The management of complexity in project management –
a qualitative and quantitative case study of certified project
managers in Germany

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Doctor of Business Administration

2015
Declaration of Originality

I hereby declare that this thesis and the work reported herein was composed by and originated entirely from me. It is submitted in the accordance with the requirements of the degree of Doctor of Business Administration (DBA) in the Faculty of Business, Education and Professional Studies. Information derived from the published and unpublished work of others has been acknowledged in the text and references are given in the list of sources.

SIGNATURE

DATE 11th of November 2015
There are so many people to whom I have to thank. If someone is missed out here, I apologize for this herewith at the first.

First of all I would like to thank Dr. Adele-Louise Carter, my first supervisor. She always was available when I needed her advice and support (in methods, administrative stuff and the topic itself). Her replay to calls or emails was within 48 hrs, no matter where in the world we've been. Whenever possible I tried to discuss with her my thesis face to face. On the other hand she supported me with great tips in literature, easily to understand the different existing methods. Second I would like to thank Dr. Ivana Adamson, my second supervisor. I remember till today the discussion in my first lecturing module where we discussed how to get a pigeon walking a certain line. She is perfect in methodology and encourages discussions, which are sometimes hard to follow and understand, but good in reflecting and thinking about different viewpoints. She made me keen in the methods and methodology part. Also I would like to thank Dr. Philippa Ward, head of this program at the University of Gloucestershire. I was in one of the first groups who performed this program as a part time student abroad. I remember the trouble at the beginning and also here with the German agency in Munich. I can only say: what a great job! The program has developed from the organisational perspective so much that today the covered distance is more than to another galaxy. Further has she a phenomenal mind. She remembers all the names of students and their concerns. Her response time is almost as fast as the response time of my first supervisor, but she has more students to supervise.

I would like to thank Florian Müller-Schunk, Christoph Diekhöfer, Stephan Meyer, Andrey Gubichev and Dr. Dirk Finkenrath without their moral support I would have never started this thesis. They were also great partner for sharing ideas, views and unconventional approaches.

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Finally I have to thank my dad, mum and sisters, which I haven’t seen often during this time. Without them I would have never be enabled to gain my academic education. This thesis is dedicated to them.
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<tr>
<td>AACE</td>
<td>Association for the Advancement of Cost Engineering</td>
</tr>
<tr>
<td>AC</td>
<td>Actual Costs</td>
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<tr>
<td>ACCI</td>
<td>Australian Chamber of Commerce and Industry</td>
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<tr>
<td>ADM</td>
<td>Arrow Diagram Method</td>
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<td>AHP</td>
<td>Analytic Hierarchy Process</td>
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<td>AIPM</td>
<td>Australian Institute of Project Management</td>
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<td>AMA</td>
<td>American Management Association</td>
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<tr>
<td>ANP</td>
<td>Analytic Network Process</td>
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<td>ANSI</td>
<td>American National Standards Institute</td>
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<td>ANTA</td>
<td>Australian National Training Authority</td>
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<td>APM</td>
<td>Association for project management</td>
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<tr>
<td>AQF</td>
<td>Australian Qualification Framework</td>
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<tr>
<td>BAC</td>
<td>Budget At Completion</td>
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<tr>
<td>BCA</td>
<td>Business Council of Australia</td>
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<td>Boston Consulting Group</td>
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<td>BoK</td>
<td>Body of Knowledge</td>
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<td>BS</td>
<td>British Standard</td>
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<td>BSB</td>
<td>Business service training package</td>
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<td>Balanced Score Card</td>
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<td>BSI</td>
<td>British Standard Institute</td>
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<tr>
<td>CAPM</td>
<td>Certified Associate in Project Management</td>
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<td>Council of American Survey Research Organisations</td>
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<td>CBA</td>
<td>Cost Benefit Analysis</td>
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<td>CCP</td>
<td>Critical Chain Project management</td>
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<td>CCTA</td>
<td>Central Computer and Technology Agency</td>
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<td>Acronym</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
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<td>CMAJ</td>
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<td>Concept Map</td>
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<td>CMMI</td>
<td>Capability Maturity Model Integration</td>
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<tr>
<td>CNN</td>
<td>Cable News Network</td>
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<tr>
<td>CPD</td>
<td>Continuous professional development</td>
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<td>CPI</td>
<td>Cost Performance Indicator</td>
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<td>CPM</td>
<td>Critical Path Method</td>
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<td>CPO</td>
<td>Chief Project Officer</td>
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<td>CPPD</td>
<td>Certified Practising Project Director</td>
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<td>Certified Practising Project Manager</td>
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<td>CPPP</td>
<td>Certified Practising Project Practitioner</td>
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<td>CTA</td>
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<td>CV</td>
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<td>DEST</td>
<td>Department of Education, Service and Training</td>
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<td>DIN</td>
<td>Deutsches Institut für Normung</td>
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<td>DMM</td>
<td>Domain Mapping Matrix</td>
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<tr>
<td>DNA</td>
<td>Deutscher Norm-Ausschuss</td>
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<td>DoD</td>
<td>Department of Defence</td>
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<tr>
<td>DSM</td>
<td>Data structural matrix</td>
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<td>EAC</td>
<td>Estimate At Completion</td>
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<tr>
<td>EAM</td>
<td>Enterprise architecture model</td>
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<tr>
<td>EBIT</td>
<td>Earnings before interest and tax</td>
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<tr>
<td>ECV</td>
<td>Expected Commercial Value</td>
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<tr>
<td>ENAA</td>
<td>Engineering Advancement Association of Japan</td>
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<td>ESC</td>
<td>Engineering Standards Committee</td>
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<td>ESOMAR</td>
<td>European Society for Opinion and Marketing Research</td>
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<td>ETA</td>
<td>Estimate To Complete</td>
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<tr>
<td>EV</td>
<td>Earned Value</td>
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<td>EVM</td>
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<td>FGI</td>
<td>Focus group interviews</td>
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<td>FMEA</td>
<td>Failure Mode and Effects Analysis</td>
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<td>GAPPS</td>
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<td>GPM</td>
<td>Gesellschaft für Projektmanagement</td>
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<td>IBM</td>
<td>International Business Machines Cooperation</td>
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<td>IBSA</td>
<td>Innovation &amp; Business Skills Australia</td>
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<tr>
<td>ICB</td>
<td>International Competence Baseline</td>
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<td>IMSA</td>
<td>International Management System Association</td>
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<td>IPMA</td>
<td>International Project Management Association</td>
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<td>ISO</td>
<td>International Standardisation Organisation</td>
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<tr>
<td>IT</td>
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<td>Japan Project Management Forum</td>
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<td>KPI</td>
<td>Key Performance Indices</td>
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<td>LC</td>
<td>Life Cycle</td>
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<tr>
<td>MDM</td>
<td>Multi Domain Matrix</td>
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<tr>
<td>METI</td>
<td>Japanese Ministry of Economic, Trade and Industry</td>
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<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>MMAP</td>
<td>Mind Map</td>
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<td>MRS</td>
<td>Market Research Society</td>
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<tr>
<td>MPM</td>
<td>Multi Project Management</td>
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<tr>
<td>MTA</td>
<td>Milestone Trend Analysis</td>
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<td>NADI</td>
<td>Nationaler Norm-Ausschuss der Deutschen Industrie</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NCSPM</td>
<td>National Competency Standard for Project Management</td>
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<tr>
<td>NPV</td>
<td>Net Present Value</td>
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<tr>
<td>NQF</td>
<td>National Qualification Framework</td>
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NTIS: National Training Information System
OEM: Original equipment manufacturer
OGC: Office of Government Commerce
P2M: Project and Programme Management for Enterprise Innovation
PDM: Precedence Diagram Method
PERT: Programme Evolution and Review Technique
PgM: Programme Management
PgMO: Programme Management Office
PLC: Project Life Cycle
PM: Project Management
PMA: Programme Management Architect
PMAJ: Project Management Association of Japan
PMBoK: Project Management Body of Knowledge
PMC: Project Management Coordinator
PMCC: Project Management Certification Center
PMF: Project Managers Forum
PMI: Project Management Institute
PMO: Project Management Office
PMP: Project Management Professional
PMR: Project Manager Registered
PMSA: Project Management South Africa
PMS: Project Management Specialist
PMSGB: Project management Standards Generating Body
PPM: Project Portfolio Management
PPMO: Project Portfolio Management Office
PRINCE2: Project IN Controlled Environments
<table>
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<tr>
<th>Abbreviation</th>
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<tr>
<td>PROMT</td>
<td>Project Resource Organisation Management Planning Technique</td>
</tr>
<tr>
<td>PV</td>
<td>Planned Value</td>
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<tr>
<td>QM</td>
<td>Quality Management</td>
</tr>
<tr>
<td>RASCI</td>
<td>Responsible/Accountable/Support/Control/Inform</td>
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<tr>
<td>RegPM</td>
<td>AIPM registration process for project management</td>
</tr>
<tr>
<td>ROI</td>
<td>Return on Invest</td>
</tr>
<tr>
<td>ROS</td>
<td>Return on Sales</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>SAQA</td>
<td>South African Qualification Authority</td>
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<tr>
<td>SCAMPI</td>
<td>Standard CMMI Appraisal Method for Process Improvement</td>
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<tr>
<td>SCM</td>
<td>Structural Complexity Management methodology</td>
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<tr>
<td>SEI</td>
<td>Software Engineering Institute</td>
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<tr>
<td>SMAC</td>
<td>site man-hours and costs</td>
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<tr>
<td>SMART</td>
<td>Specific, Measurable, Realistic, time able</td>
</tr>
<tr>
<td>SNA</td>
<td>Structured Network Analysis</td>
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<td>SPI</td>
<td>Schedule Performance Indicator</td>
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<td>SPM</td>
<td>Academic Project Management society</td>
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<td>SPSS</td>
<td>Statistical Package for the Social Science</td>
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<td>s.s.</td>
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<td>SV</td>
<td>Shedule Variance</td>
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<tr>
<td>TCO</td>
<td>Total Cost of Ownership</td>
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<td>Total Complete Performance Indicator</td>
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<td>USAF</td>
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<tr>
<td>VAR</td>
<td>Variance At Completion</td>
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<td>Work Package</td>
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ABSTRACT
With the increased globalization and expansion of the markets worldwide, companies have to struggle with increased competition. Therefore, organisations have begun to offer advantages such as a personalisation of products to potential customers. Market conditions and legal policies can make it challenging to predict whether those advantages can be realized. Project managers are often in the position of having to fulfil these requirements; in continuously changing influencing factors that make tasks difficult to manage. These circumstances create complexity. Frequently, managers are unaware that complexity has created problems in a specific project. Often, the traditional standards of project management no longer provide a sufficient support to managers of complex projects.

