief, perspective and values. That's why it isn't as easy to share as explicit knowledge. Tacit knowledge can for example be attained through dialogue, storytelling, action learning and brainstorming.

Individuals having high amount of tacit knowledge within a certain area are usually considered as experts within their organizations and organization's less-experienced members frequently seek their guidance and inputs.

I.6.2 Basic Knowledge Elements

Knowledge can also be classified according to in which source it is rooted. Different sources of knowledge are often categorized to following three basic knowledge elements: *methods and tools*, *cases* and *experience*.[26]

Methods and tools

Methods and tools provide support and structure for the work with models, templates and checklists. They are used for the activities that are required in projects, like execution of re-engineering process or how to design a sales organization, the product-development process or a logistics in a specific industry. Methods can also be described as enablers of the communication between employees: *"An important function of method is to create a common language for the organization, so that when I say 'process model', everybody knows what I mean."* (Senior consultant Ernst & Young)

Cases

Cases are documents (proposals, process models, marketing support, educational material, benchmarks etc.) that are stored to company's database. Cases are examples how work was done in previous similar projects: they provide concrete examples of working. Documents that are used in new cases are often derived from old cases. This saves time for creating the documents fully again and provides a shared frame of reference and terminology.

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[25] *Andreas Werr and Torbjörn Stjernberg Exploring Management Consulting Firms as Knowledge Systems*

[26] *Andreas Werr and Torbjörn Stjernberg Exploring Management Consulting Firms as Knowledge Systems*

Experience

The third element of knowledge is employees' experience and it is often to a large extent tacit knowledge. It is usual that an experienced or senior employee shares his experience to inexperienced or junior employee and has a more monitoring role in a project.

These three different elements of knowledge have relations to each other and together they form the basis of organizational knowledge. *Werr and Stjernberg* have described the interrelations of the knowledge elements in their study like represented in figure 1.

Tacit

Knowledge

Experience

Provide language to

articulate

General   **Articulate,**   Specific

Knowledge   **make visible**   Knowledge

Translates   **Translates**

Methods and

tools   **Provide language to**   *Cases*

      Specify and   **articulate**

      Exemplify

Articulate
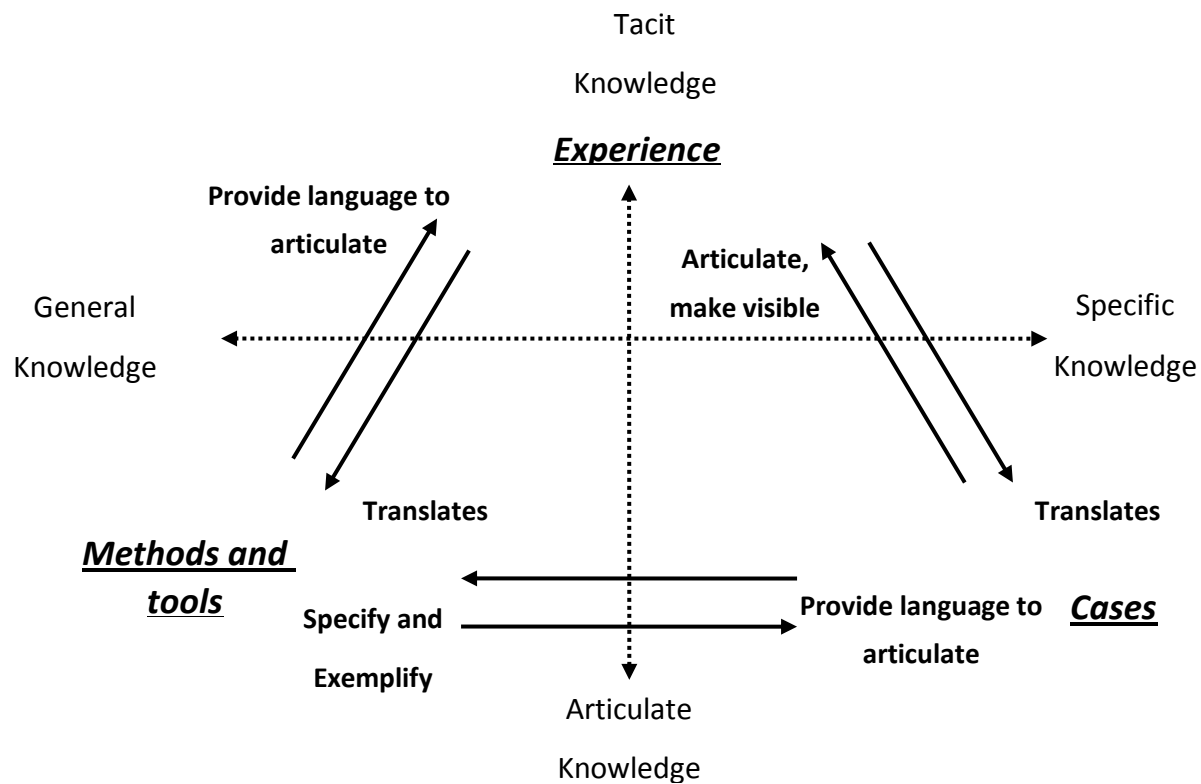
Knowledge

Figure 17. Three basic elements of the knowledge systems and their interrelations

I.6.3 Two different strategic approaches to Knowledge Management

Because the two dimensions of knowledge - explicit and tacit - vary so much, they also require very different kind of approaches and management strategies.

Codification strategy

This strategy is applied for managing explicit knowledge. It is so called "people-to-documents" approach that allows many people to search and retrieve knowledge from company databases without having to contact the person who originally developed it. Codification strategy is used by organizations that work with standardized and repetitive tasks, often concentrated on computer-based businesses.

Personalization strategy

For its part, personalization strategies are selected when tacit knowledge is attained. Tacit knowledge is shared through direct "person-to-person" contact because it is too rich and subtle to be shared through documents. Personalization strategy is applied by companies that offer highly customized solutions to their customers. Such firms need to differentiate from the competitors, but using codification strategy wouldn't differentiate them enough. This is because codified knowledge is often such kind of knowledge that also the competitor knows or can easily find out[27]. That's why personalization strategy needs to be used.

There are knowledge management researches that argue it is inconvenient for a company to try to excel in both strategies - they will risk failing at both. Companies should instead focus on one strategy and use the other one in a supporting role. The company's main strategy for knowledge management should reflect its competitive strategy[28].

"The organizational challenge is to identify the 'best' knowledge to synthesize as well as to motivate employees to take part in this process of synthesis by submitting their articulate knowledge to the rest of the organization." (Dunford, 2000)

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[27] *Haas & Hansen, 2004*

[28] *Morten T. Hansen, Nitin Nohria and Thomas Tierney, What's Your Strategy for Managing Knowledge? Harvard Business Review, Marc-April 1999*

Chapter II. Research: Innovation Management in ABB

II.1. ABB Group

Formed in 1988 by the merger of two long-established engineering groups, ABB has about 120,000 employees and operations in more than 100 countries in every region of the world.

Today, ABB is one of the world's leading engineering companies, helping customers to use electrical power effectively and to increase industrial productivity in a sustainable way.

II.1.1 Organization

ABB uses a global matrix structure with 65 business areas -product lines- on one side of the matrix and over 100 country managers on the other side. Within the matrix the company is subdivided into 5,000 profit centers of 40-50 employees in average.

ABB has not only pioneered many of today's power and automation technologies, but maintains a technology advantage in these areas through sustained investment in research and development. Their R&D strategy continues to be driven by their customers' need to improve performance while minimizing cost. That means improving energy efficiency, cutting waste and providing reliable power supplies.

Through their R&D centers around the world, ABB maintains close ties to their customers and technology partners. In recent years, they have increased their research presence in growing markets such as India and China, and strengthened their presence in the US. ABB works closely with more than 70 of the world's leading universities and research institutes, including the Massachusetts Institute of Technology, ETH Zurich, the Indian Institute of Science in Bangalore, KTH Royal Institute of Technology in Sweden and Tsinghua University in Beijing.

II.1.2 Strategy, mission, vision

ABB's strategy

ABB is a global leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact.

With their technology leadership, global presence, application knowledge and local expertise, they

offer products, systems, solutions and services that allow their customers to improve their operations – whether they need to increase the reliability of a power grid or raise productivity in a factory.

Focusing on their core strengths in power and automation technologies, they strive for organic profitable growth. Their global manufacturing base ensures consistent top-quality products and systems – made in ABB – for customers around the world. Their customers have broad and easy access to ABB's offerings - whether they buy from directly or through distributors, wholesalers, system integrators or other partners.

The way of doing business is values-based, leadership-driven and performance-oriented.
In order to work effectively, they have to understand where they are going and what they are working towards.

ABB's mission is what they are striving to be while their vision is where they see themselves in a few years time. The business principles define their core values as a company.[29]

ABB's mission

Improve performance: ABB helps customers improve their operating performance, grid reliability and productivity whilst saving energy and lowering environmental impact.
Drive innovation: Innovation and quality are key characteristics of their product, systems and service offering.
Attract talent: ABB is committed to attracting and retaining dedicated and skilled people and offering employees an attractive, global work environment.
Act responsibly: Sustainability, lowering environmental impact and business ethics are at the core of their market offering and their own operations.

ABB's vision

As one of the world's leading engineering companies, they help their customers to use electrical power efficiently, to increase industrial productivity and to lower environmental impact in a sustainable way. ***Power and productivity for a better World*** is the slogan that reflects ABB's mission and vision.[30]

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[29] *ABB Group, World Wide Web, ABB Group Strategy (Copyright Notice in appendix)*

[30] *ABB Group, World Wide Web, ABB Group Strategy: Mission and Vision 2011 (Copyright Notice in appendix)*

II.1.3 R&D Execution

In order to effectively and efficiently execute R&D activities, some common processes and tools have been established and should be followed as described below. The next paragraphs define the global R&D execution that is carried out at the ABB Group.

Organization in executing R&D

Group Function Research and Development (GF-RD) governs the direction and execution of R&D. In order to combine business orientation with innovation and market vigilance, the Technology Core Team, consisting of the division technology managers, the Corporate Research (CR) global lab managers, the Controller GF-RD and the Chief Technology Officer (CTO), acts as the main decision-making body within the technology function.

Regularly CTO reviews the technology with each division and quarterly progress reviews of the two global corporate research labs are institutionalized. Steering teams, consisting of division and Business Unit (BU) technology managers and CR Global Lab Managers, regularly review the portfolio of R&D programs.

Innovation strategy for technology and R&D

Division and BU technology managers define a strategic technology plan (STP) as part of the overall division and BU strategies. CR Program Managers derive a STP for their research program on the basis of the Group/division/BU strategies.

A STP shall contain as a minimum three parts:

- A strategic technology analysis (market trend assumptions and risks, customer needs, competitor analysis, technology leadership analysis and SWOT)
- An innovation strategy and roadmap for technology and R&D
- R&D related strategic actions with time plan, responsibilities/organizational structure, costs and measures to monitor and control its success.

Processes in executing R&D

Executing R&D comprises in general five processes:

- Identify opportunities for new or enhanced products, services or processes.
- Manage the research and development portfolio.
- Design and develop the new or enhanced products, services or processes.
- Bring the new or enhanced products, services or processes to market.
- Capture actual return on investments.

Identify opportunities for new or enhanced products, services or processes

Opportunities for new or enhanced products, services or processes are identified systematically from internal sources (e.g. own skilled employees, own observational research of customers, competitors and markets, testing of ideas), and external sources (e.g. from existing customers, customers of competitors, customers in adjacent areas to their offerings, suppliers, related industries, research institutes and universities).

Ideas should focus on

What job or problem their existing or new customers need to get solved. Thus, focus on the outcome existing or new customer desire vs. focus on product features only.

Reducing ABB's and/or customers cost structure while keeping or increasing the same quality and functionality.

Ideas that initially cover simpler customer needs or "good enough" performances should not be discarded if they address a rapidly growing customer segment or will create differentiations to competitor offerings that customers like. Those ideas could give rise to disruptive innovations.

The identification of new ideas is the task of each ABB employee and cannot be delegated.

Working together on the interface between markets and technologies will lead to a better understanding of customer needs and technology opportunities and help to initiate R&D projects for and with strategic customers. This will also enhance the strategic role of research in the creation of options, both for new business as well as protecting their existing businesses against future market and regulation uncertainties.

Manage the research and development portfolio

Once ideas have been generated for new products, services or processes, managers must decide:

What ideas shall they turn into a R&D project, which ideas to defer or to turn down.

What type of R&D project should be focused on, e.g. a pre-study, university cooperation project,

technology scouting, technology development or product research and development project, or a combination of those.

Whether the R&D project should be done internally, done collaboratively, licensed from another organization, or outsourced.

What resources are needed and how the project organization should be set-up.

A detailed project plan for a R&D project has to be defined. It needs to answer the WHAT (objective and deliverables, value to end-customer, value to ABB), WHY (link to the Group/division/BU strategy/STP, beneficiary product line and markets segments, expected market volume, financial impact and valuation), HOW (technical descriptions, before/after etc.), and WHO (project organization, milestones, duration, project costs per year).

Valuation criteria for selecting a R&D project among several alternatives need to consider qualitative and quantitative aspects: Alternatives are examined in terms of e.g. their alignment with Group/ division/BU strategy, existing/future/latent customer needs, differentiations and competitor blocking aspects, option considerations and probability of success. On the basis of those qualitative aspects, the value of each alternative in terms of incremental effects on ABB's future profitability shall be estimated and different scenarios established (e.g. using NPV and ROI calculations). Financial metrics alone, without highlighting the underlying assumptions, risks and the qualitative assessment, should not be used as a rank-ordering tool. This is valid especially in the early stages of the R&D activity when the accuracy will necessarily be low.

The underlying assumptions and risks in valuing the R&D alternatives need to be documented and continuously monitored. If the circumstances are changing, then the valuation and the R&D portfolio need to be adapted.

Division and BU technology managers decide upon R&D projects, whereas CR Global Lab Managers and CR Program Managers decide about corporate funded R&D projects. Steering teams regularly review the portfolio of R&D.

Design and develop new or enhanced products, services or processes

Design and development processes usually comprise the development of concepts, product planning, and detailed product and process engineering. The execution needs to be organized effectively and efficiently to reduce innovation lead times and reduce any cost of poor quality in the business. Helpful is to "test and learn" early and frequently enough and to have the determination to change course when needed. Especially when doing R&D related to a non-existent market, rough pilot or testing market approaches are recommended.

Division and BU technology managers regularly review the progress of any R&D projects, whereas Global Lab Managers and CR Program Managers regularly review corporate-funded R&D projects. They decide upon continuing, redefining or changing course (e.g. when new information arrives), deferring or stopping the project in due time.

Bring the new or enhanced products, services or processes to market

After the design and development phase, the resulting product, service or process specifications will be realized in the beneficiary BU and finally released to the market. The execution needs to be organized effectively and efficiently to enable:

Effective production (e.g. low production costs, low environmental and safety incidents, low number of failures or returns from customers, excellent relationships with suppliers).
Effective marketing distribution and sales of it (e.g. increase of orders from new products).
A rapid launch of the new or enhanced offering (e.g. short time from start of pilot production until full volume capability achieved, low number of redesign cycles).

Division and BU technology managers supervise the launch, including the one of corporate R&D efforts. The Corporate Research Center (CRC) needs to take an active role in transferring the results of R&D into the business and technically supports the launch to the market.

Division and BU technology managers decide upon licensing the technology to third parties. Patents that are not of use for the divisions/BUs are actively licensed out or sold to third parties by GF-RD.

Capture the return on investment

Division and BU technology managers evaluate the business impact of their funded R&D, whereas CR Program Managers do the impact evaluation of corporate-funded R&D based on inputs from the business. Those results will be used for further communication to Executive Committee (EC). Specific guidelines from GF-RD need to be considered.

Tools in executing R&D

Execution of R&D can be structured and facilitated by applying common tools. Those tools need to be understood as common denominators that can be adjusted to specific business needs. Businesses or CRCs are free to use additional tools in executing R&D.

Product development funnel

The process of transforming new technologies into new or enhanced products, services or processes can be described as a funnel (see graph below) in which the wide opening at the outset indicates the maximum flexibility for concepts, product designs, and manufacturing processes.
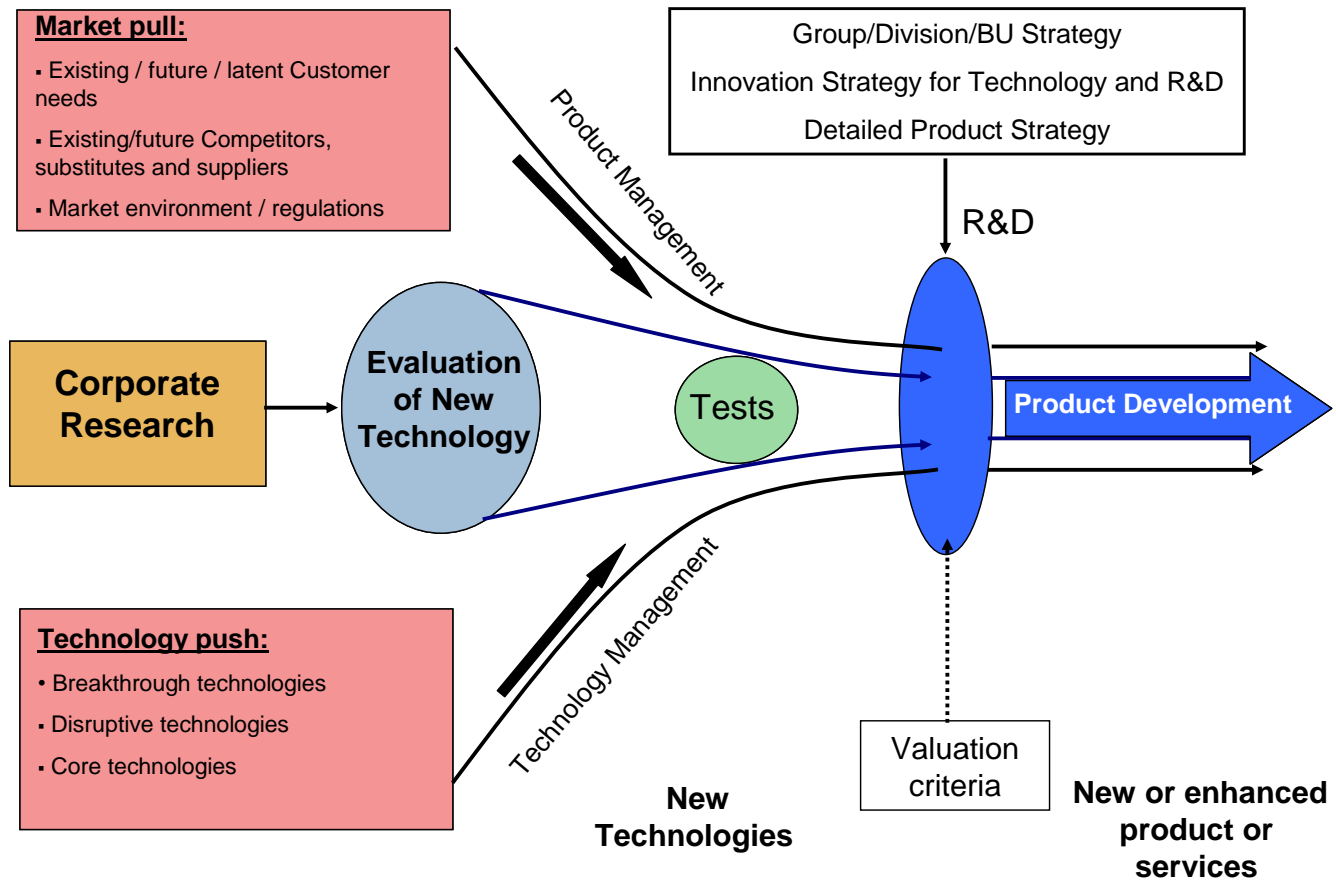
Figure 18. Product Development funnel at ABB

The product development funnel demonstrates how options get discarded as the new technologies become better defined and the influences from customer and market environments (market pull), from technology possibilities (technology push) and from the strategy and the valuation criteria, which finally lead to the selection of a specific product, service or process development.

Gate Model

The ABB Gate Model is a decision and management model to be applied for developing new technologies and new or enhanced products, services or processes. It provides a structure for allocating resources among projects by defining the decision-making criteria to continue, enhance, defer, redefine or stop a R&D project at any time.

Those decisions are taken at defined stages, when engineers and managers review on the one hand the development of the project and on the other hand any related evolutions in customer needs, technologies, regulations and competitor activities and their impact (see graph below).

The purpose of using the ABB Gate Model is to ensure that:

- ABB's money is spent on the most promising R&D projects, and is prioritized according to business considerations.
- The R&D project is in line with Group/division/BU strategy/STP and does not deviate from it during the development phase.
- Decisions on continuing, enhancing, deferring, redefining or stopping the project are taken on due time.

The decision taker (i.e. the direct customer for the end result of the R&D project, or the product owner for product developments, or the product developer for technology developments) requests the application of the Gate Model, controls it and leads the reviews.

It is important that the Gate Model is not applied as a bureaucratic and formalistic process since it would then not achieve its purpose. The depth of details and applying checklists etc. needs to be adjusted to the specifics of the R&D project.

G1	G2	G3	G4	G5	G6	G7
Agreement to start	Agreement on scope	Agreement on start project execution	Confirm execution	Agreement on readiness for Introduction	Release / Handover	Capture return on investment
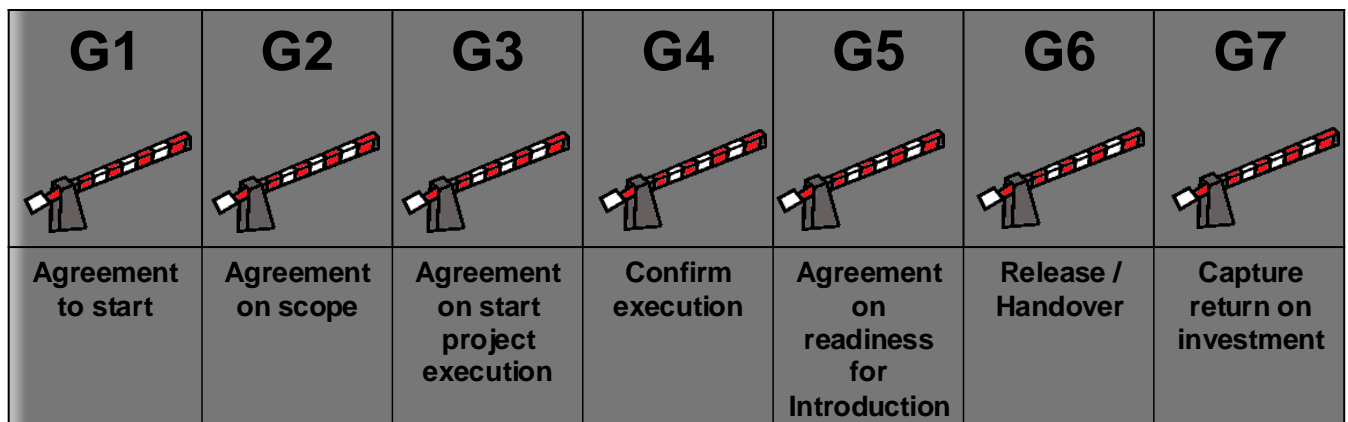
Figure 19. ABB's Gate Model

II.1.4 Intellectual Property: Patent Application Process

When an inventor has made an invention inside ABB, the inventor enters required information into a Lotus Notes interface of ABB to make an application for obtaining a patent. Then the invention

disclosure is submitted to an ABB patent department. The administrator at the ABB patent department assigns a Patent Attorney and a Review Manager. The Review Manager can optionally assign additional reviewers that state their opinion on the new invention.