This research investigates how current standards of project management address complexity, and whether a supplement is necessary. Complexity strengtheners are investigated. One standard Project Management Institute (PMI) is selected as an example to analyze the influence of strengtheners on PM-processes. A funnel model is developed based on these research findings. This is aimed to help managers in their daily practice and support them in categorizing the complexity of their projects. Based on this model, managers should be able to recognize the actual strengtheners of complexity and which processes of their project are affected. Finally, a possible adaption of the standard is researched. A proposition for a new comprehensive guide is designed to support managers carrying out complex projects.

The key managerial implication of this research is the development of a five-step model for handling complexity in projects: forming, storming, norming, performing, and adjourning. Furthermore, the intent of this thesis is to make a valid contribution to the management literature. For handling complexity the new funnel model should close the gap between the recognition of complexity in a project and underlying causes. The new five-step model thus provides project managers helpful guidelines for handling complex projects.

This research applies a mixed method, consisting of a survey (quantitative method) and focus interviews (qualitative method) with experts of project management (PMI) in Germany. There are approximately 4,900 PMI certified project managers in Germany; more than 170 participated in the survey (3.6%). This is considered sufficient to provide
reliable results for this research. Further, three focus interviews deepen the knowledge and validate the results of the survey: Complexity is an actual problem in project management. Existing standards are sufficient for project management, but complexity cannot be standardized. This thesis proposes to help project managers to resolve project complexity by providing guidelines for navigating through complex projects.
1 INTRODUCTION OF THE RESEARCH

1.1 AIM OF THE RESEARCH
Project management (PM) means planning, controlling, and steering of a temporarily limited endeavour (Jankulik, Kuhlang, & Pfiff, 2005; Lester, 2007).

Definitions in management literature tend to be polymorphic. Over the years, several authors have simplified and clarified the definition of complexity. Complexity as such is characterized by its features, rather than by a single definition: continuous - motion/momentum, increasing complexity/non-transparency, spontaneity of hierarchy, adaption, a large amount of different elements, irreversible and tempered by given restrictions (Ehrlenspiel, 2009; Feess, 2013; Pruckner, 2005; Riedl, 2000; Schwarz, 2011; Valle, 2000).

Complexity describes a system with two or more components or variables; it has many interrelated parts or aspects (Ireland, 2007). Existing project management standards do not sufficiently or adequately tend to address complexity and how to treat it (Remington & Pollack, 2007). Many projects can fail due to complexity of a project (Koch, 2008).

This research was designed to develop a method to treat complexity in project management. The Project Management Institute (PMI) standard was used as it is globally recognized and accepted. How can the project managers better observe the complexity of projects? Are improvements possible? To respond to these questions, structured questionnaires and focus groups will be deployed, using certified specialists and professionals. This investigation covers:

a) Selection of one project management standard as a basis.

This includes the selection of one project management standard on which this research is based (for the purposes of this research treated as objective criteria). This project management standard can be generalised as a synonym for the most existing standards worldwide, because it was the first created standard, on which other standards at least partly relay on. In part, worldwide standards reference this standard. Findings from this standard can be “reverse engineered” to other existing standards. The single processes of standards were cross-compared.
b) Identification of controllable or uncontrollable variables causing complexity in managing projects.

An almost endless number of strengtheners for complexity are listed in the literature. It was necessary to identify the specific strengtheners that are relevant for project managers and those that are the most critical. The specific strengtheners that generate complexity in projects were investigated and prioritised. According to the experts, project managers, in particular, should be prepared to address, observe and evaluate those strengtheners.

c) Production of a diagram representing complexity in specific fields of industry related to size and life cycle of projects.

A comprehensible and applicable model was developed with the intent of supporting young and/or less experienced project managers with the task of identifying processes for complexity in projects. However, this model also has relevance for experienced project managers.

d) Approaches for addressing complexity in project management and possible improvements for existing project management standards.

Different methods of visualising and handling complexity in the existing literature on complexity and in project management standards were investigated. Research participants were questioned about their approaches in practice. Project management standards were researched for their actual impact on handling complex projects; those standards were then reviewed to determine whether a modification is necessary to deal satisfactorily with complex projects.

Based on the above, a modification of project management standards shall be offered. This is done by developing a model that is similar to well-known models such as the sequences of development in small groups by Tuckman (Tuckman, 2001).

1.2 PHILOSOPHICAL VIEWPOINT

Quantitative principles strongly influenced this research design (Giddings, 2006). The researcher applied a mixed method approach. The survey represents the quantitative portion and the qualitative data was obtained via the focus group. Over time, the researcher developed a positivistic stance. The factual knowledge thus not based on a single observation, but was communicated and shared with others and supported by evidence. Research questions were tested by a careful analysis of the measures (Neumann,
The philosophical viewpoint positivism assumes independence, values freedom, operationalisation, generalisation, and reductionism (Easterby-Smith, Thorpe, & Jackson, 2012).

The literature review presented the causes for failed projects, which defined the criteria for this investigation. Research begins with a hypothesis that will be verified or invalidated based on the analysis of observations and phenomena (Easterby-Smith et al., 2012). According to Popper knowledge “can never be proven or fully justified, they can only be refuted” (Popper, 2002). So, the reasoning can be refuted if only one instance of negative evidence exists. The reasoning states only the evidence collected. Therefore, the explanations must meet two conditions: First, no logical contradictions are allowed; second, the explanations must be consistent with the observed facts that result from surveys and focus group interviews (Neumann, 2000).

1.3 **Procedure of the Research**

The phases of the literature review, the mixed case research (survey and interview), and the conclusion of this thesis are shown in Figure 1.

![Figure 1: Phases for execution of thesis (developed by author)](image)

In phase I, the target and motivation of the research and the management and complexity fields were defined; standards and methods were described by a review of the existing literature. Phase II, the one of the described project management standards and one method to control complexity were selected, suitable to the aim of this thesis. In phase III the survey and focus group interviews were performed for investigating optimal
handling of complexity in project management. Finally in phase IV the conclusion of the analysis and the next steps were stated.