There are two options for the decision process:

In the first option, the decision process starts with the assignment of the Decision Maker by the Review Manager. He can also make an optional proposal for the Decision Maker. Ones the Decision Maker makes a decision, the next step of the patent application is processed by the Patent Attorney.

In the second option, the Review Manager makes the decision with no extra assignment of a Decision Maker. Then, analogue to the first option, the patent application is processed by the Patent Attorney.

The Patent Attorney works out the Patent Application and if the decision is positive, the patent application is filed with the Patent Office. The invention disclosure is transferred to the Patent Database. Otherwise, if the decision is negative the invention disclosure is abandoned and the application is cancelled.

II.2 ABB Switzerland Ltd.

ABB Switzerland is a key member of ABB's global network, offering comprehensive technology expertise and extensive relationships in the marketplace and with customers. The organization of ABB Switzerland employs approximately 6300 workers. It is headquartered in Baden and has overall responsibility within the ABB Group for a range of products and systems.

ABB Switzerland received the highest marks as an employer. ABB is often in the first place in surveys of Swiss students of engineering and technical major. Employees appreciate the innovative strength of the company and its product portfolio, which sets the pace in the market. Other advantages are the versatile and interesting tasks they perform, the personal responsibility they are given and, not least, the international environment of ABB that comes from working with colleagues from 80 different countries.

ABB has a lot to offer to professional committed team players with social skills. Project management responsibilities with great discretionary power, foreign missions and training opportunities are tailored to the jobs, offering good development and career opportunities. General working conditions are also attractive. Flexible work schedules and 11 daycare centers in different places give employees greater freedom. ABB is also a leader helping employees to achieve a healthy work life balance.

ABB customers in Switzerland are attended by a competent sale and service organization, a key account team and at a local level by one of the five regional offices. These employees supply products, systems and services and provide comprehensive ABB range contacts to all units of ABB in Switzerland and to the ABB Group.

With its broadening network, a wide knowledge of specific industries and proximity to customers, ABB sales and service experts give advice and technical support to its customers.
All these facets also ensure high availability and efficiency of their staff. Organization's portfolio covers services for products and systems throughout the life cycle, complete equipment maintenance in some areas, and advice on energy efficiency.

ABB Switzerland understands under "innovation" basically a constant renewal of the entire enterprise, whether in political, technological, organizational or personal aspects. ABB focuses on the awareness that it is not possible to live today in much of yesterday's innovations. Therefore the ABB Switzerland organization sets its objectives on developing a pioneering spirit for the creation of innovative ideas for the future. In this sense, employees are encouraged to constantly think ahead and actively contribute

with their ideas. One example is the Innovation Fund, which offers innovative ideas initial financing.

Technology and market leadership is developed and maintained by taking responsibility for customers. For a technology company such as ABB, successful innovations are survival. The research center in Baden is one of seven research centers around the world. It employs approximately 180 employees from more than 30 countries. Research projects are mainly carried out in the areas of Power electronics, high voltage technology, automation technology and Materials Science. The Swiss Center also carries the responsibility for the global ABB research in energy technology.

The research is focused to improve and redesign methods and technologies that are often the basis for products and systems. This is done in an active collaboration between ABB's research centers and the operational units. As a main goal ABB is always pursuing sustainability: energy consumption should be reduced and reduced environmental impact.

II.2.1 Organization ABB Switzerland Ltd.
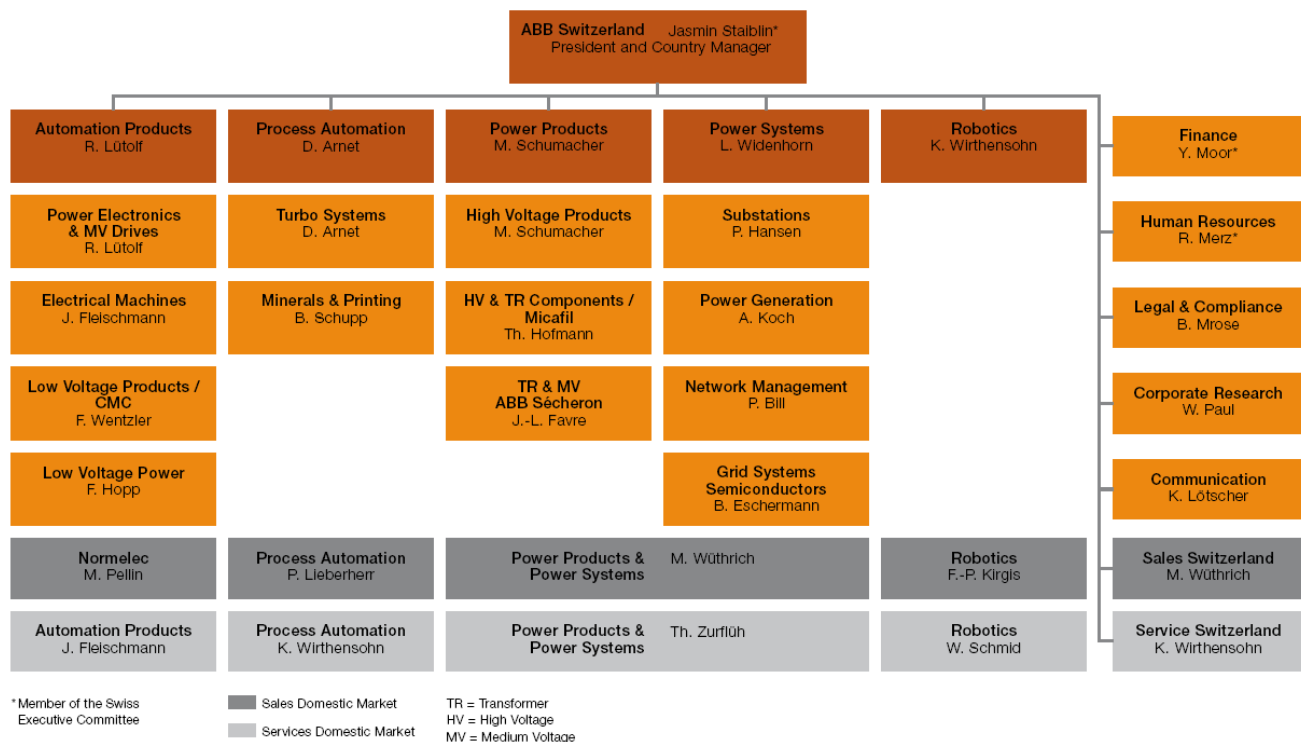
Figure 20. Organization ABB Switzerland Ltd.

II.2.2 Innovation Fund of ABB Switzerland

ABB Switzerland launched an Innovation Fund for seed financial support of innovative project ideas among their staff.

Innovation is a key issue for ABB worldwide. For this reason, ABB Switzerland has established an Innovation Fund, which supports the implementation of innovative ideas. The Innovation Fund supports creative project ideas that often rise form an interdisciplinary cooperation of different units or that are so new that they should be given special attention in addition to the daily business. The ABB Switzerland thus offers a selective start-up funding. The concrete follow-up and implementation of ideas is then promoted to the local competent business units. All business units of ABB Switzerland are involved in this innovation fund.

Although at a technology company like ABB, products, systems and service are very important, the innovation fund is broadening. Innovations take place at all levels and in all areas of the company. Therefore, the Innovation Fund aims to promote all the ideas that contribute to the improvement of practices, procedures, practices or production processes.

Each submitted project application is reviewed by a team of experts on innovation potential and feasibility. The expert team consists of executives of ABB Switzerland. The preselected ideas by the team of experts are then presented to the management team at ABB Switzerland. This decides which applications will receive from the innovation fund start-up financing. [31]

II.3 ABB High Voltage Products-High Current Systems Generator Circuit Breakers PTHG

With world-leading SF6 technology, ABB's Generator Circuit Breakers assist all type of power stations all around the globe to increase both safety and efficiency. These improvements are possible since a GCB provides three main benefits:

Simplified operational procedures

The installation of the generator circuit-breaker directly in the connection between the generator and the main transformer provides a clear and logical plant arrangement.
During the starting-up or shutting-down of the generator only one circuit-breaker has to be operated

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[31] *ABB Switzerland in Brief, CH-COM 2009*

thus reducing the number of switching operations necessary.

The responsibilities for the operation of the power plant and the high-voltage grid are clearly defined.

Improved protection

The differential protection zones of the generator, the main and the unit transformers can be arranged to achieve maximum selectivity.

Generator-fed short-circuit currents are interrupted within a maximum of four cycles whereas the reduction of the fault current by the de-excitation equipment requires a number of seconds.

Higher power plant availability

Simplified operational procedures and clearly defined operational responsibilities reduce the likelihood of operational errors.

The synchronization of a generator with the high-voltage transmission network can be carried more reliably with a generator circuit-breaker than with a high-voltage circuit-breaker.

The use of a generator circuit-breaker allows the unit auxiliaries supplies to be drawn directly from the high-voltage transmission network at all times. Supply from this source is considerably more reliable than that from a local sub-transmission network.

The focus on excellence makes ABB a premier supplier of Generator Circuit-Breakers. They continuously invest in new technology and never compromise in quality. With a short delivery and commissioning time, more than 5000 GCBs with the SF6 technology have been installed worldwide since 1985.

II.3.1 Organization High Current Systems- PTHG
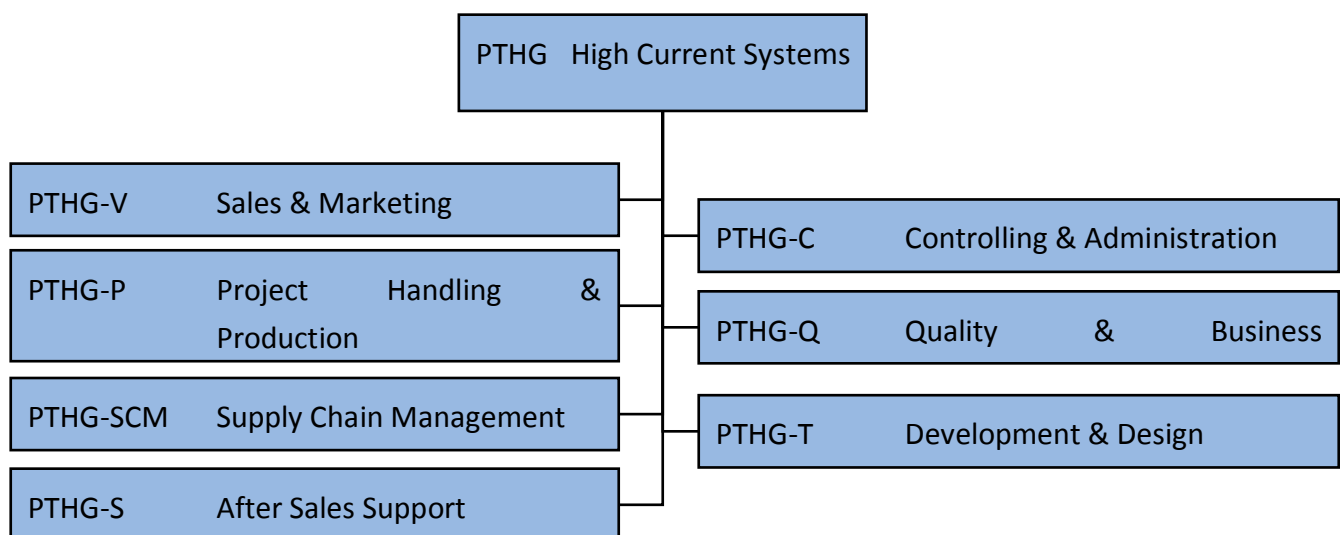
Figure 21. Organization High Current Systems

ABB High Current Systems is organized in eight departments. The organizational departments are: Sales & Marketing, Project Handling and Production, Supply Chain Management, Development and Design, After Sales Support, Controlling and Administration and Quality & Business Improvement.

II.3.2 Product portfolio

Generator circuit breakers are a critical component in power plants, protecting both the generator and the power transformer. ABB has the broadest GCB portfolio on the market, covering power ratings of more than 1500 MW and nominal currents in excess of 50,000 A.

About 70 percent of the world's GCBs are engineered and manufactured by ABB Switzerland Ltd.
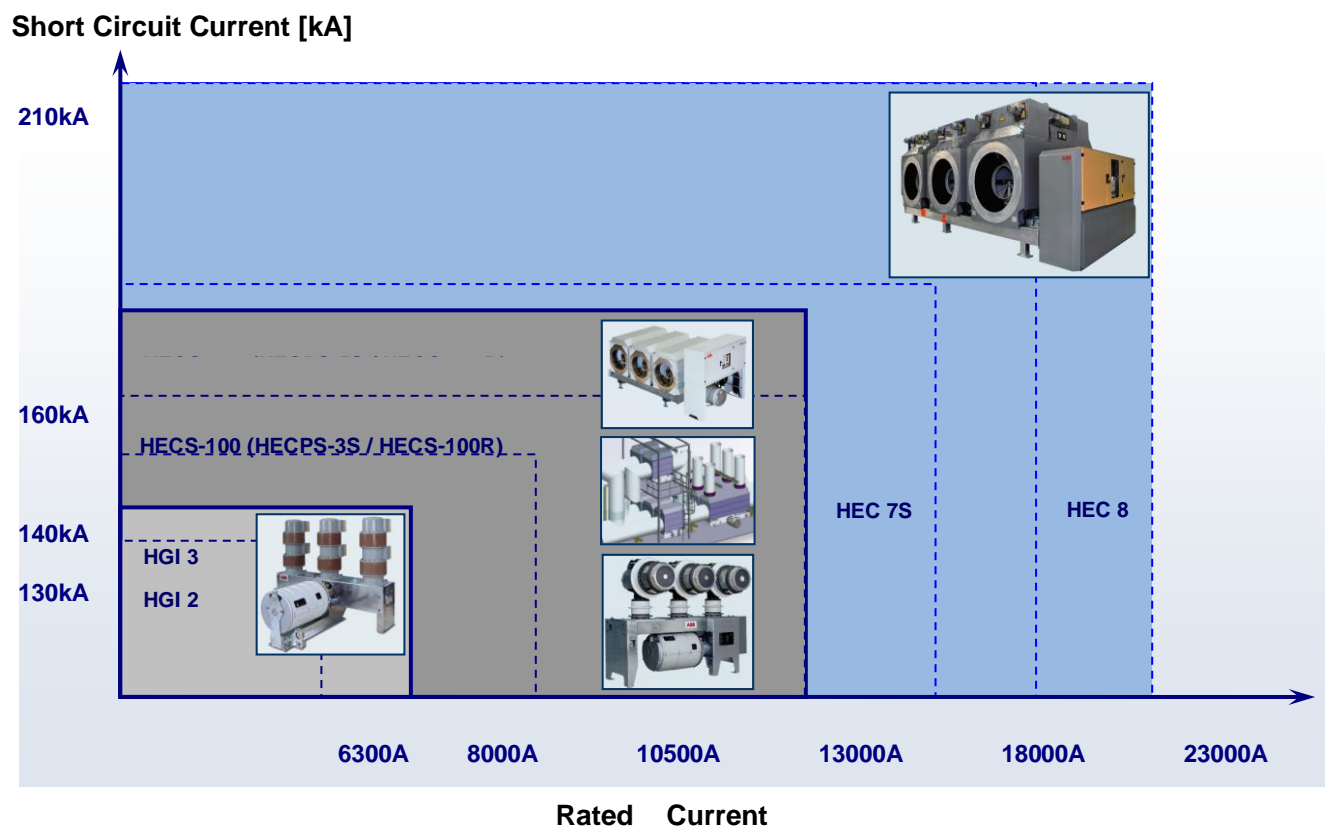
Figure 22. Generator Circuit Breaker Product Portfolio

II.3.3 Change Process: from traditional to Lean Production

For the last two years ABB PTHG has focused on improving the production of Generator Circuit Breakers. The goal has been to reduce the required time for delivering a GCB unit. The delivery time, the time from the product ordering to its shipping had to be reduced from 6 months to only 2 months. To achieve this goal there has been put focus on all processes. Analysis of the value stream and the definition of the interfaces of the processes have been done in order to optimize and standardize the order execution process.

Due to that goal, all the departments in ABB PTHG had to change their internal processes focusing on eliminating wastes. The most important improvement has been done in the production. The production time has been reduced from 3 weeks to 18 hours. The optimization has been done based on the Toyota Production System, also generalized in the LEAN Philosophy.

Cultural Aspects

Most of the workers at ABB PTHG were used to a traditional manufacturing. The first step in the introduction of the new production methods has been to change the mentality of everybody involved in the change process. For this purpose, the responsible persons did a benchmark, visiting other companies that were already applying new optimized production processes. In this early stage of the change process, the involved people had to identify that a new working culture was needed. Overcoming the mental hurdles is the basis to find out new improvements and strengths the cooperation in order to improve all production processes. This change process is an evolution of the corporate culture and need to focus on continuously improving all processes.

Lean Philosophy

According to the new management strategy, all production processes have been analyzed step by step and redefined eliminating the wastes defined by the Lean Manufacturing philosophy.
The key principles of lean manufacturing are:

Perfect Quality from the first time. It is expected to search for zero defects and early detection and resolution of problems

Minimization of waste. Eliminating all activities that bring no value added. Search the optimal use of scarce resources, i.e. capital, people and space.

Continuous improvement. Focus has to be put on: reducing costs, improving quality, increasing productivity and information sharing.

Process 'pull' means the products are pulled, in the sense of request, by the end customer, not pushed by the end of production

Flexibility in the sense of quickly produce different mixtures of a variety of products without sacrificing efficiency due to lower production volumes.

Construction and maintenance of **long term relationship with suppliers,** taking agreements and sharing information.

Lean is basically everything related to getting the right things in the right place at the right time, in the right quantity while minimizing waste, being flexible and open to change.

The focus is put on the reduction of the 7 types of "wastes" in manufacturing products. These are the wastes that have to be eliminated[32]:

1) **Transportation** (Unnecessary movement of materials)

2) **Inventory** (Excess of inventory not directly required for all components)

3) **Motion** (People or equipment moving or walking more than is required)

4) **Waiting** (Waiting for the next production step; periods of inactivity)

5) **Overproduction** (Production ahead of demand; production should be stopped)

6) **Over Processing** (Resulting from poor tool or product design creating activity; rework and reprocess)

7) **Defects** (Reduce the effort for inspecting and fixing defects)

Optimized Production Layout

The production and assembly layout is divided into to main areas: The preassembly area and the final assembly area. The purpose is to reduce the movement of materials. The preassembly area is also divided into 6 different areas, where the smaller parts are assembled. The final assembly area is designed as a railed assembly line and divided into 9 tacts. Each preassembled part is transferred laterally to the assembly line.

According to the material „Pull" theory, between the preassembly and the final assembly line the position of the preassembled parts is marked on the floor. Ones the preassembled parts are taken from its position in order to supply the assembly line; the next preassembled part can be placed in the marked position again. Each finished preassembled part has a marked position in the factory. If the position is unavailable, there is no chance to follow on producing this part. There is no accumulation

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[32] *Womack, James P. and Daniel T. Jones, Lean Thinking. Free Press, 2003*

of preassembled parts, minimizing the waste and improving the material flow.

For each of the tact a maximum tact time of 120 minutes is defined, and four persons work simultaneously on it. Depending on the production demand the four unit teams are fixed positioned in a tact area. If the production demand is lower than the capacity, the four person teams move from tact to tact with the GCB. This permits the production planning to flexible adapt the production capacity to the demand and avoid overproduction.
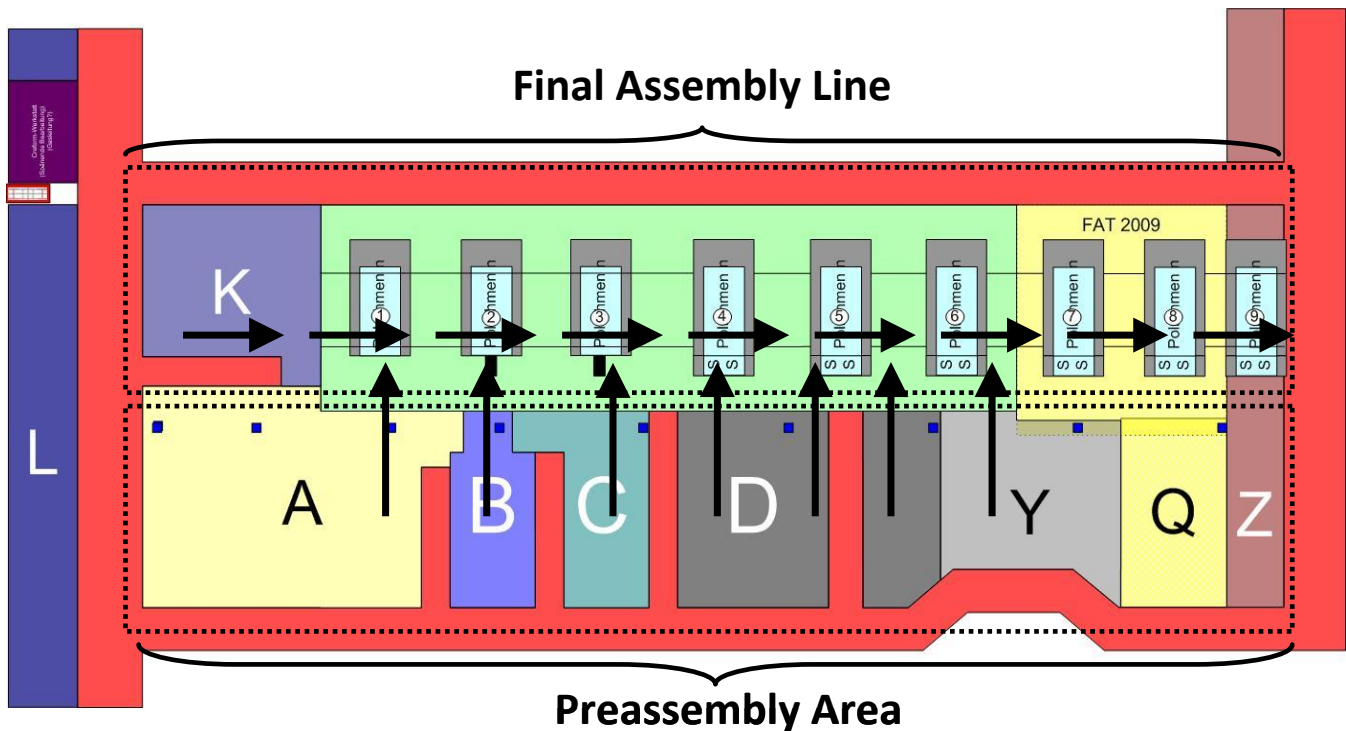
Figure 23. Production Layout-Material flow

Logistics of parts

In order to minimize material movements and waiting times, one of the most important aspects is the definition of the logistic of parts. A logistic development team has worked on the definition and supply of the different parts for manufacturing. All needed parts have been classified into three types: A parts, B parts and C parts.

The A-parts are customized parts, characterized for their large dimensions and weight. This are brought Just in Time by the supplier to the assembly line. Each part has a marked position on the floor for its visual and clear identification. Just in Time (JIT) is the system of organizing production for factories based on the Japanese principles of the Toyota Production System. The aim is to increase productivity while reducing the cost of managing storage and losses due to unnecessary stocks.

The B-parts are ABB specific components used during the preassembly. Each component type has assigned a "Kanban" card. "Kanban" comes from the Japanese language, where "kan" means "visual," and "ban" means "card" or "board". It is a term that is used in the manufacturing world to identify cards that are linked to the intermediate or final products of a production line. The cards act as witness of the production process.

This card provides the internal logistic supply with the code number and the position of the component in the preassembly. B-parts are smaller than A-parts and are stored in a warehouse next to the preassembly area. B-parts are put into boxes in the preassembly area. A limit amount for each part is defined. When this amount is reached, the persons responsible for the area takes the Kanban card and puts it into a box. The demand for new components is triggered. The internal supply takes this card and supplies the missing parts. Production is driven by demand and the Kanban is the signal from the client that indicates that a new product must be manufactured or supplied to fill the stock point.
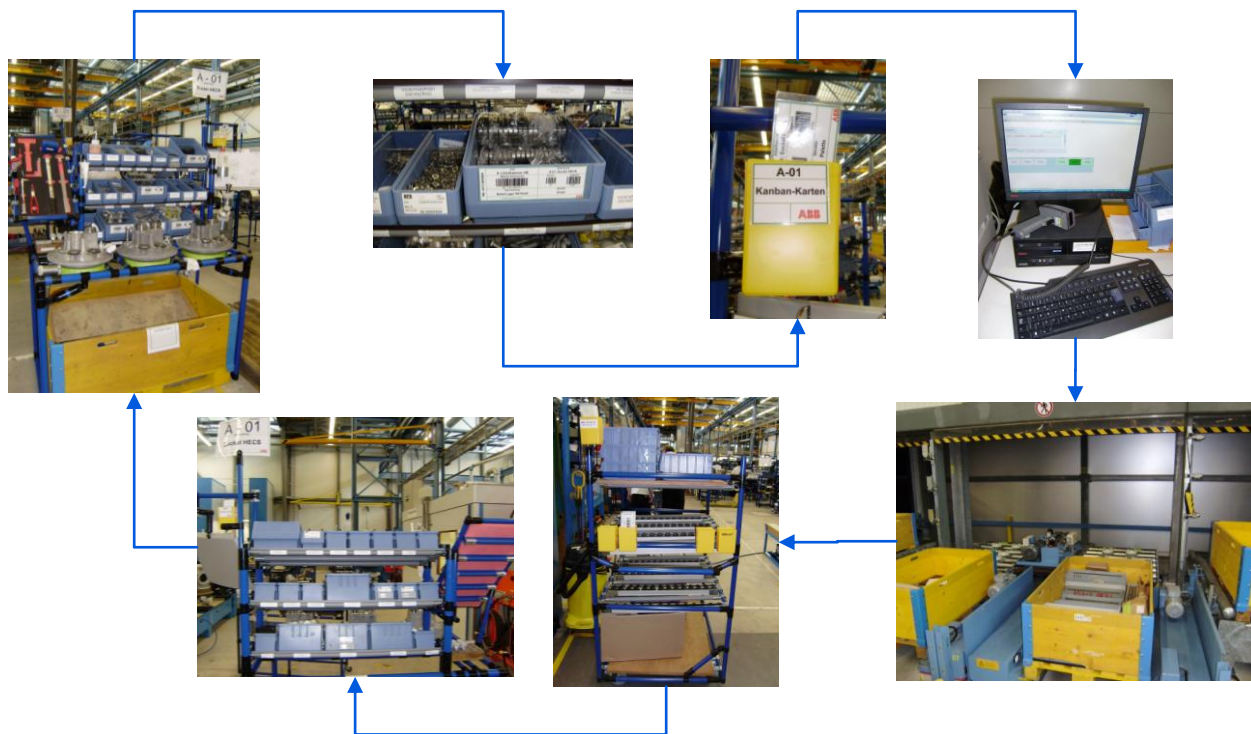
Figure 24. B-parts supply - Kanban Process

The third type, the C-parts are standard parts supplied by extern companies. They are put in boxes equipped with Radio Frequency Identifier (RFID) sensors. Ones the amount of components is less than

the minimum defined the responsible person has to turn the box. When turning a radiofrequency signal with the code of the component is sent to the base station installed in the facility. This station receives the signal and forwards it to the external supplier as an order. The external company goes into the production facility and refills the ordered components in their boxes.
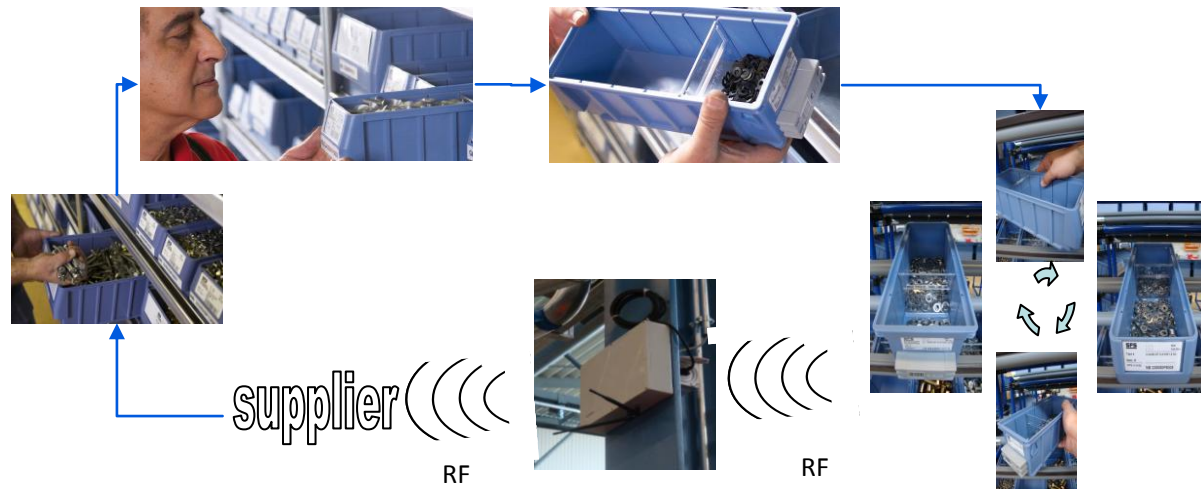
Figure 25. C-Parts supply with RFID

Quality: Cleanliness and order evaluation

Quality starts with cleanliness and order. This is one of the main statements of the 5S Method.

The 5S method is named after the first letters in Japanese of each of its five stages. This Japanese management technique is based on five simple principles

Seiri (整理): Organization. Separate unnecessary.

Seiton (整顿): Order. Locate necessary.

Six (清扫): Clean. Remove dirt.

Seiketsu (清洁): Standardizing. Signal abnormalities.

Shitsuke (躾): Discipline. Continue to improve.

Encouraging efforts in this direction to ensure that the plant is clean and tidy is everyone's job and is also an example of how people feel integrated into business objectives. Therefore in the plant "Broom Points" have been created at each area, and periodical evaluations are performed.

The integration of 5S satisfies multiple objectives:

- Delete the workspace that is useless, eliminating the unnecessary.
- Organize your workspace effectively; a place for everything and everything in its place.
- Improve the cleanliness of the places, standardizing cleaning.
- Prevent the appearance of dirt and disorder, extending the application throughout the organization and develop evaluation systems.

Order and Cleanliness is also a good way to start the development of working groups, beginning with a proposed venture between bosses and employees, where the objectives are to raise short-term and the result will affect everyone.

Kaizen - Continuous Process Improvement (CPI) in the office

"Kaizen" comes from the Japanese language and stands for "change for the better" or "improvement", the common used translation is "continuous improvement".

In ABB PTHG the Continuous Process Improvement (CPI) includes four main actions. Introduce and improve the 5S method in the office, the creation of Quality Circles and spotlight on Process Development and Process Improvement.

Quality Circles consist of different employees from different departments that meet together to coordinate and speed up the resolution of failures and assure that the root cause is eliminated.

The improvement process is a daily activity that goes beyond simple productivity improvement. It uses all the potential of all employees to improve continuously. It is also a process which, if done correctly, humanizes the workplace. It aims at eliminating overly hard work and teaches people how to conduct experiments in their work using the scientific method in order to identify and eliminate waste in business processes. The successful implementation requires "the participation of workers in the improvement."

The Process Development is structured into different groups. On one hand there is a group that concentrates in the development of production processes on the basis of the elimination of wastes, and on the other hand the different departments work together to design, define, implement and further improve simple and clear business processes using value stream analysis.

II.3.4 ABB PTHG R&D Innovation Example

An ABB innovation has increased the performance of generator circuit breakers by more than 25 percent while simultaneously reducing the footprint, weight, noise levels and maintenance requirements of these critical power plant components.

The innovation has enabled ABB to increase the nominal current of its HECS family of generator circuit breakers (GCBs) from 18,000 amps (A) to 23,000 A, an increase of almost 28 percent.

Previously GCBs of this rating required a so-called 'forced' cooling system of pumps, fans or motors to counteract heat dissipation and keep sensitive breaker components within their rated temperature tolerances.

ABB has eliminated the need for these cooling devices by developing an innovative heat pipe cooling system that makes the HECS range lighter, slimmer and quieter than was previously possible.

In addition to offering a substantial increase in nominal current capability, the maintenance requirements of the new GCBs are – as with all HECS breakers - extremely low.

Nominal and short-circuit currents generate a tremendous amount of heat. The higher the nominal current, the more heat is generated. A cooling system – either natural or forced - is therefore required to keep the breaker within its temperature limit.

ABB's HECS breakers are quieter, smaller and lighter thanks to an innovative approach based on a heat pipe cooling concept.

A forced cooling system is itself a generator of heat, which in turn limits the nominal current capability of the GCB to 18,000 A, as well as creating extra weight and a larger footprint.

Natural cooling has its own engineering challenges and only becomes feasible for nominal currents above 13,000 A by increasing the dimensions, weight and footprint of the breaker components.

The success of the ABB heat pipe solution is to solve the limitations of the two existing technologies. It requires no electricity to operate and is virtually maintenance-free and silent.[33]

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[33] *Daniel Chartouni, Martin Lakner, Giosafat Cavaliere, Performing at a higher level: Advanced heat pipe cooling increases circuit breaker performance by over 25 percent, ABB Review 4/2007*

Chapter III. The Assignment

This chapter presents the process that has been object of the study and basis of the practical work done in ABB.

For the last two years there has been an improvement change in the way the production is structured and implemented. This change has developed from a traditional production process to a flow assembly line process based on the Lean Production System. In the second Chapter of this Thesis a better insight into the production process has been clarified.

Due to this change, the execution of the Factory Acceptance Test has developed to the most critical step in the assembly line. That is why it is important to stress that the customer and its attendance at the Factory Acceptance Test can have a strong influence in the production timing. In order to minimize this effect, all the testing process has to be analyzed, defined, optimized and supported with tools to avoid this risk.

According to that fact, the project consists of improving and defining the process of the Factory Acceptance Test of the Generator Circuit Breaker from a customer oriented point of view. The goal is to develop the relationship with the customers and strength the ABB brand.

For this purpose the project managers that are in charge of leading the customers through the Factory Acceptance Test have to adapt and be trained in the new defined standard FAT process.
According to the continuous improvement processes, innovation has to be applied to the FAT process.

III.1 Factory Acceptance Test Determination

The Factory Acceptance Test is made by the manufacturer, ABB Switzerland Ltd, at the factory as part of the process of producing the generator circuit breaker. In the most cases, the customer attends this test in order to certify that the design specifications and manufactured product fit with their requirements. If the generator circuit breaker is completely assembled prior to shipment, some of the production tests are made after final assembly; but other tests can often be made more effectively on components and subassemblies during manufacture.

If the generator circuit breaker is not completely assembled at the factory prior to shipment, appropriate tests on component parts shall be made to check the quality of workmanship and uniformity of material used and to assure satisfactory performance when properly assembled at its

destination. This performance may be verified by making tests after delivery.

The focus of the Factory Acceptance Test is the execution and certification of the routine tests as indicated in the international standards.

For testing a GCB- system two different standards have to be applied. The generator circuit breaker itself has to be tested according to the IEEE standard C37.013-1997, all other components according to IEC standard 62271 ser., 2001.

During the Factory Acceptance Test an abridgement of the routine test are performed. A copy of the production test report will be handed over to the attendee of Factory Acceptance Test. He confirms the successful acceptance of production test, by signing the original of the production test report.

III.2 Agents

III.2.1 ABB PTHG Project Management

In ABB PTHG, the responsible department for the FAT is the Project Execution department. Within this department there are project managers responsible for different regions that cover the whole world market.

In order to manage an international market it is important that the project managers have cultural sensitivity for other cultures and traditions. Due to this fact, the group is conformed by a mixture of different nationalities. There are Swiss, German, Iranian, Japanese, Italian, Bulgarian and Netherlands. This broad spectrum of nationalities enriches the ability for intercultural communication.

III.2.2 Customer

The market share of ABB's Generator Circuit Breaker is about 70% of the entire world market.
Due to this fact, the nature of the customers and attendees at the FAT is very wide. There are customers coming from North America, South America, Europe, Asia and the Middle East. In most cases customers come with external inspectors or consultants that are in command for the technical supervision of the Tests.

III.3 The Goal: Strategic Implications

The goal of the project is to develop the relationship with customers and strength the ABB brand in order to increase customer loyalty. How is it possible to improve loyalty of an already well positioned product in the market?

The Generator Circuit Breaker is already perceived by the customers as a High Quality product. Customers choose ABB for its high technology and its sustainable investment in Research and Development.

In this project we go a step forward and besides delivering a service to the customers, "Factory Acceptance Test", we aim at staging an experience to our customers, "The Factory Acceptance Test Event". Innovation arises from applying the "**Experience Economy**" theory for industrial products instead of consumer products.

The term **Experience Economy** was first described in a book written in 1999 by *B. Joseph Pine II and James H. Gilmore*, entitled *"The Experience Economy."* It describes the Experience Economy, as an economy following the agrarian economy, industrial economics and the economics of newer services.

The main thesis stated by *Pine and Gilmore* is that companies should organize memorable events for their clients, achieving that memory becomes the product, the "experience". More advanced experience businesses can begin to charge for the value of the "transformation" that offers an experience. This, they say, is a natural progression in the value added by the business over its inputs. Experience Economy is also considered as the most important foundation for customer experience management.

The next figure describes the economy evolution and the relation between the price, the strategic competitive position and the value for customers.[34]

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[34] *B. Joseph Pine II and James H. Gilmore, The Experience Economy: Work Is Theatre & Every Business a Stage, published in April 1999 by Harvard Business School Press.*
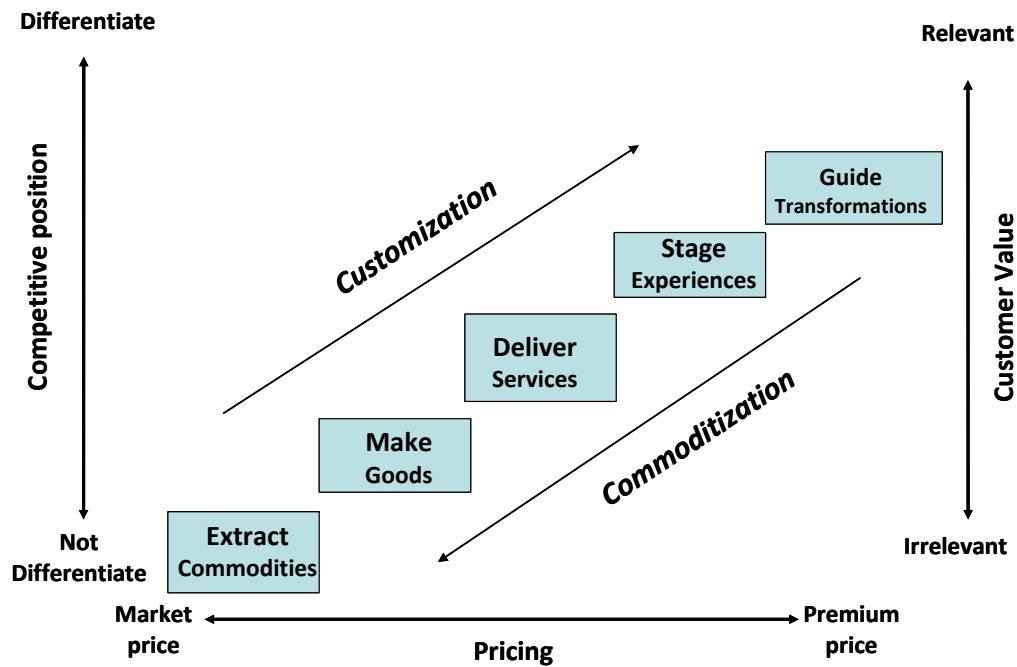
Figure 26*. The Progress of Economic Value*

III.4 The former FAT Process

For a lot of years, the Factory Acceptance Test has been done without focusing on customers. The process was focused on the product and the tests done during the acceptance. Due to that fact, the customer care was not important at all. The ABB representatives didn't try to satisfy customers on an experience level. Their awareness for customer orientation was very low because the product was qualitative enough and they assumed that the Factory Acceptance Test was only an additional step in the delivery of the product.

Some of the main problems that occur during the FAT were caused by deficient preparation towards the customers. The main failure owed too much improvisation. Each FAT was executed in a different way and the customer couldn't recognize from one FAT to another any structure, any defined process, etc. The ABB representatives were relying too much on improvisation and the uniformity of the FAT was inexistent. Because of that, customers were sometimes left alone in meeting rooms waiting for answers. ABB representatives had to look for documents that were not prepared before customer's arrival. If I were a customer, I would have the feeling of loosing time and in some situations and sometimes also losing confidence towards the company.

Customers were not lead through the process by the company representatives. On the contrary, the customer had to ask continuously for organization information and technical aspects. The ABB representatives were stumbling through the complaints and questions of the customers.

III.5 Approaching the process improvement

When approaching a customer process improvement with a focus change it is necessary that the person involved is convinced of the need for change. If a change is forced in a compulsory authoritarian way, the involved workers don't assume the importance it has. The company representatives have to recognize the need for change and understand the reasons behind the improvement. The first milestone is to recognize that the FAT can be executed in a more professional and customer oriented way. The next paragraphs introduce some possibilities to persuade and involve the responsible persons in the change process.

Workshops

Ones the awareness for change is awakened the next step consists of involving the persons in the creation and definition of the new process. People have to get the possibility to contribute with their ideas and debate, inside the group, which of them are more useful and applicable. Thus, the project managers were invited to participate in different workshops to generate ideas to improve the customer experience.

The first workshop was focused in the process definition. The Project Managers were divided into two teams and they had to define all the steps of a FAT, including possible perturbations and needed infrastructure. Each team came out with a different process. Then it was clear that unity was missing. Despite, each team also included new steps in the FAT to raise the experience of the customers during the FAT.

The second workshop had the focus on the soft aspects of the relationship with the customers. In this case PMs were required to define based on their experience different cultural aspects of the different regions around the world. They were also required to define cultures based on seven different dimensions. In addition to this tasks aspects related to the required documentation to handle out to the customers and required resources were also worked out.

I the third one the importance and urgency of each of the improvements was defined. With a portfolio framework the most urgent and effective actions were selected for implementation.
Each of the workshops took approximately 8 hours. In the workshops, theory and practice were combined and supported with multimedia elements. The results were written down on white boards, flipcharts and on the wall with cardboards. (*See workshop Results in ANNEX C.1 to C.3*)

Self analysis

Another technique applied for the process improvement has been the use of video recording. The project managers were conduced to different situations simulating conversations with customers and reactions to their complaints. These simulated situations were recorded with a video camera. Then each video was played in front of the group and commented.

This technique is very helpful for self analysis. There is nobody that tells you how you perform. You see yourself and you can derive your own conclusions. You see how your body language is, how you react when you get nervous.

III.6 The FAT Event: Deliver a Customer Experience

III.6.1 The new FAT Process Flow

In ABB PTHG it is necessary to define flow chart diagram in order to embed it into the consisting workflow processes. For this purpose a customized version of Microsoft Visio, called ViFlow, is used. The objective of the workflow process is to define how the work has to be done, improving efficiency, standardization and quality through all the business process.

The process flow starts with setting up the date with the client for the Factory Acceptance Test Event and ends up with the release of the Generator Circuit Breaker for packing and shipping. The steps in between will be analyzed and defined in the next paragraphs, taking in account, the process, the documents, the infrastructure, possible perturbations and soft skill aspects. Further on in this Thesis we will explain the design, creation and deployment of an IT tool based on a Lotus Notes platform. This tool will support and optimize the interrelation between the process and the documents. All the information related to the possible perturbation aspects as well as the soft skill aspects are also included in this study.

The next Figure sets up the framework for the process flow analysis. This framework is different than the one used in the workflow definition in ABB. It has been created in order to understand better all the steps of the process and contribute to a deeper analysis for improved customer satisfaction.
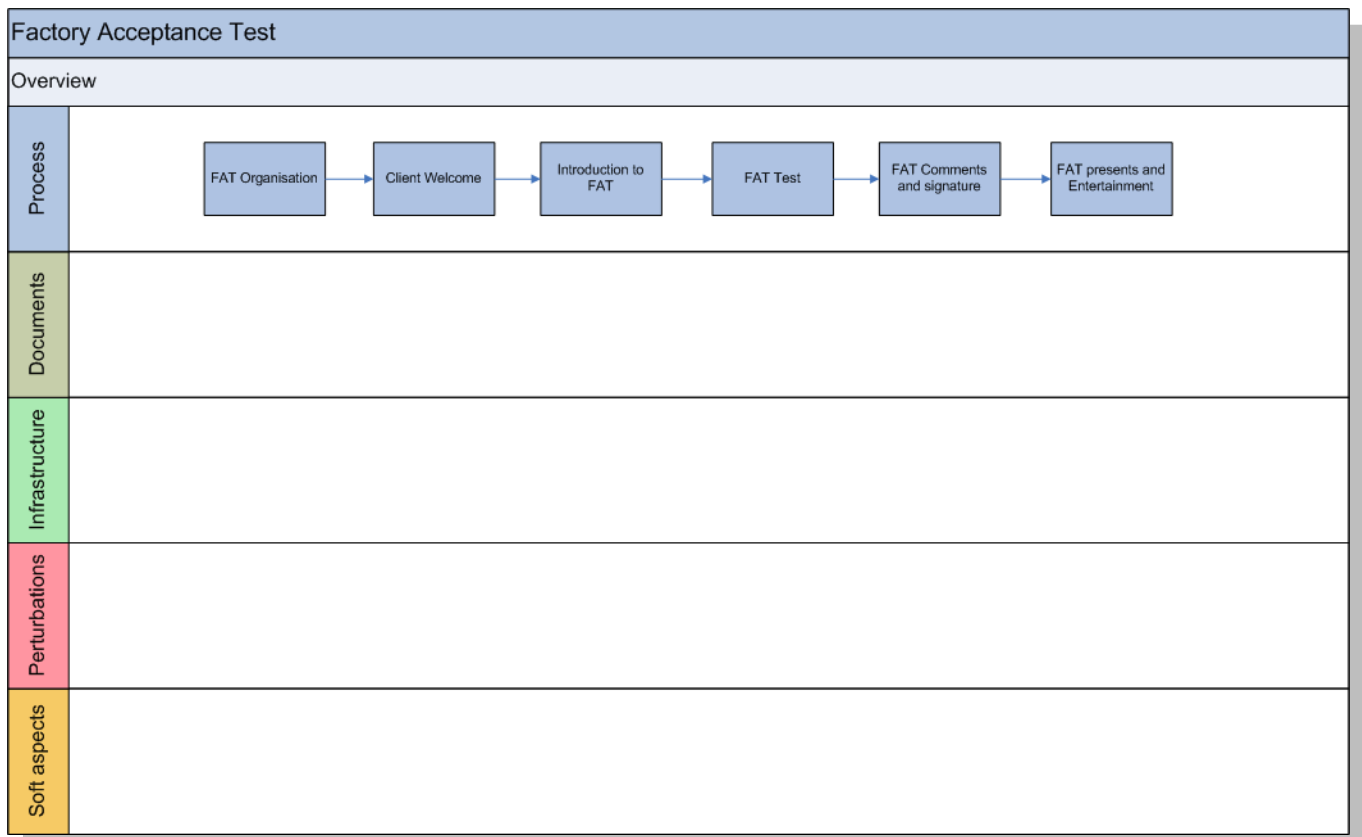
Figure 27. Process flow Overview

Organization of the FAT

The organization of the FAT starts with setting up the date with the client. Once the date is fixed the project manager has to write an invitation letter to the client in order to get the visa for Switzerland. Then the reservations of the hotel and the flights for the stay of the customer have to be booked.
Prior to arrival of the client the agenda has to be defined and send to the customer with a draft of the test program.