1.4 Ethics in research
This research relied on the results of a quantitative survey and qualitative focus group interviews. All research participants were informed about the potential risks regarding the usage of their data (Silverman, 2009). The questionnaires were administered anonymously and participation was voluntary. Focus group interviews were conducted after a relationship of trust was established with the participants. Uncertainty about the process was addressed during a feedback session and solved mutually between the researcher and the participants. The names of interview participants were kept confidential (Simons, 2012).

Survey and interview data were stored electronically and notes were deleted after the end of the research degree. No data resulting from the surveys and interviews were used without the prior permission of participants. Security of all data was assured and published anonymously with the research findings (McNiff & Whitehead, 2011b).

The participants received no financial or other form of support.

1.5 Bias and limitations of the research
The first potential bias in this thesis could be the researcher's Project Management Institute (PMI) membership and an assumed preference for this organisation. The credibility of the PMI standard is demonstrated by its use worldwide; which is measured by PMI membership and quantity of certifications. PMI complies with universally accepted norms that are available in a variety of countries in many languages. The researcher's long standing relationship with this organisation affected this thesis in hopefully positive manner based on a familiarity of the standard structure. The design of the questionnaire and interview was based on the PMI standard. All major existing official standards for project management worldwide and their process were previously analyzed to ensure a common understanding of project management.

The researcher's experience as a consultant in project management, which included managing projects on the verge of failure, could influence the interpretation of the results. This limitation was reduced by the survey being constructed on the basis of an extensive literature review in project management and complexity. Only the participant responses to the survey were used. Mind-set of the participants during the survey was
not influenced. Data were stored electronically. Interviews were structured on the findings of the survey. Graphs of survey findings are always shown together with the questions for the interviews. These are documented in the interview guide. Open discussions between the interviewees were audio recorded and then extracted from the transcription. In the analysis, the findings of the survey, the interviews and the literature were compared; the researcher’s opinions and statements are clearly defined.

Second, the investigation could be biased because it is performed in a locally limited area (Germany) with one selected project management standard as a basis. This might impact the generalizability of the findings. But the selected standard was compared in its processes with other internationally accepted standards. Those standards are derived from a similar foundation and differ only in detail. Therefore, a “reverse engineering” to other standards should be given.

Surveys and interviews were performed predominantly with certified project managers. However, non-certified project managers were included (only eight participants out of 96). This fact could lead to different interpretations, but is seen as a marginal effect. These eight non certified participants are only a minority, but still experienced in managing projects. Further research was limited to Germany, possible that culture and values subconsciously influence the interpretation of results. In non-western cultures (differing from German culture) such as the Middle East or Asia, the interpretation of questions, the reflection and discussion of the survey and in the focus groups might lead to a minimal variation in the findings. But the selected standard (PMI) is worldwide used. It is therefore a cross-cultural standard, respecting cultural differences. Further globalisation leads to a unification of key issues in project management. This limitation to one standard and the focus on a localized area was necessary for a proposal of sufficient handling complexity.

Third, the survey was published primarily on the Internet, distributed via a link on a public PMI platform only in Germany, and via email; therefore, it was universally accessible. Theoretically, non-members of PMI and project managers from any other place in the world could participate if they chose. However, the decision to use a PMI platform based in Germany and conducted in the German language made participation of non-PMI members and strangers unlikely. The wide distribution of the survey also allowed Project Management Professional (PMP) certified individuals to examine the results of the survey and to give feedback about whether those results were applicable. The evalu-
ation of the survey was performed only with complete fulfilled questionnaires. 176 questionnaires were returned from out of approximately 4,900 certified PMI members in Germany (Lehmann, 2014), 96 were completed and sufficient for the research. This return rate of 3.6%, and respectively 1.99% of the basic population (certified members of PMI in Germany) could be although considered as acceptable for the purposes of this research. But all members of the basic population were contacted online and had the chance to participate in the survey. Participation was up to contacted participants itself. A pre-selection was performed, only fully completed questionnaires were used for research purposes. Questions were formulated to be neutral and were not influenced by the researcher's biases. Questions were formulated in a standardized way; therefore the answers were not impacted directly by the researcher. The findings were analyzed by statistical software and are reproducible.

Fourth, the Focus Group Interviews (FGI) were recorded via a mobile device. This allowed the researcher to focus more on the questions and the answers of the participants during the interviews. Afterward, these records were transcribed. Even using a high quality external microphone, white noise could be heard on the recording because the FGIs took place in partially open and public areas. Therefore, the answers were sometimes hard to understand. Three FGIs were performed in Germany. In the author’s view, this was a satisfactory sample because in each case no less than eight interviewees participated.
2 LITERATURE REVIEW

The research questions were formulated after completing a literature review of how management and complexity were treated in the past and how they are currently handled. The corresponding findings in the literature were cited. The literature review was generated according to the rules of the Cochrane handbook (Higgins & Green, 2008), which is generally used in scientific research.

Published theses, dissertations, and journals were cited. The Cochrane handbook is known for its focus on improved decision making by preparing, maintaining, promoting, and the accessibility of systematic reviews of evidence which underpins them (Higgins & Green, 2008).

The focus is on three factors:

– Identifying current knowledge in managing projects focusing on a PM standard.
– Identifying the gap and the characteristics and symptoms of the problem (Van de Ven, 2007) – in this case in managing complexity.
– Examine how complexity is treated using the existing methods and procedures, which might be integrated later into the modified PM standard.

With this systematic review according to the principles of the Cochrane handbook, a representative selection of studies was gathered that prevented a bias of the basic data. Furthermore, an attempt was made to consider all the necessary and relevant studies.

The processes for performing the literature review as a basis for research is listed in the following seven steps (Gough, Oliver, & Thomas, 2012):

1. Initiation
2. Review questions and methodology
3. Search strategy
4. Description study and characteristics
5. Quality relevance and assessment
6. Synthesis
7. Using results
The logical structure of the literature review was divided into management and complexity.

First, the field of management with its subfields of multi project management (MPM), project portfolio management (PPM), programme management (PgM), and project management (PM) was described. After defining all the subfields and setting up a comparison of the different project management standards, the standard that is used most commonly worldwide and satisfied the most requirements of the other standards was selected.

The second field was complexity. What do we mean when we talk about complexity inside a project, and how does the former affect the later? How can complexity be defined, illustrated, and made understandable? Different methods for handling and reducing complexity were discussed.

Keywords were listed in a mind map for the topic of project management and complexity management. Using these keywords, different online databases such as Emerald and Ebsco were searched, as well as those of PM organisations.

In addition to the research performed using databases, the researcher attended several lectures on complexity and management in order to gain more knowledge and to learn new approaches of managing complex projects. Subsequently, discussions ensued with specialists about the specific topics of this thesis.

During the course of this research, two books were published that address handling complex projects. These were the only books found that directly speak to the issues of the integration of project management and complexity. These books were considered as relevant for the review because they represent the first approach that tries to support project managers in complex projects. They were analyzed in detail, but were found to follow an approach other than the one used in this thesis.

A book edited by Hass, Managing Complex Projects: A New Model, includes some contradictions. Gary Gingrich (as cited in Hass, 2009) stated: “... science of complexity, however, does not yield answers, at least not in the sense that we have typically sought to describe our world and predict its events since the beginning of the Scientific Revolution.
What it does yield is a new way of thinking about the world…” This statement supports the concept that it is not possible to standardize the concept of complexity.

Hass (2009) believes that the traditional PM standard is still valid and effective. The strengtheners for complexity from Haas are: organisational/commercial change; risk, external constraints and dependencies; requirements volatility; problem/solution clarity; flexibility; urgency, etc. (Hass, 2009).

Hass (2009) suggested the following three steps for managing complexity:

1. Selection of right project manager
2. Selection of the right project cycles
3. Selection of the right management style

The ability of a project manager to handle complex projects is also based on his or her: level of experience, degree of knowledge, skill set, and leadership skills. For Hass (2009), the quality of leadership is related to soft skills like leadership, culture, being human, understanding staff needs, negotiation skills and political savvy, which are integrated with the experience and seniority of project managers.