Once the customer travel has been organized, the project manager has to set up all the documentation and inform the different departments within the BU at ABB Switzerland Ltd. In case of failures or specific questions a contact person of the appropriate department is available and can be called in order to support the project manager.

During the execution of the FAT a small catering is offered to the attendees. Ordering it is another step of the preparation.

To improve the welcome process of the client, two new actions have been defined. On one hand an

automatic registration of the attendees at the reception and on the other hand a welcome message including the attendee's name, company name and project name in a flat screen at the entrance of the main building. The purpose of these new actions is to evince to ABB's customers how important they are and to confirm that ABB is waiting for them and appreciate their visit.
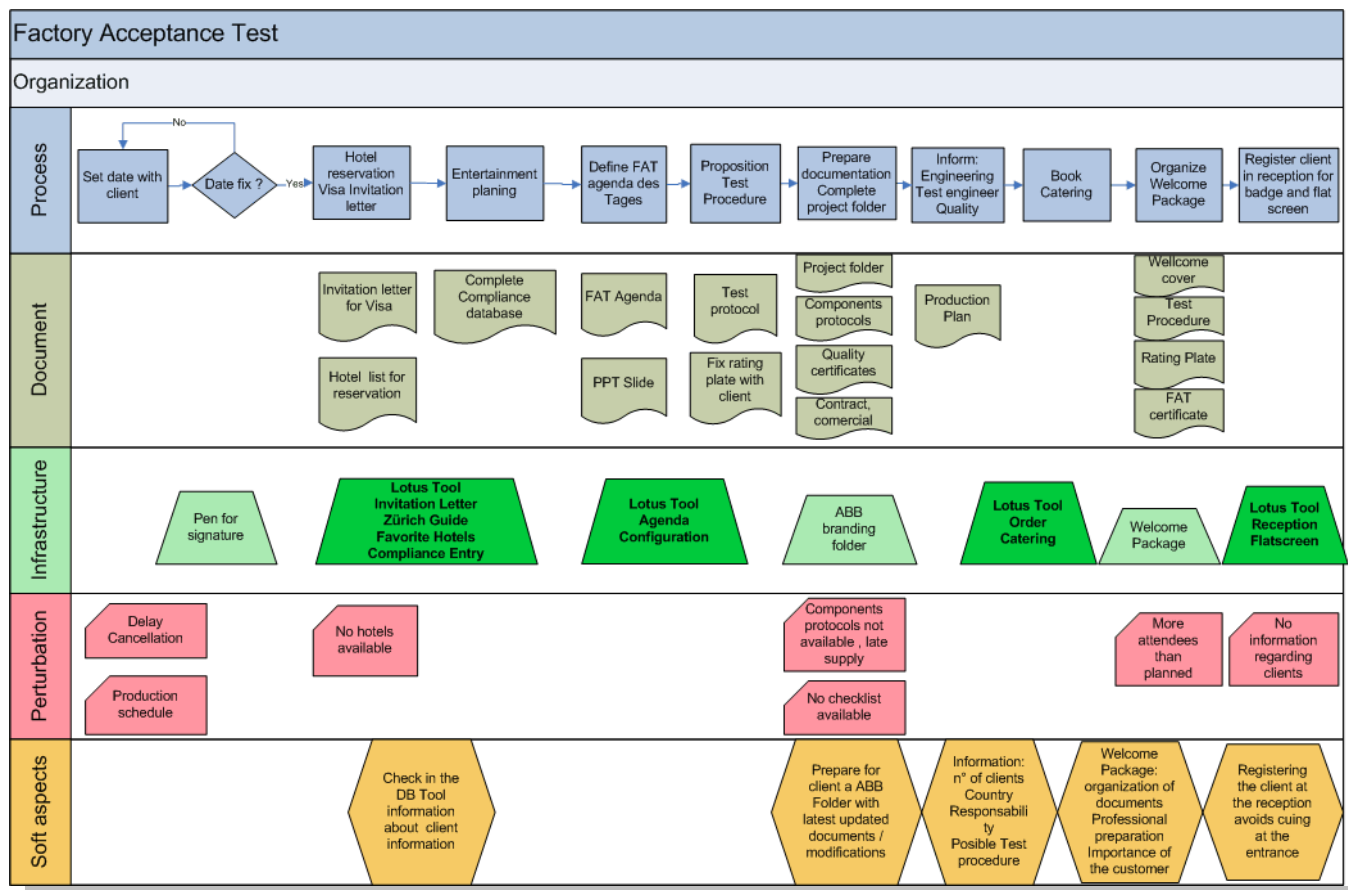
Figure 28. FAT Organization

Client Welcome

The client welcome can start from three different places. If the client is at the hotel the project manager can pick him up there. If the client just arrived at the airport, a transport has to be organized, (e.g. a Taxi). The third and most common start is at the reception. The client comes directly to the facility and is welcomed by the project manager.

After a trustful handshaking the already prepared visitor badges are delivered and the client is accompanied to the meeting room. *(See process flow diagram in the additional figures ANNEX A)*

Introduction to FAT

The introduction to FAT has been defined in order to introduce the customers to the Fat Event. After exchanging the business cards, the project manager offers customer a small catering consisting of coffee and pastries. The introductory presentation to the FAT is displayed in a Smart Board that is installed in the meeting room. The smart board is designed as an integration of a white board and a beamer. The main functionality of the smart board is the touch screen feature. The project manager has to introduce the company and explain the Agenda of the FAT Event to the customers. In this interactive presentation there are other contents available to show, i.e. *Facts and figures of ABB High Current Systems*, a *branding Video*, the *Test Program,* a *technical explanation of the Tests,* the *Product Portfolio and Performance Explanation Information* and the *Security Recommendations*.

Besides introducing the company to the customers the introduction to FAT allows the project manager to explain technical aspects of the tests that will be proceed. By explaining the technical aspects, the project manager achieves that all the present persons have the same knowledge about the technical part. The equality regarding technical aspects improves the communication between customer and project manager and permits a more efficient development of the FAT Event.

At the end of the presentation, the PM must distribute the Security Recommendation leaflet to everyone present and explain it. Visitors must sign and certify that they have understood the safety briefing before they are accompanied into the test field and the test starts.
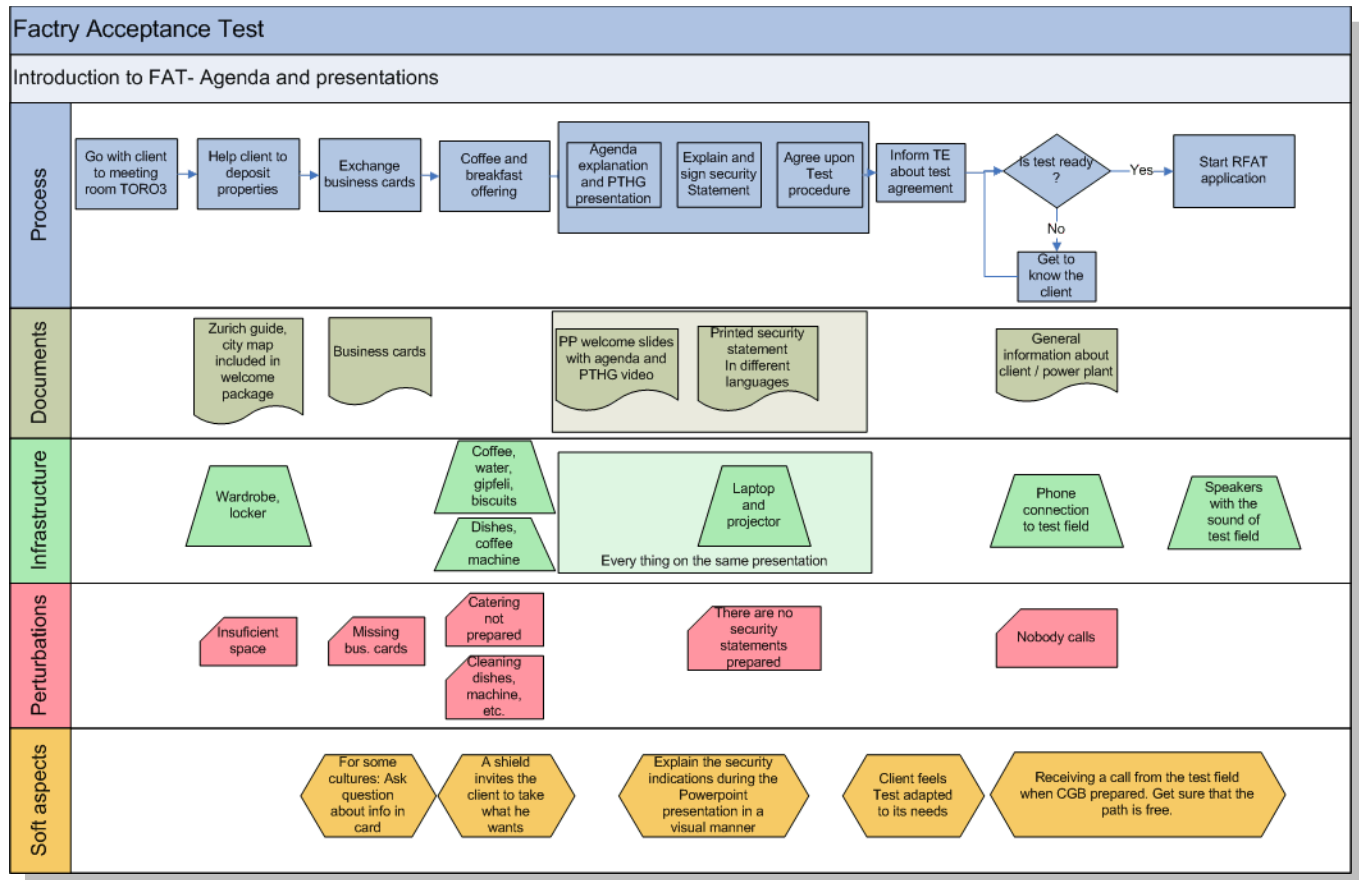
Figure 29. Introduction to FAT - Agenda and presentations

FAT Tests

The Program description listed below is a proposal and covers all major tests on the GCB- system. Additional tests, deviating from the list below and according to the list of production tests may be provided on attendee's request, but without exceeding the 2 hours tact time set up by the improved manufacturing process. An example of the Test Protocol is in the *ANNEX D*.

Description		Protocol
	High Voltage Test	**2**
	1. Circuit breaker and disconnector (life parts) to ground 2. With the starting switch contacts open and closed to ground 3. Across the open disconnecting switch contacts 4. SF6 density monitor with falling density 5. Manual operation of C, O1 and O2 6. Across the open circuit breaker contacts	2.1 2.4 2.3 9.11 6.7 2.2
	Circuit Breaker	**4**
	1. Movement of breaker contacts at rated control voltage and fully charged spring 2. Timing tests at rated control voltage and rated SF6-pressure 3. Demonstration that the breaker is electrically trip-free	4.4 4.5 4.3
	SRM	**5**
	Electrical resistance of current path test with 500 A	5
	Circuit Breaker Drive Test	**6**
	1. Operation of the pump motor at min and max rated voltage 2. Current consumption of pump motor at rated voltage 3. Operation of spring stroke switch	6.3 6.4 6.6
	Disconnecting, Earthing and Starting Switches (Auxiliary Breakers)	**7**
	1. Operation at min and max drive voltage 2. Total operation at min, max and rated drive voltage	7.1 7.2
	Auxiliary Breaker Drives	**8**
	1. Current consumption of the drives at rated voltage 2. Operation of key interlocking and auxiliary switches	8.2 8.1
	Control Signals, Alarms and Interlockings (Signal Test)	**9**
	1. Operation at min and max control voltage 2. Operation of signal and alarms 3. Interlocking conditions according to the wiring diagram 4. Control of the heater according to wiring diagram	9.1 9.2 9.3 9.8

Figure 30. Program Description
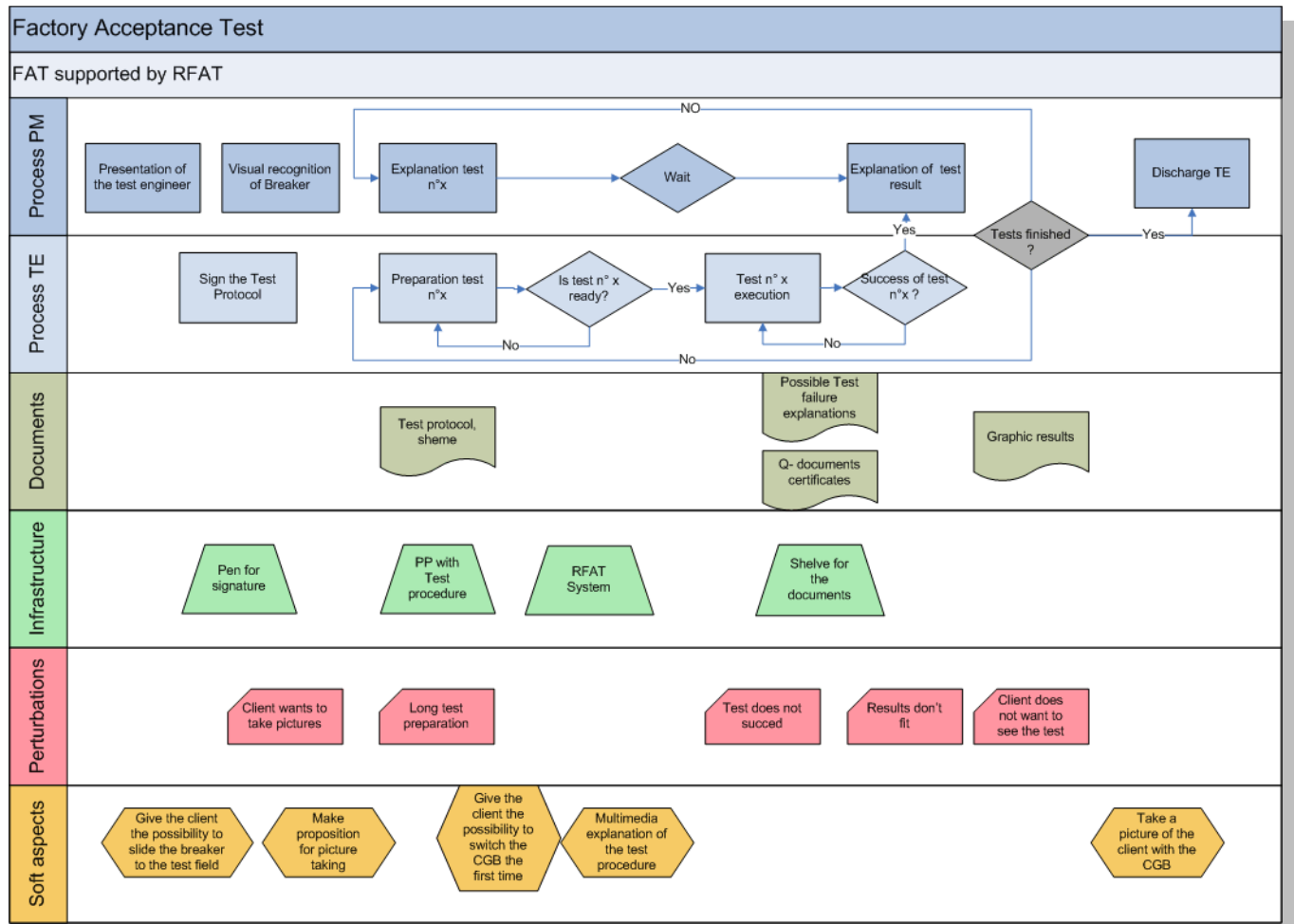
Figure 31. FAT Test supported by RFAT

FAT Comments and Signature

After the production tests, an updated report of the results is handed out to the client. After commenting project specific aspects, this report is signed by the customer and the ABB project manager. Then it is scanned and load into an USB stick. The ABB project manager has to create a Factory Acceptance Certificate, print it out and deliver it to the customer.
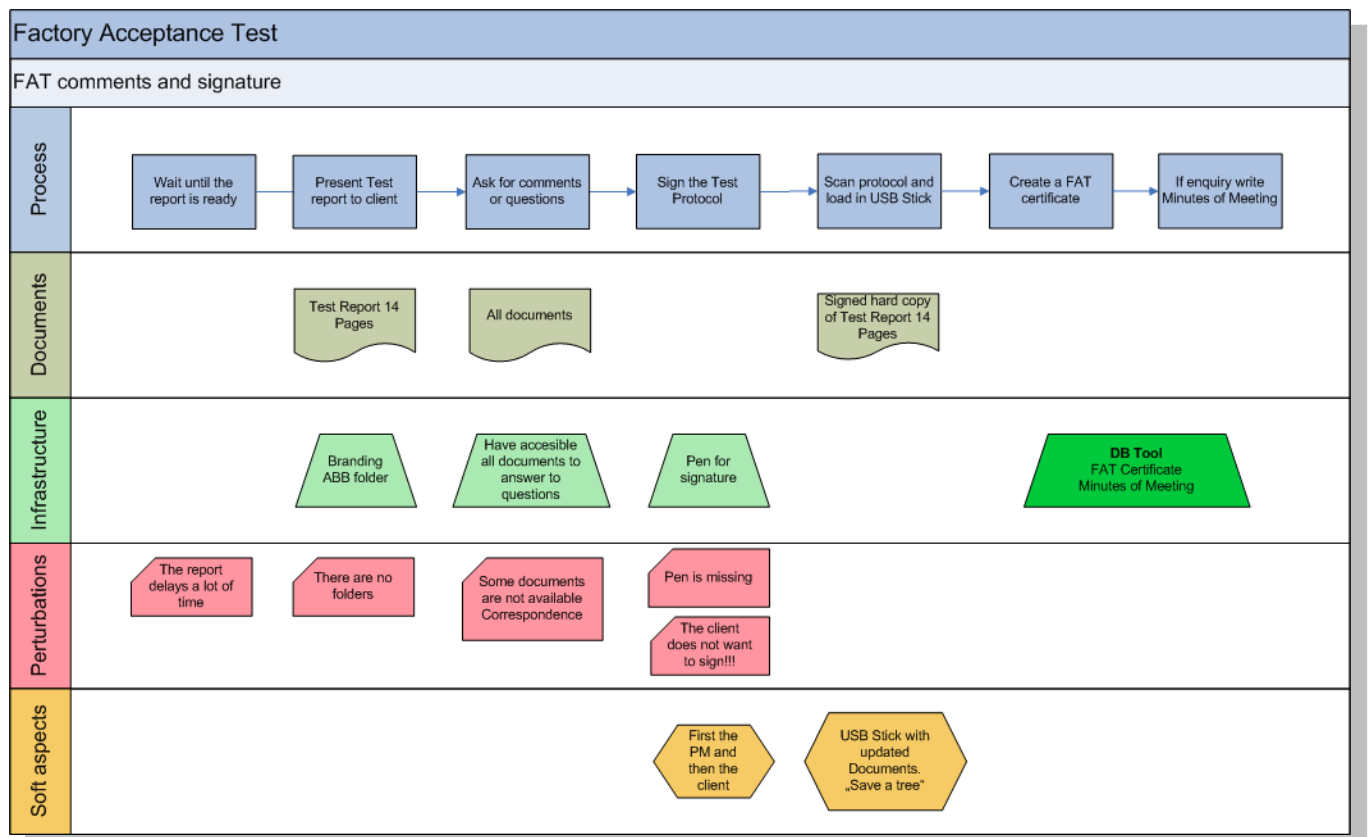
Figure 32. FAT Comments and Signature

FAT Presents and Entertainment

The attendance to Factory Acceptance Test is besides the technical aspects also a good opportunity for the ABB project managers to create a stronger relationship with the customers and get better insights into market needs. The customers came from all parts of the world and expect to be introduced and shown the insights of Switzerland and specially Zürich. Due to this fact, after the finalization of the tests, a dinner and short entertainment program is organized, respecting compliance restrictions established by ABB Switzerland Ltd. *(See FAT Presents and Entertainment figure ANNEX A)*

Chapter IV. The implementation: Communication and IT Systems for FAT

IV.1 Problem to be solved

The main challenge when changing a traditional process is to persuade the persons involved and convince them of applying it. Often there are hurdles that have to be overcome. In a process where the customer plays a main role, the person that represents ABB has to be positive and confident about the goals to be achieved.

In order to facilitate the adoption of the new process and permit the project manager to grant more time to increase customer satisfaction, time used for procedures that bring less customer satisfaction have to be automated and the required resources optimized.

Another challenge when introducing or changing a former process is the standardization. Although a process is defined explained and applied, each project manager comprehends it in a different approach. A further aspect of standardization is to manage all the documents. They have to be created according to the corporate identity and branding concept. All the documents that are handed out to the customer have to be standardized and designed fulfilling the brand and corporate identity instructions to strength the ABB brand.

In addition to the comprehension and standardization of the process, a guideline through the process has to be created to maintain quality. In order to support this guideline, checklists with the main actions have to be defined and used by the project managers from the beginning to the end of the process. Only by doing this, the omission of important actions can be avoided and the quality level fixed.

IV.2 Solution1: Customer Care and Customer Relationship Management Database

In order to solve the challenges related to the distribution of resources, standardization and quality of the process a new database tool has been programmed to support the project managers during the Factory Acceptance Test.

This tool is based on Lotus Notes platform due to the fact that this platform is common used in ABB as e-mail, calendar and organizational application.

The goal of this tool is to support the process and make the organization of the FAT easier and faster

without forgetting its purpose: Deliver an Experience to the customers when attending the FAT.

In the next paragraphs the structure, content and usability of the tool is presented and related to the process flow and process definition done in the third chapter of this study.

IV.2.1 Structure of the Tool

The structure of the tool is divided in three main areas. There are public shared documents, project specific documents and an overarching area created for additional functionalities that make available for the project managers the exchange of information related to customer care.

The tool is build up on Lotus notes Database structure, but integrates Pages in html format, Forms, views and navigators. Further on in this chapter, in the technology paragraph, the properties of each of these entities will be explained.