Furthermore, she suggests selecting the right project cycle. These cycles depend on the level of complexity. However, it can be difficult to be objective when selecting the appropriate project cycle (see Figure 2). The level of complexity in a given project is a subjective measurement, and is based on an individual’s perception and the specific constraints of a project. The different project cycles should be used as a guide for how to manoeuvre through complex projects. Factors that impact complexity include: the number of contractors involved, project requirements, potential risks, and the duration of a project. Categorization is not possible because the attitude towards complexity varies for each individual project manager.

The first level concerns independent projects that follow a linear model. At this level, traditional project management standards can be applied. The second level relates to moderately complex projects that follow the linear model with the modification of small regular iteration loops within the project cycle (Hass, 2009). The third level should be applied to highly complex projects. The listed “eXtreme model” is based primarily on the approach of situational flexibility and the experience of the project managers (Hass, 2009).
Hass assigned the models mentioned above to different types of exemplary projects (detailed in Appendix I – Approaches of handling different types of complex projects): large, long-duration projects; large dispersed, culturally diverse teams; highly, innovative, urgent projects; ambiguous business problems, opportunities and solutions; poorly understood, volatile requirements; highly-visible strategic projects; large scale change initiatives, and significant dependencies and external constraints. These projects are not industry specific and cannot be applied in general. Nor do they indicate where to focus in projects on possible complexity strengtheners/ vulnerable processes.

Hass’s approach is an amendment where participants requested specific tools and methods for their projects how to overcome complexity.


This guide does not provide any tools for handling complexity, nor does it link to the current PMI Project Management Body of Knowledge (PMBoK V5). Therefore, the aim of this guide is not to improve the project management standard and does not relate to any processes mentioned in the PMBoK. The guide concentrates on stimulating critical
thinking about complex projects and indicates where to focus on emergent problems. This guide provides an assessment that is easy for managers to use. Scenarios and valuable practices are generated from the results of that assessment, and actions are recommended for reducing complexity. However, the assessment does not provide a categorization for the complexity of a project. The goal is to provide the manager with tools that will provoke reflection.

The practice guide *Navigating Complexity* is not linked with the existing standard and does not categorize complexity. This was also recommended in the focus groups and in the survey.

This issue raises the following questions: How can a user know that the given examples are pertinent to a specific project? Is it possible to apply the assessment to all existing projects in all industries? Does a limited project budget render the assessment inapplicable? These questions could elicit answers that might be difficult to analyze.

The basis for this guide *Navigating Complexity* is related to leadership, project management techniques, and strategic/business management. The project management standards of PMI can still be viewed as fundamentally valid. Although the strategic/business management is not part of this research; it can be viewed as valuable experience for project managers, but can be seen also as experience by the project manager. With experience, project managers gain skills in leadership and strategic management.

The guide provides the following recommendations for handling complexity:

- Prior project approval by risk assessment, reference as class forecasting and external audits
- Project manager and the project team must be matched to the project
- Understanding of the nature of the project must be given; experienced, qualified team and leadership/business skills are required
- Expert opinions and recommendations should be heeded
- Integration has to be managed effectively
- Focus should be set on change management
- Resilient mind-set has to be encouraged
- Oversimplification must be avoided
- Attention should be given to details because they could influence major changes
Reflective thinking has to be encouraged

The practice guide *Navigating Complexity* speaks to the theoretical and general influences of complexity. The PMI guide is related more to influence the behaviour of humans and systems.

Both Haas (2009) and PMI (2014) recommend the necessity for soft skills and an assessment to support the selection of the right scenarios/methods for definition of the next action (Hass, 2009; Project Management Institute, 2014). Also this thesis not only identifies specific strengtheners that generate complexity in a project, it describes the handling of complexity concerning soft skills, methods and systems. This procedure is situated in the middle of handling complex projects. Before the project manager selects the right method and defines the action, he/she and the project team must recognize the complexity of the project and identify the processes inside the project that are affected by complexity.

For handling complexity concerning soft skills, methods and systems, the stages of the Tuckman model constructing a team seems also suitable solving complex projects. Tuckman developed a model which describes the stages of group development. He describes five stages how a group is developed as follows (Tuckman, 1984):

I. **Forming** – Initiating the team  
II. **Storming** – Competition of various ideas for consideration  
III. **Norming** – Establishing rules, methods, behaviour, values and tools  
IV. **Performing** – Channelling the group energy into the task by interpersonal structure and flexible/functional roles  
V. **Adjourning** – Dissembling the team as task is completed

The similarity between his approach forming teams and managing complexity is that both cannot be predicted nor will be repeated in a similar way. The merit of Tuckman’s model is the flexibility of developing teams, similar to managing complexity. Even when Tuckman has described his model as linear, other describe it as more cyclic (Bales, 1965). Single stages overlap and the closure of a stage cannot be precisely defined. Similar characteristics exist for handling complexity.

For handling the rarely unpredictable complexity is created in a cyclic way according to the Tuckman model.


**Literature Conclusion**

Existing literature on handling complex projects speaks to the individual manager, the styles of management, and project handling. In addition, the focus is on assessing complex projects and providing scenarios that relate directly to specific projects. However, no link was found to existing project management standards. During the course of the extensive literature review, the researcher was unable to find work that defined how complexity could be manifested and where complexity could arise in projects. The review did not yield work that focused on the validity of using the current standards of project management to handle complex projects. Furthermore, a comprehensive view of handling complex projects that relates directly to this research was not uncovered in the existing literature. Therefore, the literature addressing complexity and project management was investigated.
3 MOTIVATION FOR THE RESEARCH

In 1959, the Harvard Business Review published the first known article about project management; *The Project Manager*, by Paul O. Gaddis (Gaddis, 1959). He described the role of a project manager and the type of a recommended training for managing projects (Ireland & Cleland, 2006).

Traditional project management was established in the 1960’s in the Department of Defence of the United States of America and NASA (T. Mayer, Wald, & Gleich, 2008). A variety of standards were developed based on the examination of concluded difficult projects. Therefore, a wide variety of different project management methods and standards are currently used worldwide. The current needs of project management are not served by the inconsistency of those standards (T. Mayer et al., 2008). "If we fish for absolutes in the seas of uncertainty, all we watch are doubts" (Hock, 1999, p. 225). Linearity as it has been used to date is not a viable solution for handling complex projects, which implies that traditional PM is not correct for handling complex projects.

Project managers must accept that not everything can be controlled in project management. A fallacy of traditional project management is that a manager can always understand, predict, and control an environment. The concept of individual empowerment needs to be transformed in project management (L. Crawford, 2013).

Today, managers frequently express surprise when projects do not turn out as planned. Since Gaddis’ 1959 article was published, project management has been the subject of many books and conferences. However, the estimated failure rate of all projects is above 30% and in sum 75% are not successful (M. Frank, Sadeh, & Ashkenasi, 2011).

The Chaos Report of the Standish Group (2010) stated that almost 75% of all projects fail because they do not achieve their objectives. This is a continuing development as shown by a comparison of recent statistics that refer to earlier chaos reports of the Standish Group (Holmes, 2001; King, 2005; Maylor, Vidgen, & Carver, 2008; The Standish Group, 2001).

A major reason for this development has been ascribed to complexity. It has been suggested that this is caused by increasing globalization, internationalization, and virtual-
ization of projects (Scheiter, Scheel, & Klink, 2007), which has occurred as a result of the growing dynamic nature of worldwide markets and heterogeneity of customers (Friedli, Werani, Thaler, Stieneker, & Kickuth, 2006). Complex projects are defined by having an interdependent relationship with users, technology, context etc. (Hass, 2009).

In Figure 3, the number of failed projects that has increased continuously since 2002. However, challenged projects and projects that have not been completed on time or within budget have decreased. Over 65% of all projects fail or are less than completely successful. Forecasts show that a turnaround is not in sight, due to the increasing difficulty and complexity of projects. It can be assumed that this trend will continue.

![2002 - 2008 project resolution](image)

Figure 3: 2002 - 2008 project resolution (source: The Standish Group - Chaos Report (2009))

These poor results could be caused by a variety of factors that originate with management. Managers might not be able to recognize early warning signs and the associated risks. Additionally, there might be a lack of understanding of complexity and the relationships of involved personnel (T. Williams, Klakegg, Walker, Andersen, & Magnussen, 2012).