Public Shared Documents

This area contains all process relevant documents that are standard through all the projects. The goal of these documents is to provide the users of the database with up to date information. In this area the project managers have also access to common used documents for the Factory Acceptance Test, like for example the Test procedure, security recommendations, transportation guides, etc. These documents can be accessed by clicking on different buttons that are linked to different repositories of documents. The documents are linked to the database tool from other databases, SAP Servers or common network drives.

This compilation of links reduces the time to get the document and increases the efficiency and the quality of the process due to a self updating link system.
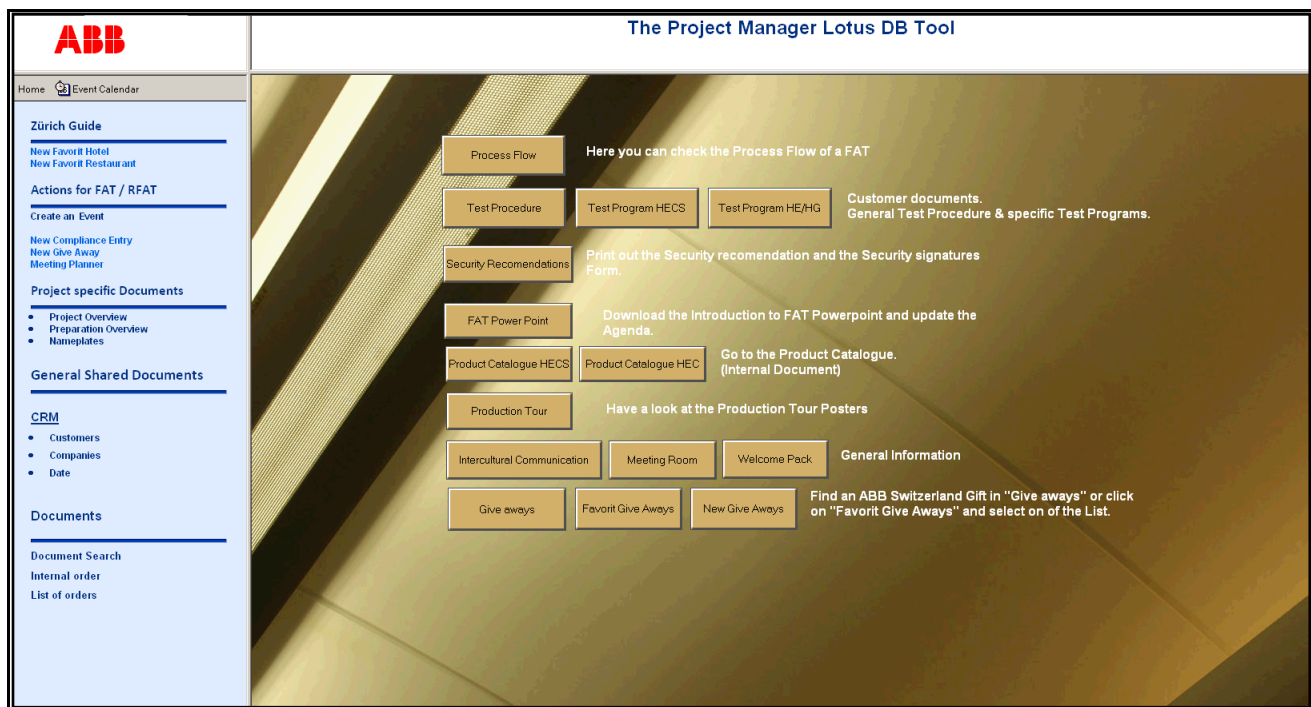
Figure 33. General Shared Documents

Project Specific Documents

The project specific documents are: "Invitation Letter", "Agenda Configuration", "Reception and Flat screen", "Catering Ordering", "The Checklist before FAT", "The Checklist after FAT","FAT Certificate" ,"FAT Feedback" and "Minutes of Meeting-(MOM)". In this group only the project manager (PM) who created the documents has access to them. They are attributed with restricted access rights
And only the owner can modify and delete them.

This provides the PM with an overview about all the projects he manages without having to filter out the projects of the other PM. The objective of the tool is to help the PM to prepare and to execute the process in the most efficient way. Hence, the automation of the document generation is implemented in the tool and later on will be explained.
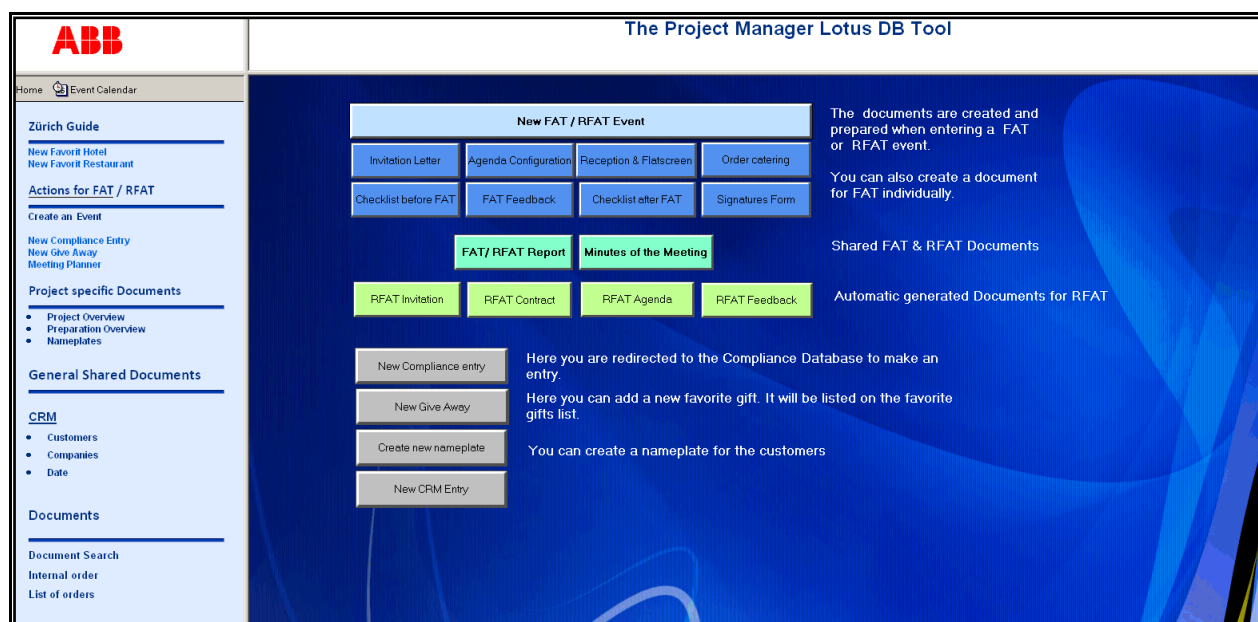
Figure 34. Actions for FAT / RFAT

Zürich Guide and additional functionalities

For the achievement of an optimal customer care process and the optimal customer experience, there is designated in the database a customer care section named "Zurich Guide".

The PM can find in this section: List of hotels, restaurants, museums, city tours, travel information and useful contents regarding multicultural communication and behavior. This information is structured by categories in order to simplify and accelerate the search and finding process. This information is created cooperatively by all the database users. To prevent of a wrong use of the database each entry has attached its author. Everybody that enters data e.g. a new hotel, a new restaurant or a new customer gift is contributing to a general sharing of useful information to the other database users.

On one hand there are lists that can be looked and on the other hand there are forms and views where project managers can entry new items. This is a cooperative way of managing information and share the experience between them. The goal of this area is to optimize the selection of services depending on the customer's needs. This is an approach for codifying knowledge that normally would be shared in a personalized way.

In addition to the "Zürich Guide", there is programmed a resume of all the customers and companies that come to the FAT. This is a "Customer Relationship Management" CRM list sorted by name, date or project name.
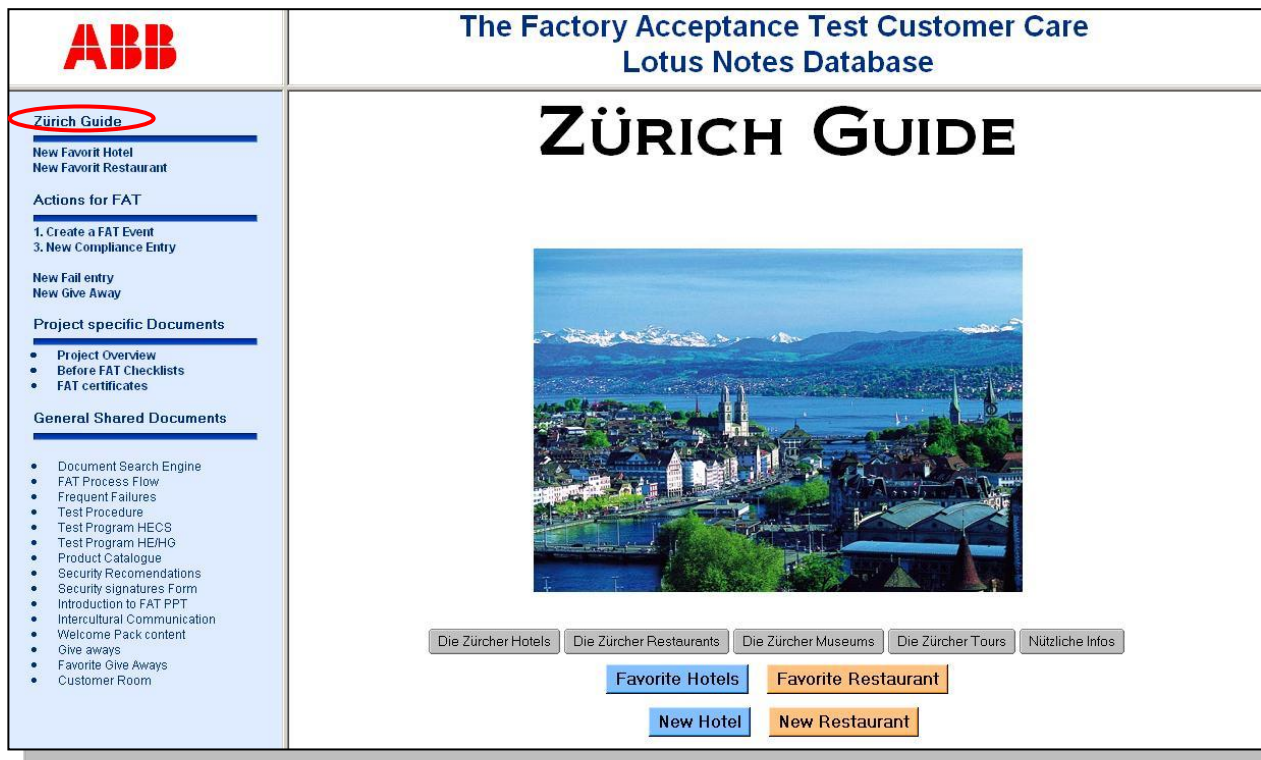
Figure 35. Zürich Guide

IV.2.2 FAT Preparation

The preparation of the Factory Acceptance Test starts with setting up the date and the attendees for the FAT. Therefore the first step is creating a "**FAT Event**" in the tool entering the necessary information that is shared between all the project specific documents: *SAP number*, *the name of the project*, *the name of the attendees*, their *companies*, the *date* of the FAT and the selection if it will be done on-site or remotely (RFAT). Depending on the FAT / RFAT selection different type of documents are generated. In case that the FAT is done on-site, the created documents are: *Invitation Letter, Agenda Configuration, Reception and Flat screen, Catering, the Checklist before FAT, the Checklist after FAT, FAT Certificate, FAT Feedback* and *the Minutes of the Meeting (MOM)*.

Else, if the FAT is done remotely through the Remote Factory Acceptance Test tool, the generated documents are reduced to *the RFAT Invitation, RFAT Contract, the RFAT Agenda*, and *the RFAT Feedback*.

Once this main data is introduced, this is spread through all the documents, just by clicking on a button. The code that implements this function can be looked up in the *ANNEX E.1.*This automation enables the PM to create all the documents at once without having to create and enter all the data in each document manually. Each of this documents / forms has a specific function in the whole process.

The determination of these documents is explained to give a better inside on the influence for the customer satisfaction.

The fact that the forms are automatically created and grouped in the same list, sorted by project, increases the efficiency. The estimated time that is saved due to this functionality can oscillate from 45 minutes to 1 hour and 15 minutes for each FAT Event preparation.

After the project specific documents have been prepared then they have to be processed by the PM.
To access all the generated documents a list of all documents is accessible. All the documents are grouped by SAP number and permit the PM to get a better overview. The centralized management of all the documents related to one project impedes that documents clutter.

Figure 36. Project Overview

Agenda Configuration

The document "Agenda Configuration" has to be accessed by clicking on it twice in the "Project Overview".

The date, name of the project, and the PM are automatically fixed in the document. Then, it has only to be entered the start time and end time for each routine block. It is possible to bind together two blocs. Clicking on the button "Show schedule Modules", an overview of all the blocks pops up.

The agenda configuration tool aids the project managers to structure the Factory Acceptance Test day

and standardizes the names given to the different blocs.

The agenda is sent to the customer in advance. Our goal is to satisfy the expectations of the customer. When the project manager defines the agenda of the day, he is influencing the future expectations of the customer. According to the aim of satisfying customer needs, the project manager has to ask the customer in advance if the agenda proposal covers all the items and if necessary adapt it to their requirements.

Reception and flat screen

As it has been mentioned before, an automatic reception registration and welcome message has been introduced to the process. For this purpose the form "Reception and flat screen" has been programmed and is listed in the project overview with all the other project specific documents.
Once the form is open the arrival time and the duration of the stay of the customers for the FAT has to be entered.
By clicking on the button "**E-mail for reception"** two e-mails are automatically created and send. One is sent to the reception of the main building in order to prepare the visitor badges before the arrival of the customers. The code for the implementation is listed in the *ANNEX E.3*.
The other e-mail is sent to the IT managers to ensure that a welcome text will be shown in the flat screen at the entrance of the main building.

"Verpflegung"- Catering

According to the definition of the process of the third chapter, the form "Verpflegung" is used for ordering the catering on the date of the Factory Acceptance. The number of customers is automatically calculated from the created "FAT Event". After the form is processed by the PM the button "**Order**" has to be clicked. Thus, an automatic e-mail with the necessary information will be sent to the catering supplier. The code that implements this function is listed in the *ANNEX E.2.*

The Checklist before FAT

For each "FAT Event" a new checklist is created. In this checklist all the necessary preparatory steps are listed. The PM can always look up the checklist and edit it. It becomes a useful tool to standardize the preparation of the FAT within all the PM. This form permits the monitoring of the preparatory process and contributes to maintain the quality standard of the FAT process.

Figure 37. The Checklist before FAT

IV.2.3 FAT Execution

The performance of the Factory Acceptance Test should always have the same structure. This structure is defined in blocs and has a predefined duration time. In the next paragraphs, the nine different blocs are described. The PMs can decide if they want to include all the blocs in the FAT Agenda and its sequence.

Reception > Welcome > Introduction to FAT > Tests > Lunch > Production Tour > Spare parts > Paper work > Closure

Reception

The customer is picked up at the hotel, or at the reception of the ABB building. The Badge has to be handed over quickly without interferences. The project manager greets the customers and accompanies them to the meeting room.

Welcome

In the meeting room there has to be ready prepared and available: the introductory presentation for the FAT, the welcome packs, the name plates that are automatically created in the Lotus Notes tool, one for each attendee, and the preordered catering.

The contents of the welcome pack can be looked up in the database in *Welcome Pack Content*. The specific test program can be also downloaded clicking on the links *Test Program HECS* or *Test Program HE / HG*.

The project manager has to explain to the customers what the Welcome Pack consists of and offers to the attendees to feed themselves with the catering.

Introductory Presentation to the FAT

In the introductory presentation the PM has adjusted the agenda in advance so that it matches the one sent to the customer.

The presentation can be downloaded by clicking on *Introduction to FAT PPT*. The introductory presentation to the FAT is displayed in a Smart Board that is installed in the meeting room. At the end of the presentation, the PM must distribute the Security Recommendation leaflet to everyone present and explain it. To assure the understanding of the Security Recommendations, it is available in 7 different languages: German, English, Spanish, French, Italian, Chinese and Russian. The leaflets can be downloaded and printed out by clicking on *Security Recommendations*.

Visitors must sign and certify that they have understood the safety briefing before they are

accompanied into the test field.

There is a signatures document programmed, which can be downloaded and printed out when clicking on *Security Signatures Form*.

Tests

After the introductory presentation to the FAT, the tests have to be started. Due to the assembly line production, the test can only last 120 minutes. The execution of the tests will be headed by the test engineer. The attendees can follow the tests with the work copy of the test protocol.

The project manager must be available for the customer during all the time and make brief statements on the tests as well as answer the questions, related to the tests, the customer asks.

The test procedure is done according to the final testing instructions and international norms and standards.

Lunch

After the two-hour test, the project manager goes with the client to have lunch. The choice of the restaurant is up to the project manager. It is important to look out for special conditions, such as vegetarian, allergies, etc.

During the lunch, the PM has to build up the confidence of the customer. To prepare himself for it, he can look for culture-specific features in *Intercultural Communication*. Small talk topics and habits are consultancy given in this document.

Production-Tour

After lunch starting with a production Tour is recommended to follow on with the FAT. The PM shows the customer how production is structured and how innovation, quality and reliability are implemented in ABB PTHG.

For the Tour, the production facility is equipped with stage posters. The posters help the PM to support its statements and make the information more accessible and clear for the visitors.

Spare Parts

In case that spare parts have been ordered with the project, the PM has to show them to the customer and get them approved.

Paper Work

Once the project manager has received the completed, updated test protocol and the component protocols, he asks the customer to sign it.

Thereafter, the project manager creates a FAT certificate. In the database tool this document is generated and can be printed out.

Figure 38. FAT Certificate

The complete protocol and certificate should be signed by the attendees and the PM, scanned as PDF file and load on the ABB USB stick included in the Welcome Pack.

If the customer requires it, the PM can write the *Minutes of Meeting* document in cooperation with the attendees.

Questions that were asked by the customer during the inspection and were not answered yet should be responded now.

Closure

The closure process should be started with a short questionnaire about the day. Feedback on possible improvements can be taken and later recorded in the form *FAT Feedback*, also available in the database.

The PM accompanies the customers to the entrance, gives them a small present, takes the badges and once outside the building, say goodbye.

IV.2.4 FAT Evaluation

After the FAT, the PM has to record the inputs of the customer in the database filling out the form *FAT Feedback. (See FAT Feedback document in ANNEX F.2)*

If an error has happened during the FAT the PM has to record it in the form *Frequent Fails*. This form can be reached by clicking on *New Entry Fail*. This form contains information about the *Contact Department* and has a categorization on *criticalness*.

The entire list of errors can be checked later on, clicking on *Frequent Fails*. The list can be viewed categorized by *Contact Department* or *Criticalness*.

The Checklist after FAT

The checklist after FAT is a project specific document contained in the *Project Overview*. It provides the PM an internal report of the FAT. Missing activities and its responsible department as well as the handed and missing documents are listed here.

After adjusting the distribution list, all the selected recipients receive a copy via e-mail. The release of the packaging can also be created automatically clicking a button.

(See the "Checklist after FAT" in ANNEX F.3)

IV.2.5 Technology: IBM Lotus Notes

Lotus Notes is an application suite that includes the following components:

- e-mail
- calendaring and scheduling
- address book
- database
- web server
- programming

Unlike other application suites (like Microsoft Office) that split these pieces of functionality into separate products (like Outlook, Access, Front Page, etc.), Lotus Notes presents all of these components with a single front-end.

For the most part, Lotus Notes is known only as an e-mail system, but this is not necessarily its major strength as a product. The e-mail functionality is probably the most recognizable component. It has most or all of the features of the other popular e-mail products on the market, including calendaring and scheduling, address book, to do lists. It uses standard-based mail protocols such as POP3 and SMTP. Because Notes is composed of a client and a server, users benefit from reading and responding to e-mail, and administrators can use it as an entire e-mail environment.

For all practical purposes though, everything in Notes is a database. Individual users have their own e-mail database, and groups of users can share applications based on Lotus database storage system. These applications can be designed to display, add, or manipulate information. While sharing the applications, the user groups are sharing all the data that is located in the database. The transfer of knowledge can be strengthened, creating modules of programming code that will perform background, scheduled, or on-demand tasks.

The Lotus Notes client is a desktop application that organizes and displays databases on a user's local workstation. The physical database files can be stored either on the workstation itself or on a server.
The databases can be highly customized to present the data that is associated with them. Depending on the needs of the users, the interface can be designed to fit with the requirements and achieve a user friendly interface. The powerful capability of Lotus Notes is the integration of different programming languages under the same application.

Due to the fact that the programming layer is built-in to the Notes databases, a developer can embed code throughout the database design to automate certain actions without having to install or configure external programs or processes. This built-in programming layer makes it possible to build

workflow applications that interact very fluidly between both application databases and e-mail.

The Lotus Notes Domino web server can also be applied to interact with other applications or programming languages such as IIS, Apache, Java servlets and JSP pages.

On a more technical level, Notes/Domino provides a very granular security model that allows a developer to "lock down" access to all or parts of a database. In this way, you can combine private and public data within a single database or across a single server.

With all of this functionality, it may be hard to envision what possibilities Notes can actually provide. Some examples are:

- discussion forums
- document repositories
- expense approval systems
- web-based request systems

Using the capabilities of Notes to interact with other database systems and other web technologies can also be used as a client-based or web-based information portal that bind together a number of different data sources. Lotus Notes can be a stand-alone data repository, a front-end to numerous other data repositories, or many things in-between.

IV.2.5.1 Lotus Notes architecture

Lotus Notes databases are unlike relational databases, document-based databases. In other words, data and design elements are stored in form of documents; each document bears a unique ID. A document can have multiple fields (items) of different types (i.e. text or numbers). The content is decoupled from the display.

To view and modify data content of the documents, masks (forms) are used that can be freely designed. In so-called views as well as folders, lists of documents from the database can be filtered and displayed in a table. Using self-written programs (agents) actions can be executed or scheduled. All the contents of a database that includes file attachments can be searched via the integrated full-text search. This is true not only for local databases on a Lotus Notes client, but also for databases that are distributed across multiple Domino servers in a Domino domain.

File of Lotus Notes databases end with the suffix. NSF: Notes Storage Facility.

Differences with other database systems: Notes databases are non relational databases. They follow a document and not a data model. Documents may (but need not) have a hierarchical relationship to each other.
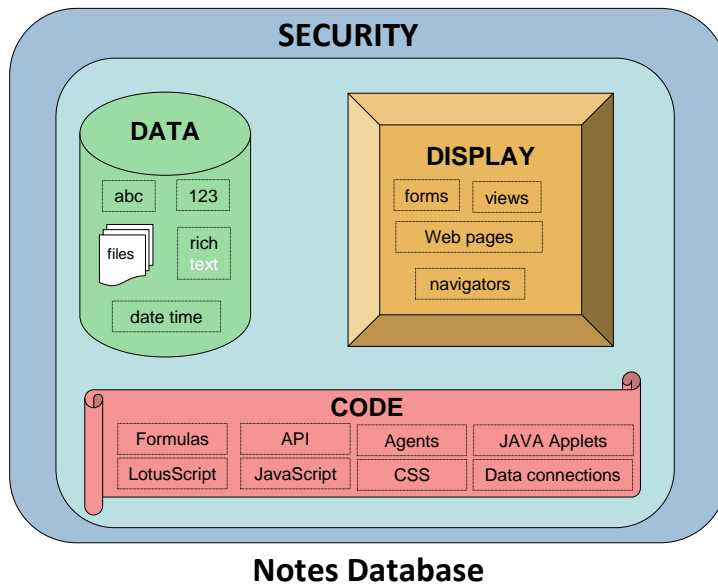
Notes Database

Figure 39. Lotus Notes Architecture

Relations are programmatically made to Notes databases. Fields can contain multiple values, representing a master-detail table in a Relational Database Management Systems (RDBMS).