This was confirmed by the Project Management Office (PMO) maturity study of the University of Erlangen-Nuernberg in 2009. This study was performed in large and small businesses in Germany and confirmed that 63.3% of all projects fail due to complexity (Amberg, Prinz, Sandrina-Arndt, & Thomas, 2009). Furthermore, the reports of PMI stated that “research, which is consistent with other studies, shows that fewer than two-
thirds of projects meet their goals and business intent and about 17% fail outright. Success rates have fallen consistently since 2008 (Project Management Institute, 2013).

Other studies forecasted challenges that would arise in project management over the coming decade. According to the 2011 IBM survey: “The essential CIO” stated that 3,018 managers (57%) expect a strong increase in complexity and changes within projects till 2017. Also in the Gartner survey of PMO leaders, 30% expect that the most significant change is requested for leadership of complex initiatives driving specific goals (Swanson, 2012). A survey of managers noted that one of the biggest challenges in contemporary business practice is the management of complexity, which is the result of a growing global network in economics, politics, and logistics (von der Eichen, Stahl, Odenthal, & Vollrath, 2005).

Examples from different industries can therefore be listed which challenged/failed in past (Flyvbjerg, 2014; Hass & Lindbergh, 2010):

- Suez Canal construction EG → overrun by 1900%
- Sydney Opera House construction AU → overrun by 1600%
- Montral Olympics sport CA → overrun by 1300%
- Concorde Supersonic aeronautic FR/UK → overrun by 1100%
- Furka Base Tunnel construction CH → overrun by 300%
- Boston Big Dig Artery construction US → overrun by 220%
- Copenhagen Metro transportation DK → overrun by 150%
- Shinkansen Joetsu transportation JP → overrun by 100%
- Bangko Metro transportation TH → overrun by 70%
- Mexico City Metroline transportation MX → overrun by 60%
- Acquisitioned R&D defence US → overrun by ~42%
- Mars mission NASA aeronautic US → overrun by 30%

This trend correlates to the revolution in information technology (IT) that occurred over the past several decades. Systems that were originally closed are now intertwined with others, which increases the complexity. For example, companies face more competition because customers use the Internet to search for and compare businesses that sell similar products and services (Sargut & Gunther McGrath, 2011). Because the IT revolution altered the business world by providing faster, cheaper and smarter solutions, business processes became more complex. In order to survive in a quickly changing environment,
companies created alliances, consortia, partnerships with suppliers, customers, key political groups, competitors, and regulatory entities (Hass, 2007; Thamhain, 2013). The level of ambiguity in projects increases as more people or organisations become involved and as different technologies are introduced by these mergers (Thamhain, 2013). Often it is not possible to predict the outcome of complex systems. While relationships can be identified in complex systems, planning is less reliable because a specific behaviour that occurred in the past may not occur in the future (Sargut & Gunther McGrath, 2011).

Hirschman stated that projects, such as those listed above, and megaprojects in general would not have been initiated if cost overruns could have been predicted (Flyvbjerg, 2014). To prevent those obstacles, this thesis shall provide an approach to identify possible complexity traps in the field of project management before they occur. A variety of factors can create complexity: internal aspects are behavioural and dynamic complexity; external aspects occur via stakeholder or interfaces to existing systems (T. Williams et al., 2012).

With increased complexity, projects benefit from complex system thinking (Remington & Pollack, 2007). Traditional project management methods are based on hierarchical lines of authority, centralized control, or repetitive jobs methods (Widemann, 1990). It should be understood that the traditional PM approach is plan-based, linear, and relies on the breakdown of a problem. Uncertainty and complexity are not included in the traditional approach (Swanson, 2012).

Over the past several years, one method that companies have used to reduce complexity is by creating platforms or building block systems for Research and Development (R&D) (T. Mayer et al., 2008). Complex projects compel team members to be open-minded and think about new possible solutions, which stimulates creativity, knowledge, curiosity, and promotes networking. Project management is rarely seen as a field of science; rather, it is viewed as a discipline that requires a specific set of practical skills. Project management is widely seen as adaptable to every class of business and type of project (T. Mayer et al., 2008). This attitude must be examined and transformed because current levels of knowledge are insufficient to achieve a satisfactory degree of success in today's projects. Management is the key for handling complexity (Baecker, 1997; Schueller, 1994; Schwaninger, 1989; Schwaninger & Koerner, 2001) and necessary for large com-
plex projects or undertakings to ensure success (Harrison & Lock, 2004).

Project managers need to be prepared for twenty-first century projects, which necessitate more aggressive time schedules and inflexible budgets. Furthermore, the requirements of contemporary projects are often ambiguous and poorly understood (Hass, 2009). To increase the successful completion of projects, both the management of projects and the complexity must be investigated. Relationships must be identified and proposals should be formulated that would enable better management of complex projects moving forward.

**Motivation conclusion**

The traditional belief is that everything can be controlled and predicted in a project and its environment (L. Crawford, 2013). However, increased globalization, and virtualization of projects causes a correlative rise in complexity and mirrors the dynamic nature of the markets (Scheiter et al., 2007). Both practical and academic studies have confirmed that the key problem facing project managers is the inability to recognize complexity and its early warning signs (T. Williams et al., 2012). This leads to projects with unsatisfactory results. Currently many companies try to control complexity by using a module structure on products; however, it is also necessary to prepare project managers for the unique demands of twenty-first century projects (Hass, 2009).
4 MANAGEMENT

This chapter starts with an introduction to management and its history, definition, and necessary skills. It is further divided into the different levels of management. Different hierarchies in managing projects are explained: multi project management, programme management, and project management. Here the motivation, method, target, and results are described for project management.

That section demonstrates the link between project management and management in general, and will show the similarity in the division of hierarchical levels in each entity. The special types of a managerial form have their origin in management as based on The Principles of Scientific Management by Frederick Taylor.

Based on the focus on project management in this research, the worldwide existing standards are compared and the most appropriate standard is selected.

4.1 MANAGEMENT – WHAT IS IT?

4.1.1 HISTORY OF MANAGEMENT

In 1911, Frederick Taylor introduced the term management in organisations and published the pioneering work, The Principles of Scientific Management. In his book, Taylor described the scientific basis of optimization in management, work and organisations. The intent of his work was to promote wide-reaching prosperity and to provide solutions for social issues (Taylor, 1967).

Management can be differentiated into “industrial management” and “social management.” The aim of “industrial management” was to utilize human, capital, and material resources in the most efficient way, and was based on hierarchies. Industrial management also handles machines for production, which lowered costs and increased profits (Weatherly, 2009). Henry Ford exemplified this type of management when he introduced the assembly line in his car factory (1913). The same approach was followed by Henri Fayol and Mary Parker Follett. These early managers avoided categorizing human beings on the same level as material and capital. At the time, the management was considered to have greatest impact on a company by forecasting, commanding, coordination, planning, organizing, and controlling. Mary Parker Follett stated that management
is the art of getting things done by people (Barrett, 2003; Golden Pryor & Taneja, 2006).

As the industrial style of management expanded into the social environment, the human being became a subject of greater focus (Mayo & Proske, 1949). In the 1930’s, investigations at the Hawthorne factory showed that work performance depends on objective restrictions, such as industrial restrictions, and also on human and social restrictions, the “Hawthorne effect” (Mayo & Proske, 1949). Society moved from an industrial era to a service-orientated era. Competition started to speed up with faster growing markets, internationalization, and the faster development of new products. With the development of “social management,” the human being was no longer treated as a resource like machinery. Humans were established as being central to an organisation. Fair treatment was considered as a right, and considerations were given to an employee’s private and social life. Daily work life became characterized by co-operative planning, acting, and reciprocal influence (Weatherly, 2009).

The management field was divided into branches such as: human resource management, operations management, strategic management, marketing/ sales management, financial management, and information technology management. These six branches of management combine planning, organizing, staffing, directing, controlling, and motivation of their employees. Today, this approach to management is still being used within organisations.

4.1.2 Definition and Skills of Management
Management has its semantic roots in the Latin phrase *manum agere*, which means “guiding with the hand” (Waite & Hawk, 2009). Malik (2007) supported this definition and Weatherly’s “social management”: Malik argued that management is much more than guiding. The management of an organisation must be concerned with communication and should assess and include an individual’s talents and skills in its development (Malik, 2007).

Employees represent assets to an organisation. The knowledge and experience of each individual can be harnessed to improve the entire organisation (Malik, 2007). Managers deal with the structural conditions within an organisation and determine clear targets, instructions, and key performance indices (KPIs). They also know the importance of motivating and coordinating people and must avoid the continuance of failures.
Management cannot be reduced to a single aspect, such as guiding employees or business administration. Management is dynamic and diverse in denotation and practice (Brudney, O’Toole, & Rainey, 2008; Malik, 2007; T. Mayer et al., 2008). Therefore, managers tend not to be specialists, but skilled in many areas. Unlike specialists, effective managers need to have an understanding of a multitude of functions; for example, the design and development of complex and productive social systems. In order to maintain an effective working relationship with specialists, managers need to maintain a working knowledge of an individual’s area of expertise (Malik, 2007).

Today, effective managers are expected to have a resilient personality, social competence, method competence, and project expertise. The manager shapes an organisation and provides the guidelines of communication with personnel (T. Mayer et al., 2008). Malik illustrated management in his model of “St. Gallen.” His recommendations for management competencies are closely related to those of Mayer. The internal tasks of management include: defining targets; choosing measures and instruments (for strategy); sustaining culture with responsibility, guidance, and knowledge (for culture); and maintaining structure with processes and consistency (for structure). Externally, these virtues are surrounded and influenced by the environment of the organisation, its culture/ politics, and its governance (Malik, 2007). The lists suggested by Mayer and Malik are similar and are best used in combination with each other because Malik does not mention basic knowledge and Mayer omits the external influencing factors and the strategic aspect. A combined graph is shown in Figure 4, where all virtues of modern management and their different influencing factors are integrated.
In an organisation, management influences and shapes the internal atmosphere or culture, and the governance of the external environment. Alternative management is influenced by its environment externally and internally by the employees. In Malik’s (2007) “St. Gallen” management model, communication between employees and management is required in order to avoid misunderstandings and to improve teamwork (Malik, 2007).

4.1.3 **MODES OF MANAGEMENT**

Different modes of management exist: entrepreneur, adaptive, and planned (Wirtz, 2010). The target of the entrepreneurial mode is growth. Because decisions are made in an unstructured way, they can be risky but proactive for small business. One advantage of the entrepreneurial mode is a high degree of flexibility, which is appreciated by investors and allows for a high level of adaptability (Wirtz, 2010).

The adaptive mode of management is based on a willingness to adjust strategy. The adaptive mode of management does not include a defined vision or specific guidelines
for decision making. Managers aim to achieve a consensus with all stakeholders. Reactive decisions are not linked together; the strategy and decisions can be formulated step-by-step and quickly adapted to the requirements of stakeholders. All in all, this mode is characterized by a short-term orientation (Wirtz, 2010).

The third mode of management is the planning mode. The target here is to achieve maximum efficiency by realizing large scale effects. The planning mode of management is based on several prerequisites, including: clearly defined and stated targets that are linked together across the entire organisation, a stable situation for the organisation, and proactive and reactive decision making that is based on an analytical method and long-term planning. This situation is mostly seen in big business (Wirtz, 2010).

To handle large businesses, the three modes are often mixed. They can be linked to different stages of development (Wirtz, 2010):

1. Growth: entrepreneurial mode
2. Implementation: adaptive mode
3. Degeneration: planning mode

Different constellations of power inside a business use different decision-making processes; therefore, they adopt different modes. The entrepreneurial mode of management can be illustrated by the following example: the head of a research and development department might have linked some personal interests to certain risky decisions (Afuah, 2003). Production operates in a planning mode intended to realize growth by using scale effects, whereas marketing operates in an adaptive mode because the stakeholders have a strong influence on short-term adaptation (Wirtz, 2010). Another example of the adaptive mode is the implementation of the electronic stabilization program (ESP) system in the Mercedes Benz A Class, after the vehicle failed to pass the Elk Test. The car did not keep the lane stability at a speed of 50 km/h and 80 km/h. Afterwards Mercedes started a campaign promoting the vehicle as the safest compact car in the world.

4.1.4 LEVELS OF MANAGEMENT
The three modes of management described before are practised at three management levels. Kleiman (2009) divided them into top-level management, middle-level management and first-level management. Brudney et al. (2008) and Moore (1995) distinguished between three management directions: outward management, upward management and
downward management.

The first, outward management defines domains of autonomy and space where an organisation can operate in the field of its political environment. This corresponds to Kleiman’s (2009) top-level management. The second, upward management connects the downward management to outward management by networking and preparing data such as KPIs and other variables. Thus, the upward management level is equivalent to Kleiman’s (2009) middle-level management. The third, downward management represents the cooperation of employees with no management function who plan the organisation’s work. It involves the institutional environment and the company’s culture. Table 1 shows a synopsis of the three management levels in nomenclature and content according to Kleiman (2009), Brudney (2008), and Moore (1995). In terms of the significance of decisions, the top-level management represents strategic management, the middle-level management represents short-term strategic or tactical management, and the first-level management represents operative management. In large organisations, management levels can be made more complex by the addition of levels or staff units.

<table>
<thead>
<tr>
<th>Definition by Level</th>
<th>Strategic</th>
<th>Tactical</th>
<th>Operative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>top-level management</td>
<td>middle-level management</td>
<td>first-level management</td>
</tr>
<tr>
<td>Kleiman (2009)</td>
<td>outward management</td>
<td>upward management</td>
<td>downward management</td>
</tr>
<tr>
<td>Managers normally belong to the Board of directors, Vice President, CEO etc. They are mainly responsible for controlling of all internal departments which is a system of own component strategy like financial strategy, technological strategy, market strategy, sales strategy etc. and developing strategic goals which needs to be unison with the internal and external political environment of the organization.</td>
<td>General managers, branch managers, department managers, program manager, portfolio manager are members of the mid-level/ upward management section. They execute the organization’s plans in conformance with the companies’ policies. For demonstrating the gap between the strategic level and the operative level, they define and discuss the information and policies from the top management and break them down to managerial pieces. It is important that they inspire and provide guidance to the operative level management. In instrumentation for guidance and inspiring are reward systems supporting the cooperative behavior and group level performance indicators. The tactical level is the execution instrument for the strategic level and is therefore functional and ideal for implementing the chosen strategy within the organization.</td>
<td>On operative level we will find supervisors, section officers and foreman and project managers. By focusing more on controlling and direction on management functions, they define together with the employees single work packages which are than assigned to them. It is a guiding and supervising task on a day by day activity. It is important for employees that the priorities are not changed arbitrarily, otherwise babel and resistance could come up. On the other side the planning in the operative level is not allowed to be too static as failures would spread out rapidly. It must be a well-tuned mixture in planning of flexibility and static. Besides this they make recommendations, suggestions and communicate as a megaphone of the employees to the next level above → the operative manager officiate as an “image builder” considering that they are the only ones who can build up the communication between higher management and employees.</td>
<td></td>
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Table 1: Management levels: nomenclature and content (based on Kleiman, 2009; Brudney, 2008; Moore, 1995)
4.1.5 **SUMMARY OF MANAGEMENT THEORIES AND PRINCIPLES**

In conclusion, since the beginning of the twentieth century, management styles have changed dramatically. However, management is still based on approved qualities and is affected by its environment. A changing environment leads to the increased complexity of projects. Consequently, the management methods described above are not adequate for handling complex projects. Complex projects require multi-project management. The main goal of this work is to show the handling of complexity within a project. The next step is to define multi-project management more precisely beginning with portfolio project management as top level or strategic, down to project management as first level management or operative.

4.2 **MULTI-PROJECT MANAGEMENT (MPM) – STRATEGIC AND OPERATIONAL APPROACH**

4.2.1 **DEFINITION OF MPM**

The term is composed: “multi” means more than one or many; “project” – is a defined enterprise with a definite beginning and end; “management” means guiding. Therefore, multi-project management can be defined as the act of guiding many onetime enterprises with a definite beginning and end. According to Hugh Ryan from Anderson Consulting, guiding and controlling of all projects in a company has acquired an increasing importance in recent years. MPM is a critical issue for competing in today's economy (Dinsmore & Cabanis-Brewin, 2011; Pennypacker & Dye, 2002). In practice, MPM is normally conducted by a project management office (PMO) (T. Mayer et al., 2008; Pennypacker & Dye, 2002). MPM guarantees an efficient and effective management by providing direct or indirect support for all projects. Indirect support consists of the professionalization of project management by creating a project landscape where the success factors such as roles, structures, processes, methods, communication models and systems, and incentive systems are clearly defined (T. Mayer et al., 2008). The PMI defined the PMO in the following terms: “An organisational body or entity assigned various responsibilities related to the centralized and coordinated management of those projects under its domain” (Stackpole et al., 2008). A major advantage of a PMO is centralized coordination, which fosters increased performance from the projects because the project leader, line manager, and the PMO are communicating on the same level (T. Mayer et al., 2008). In general, specialized engineers should not belong to the PMO because their focus is on the specific details or internal structure of a project. The overview of the project must be kept in focus in order to perform efficient decision making in are-
as such as the prioritization of resources.