Notes stores all design elements (i.e. forms, views, agents, etc.) of an application also in the form of Notes documents. While in the RDBMS for the data schema and the views is as usual, save notes and masks (forms) and resources (CSS, jpg, java, etc.). All design elements are signed and thus allow for a delicate version control.

Notes documents are not tied to database tables. Therefore Notes documents can contain any fields. A change in the mask layout has no effect on stored data.

A special feature is the support of a RichText field type. Here, formatted text, attachments or embedded objects (images, OLE) can be stored as objects. Rich text fields together with the Lotus Notes client allow a particularly user-friendly interface.

Notes documents and design elements can be with available materials from / to XML conversion. Between two computers only databases are replicated using the same replica ID.

IV.2.5.2 Lotus Domino Designer

Domino Designer provides a stand-alone integrated development environment (IDE) that Notes application developers use to build and deploy secure applications. Using a Notes client or a Web browser, users can view these applications. The IDE gives the Notes application developer access to:

- Notes design elements, such as forms and views
- Web design elements, such as framesets, pages, and outlines
- The Notes Formula Language, which includes @commands and @functions
- LotusScript, JavaScript and Java

IV.3 Solution2: Remote Factory Acceptance Test

As it has been explained above, the Factory Acceptance Test is embedded in the assembly line and has a limited time of 120 Minutes. In addition to that fact it has to be witnessed by the customers. This set of conditions can spawn risky situations and delays in the production schedule that have to be minimized. For this purpose a new IT system has been created in order to eliminate the place dependency for witnessing the test by the customers. This tool is the Remote Factory Acceptance Test (RFAT).

The Remote Factory Acceptance Test has been designed as an ABB web browser application that supports the visualization of Factory Acceptance Tests from any part of the world.
This is achieved through a camera system that provides a complete overview of the test execution and its results.
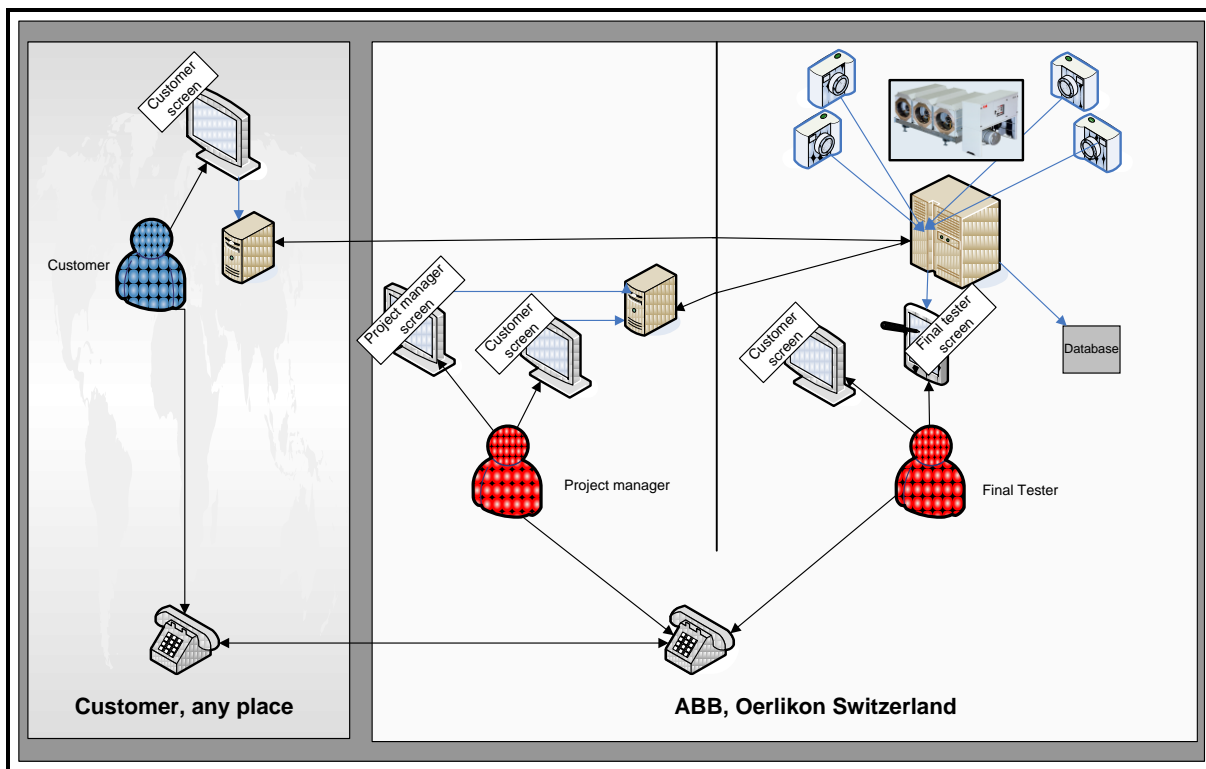
Figure 40. Remote Factory Acceptance Test (RFAT) System

IV.3.1 Benefits of the Remote Factory Acceptance Test

- Customers profit from eliminated place dependency of the Factory Acceptance Test reducing travel expenses.
- They can include an unlimited number of participants, increasing the technical knowledge for their team.
- They directly communicate with the ABB project manager; there are no delays due to organizational problems.
- Flexibility is improved if participation changes within a short amount of time.
- Customers have international connection, increasing their flexibility to witness the test independent of their present location.
- They additionally obtain widespread information about other Generator Circuit Breakers from ABB's portfolio and extended technical information related to the Factory Acceptance Test.
- It provides easy and safe online access through a live connection, enabling ABB to give you quick and broad support to satisfy customer's needs.
- Overall it contributes to save time and costs and supports the aim of a more sustainable world.

IV.3.2 System

The system consists of seven IP cameras positioned in the test filed. There are four fixed cameras, a top view camera and two mobile cameras. All the cameras have Power over Ethernet (PoE) technology. This technology permits the cameras to get the power through the Ethernet or LAN cable and don't need an external power supply. The camera system is based on the Internet Protocol (IP) allowing an easier design of the web platform.

The web platform has three different interfaces: the tester screen, the project manager screen and the customer screen.
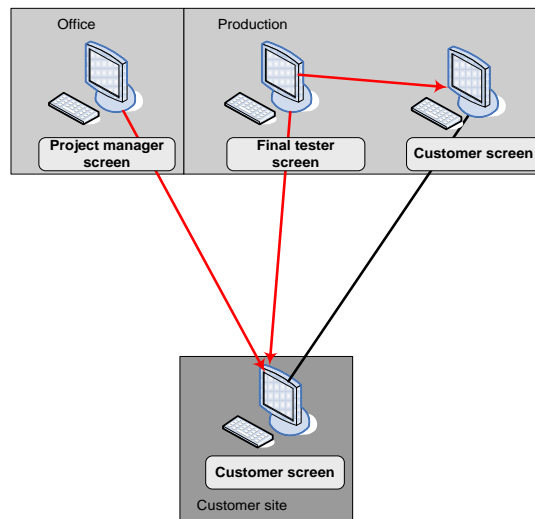
Figure 41. RFAT System screens

The tester screen permits the test engineers to manage the system during the execution of the tests. It has mainly three functions. The first one consists of changing the status of the test being proceeded, form preparation status to execution status. The second function enables the test engineers to introduce the result of each test. The results are numeric and have to be in the correct range of the specification. In this case the test engineers mark the test as successful or otherwise as failed. The third function enables the test engineers to see the current view of the cameras in order to provide the customers with the best images.

Figure 42. Final Tester Screen

The project manager screen is the system management interface. For each test program that has to be performed, the project manager has to enter the Generator Circuit Breaker configuration, according to the specification. This project manager interface is used to invite the customers for the Remote Factory Acceptance Test. The name, the country and the e-mail of the customer have to be entered. Once the information is complete, the PM invites the customer. The number of customers that can witness the test is open. Each customer receives an e-mail with the invitation and an attached internet link.

Figure 43. Project Manager Screen

The customer screen is accessed by the customers by clicking on the link sent in the invitation. The RFAT tool is displayed in a common web browser, i.e. Internet Explorer, Mozilla Firefox, etc. This is the main interface the customer views during the tests. The screen is split in five different frames.

The main frame shows the cameras of the test field. During the preparation of the tests, the customer is allowed to change the camera that is currently displayed by clicking the selected one from the interactive camera map. During the execution of the tests the customer is forced to view the cameras predefined by the tool. The decision to fix the cameras has been taken to help the customer to see the best images during the execution. The customer is informed by the status of the test in the bottom right split of the interface. If the status is preparation the color is set in blue. Else if the status is execution the color is set in red.
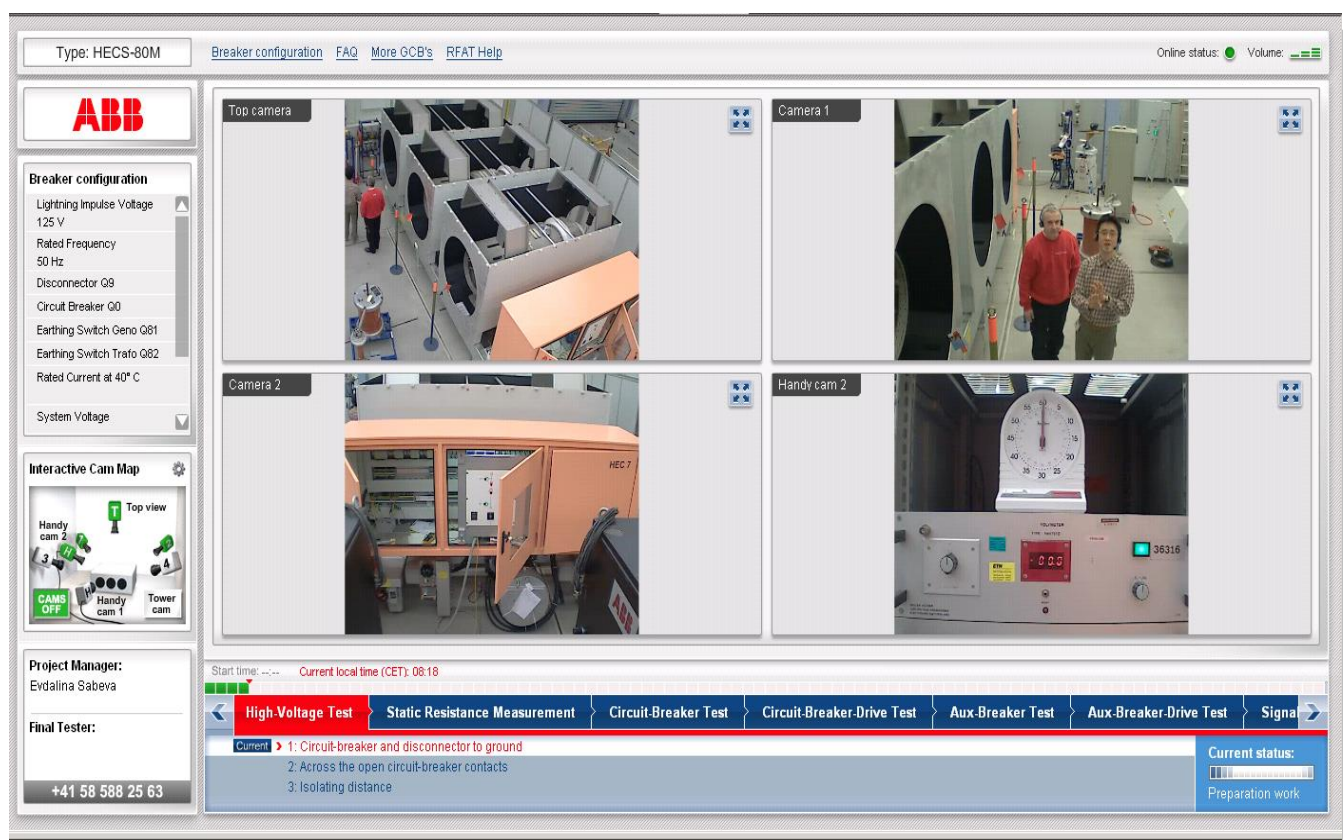
Figure 44. Customer Screen

The lateral split includes an interactive camera map, the breaker configuration as well as the name of the PM and the test engineer in command of the test. The upper split includes four links to relevant information for the tests. The first link forwards the customer to the configuration of the breaker and to the name plate with the specifications. The second link "FAQ" contains the Frequently Asked Questions related to the system customers usually do. The third link "More GCB's" contains marketing information regarding to the company, the products and the organization. Customers can download the product brochures as well as the after sale service information. Other information regarding to the history, the organization as well as the location of the company can also been looked up.

One of the goals of the RFAT tool is to present the test in the most efficiently and user friendly way. For this purpose, in the bottom split of the customer interface the test program is described in an arrow format. The customer has during all the Factory Acceptance Test an overview of the already executed tests with the detailed results, the test that is currently performed and the next missing tests. The use of colors is used to present the contents in a more user friendly way and helps the customer to follow the FAT easily.

IV.3.3 Architecture

As it has been introduced before, the system is web based. Like all web based systems it is a server-client system. The study of the architecture of the RFAT system is based on the Open System Interconnection (OSI) Reference Model[35]. This model defines 7 different layers of network architecture. The seven layers of the OSI Model are defined form the higher level, the Application layer to the lower level, the Physical layer. In between different technologies can be chosen to ensure optimized network architecture. The next paragraphs explain which technologies have been used for the RFAT System, based on the OSI Model that is schematized in the next figure.

The OSI Layer Reference Model			
	Data unit	**Layer**	**Function**
Host layers	DATA	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Interhost communication
	Segment	4. Transport	End-to-end connections and reliability
Media layers	Packet	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing
	Bit	1. Physical	Media, signal and binary transmission

Figure 45. OSI Layer Reference Model

The system consists of IP-cameras, a router, a switch, servers and client computers.
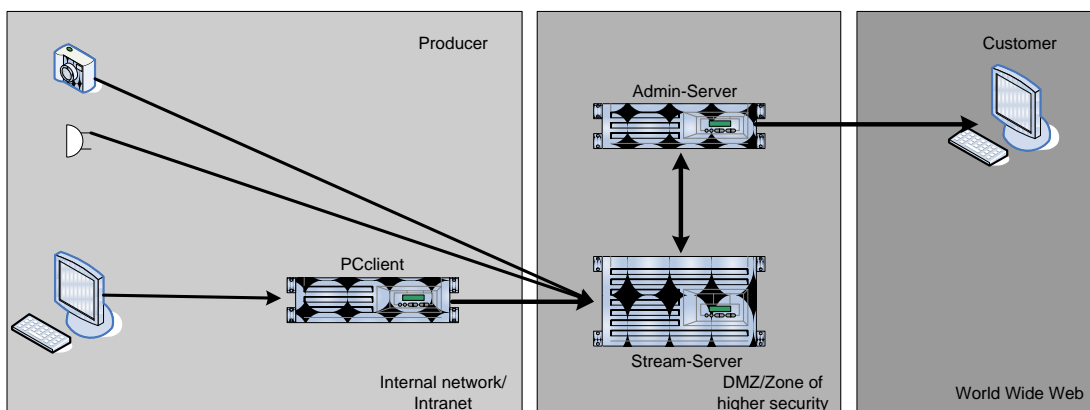
Figure 46. RFAT Network Architecture

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[35] *OSI Reference Model — The ISO Model of Architecture for Open Systems Interconnection, Hubert Zimmermann, IEEE Transactions on Communications, vol. 28, no. 4, April 1980, pp. 425 - 432.*

Related to the first layer, the physical layer, it is important to mention that the IP-cameras are powered over the Ethernet cable. Power over Ethernet (PoE) is a technology that incorporates power to a standard Local Area Network (LAN) infrastructure. Allow the power supplied to the network device using the same cable used for network connection. This technology eliminates the need for power outlets at camera locations and enables easier installations.

For the Data Link layer, the system uses ABB's LAN. The computers in the LAN run behind a firewall connected to a public network like the Internet. One or more computers also run outside the firewall in the Demilitarized Zone (DMZ).

In computer security, a Demilitarized Zone (DMZ) or perimeter network is a local network that sits between an organization's internal network and an external network, usually the Internet. The purpose of a DMZ is that connections from the internal and external network to the DMZ are permitted, whereas connections from the DMZ are permitted only to the external network. The computers in the DMZ cannot connect the internal network. This allows computers from the DMZ to provide services to the external network while protecting the internal network in case intruders compromise the security of computers located in the DMZ. For any of the external network that wants to connect illegally to the internal network, the zone becomes a dead end.

The DMZ is used to locate the Stream Server and the Admin Server that need to be accessed from outside.

The third level of the OSI Model is the Network layer. Due to the fact that the cameras run directly from the network and have a built-in Web server with its own Internet Protocol (IP) address, the IP is the implemented protocol for the whole RFAT System.

The IP is a connection orientated protocol used by both the origin and the destination for data communication over a packet switched network. The data in an IP-based network are sent in blocks known as packets or datagrams. In particular, in IP no setup is required before a computer tries to send packets to another with which it had been reported before.

The Internet Protocol provides an unreliable datagram service also called best effort. IP provides no mechanism for determining whether or not a packet reaches its destination and only provides security for the headers and not for the data transmitted. Reliability is provided by the protocols of the transport layer.

Because different applications, for example, telephone, email and video surveillance can use the same

IP network, it is necessary to control the sharing of network resources to meet the requirements of each service. One solution is to make routers and network switches work differently for each type of service (voice, data and video) of network traffic. By using the Quality of Service (QoS), different network applications can coexist on the same network without consuming each bandwidth of the others.

The term Quality of Service refers to a number of technologies, such as DSCP (Differentiated Services Code Point), which can identify the type of data contained in a package and divide packets into classes to prioritize their traffic forwarding. This prioritization allows that substantial flows are handled before lower priority flows.

Due to the fact that the RFAT System delivers real time video through the internet to any part of the world, all switches, routers and network video products that are installed admit QoS adjustments.

One of the objectives of the RFAT is to provide any customer the possibility to follow the FAT from any part of the world. For this purpose the System is web based. According to the OSI Reference Model, the application layer uses the well known HyperText Transfer Protocol (HTTP). This protocol is used for every transaction from the Web. HTTP defines the syntax and semantics used by the software elements of web architecture to communicate. It is a transaction-oriented protocol and follows the request-response scheme between a client and a server. The client makes a request from a browser. The information transmitted is called resource and is identified by a Uniform Resource Locator (URL), also known as a normal Internet address or link.

This RFAT architecture allow that the project manager simply send a URL or link to each customer. The customer opens the URL in a browser and without any installation and specific hardware requirement the FAT can be witnessed through the RFAT application. The minimum hardware and software requirements can be checked in the *ANNEX G*.

Chapter V. Conclusions

V.1 Customer Feedback

The goal of the improvement of the FAT process is to stage an experience to the customer that attend locally or remotely the Factory Acceptance test of the Generator Circuit Breakers. Because the experience a customer has is very subjective and difficult to measure, the creation of a customer feedback evaluation has been included in the project. There are to types of feedback recordings. On one hand the PM have to record the performance of each FAT in the DB tool. On the other hand, customers are directly asked by the PM supervisor after each FAT. The integration of the performance feedback done internally and the external feedback given by customers help to understand how customers have experienced the FAT and which elements and improvement actions can be done. Both, the FAT internal performance Feedback as well as the customer survey feedback are listed in the *ANNEX F.1 and F.2*.

Since the start of the implementation in December 2009 until today, 23 February 2010, the obtained feedback has shown acknowledgment by the customers that the process has been improved. Customers evaluate positive the RFAT Tool, the new infrastructure and the structure of the FAT Event. Customers have included also new proposals for the RFAT, like for example a better conference system to improve the communication between project managers, test engineers and them. According to that feedback a new conference concept has been developed and installed in the new customer room.

V.2 Conclusion

ABB's strategy combines the needs that arise in the markets, Need Pull, with the development of technologies based on competitive advantages and core capabilities of the company, Technology Push. The decision-making is based on expert's knowledge and investments are allocated for new product development and process improvements focused on operational excellence.

The targets are set focusing on customer orientation and therefore a more effectively position in the global market, while constantly improving business processes to achieve efficiency and reduce production costs, of course, maintaining the quality and confidence on ABB's products.

The difficulty in implementing the optimization of the FAT has been the inclusion of two strategic trends: operational efficiency in production processes and product differentiation for customer focus. The use of ICT-based tools has supported the improvement of the process and enabled faster deployment and a higher degree of acceptance by the PM. It is important to stress, that the tools

described in this document have not been the final goal, but the way to achieve the objectives defined by the management of the company. These tools enable to solve operational needs that have emerged when optimizing the entire production process, keeping the strategic objective of meeting customer expectations and deliver a customer event.

After the implementation of the new process, other departments have welcomed the use of these tools, to the extent, that new projects have been created in the same strategic direction that require the use of similar tools. The Service Department, which organizes trainings of the product internationally, has expressed interest in apply similar tools for the organization and execution of courses. On one hand, the Database Tool to optimize the organization and planning of the courses for customers and, on the other hand, the incorporation of remote visualization systems to deliver Remote Trainings to the global market.

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ANNEX
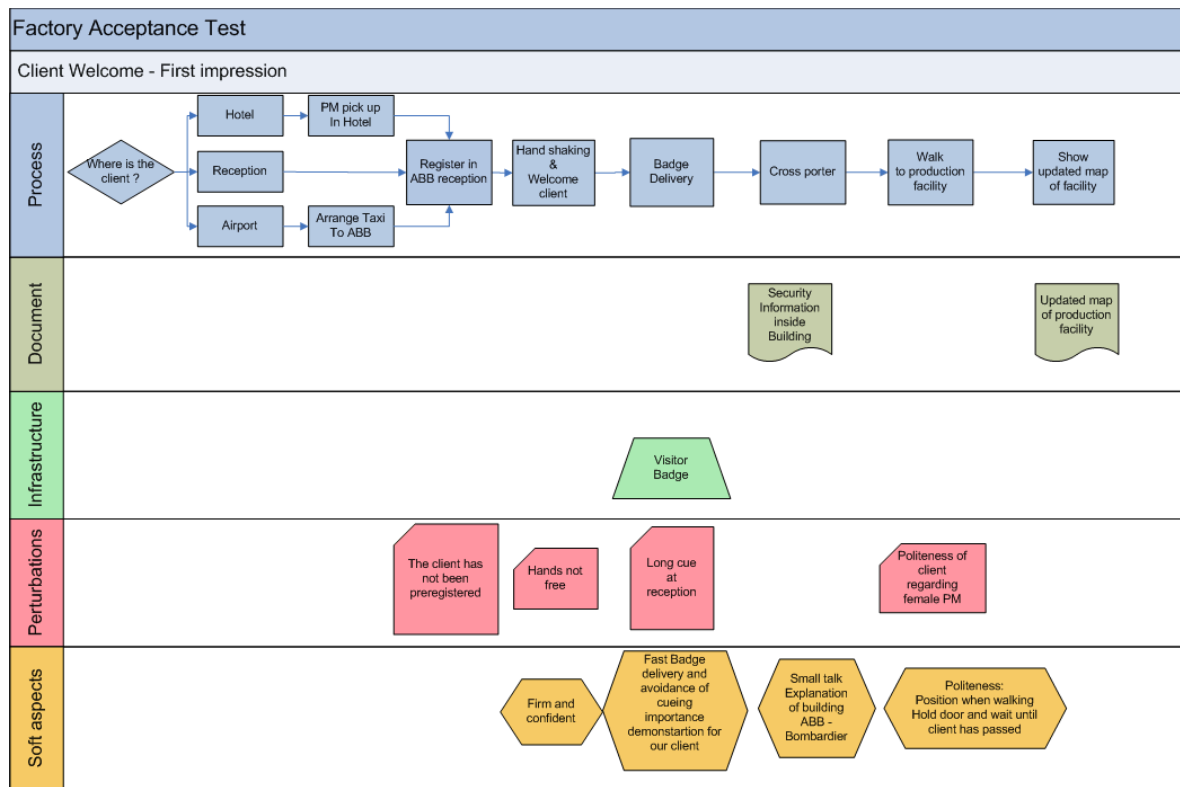
A. Additional Figures

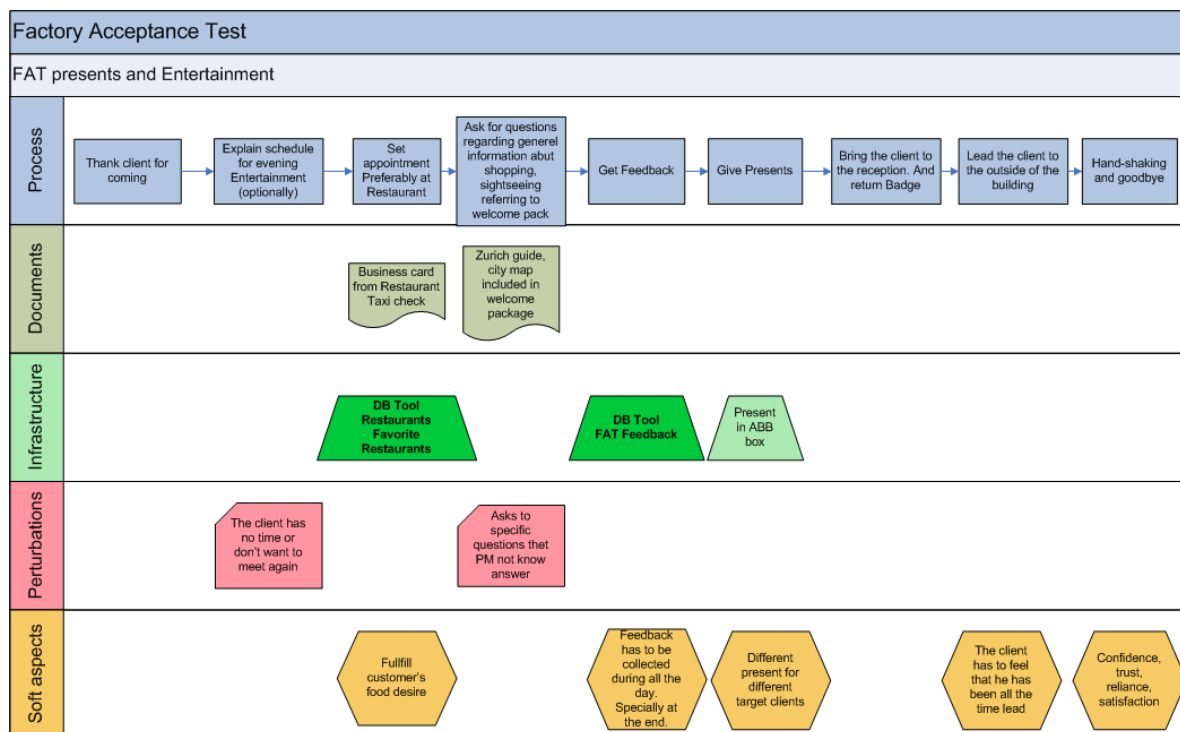
Figure 47. FAT Client Welcome

Figure 48. FAT Presents and Entertainment
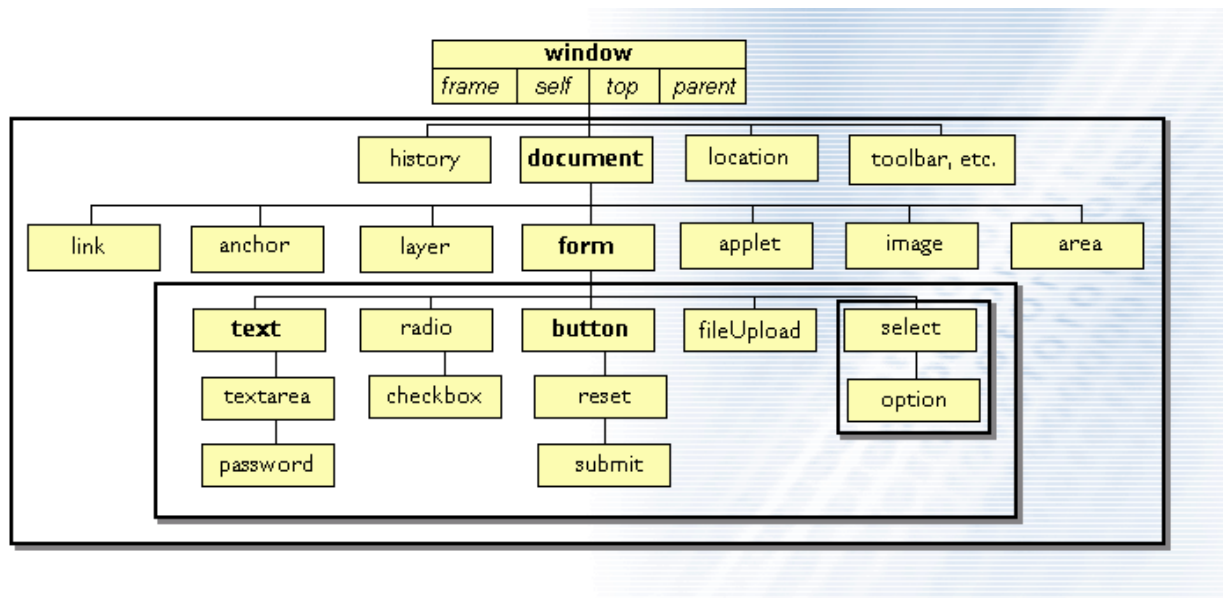
Figure 49. JavaScript Object Model
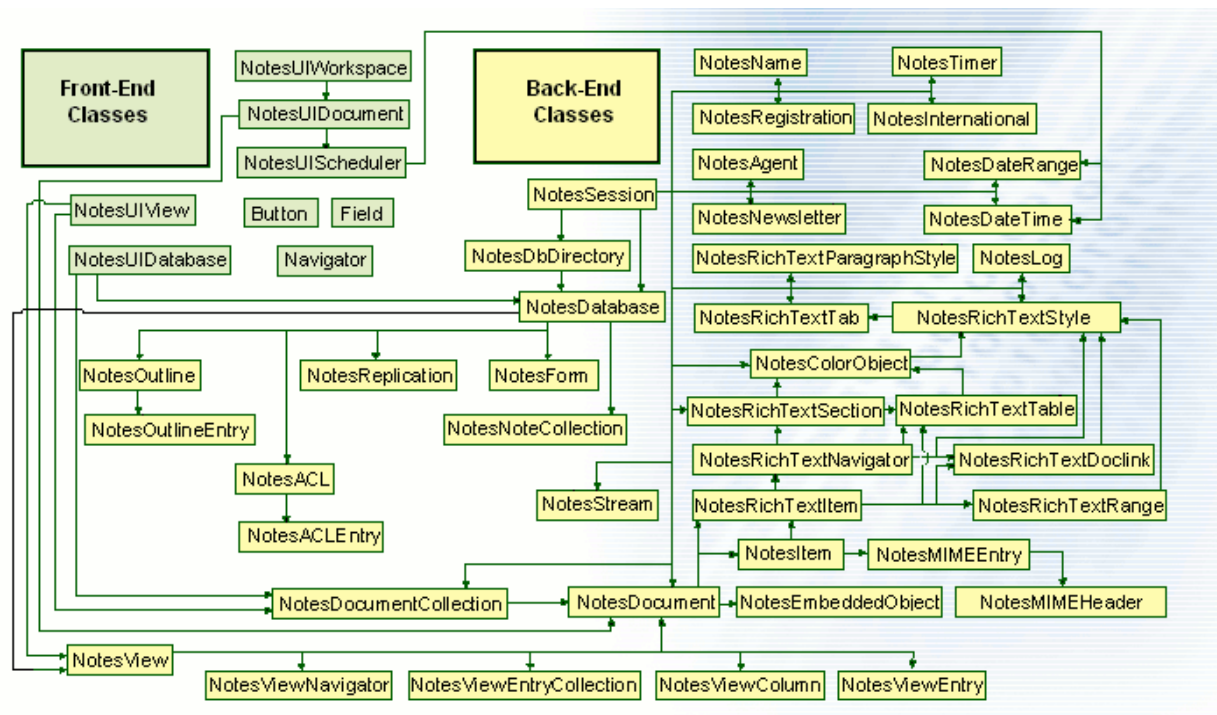
Figure 50. Domino Objects for Lotus Script and OLE

B. ABB Group World Wide Web Copyright Notice

Copyright Notice

C. Workshops

C.1 First Workshop Results

Kunden Erfahrung und Gefühle
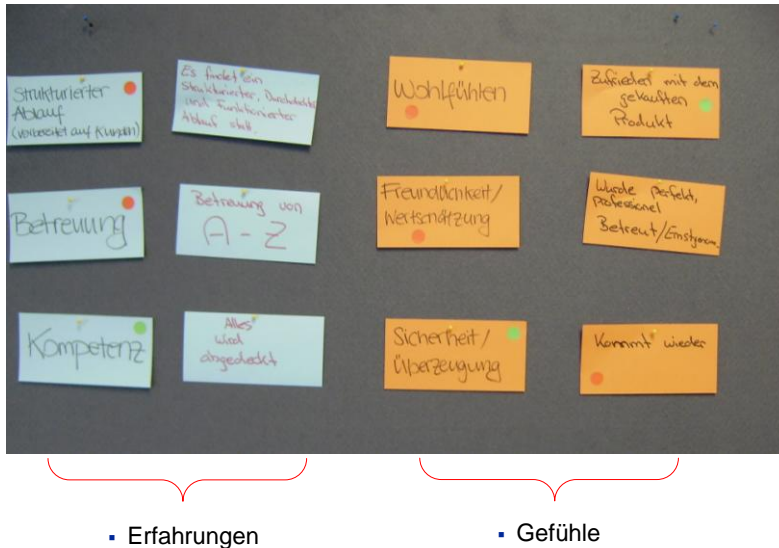
- Erfahrungen
- Gefühle

Brainstorming
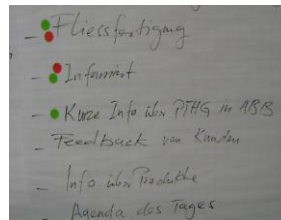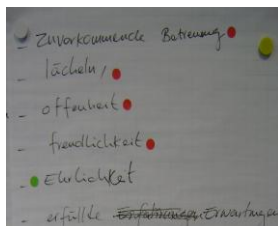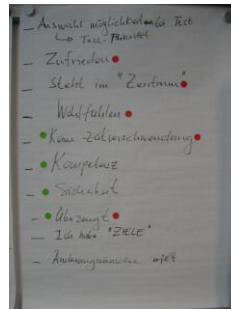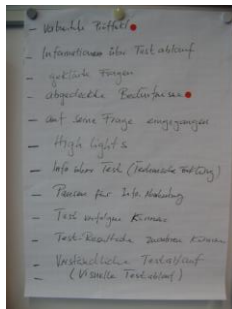
Inhalt der Kunden Erfahrung

- Die Teams
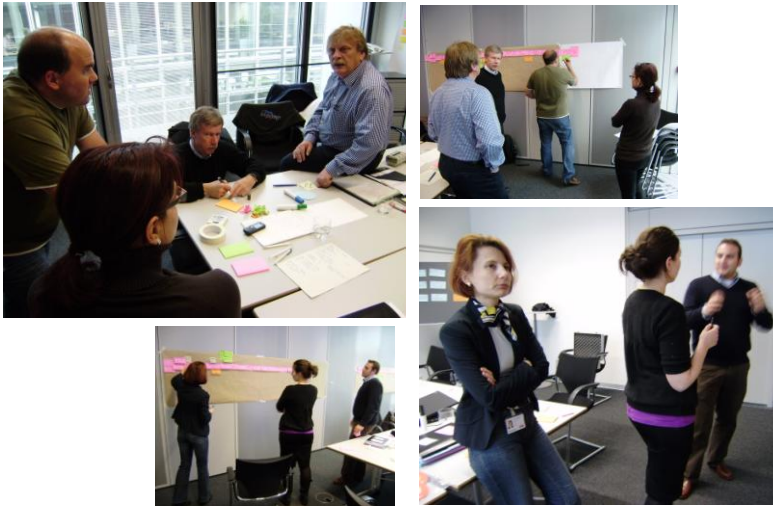
Inhalt der Kunden Erfahrung

- Zwei FAT Abläufe

	Prozess		Infrastruktur & tools		Störungen

Anmerkungen bzg. Kunden   Teilprozesse

C.2 Second Workshop Results

Die Dokumente

Die Einrichtungen
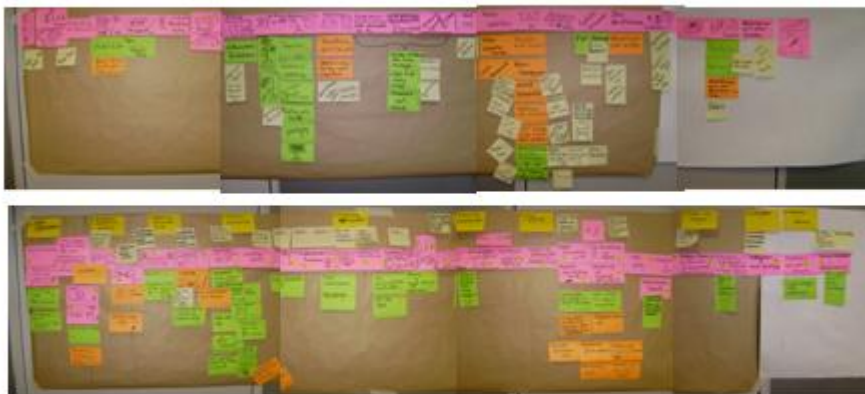
Kulturen Definieren
Die Dimensionen der Kultur

- **Regionen Einordnen:**
- **Aufgabe 2. (30 Minuten)**
- **Ordnen sie mit Farbpunkte jede Kultur/Region auf den Dimensionen ein:**
  - North America
  - South America
  - North Asia
  - Asia-Pacific
  - Middle East & Africa
  - Mediterranean & central Europe
  - Northern & Eastern Europe

Die sechs Ebenen der Kultur

Die Merkmale der Kulturen / Regionen

C.3 Third Workshop Results

D. Test Report for FAT

<u>System Tests</u>

		Unit	specified	tested
1.	Completeness in compliance with the order			
2.	Power frequency withstand voltage tests on major insulation components with minimum SF6-density of 34.7kg/m^3	Hz, s		--
2.1	Life parts (circuit breaker, disconnecting switch) to ground	kV		
2.2	Across the open circuit breaker contacts	kV		
2.3	Across the open disconnecting switch contacts	kV		
2.4	With the starting switch contacts closed to ground	kV		
3	Power frequency withstand voltage tests on control and insulation of the system enclosure / secondary wiring of CT's and PT's	Hz, s / kV	2 / 2.5	--

<u>Circuit Breaker</u>

		Unit	specified	tested
4.	Mechanical, timing and leakage tests on the circuit breaker			
4.1	Operation at min./max./rated control voltage	V DC		
4.2	Mechanical operation tests with the spring fully charged and max. (rated) SF6-density of 40.7kg/m^3			
	- min. control voltage	--	5xC / 5xO	
	- max. control voltage	--	5xC / 5xO	
	- rated control voltage	--	5xCO	
4.3	Demonstration, that the circuit breaker is electrically trip-free	--	--	
4.4	Movement of breaker contacts at rated control voltage, rated SF6-density and fully charged spring:			
	- OPEN operation	m/s		
	- CLOSE operation	m/s		
	- OPEN at CLOSE OPEN operation	m/s		

		Unit	specified	measured			diff<3ms
				L1	L2	L3	
4.5	Timing tests at rated control voltage, rated SF6-density and fully charged spring:						
	- CLOSE operation	ms					
	- CLOSE operation with impulse < 15ms	ms					
	- OPEN operation (coil O1)	ms					
	- OPEN operation (coil O1) with impulse < 15ms	ms					
	- OPEN operation (coil O2)	ms					
	- OPEN operation (coil O2) with impulse < 15ms	ms					
	- CLOSE-OPEN operation	ms					
4.6	Leakage test (SF6 gas, during assembly)	g/a		o.k.	o.k.	o.k.	--
5.	Electrical resistance of current path test with 100A DC across circuit breaker and disconnecting switch	µΩ					--

<u>Circuit Breaker Drive</u>

		Unit	specified	tested
6.	Tests of the circuit breaker drive			
6.1	Operation at minimum coil voltage:			
	- CLOSE operation	V DC		
	- OPEN operation (coil O1)	V DC		
	- OPEN operation (coil O2)	V DC		
6.2	Resistance of the coils:			
	- Closing coil (C)	Ω	±10%	
	- Tripping coil (O1)	Ω	±10%	
	- Tripping coil (O2)	Ω	±10%	
6.3	Operation of the pump motor at min. and max. voltage	V DC		
6.4	Current consumption of pump motor at rated voltage	A	< 10	
6.5	Auxiliary switch according to the wiring diagram	--	--	
6.6	Operation of spring stroke switch	--	--	
6.7	Manual operation of C, O1 and O2	--	--	

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Disconnecting, Earthing and Starting Switch(es)

		Unit	specified	tested
7.	Mechanical tests on the disconnecting, earthing and starting switch(es), where applicable			
7.1	Operating at min. and max. drive voltage	V AC		
7.2	Total operations at min., rated and max. drive voltage:			
	- Disconnecting switch (Q9)	--	5/5/5	
	- Earthing switch (Q81)	--	5/5/5	
	- Earthing switch (Q82)	--	5/5/5	
	- Starting switch (Q91)	--	5/5/5	

Drive(s) for Disconnecting, Earthing and Starting Switch(es)

		Unit	specified	tested
8.	Tests of the drive(s) for the disconnecting, earthing and starting switch(es), where applicable			
8.1	Operation of key locking and auxiliary switch(es)	--	--	
8.2	Current consumption of the drive(s) at rated voltage:			
	- Disconnecting switch (Q9)	A	< 5	
	- Earthing switch (Q81)	A	< 5	
	- Earthing switch (Q82)	A	< 5	
	- Starting switch (Q91)	A	< 5	

Control Signals, Alarm and Interlockings

		Unit	specified	tested
9.	Testing of control signals, alarms and interlockings according to the wiring diagram where applicable			
9.1	Operation at min. and max. control voltage	V DC		
9.2 *	Operation of signals and alarms	--		
9.3 *	Interlocking conditions according to the wiring diagram	--		
9.4 *	Control cabinet heater	W		
9.5	Circuit breaker drive heater	W		
9.6	Arching chamber heater	W		
9.7	Heater of the drive(s) for the disconnecting, earthing and starting switch(es)	W		
9.8	Control of the heaters according to the wiring diagram	--	--	
9.9 *	Light and electric voltage outlet	--	--	
9.1	Wiring of voltage and current transformers	--	--	
9.11	SF6 density monitor with falling density:			
	- Contact signal (refilling)	--	yellow	
	- Contact signal (blocking C / O1)	--	red	
	- Contact signal (blocking O2)	--	red	

10	Leakage test of system enclosure at 20mbar / 5min.	mbar	< 5	

Remarks and comments:

* Additional fabrication numbers:
  Cicuit breaker drive HMB 4.5 ....
  Density monitor ....
  Rupture discs ....