4.2.2 **Content and Requirements of MPM**

MPM is divided on a hierarchical basis into project portfolio management, programme management, and project management. MPM operates between the strategic level or portfolio management, which is responsible for an adequate project portfolio; and the operative level or project management, which is responsible for an economic realisation of projects. Figure 5 shows the hierarchy of MPM with an increasing strategic influence from PM up to PPM. This figure was confirmed by Lester's (2007) work. He mentioned that the PPM is similar to programme management (PgM), except that the projects within a portfolio are not necessarily be linked to each other. In large organisations a PPM is responsible for several programmes, whereas in smaller companies a PPM can directly control a number of projects (Lester, 2007). Verzu (2008) confirmed this model and mentioned the environmental influences on MPM that emerge from technologies, people, processes, and the organisation. Dinsmore (2011) described the operating tasks slightly differently, stating that the MPM/PMO operates on three different stages; therefore, it has different types of PMO’s. The highest level is arranged next to top-level management as an organisation of its own, which is shown by Mayer as portfolio management. The middle level is installed as a Business Unit project office for supporting a Business Unit's projects, which is shown in Figure 5 as programme management. In Dinsmore’s (2011) view, the lowest level of MPM/PMO is the project control office. This office is directly involved in daily project business. It is equivalent to Mayer’s Project Management level. Mayer even mentions this level on a further lower level of subprojects (Dinsmore & Cabanis-Brewin, 2011; T. Mayer et al., 2008). In appendix III a possible link between project portfolio management (PPM), programme management (PgM) and project management (PM) is shown.
Each field of MPM has its own governance (Müller, Martinsuo, & Blomquist, 2008). The strategic level in PPM has more involvement in sharing resources and the organisation’s strategic goals. PgM is more concerned with the common objectives for single projects (Müller et al., 2008).

But on each level of MPM, the tool, method and process kit remains the same as a consulting and service tool for project, line and top managers. Mayer argued that, if the MPM or PMO is to perform its consulting and service role effectively, its functions must include the following (T. Mayer et al., 2008):

- administrative function (handbooks, documentation and support of project planning)
- control function (control of milestones, risk management and rapid alert system)
- coordinating function (coordinating portfolio, resource and scheduling management by using synergetic effects)
- optimising function (performing standardisation, knowledge management and...
PPM is described as one way to realise MPM (Dinsmore & Cabanis-Brewin, 2011). In addition, Figure 6 shows a summary of all core competences and tasks for an MPM. The MPM includes a complete bundle of tasks. Core competences are the optimization of: project portfolio, development of professional competence and leadership skills, resource planning and definition of processes, and methods and standards. The methodology, processes and methods, of MPM/PMO is similar to PM (Pennypacker & Dye, 2002): MPM manages a bundle of projects that harmonize and support projects of various departments (T. Mayer et al., 2008).

Figure 6: Core competences and tasks of MPM/PMO (summated by author)

MPM/PMO competences and tasks are on a higher management level than the competences and tasks of PM. MPM/PMO is involved in different tasks and competences in a widely spread field in a matrix organisation. It is complicated by interwoven duties and responsibilities. Not every stakeholder’s interest will be achieved all of the time within a MPM/PMO environment. For instance, customer projects might not be started immediately if resources are not available or cannot be shared with other projects. Other projects might have a higher prioritization and deserve more attention from management (Dinsmore & Cabanis-Brewin, 2011). MPM/PMO typically operate in a relationship that lies between friendship and enmity. For governance of top management, MPM/PMO must bring transparency into the project landscape, (e.g. by producing decision papers). This can be measured by the level of quality of data and their presentation as provided by project management. On the other hand, for project managers, MPM/PMO offers methods, instruments, and support for creating a project management culture. This is done only at a consulting level. Work effectiveness can be measured by the satisfaction
of the project side (T. Mayer et al., 2008).

Maintaining the authority of MPM/PMO is essential because it operates in a large arena. In the American Management Association Handbook (AMA), Dinsmore and Cabanis-Brewin (2011) specified that the executive board should support MPM/PMO and that direct involvement is necessary for understanding. T. Mayer et al. (2008) asserted that the support is also necessary from the Chief Project Officer (CPO), who is the director of the PMO and ensures a high level of competence of the PMO. While the executive board will not always be directly engaged in MPM/PMO, it can assist PMO positively in other ways.

In addition to the common direct support of the executive board, a clear distinction between PM and MPM/PMO is an indispensable prerequisite. The MPM/PMO team needs to have the relevant and appropriate qualifications. They must define which projects are supported by the MPM/PMO, and whether to include all of them or only selected ones. Project launch should be realized successfully and approached from the bottom-up to guarantee the suitability of daily use.

It has been shown that the MPM encompasses the entirety of managing portfolios, programmes, and projects. For this research, the specific tasks and competences of project management will be explained. PPM and PgM are explained in the appendix.

4.2.3 PROJECT MANAGEMENT (PM) – OPERATIONAL APPROACH

Definition of PM

PM is the lowest level of MPM and has the least strategic influence (see Figure 5).

PM is composed of the words “project” and “management.” The connotation and denotation of these terms have been defined differently by a variety of authors and organisations. Figure 7 shows the definition of project and management and the composition of both by various authors (Aichele, 2006; Brandon, 2006; Cleland & Gareis, 2006; Dobiéy, Köplin, & Mach, 2004; Hedeman & Seegers, 2009; Jankulik et al., 2005; Kerzner, 2009; Koehler, 2006; Lester, 2007; Litke, 2007; Pfetzing & Rohde, 2009; Sanghera, 2007; Stackpole et al., 2008; Verzuh, 2008; Weatherly, 2009).
Figure 7: Definition of project management (developed by author)

All definitions of PM have been summarized above and include: planning, controlling, steering, and the organisation of a limited time endeavour, which creates a unique product. Differences can exist in other aspects. In projects these are for example: funding limits, certain requirements, consumption of resources, activity/ work packages, complexity.
Motivation of implementing a PM

Today many international companies require approved standards for projects as published by associations like International Project Management Association (IPMA), PMI, Project and Programme Management for Enterprise Innovation (P2M) etc. (Ireland & Cleland, 2006). The motivation to implement PM can be triggered by several factors such as complexity, avoiding problems and risks, uniting stakeholder, efficiency, implementation of new or changed processes, products or services, and survival in the economy.

Complexity can be the motivation for implementing PM, particularly with projects that have frequently changing requirements and/or operate with company-wide teams. Innovation in projects can also raise complexity (Wendler, 2009). PM is necessary for complex assignments because complexity raises uncertainty, risks, and requires multidisciplinary efforts (Hamilton, 2004).

An explicit purpose for projects must be defined in order to avoid problems and risks; this is best achieved by PM (Hamilton, 2004). Problems in projects often occur because of a lack of customer involvement, poor coordination, inadequate communication, insufficient planning, a lack of a progress, and substandard quality control. Those mistakes in project management can result in unclear direction, project delay, unavailable resources, budget overruns, and poor quality (Bentley, 2010).

The problems mentioned above can lead to a total collapse of the project (Weatherly, 2009), which can be avoided or decreased by the implementation of PM (Bentley, 2010).

Another motivation to implement PM is caused by a need to increase efficiency. PM ensures the economical use of resources, delivering the predetermined benefits and products; it achieves a greater efficiency with fewer risks and less uncertainty (Ireland & Cleland, 2006).

PM is also a necessity for economic survival. A rapid change that occurs under controlled situations creates a future demand that can be easily handled by a PM. Competent management detects the need for newer, better practices, and techniques for executing the work. Therefore, PM is synonymous for driving force that enables a faster, quicker, and
cheaper way to achieve goals and to survive in the global economy and network. Organisations can remain competitive and improve continuously by using modern PM methods (Ireland & Cleland, 2006).