* Additional tests for the cooling system

E. Code implemented in DB Tool

E.1 Automation of the FAT Events: Generation of all documents

```
Sub Postsave(Source As Notesuidocument)
 'Variable Declaration
  Dim s As NotesSession, dc As NotesDocumentCollection, doc As NotesDocument
  Dim docaux10 As NotesDocument
  Dim docaux As NotesDocument,docaux1 As NotesDocument,docaux2 As NotesDocument,
   docaux3 As NotesDocument,docaux4 As NotesDocument,docaux5 As NotesDocument,
   docaux6 As NotesDocument, docaux7 As NotesDocument,docaux8 As NotesDocument,
   docaux9 As NotesDocument
  Dim SAP As Variant
  Dim customer(1 To 20) As String
  Dim company(1 To 20) As String
  Dim RFAT(1 To 2) As String
  Dim Projekt As Variant
  Dim Projektleiter As Variant
  Dim Besucher As Variant
  Dim Firma As Variant
  Dim Datum As Variant
  Dim RFATFAT As Variant
  Dim i,j,k As Integer
 'Variable Initialization
  Set s = New NotesSession
  Set dc = s.CurrentDatabase.AllDocuments
  Set doc = source.Document
  SAP=doc.GetItemValue("SAPNo")
  Projekt = doc.GetItemValue("Project")
  Projektleiter = doc.GetItemValue("PM")
  Besucher= doc.GetItemValue("Besucher")
  Firma=doc.GetItemValue("Firma")

  Datum = doc.GetItemValue("Datum")
  RFATFAT= doc.GetItemValue("RFAT")
 'Ungroup the customer names and companies in separate items
  i=1
  j=1
  k=1
  Forall items In RFATFAT
   RFAT(k)=RFATFAT(k-1)
   k=k+1
  End Forall
  Forall items In Firma
   company(i)=Firma(i-1)
   i=i+1
  End Forall
 ' Creation of CRM list
  Forall items In Besucher
   Set docaux9 = New NotesDocument(s.CurrentDatabase)
   docaux9.form="CRM"
   Call docaux9.ReplaceItemValue("project",Projekt)
   Call docaux9.ReplaceItemValue("company",company(j))
   Call docaux9.ReplaceItemValue("datum",Datum)
   customer(j)=Besucher(j-1)
   Call docaux9.ReplaceItemValue("customer",customer(j))
   Call docaux9.Save(True,False)
   j=j+1
  End Forall
 'Declaration of current workspace and uidocument
  Dim Workspace As New NotesUIWorkspace
  Dim UIDdoc As NotesUIDocument
 ' Initialization of all future created documents
  Set docaux = New NotesDocument(s.CurrentDatabase)
  Set docaux1 = New NotesDocument(s.CurrentDatabase)
  Set docaux2 = New NotesDocument(s.CurrentDatabase)
  Set docaux3 = New NotesDocument(s.CurrentDatabase)
  Set docaux4 = New NotesDocument(s.CurrentDatabase)
  Set docaux5 = New NotesDocument(s.CurrentDatabase)
  Set docaux6 = New NotesDocument(s.CurrentDatabase)
  Set docaux7 = New NotesDocument(s.CurrentDatabase)
  Set docaux8 = New NotesDocument(s.CurrentDatabase)
```

```vb
Set docaux10 = New NotesDocument(s.CurrentDatabase)
' Case FAT
If RFAT(k-1)="FAT" Then
 ' set values for Inviattion letter
 docaux10.form="Invitation Letter"
 Call docaux10.ReplaceItemValue("SAPNo",SAP)
 Call docaux10.ReplaceItemValue("Project",Projekt)
 Call docaux10.ReplaceItemValue("PM",Projektleiter)
 Call docaux10.ReplaceItemValue("PM_1",Projektleiter)
 Call docaux10.ReplaceItemValue("Attendees",Besucher)
 Call docaux10.ReplaceItemValue("Datum",Datum)
 Call docaux10.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux10.Save(True,False)
'set values for Agenda Configuration
docaux6.form="Agenda Configuration"
 Call docaux6.ReplaceItemValue("SAPNo",SAP)
 Call docaux6.ReplaceItemValue("Project",Projekt)
 Call docaux6.ReplaceItemValue("PM",Projektleiter)
 Call docaux6.ReplaceItemValue("Datum",Datum)
 Call docaux6.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux6.Save(True,False)
'set values for Empfang und flatscreen
docaux.form="Empfang und Flatscreen"
 Call docaux.ReplaceItemValue("SAPNo",SAP)
 Call docaux.ReplaceItemValue("Project",Projekt)
 Call docaux.ReplaceItemValue("PM",Projektleiter)
 Call docaux.ReplaceItemValue("Besucher",Besucher)
 Call docaux.ReplaceItemValue("Bfirma",Firma)
 Call docaux.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux.Save(True,False)
'set values for Verpflegung
docaux1.form = "Verpflegung"
 Call docaux1.ReplaceItemValue("SAPNo",SAP)
 Call docaux1.ReplaceItemValue("Project",Projekt)
 Call docaux1.ReplaceItemValue("PM",Projektleiter)
 Call docaux1.ReplaceItemValue("Anzahl",i)
 Call docaux1.ReplaceItemValue("RFAT",RFATFAT)

 Call docaux1.save(True,False)
'set values for The Checklist before FAT
docaux2.form = "The Checklist before FAT"
 Call docaux2.ReplaceItemValue("SAPNo",SAP)
 Call docaux2.ReplaceItemValue("Project",Projekt)
 Call docaux2.ReplaceItemValue("PM",Projektleiter)
 Call docaux2.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux2.save(True,False)
'setz values for The Checklist after FAT
docaux3.form = "The Checklist after FAT"
 Call docaux3.ReplaceItemValue("SAPNo",SAP)
 Call docaux3.ReplaceItemValue("Project",Projekt)
 Call docaux3.ReplaceItemValue("PM",Projektleiter)
 Call docaux3.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux3.save(True,False)
'set values for Signatures Table
docaux8.form = "Signatures Form"
 Call docaux8.ReplaceItemValue("SAPNo",SAP)
 Call docaux8.ReplaceItemValue("Project",Projekt)
 Call docaux8.ReplaceItemValue("PM",Projektleiter)
 Call docaux8.ReplaceItemValue("Attendees",Besucher)
 Call docaux8.ReplaceItemValue("Company",Firma)
 Call docaux8.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux8.Save(True,False)
'set values for FAT Feedback
docaux5.form = "FAT Feedback"
 Call docaux5.ReplaceItemValue("SAPNo",SAP)
 Call docaux5.ReplaceItemValue("Project",Projekt)
 Call docaux5.ReplaceItemValue("PM",Projektleiter)
 Call docaux5.ReplaceItemValue("RFAT",RFATFAT)
 Call docaux5.Save(True,False)
'set values for FAT Zertifikat case FAT
docaux4.form = "FAT Zertifikat"
 Call docaux4.ReplaceItemValue("SAPNo",SAP)
 Call docaux4.ReplaceItemValue("Project",Projekt)
 Call docaux4.ReplaceItemValue("PM",Projektleiter)
 Call docaux4.ReplaceItemValue("Attendees",Besucher)
```

```
Call docaux4.ReplaceItemValue("Company",Firma)

Call docaux4.ReplaceItemValue("RFAT",RFATFAT)

Call docaux4.Save(True,False)

'set values for MOM case FAT

docaux7.form="MOM"

Call docaux7.ReplaceItemValue("SAPNo",SAP)

Call docaux7.ReplaceItemValue("Project",Projekt)

Call docaux7.ReplaceItemValue("PM",Projektleiter)

Call docaux7.ReplaceItemValue("Attendees",Besucher)

Call docaux7.ReplaceItemValue("Company",Firma)

Call docaux7.ReplaceItemValue("RFAT",RFATFAT)

Call docaux7.Save(True,False)

'End case FAT

'Start case RFAT

Else

'set values for RFAT Invitation

docaux10.form="RFAT Invitation"

Call docaux10.ReplaceItemValue("SAPNo",SAP)

Call docaux10.ReplaceItemValue("Project",Projekt)

Call docaux10.ReplaceItemValue("PM",Projektleiter)

Call docaux10.ReplaceItemValue("Attendee",Besucher)

Call docaux10.ReplaceItemValue("Datum",Datum)

Call docaux10.ReplaceItemValue("RFAT",RFATFAT)

Call docaux10.Save(True,False)

'set values for RFAT Contract

docaux8.form = "RFAT Contract"

Call docaux8.ReplaceItemValue("SAPNo",SAP)

Call docaux8.ReplaceItemValue("Project",Projekt)

Call docaux8.ReplaceItemValue("PM",Projektleiter)

Call docaux8.ReplaceItemValue("Attendee",Besucher)

Call docaux8.ReplaceItemValue("Firma",Firma)

Call docaux8.ReplaceItemValue("Firma1",Firma)

Call docaux8.ReplaceItemValue("RFAT",RFATFAT)

Call docaux8.Save(True,False)

'set values for RFAT Agenda

docaux6.form="RFAT Agenda"

Call docaux6.ReplaceItemValue("SAPNo",SAP)

Call docaux6.ReplaceItemValue("Project",Projekt)

Call docaux6.ReplaceItemValue("PM",Projektleiter)

Call docaux6.ReplaceItemValue("Datum",Datum)

Call docaux6.ReplaceItemValue("RFAT",RFATFAT)

Call docaux6.Save(True,False)

'set values for FAT Zertifikat case RFAT

docaux4.form = "FAT Zertifikat"

Call docaux4.ReplaceItemValue("SAPNo",SAP)

Call docaux4.ReplaceItemValue("Project",Projekt)

Call docaux4.ReplaceItemValue("PM",Projektleiter)

Call docaux4.ReplaceItemValue("Attendees",Besucher)

Call docaux4.ReplaceItemValue("Company",Firma)

Call docaux4.ReplaceItemValue("RFAT",RFATFAT)

Call docaux4.Save(True,False)

'set values for MOM case RFAT

docaux7.form="MOM"

Call docaux7.ReplaceItemValue("SAPNo",SAP)

Call docaux7.ReplaceItemValue("Project",Projekt)

Call docaux7.ReplaceItemValue("PM",Projektleiter)

Call docaux7.ReplaceItemValue("Attendees",Besucher)

Call docaux7.ReplaceItemValue("RFAT",RFATFAT)

Call docaux7.ReplaceItemValue("Company",Firma)

Call docaux7.Save(True,False)

'end case RFAT

End If

Msgbox("Es wurden alle Projektspezifische Dokumente vorbereitet")

End Sub
```

E.2 Catering ordering

```vb
Sub Click(Source As Button)

' variable declarations

Dim workspace As New NotesUIWorkspace

Dim uidoc As NotesUIDocument

Dim was As String

Dim Vdatum As String

Dim Vanzahl As String

Dim Vtime As String

Dim Vraum As String

Dim Vkostenstelle As String

Dim Verpflegung As String

Dim session As New NotesSession

Dim username As String

Dim db As NotesDatabase

Dim doc As NotesDocument

Dim rtitem As NotesRichTextItem

' variable initialization

username = session.CommonUserName

Set uidoc = workspace.CurrentDocument

' get the database-> has to be updated once it is on the server

Set db = New NotesDatabase( "", "FAT.nsf" )

' create a new document in the database

Set doc = New NotesDocument(db)

' set the new document's form so it'll be readable as a mail
memo

doc.Form = "Memo"

doc.Subject = "Catering Order"

'Variable initialization

was= uidoc.FieldGetText("was")

Vanzahl= uidoc.FieldGetText("Anzahl")

Vraum= uidoc.FieldGetText("Vraum")

Vtime=uidoc.FieldGetText("VTime")

Vdatum=uidoc.FieldGetText("VDatum")

Vkostenstelle= uidoc.FieldGetText("Vkostenstelle")

Set rtitem = New NotesRichTextItem( doc, "Body" )

'Preparation email

Call rtitem.AppendText("Guten Tag,")

Call rtitem.AddNewline(2)

Call rtitem.AppendText("Folgende Bestellung: ")

Call rtitem.AddNewline(2)

Call rtitem.AppendText("Bitte am " +Vdatum+" um "+Vtime+"
Uhr, " +was+ "  im Raum " +Vraum+ "  für " +Vanzahl+ "
Personen bereit stellen")

Call rtitem.AddNewline(1)

Call rtitem.AppendText("Kostenstelle: "+Vkostenstelle+"")

Call rtitem.AddNewline(2)

Call rtitem.AppendText("Vielen Dank.")

Call rtitem.AddNewline(2)

Call rtitem.AppendText("Gruss, ")

Call rtitem.AddNewline(2)

Call rtitem.AppendText(""+username+"")

Call rtitem.Update

' mail the new document

Call doc.Send( False, "Antonio Vidal" )

'Call  doc.Send(  False,  "restaurama.torondo@compass-
group.ch" )

Call uidoc.Save

Call uidoc.FieldSetText("Verpflegung","Bestellt")

Messagebox("Verpflegung bestellt")

End Sub
```

E.3 Reception and Flatscreen

```vbnet
Sub Click(Source As Button)
 'variable declarations
  Dim workspace As New NotesUIWorkspace
  Dim uidoc As NotesUIDocument
  Dim Bname As Variant
  Dim Bfirma As Variant
  Dim Bezugsperson As String
  Dim BProjektname As String
  Dim Bdatum As String
  Dim Btime As String
  Dim Btage As String
  Dim IT As Variant
  Dim db As NotesDatabase
  Dim doc As NotesDocument
  Dim doc1 As NotesDocument
  Dim rtitem As NotesRichTextItem
  Dim rtitem1 As NotesRichTextItem
 ' set uidoc as current document-source
  Set uidoc = workspace.CurrentDocument
' get the database-> has to be updated once the database is on
the server
  Set db = New NotesDatabase( "", "FAT.nsf" )
  ' create a new document in the database
  Set doc = New NotesDocument(db)
  Set doc1 = New NotesDocument( db )
  ' set the new document's form so it'll be readable as a mail
memo
 doc.Form = "Memo"
 doc1.Form = "Memo"
 'set subject of E-mails
 doc.Subject = "Begrüssungstext am Empfang FAT
"+BProjektname+""
 doc1.Subject = "Badge Vorbereitung für Besucher"+Bdatum+""
  'Variables initialization
  IT=uidoc.Fieldgettext("IT")
  Bname= uidoc.FieldGetText("Besucher")
  Bfirma= uidoc.FieldGetText("Bfirma")
  Bezugsperson= uidoc.FieldGetText("PM")
  BProjektname= uidoc.FieldGetText("Project")
  Btime=uidoc.FieldGetText("Btime")
  Bdatum=uidoc.FieldGetText("Bdatum")
  Btage= uidoc.FieldGetText("Btage")
  Set rtitem = New NotesRichTextItem( doc, "Body" )
  Set rtitem1 = New NotesRichTextItem( doc1, "Body" )
 'Vorbereitung email Flatscreen
  Call rtitem.AppendText("Guten Tag,")
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText("Wir Bekommen am " +Bdatum+" um
"+Btime+" Uhr, den Besuch von: ")
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText(""+Bname+ "  von den respektiven
Firmen " +Bfirma+ "  für die Abnahme (FAT) des Projekts "
+BProjektname+"." )
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText("von den jeweiligen Firmen: " )
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText("" +Bfirma+ " ")
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText(" für die Abnahme (FAT) des Projekts "
+BProjektname+"." )
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText(" Sie werden " +Btage+ "  Tage bei uns
sein.")
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText("Bitte einen Begrüssungstext am
Flatscreen am Empfang zeigen.")
  Call rtitem.AddNewline(2)
  Call rtitem.AppendText("Vielen Dank.")
  Call rtitem.AddNewline(2)
```

```
Call rtitem.AppendText("Gruss, ")

Call rtitem.AddNewline(2)

Call rtitem.AppendText(""+Bezugsperson+"")

Call rtitem.Update

' Vorbereitung E-mail Empfang

Call rtitem1.AppendText("Guten Tag,")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText("Wir Bekommen am " +Bdatum+" um
"+Btime+"Uhr, den Besuch von: ")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText("" +Bname+ " ")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText("von den jeweiligen Firmen:")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText(""+Bfirma+"")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText("Bitte die Badge für "+Btage+" Tage
bereit stellen.")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText("Vielen Dank.")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText("Gruss, ")

Call rtitem1.AddNewline(2)

Call rtitem1.AppendText(""+Bezugsperson+"")

Call rtitem1.Update

' mail the new document

'case IT is default

If IT="" Then

  Call doc.Send( False, "Antonio Vidal" )

  'Call doc.Send( False, "daniel.meyer@ch.abb.com" )

  Call uidoc.FieldSetText("OK_1","Angekündigt an Antonio
Vidal")

  Msgbox("Die Flatscreen Ankündigung wurde an der Default
Person angekündigt")

Else

  'case IT is user defined

  Call doc.Send( False, ""+IT+"" )

  Call uidoc.FieldSetText("OK_1","Angekündigt an " +IT+ "")

End If

Call doc1.Send( False,"Antonio Vidal")

'Call doc1.Send( False, "TOROEmpfang.CHHOS@ch.abb.com"
)

Call uidoc.FieldSetText("OK_2","Informiert am Empfang ")

Call uidoc.Save

Messagebox("Empfang und Flatscreen Informiert!")

End Sub
```

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F. Documents

F.1 Customer Feedback Form

FAT QUALITY Survey — ABB

| Project manager: |
| Project name: |
| Company: |

Dear Customer:
As the Head of Project Managers of ABB, I want to thank you for giving us the opportunity to serve you. ABB appreciates your support and wants to be sure we are meeting your expectations and needs. Please take a few minutes to inform us about the expierience you had at ABB for the Factory Acceptance Test.

For each item identified below, circle the number to the right that best fits your judgment of its quality.
Use the scale above to select the quality number.

Description/Identification of Survey Item	Poor	Below average	Average	Good	Excellent	N/A
1. Overall, how would you rate the stay in Zürich for the FAT?	1	2	3	4	5	
1.2. Overall, how would you rate the Hotel you stay in?	1	2	3	4	5	
1.3. Overall, how would you rate the lunch in the Restaurant?	1	2	3	4	5	
1.4. Overall, how would you rate the transfer from the Hotel to the Factory?	1	2	3	4	5	
2. Overall, how would you rate the infrastructure at our Factory?	1	2	3	4	5	
2.1. Overall, how would you rate the security information for visitors at our factory?	1	2	3	4	5	
2.2. Overall, how would you rate the safety at our Factory?	1	2	3	4	5	
2.3. Overall, how would you rate the cleanliness and the condition of the infrastructure at our Factory?	1	2	3	4	5	
3. Overall, how would you rate the documentation adequacy regarding the FAT?	1	2	3	4	5	
3.1. Overall, how would you rate the introductory presentation to the FAT?	1	2	3	4	5	
4. Overall, how would you rate our staff's professionalism?	1	2	3	4	5	
4.1 Overall, how would you rate our staff's hospitality? (Friendliness, courtesy, responsiveness)	1	2	3	4	5	
4.2. Overall, how would you rate our staff's technical competence?	1	2	3	4	5	
4.3. Overall, how would you rate our staff's organizational competence for the FAT?	1	2	3	4	5	
4.4. Overall, how would you rate the effective use of time of our staff?	1	2	3	4	5	
4.5. Overall, how would you rate the understanding of customer needs of our staff?	1	2	3	4	5	

Figure 51. FAT Customer Feedback

F.2 Internal Feedback Form

Figure 52. FAT Internal Feedback

F.3 After FAT Checklist

Figure 53. The after FAT Checklist

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G. RFAT Technical Requirements

The following are the minimum INTERNET and HARDWARE requirement needed for the RFAT:

Screen resolution: 1024 x 768 pixels (recommended)
Processor: Core2Duo or higher

Software

Media player: Adobe Flash-Player from version 9.0115
(Download: www.adobe.com/de/products/flashplayer/)
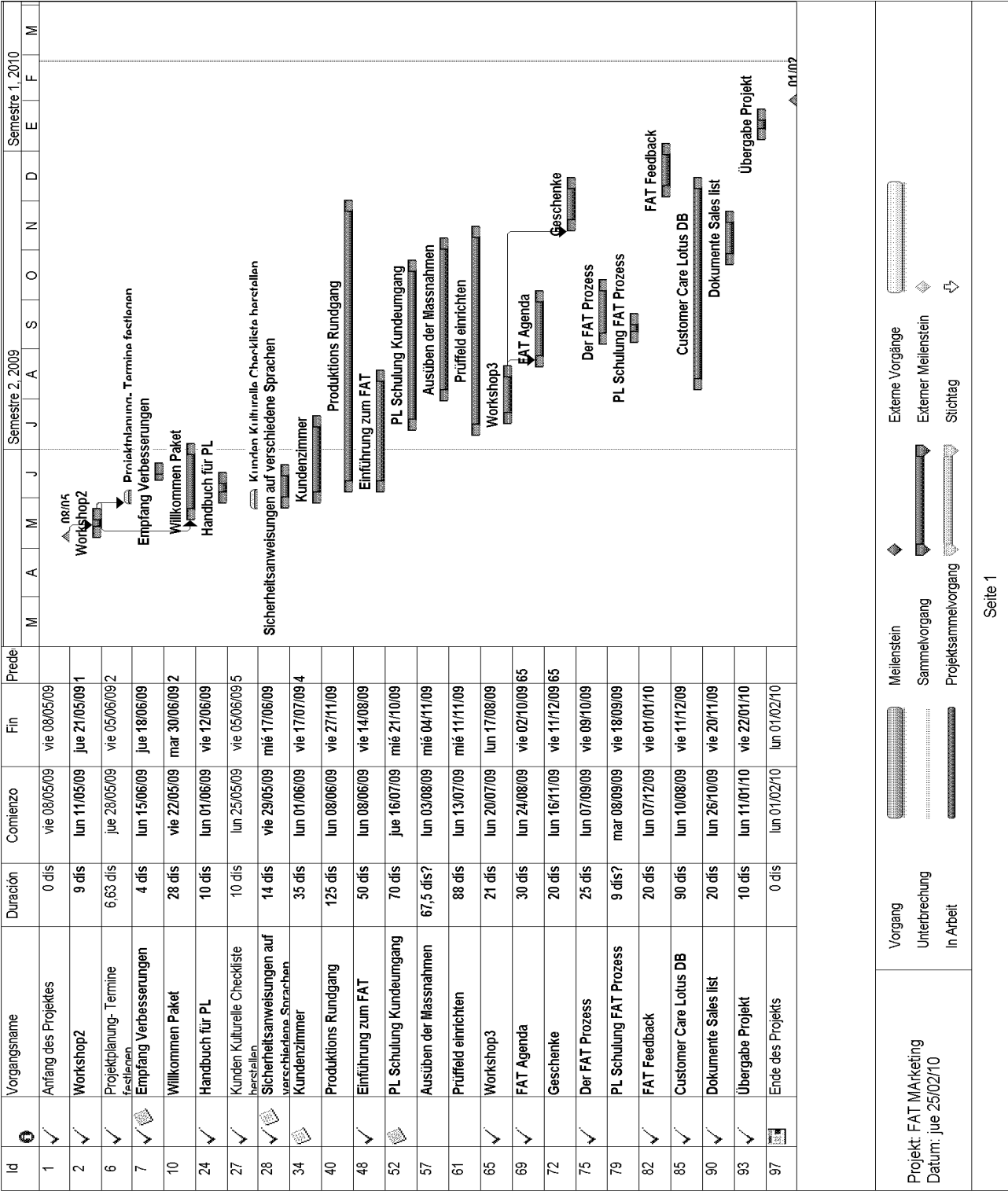Operation system: Windows XP / Vista / Mac OS / Linux
Browser: from Firefox2.0/Internet Explorer 7 / Opera 9.64 / Safari3.0

Internet access

Download speed: min. 1500 Kbit/s
Upload speed: 500 Kbit/s

H. Project Planning and Execution

Id		Vorgangsname	Duración	Comienzo	Fin	Prede
1		Anfang des Projektes	0 dís	vie 08/05/09	vie 08/05/09	
2		Workshop2	9 dís	lun 11/05/09	jue 21/05/09	1
6		Projektplanung- Termine festlegen	6,63 dís	jue 28/05/09	vie 05/06/09	2
7		Empfang Verbesserungen	4 dís	lun 15/06/09	jue 18/06/09	
10		Willkommen Paket	28 dís	vie 22/05/09	mar 30/06/09	2
24		Handbuch für PL	10 dís	lun 01/06/09	vie 12/06/09	
27		Kunden Kulturelle Checkliste herstellen	10 dís	lun 25/05/09	vie 05/06/09	5
28		Sicherheitsanweisungen auf verschiedene Sprachen	14 dís	vie 29/05/09	mié 17/06/09	
34		Kundenzimmer	35 dís	lun 01/06/09	vie 17/07/09	4
40		Produktions Rundgang	125 dís	lun 08/06/09	vie 27/11/09	
48		Einführung zum FAT	50 dís	lun 08/06/09	vie 14/08/09	
52		PL Schulung Kundeumgang	70 dís	jue 16/07/09	mié 21/10/09	
57		Ausüben der Massnahmen	67,5 dís?	lun 03/08/09	mié 04/11/09	
61		Prüffeld einrichten	88 dís	lun 13/07/09	mié 11/11/09	
65		Workshop3	21 dís	lun 20/07/09	lun 17/08/09	
69		FAT Agenda	30 dís	lun 24/08/09	vie 02/10/09	65
72		Geschenke	20 dís	lun 16/11/09	vie 11/12/09	65
75		Der FAT Prozess	25 dís	lun 07/09/09	vie 09/10/09	
79		PL Schulung FAT Prozess	9 dís?	mar 08/09/09	vie 18/09/09	
82		FAT Feedback	20 dís	lun 07/12/09	vie 01/01/10	
85		Customer Care Lotus DB	90 dís	lun 10/08/09	vie 11/12/09	
90		Dokumente Sales list	20 dís	lun 26/10/09	vie 20/11/09	
93		Übergabe Projekt	10 dís	lun 11/01/10	vie 22/01/10	
97		Ende des Projekts	0 dís	lun 01/02/10	lun 01/02/10	

Projekt: FAT MArketing
Datum: jue 25/02/10

Vorgang		Meilenstein		Externe Vorgänge	
Unterbrechung		Sammelvorgang		Externer Meilenstein	
In Arbeit		Projektsammelvorgang		Stichtag	

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