The development of new products, changes in products or alterations to organisational processes and services provide further justification and motivation for PM. No simple rule exists for when to implement a PM. Planning and execution must be adapted to change situations (Ireland & Cleland, 2006).

Finally, PM should guarantee the unity of the stakeholders of a project. All stakeholders of a project must have the same objective and should not establish individual empires. PM prevents this and compels alliance (Hedeman & Seegers, 2009).

**Method of PM**

Before PM can be initiated, the project and its targets must be announced and communicated by the management. All involved people have to recognize that PM supports a project (Masing & Pfeifer, 2007). Therefore, greater stakeholder involvement is necessary. When PM is properly implemented in the organisation, project resources are used efficiently and the strategic target is realized (Ireland & Cleland, 2006).

PM is established in an existing organisation. The organisation strongly forms and influences the planning, directing, controlling, coordination, motivation, teambuilding, welfare, administration, and communication of the project (Harrison & Lock, 2004). Different possibilities of organisation are available. PM can exist in a functional, matrix, and/or projectised organisation. Table 2 describes those classifications in detail and presents different views from several authors who agree that PM is suitable for organisations in those categories.
The functional organisation is a model that has a well-defined hierarchy. The project team reports directly to the functional manager, such as the leader of a division (Figure 8). Very little administrative staff is necessary to handle the project. The division is based on labour and an individual’s position is determined by their technical competence. Its procedures depend on the work situation and the rules define the rights and duties of personnel. Each division is independent (Hamilton, 2004; Sanghera, 2007; Stackpole et al., 2008).

![Table 2: Organisations for PM (developed by author)](image)

The functional organisation is a model that has a well-defined hierarchy. The project team reports directly to the functional manager, such as the leader of a division (Figure 8). Very little administrative staff is necessary to handle the project. The division is based on labour and an individual’s position is determined by their technical competence. Its procedures depend on the work situation and the rules define the rights and duties of personnel. Each division is independent (Hamilton, 2004; Sanghera, 2007; Stackpole et al., 2008).
The most common structure for projects is the matrix organisation. It can be displayed in three different variations (Harrison & Lock, 2004; Kerzner, 2009; Stackpole et al., 2008): the weak, balanced and strong matrix organisation. All three variations are outlined in Figure 9.
A matrix organisation integrates individuals, groups, and divisions across boundaries into a unit. Therefore, it is flexible and appropriate for linking together many divisions and companies on large-scale projects. It creates its own identity, which is necessary to manage the project by developing the team, dealing with conflicts, arranging communication, coordination, and handling information (Harrison & Lock, 2004). This type of organisation needs a project manager; however, the project manager is not assigned full authority over the project and its funding by the matrix (Stackpole et al., 2008). He or she must share the competencies with a functional manager (Litke, 2007).

A matrix organisation also has disadvantages. Potential confrontations about priorities can occur between the managers or other companies. Because authority is divided between the project manager and the functional manager, a gap can occur in the leadership of a project (Ireland & Cleland, 2006). Balancing the objectives of the project versus the aims of the functional divisions can also cause difficulties in all management levels (Hamilton, 2004). This affects the teams and impacts the loyalties of individuals from both parties. Communication must be given great consideration, particularly when dif-
ferent departments are located far apart from each other. In matrix organisation, more time must be invested to ensure a balance of power between the different parties (Lester, 2007). These advantages and disadvantages emerge with varied intensity depending on whether the matrix organisation is categorized as weak, balanced, or strong. The weak matrix focuses more on the functional concept, whereas the strong form of matrix organisation is more orientated on the project organisation as discussed in the following section.

The PM in projectised organisation is the strongest form of management. The team works full time on the project and the manager has full authority over the team (Sanghera, 2007). Therefore, the team is often brought together at one place for the duration of the project. Reports are directed to the project manager, who acts independently for the most part (Stackpole et al., 2008). Short lines of communication provide more success. Short lines of communication are also caused by the simple and flexible structure of the project organisation. Problems only might occur in projectised organisations when PM runs isolated with other projects; then synergies cannot be used as efficiently as in a matrix organisation. This is critical in high technology areas (Hamilton, 2004). Figure 10 gives an example for a projectised organisation.

![Project coordination diagram](source)

Figure 10: Projectised project organisation (source: A Guide to the Project Management Body of Knowledge, 2008)
Influences and forms of PM in different organisations are shown in the PMI table below (Table 3). Depending on the organisational form, the authority of the project manager increases from low (functional), middle (matrix) to high (projectised) (Verzuh, 2008).

Table 3: Organisational influences on projects (source: A Guide to the Project Management Body of Knowledge, 2008)

Verzuh (2008) described the selection of the appropriate PM as a competitive advantage for an organisation. The following key aspects determine the selection of PM (Verzuh, 2008):

- Authority given to the project manager.
- Communication, crossing organisational boundaries and keeping all stakeholders informed.
- Priorities competing for limited quantities of resources like funding, equipment, and people.
- Focus, the attention of a project by people and how much time they spend on it.
- Chain of command, giving the authority to people and having a short reaction time for decisions on problems.

Every PM needs a steering committee, which assesses the aims and results of a project, supports it with resources, and eliminates disruptive factors. The project team is more engaged in the development of the project, the process of the project, and the management of business processes (Masing & Pfeifer, 2007).

The project progresses in distinct phases that are combined into the “project life cycle” (PLC). This starts with the initial phase, which is also termed as the initiating phase, the
concept phase, the definition phase, or the ramp-up phase. It follows the organizing and preparing phase, which can also be termed planning or developing. The executing phase follows and includes the designing, purchasing, and fulfilment of a project. The PLC ends with the closing phase in which the delivery and termination of the project outcome is performed. The terminology used to describe the phases varies slightly depending on the author. Those differences are shown in Figure 11 (Cagle, 2004; Ireland & Cleland, 2006; Kanabar & Warburton, 2008; Kerzner, 2009; Lock, 2007; T. Mayer et al., 2008; Pfetzing & Rohde, 2009; Sanghera, 2007; Stackpole et al., 2008; Verzuh, 2008). Each phase of PLC is added to by deliverables and tasks. Deliverable in the first phase is a project charter; in the second phase, a project management plan; in the third phase, the final product; and in the fourth phase, the archiving of project documentation.

Figure 11: Project life cycle with its phases, deliverables and tasks (developed by author)

Project life cycles depend on product or service to be delivered. The standard PLC is shown in Figure 11. Phases of PLC are often sub-partitioned into “knowledge groups” for improved handling. Many authors include the following in knowledge groups: communi-
cation, scope, cost, time, risk, quality, procurement, human resources, and integration (Cleland & Gareis, 2006; Hamilton, 2004; Sanghera, 2007; Stackpole et al., 2008).

In the single phases of PLC, distinct work packages are described. These tell the stakeholders what they have to work out in detail, what resources they have to use, the available budget, the timeframe, and the next work package (Ireland & Cleland, 2006). Stakeholders are people involved in the project. It might be a single person such as an engineer or customer, or it can be a whole department or organisation. Figure 12 shows stakeholder parties, individuals or groups, that influence and form the project (Kanabar & Warburton, 2008; Pfetzing & Rohde, 2009; Verzuh, 2008).

![Figure 12: Stakeholder of a project (developed by author)](image)

Special skills and competencies are required for project managers to manage the project successfully (Brandon, 2006; Cagle, 2004; Hamilton, 2004; Kerzner, 2009; Litke, 2007). These are summated in Figure 13.
Figure 13: Skills and competencies for project managers (summatied by author)

The worldwide standards that exist for using PM. Main PM standards are:

- PMI (Project Management Institute)
- CMMI (Capability Maturity Model Integration)
- PRINCE2 (Project IN Controlled Environments)
- P2M (Project and Programme Management for Enterprise Innovation)
- ICB3.0 (International Competence Baseline)
- AIPM/ NCSPM (Australian Institute of Project Management/ National Competency Standard for Project Management)
- SAQA/ PMSGB (South African Qualification Authority/ Project management Standards Generating Body)

Further details about these standards are given in the appendix. They are partly based on the three existing international norms for project management: DIN (Deutsches Insti-
tut für Normung) 69901, ISO (International Standard Organisation) 21500 and BS (British Standard) 6079. A full explanation of those norms is given in the appendix.

**Target of PM**

The target of project management is to control and balance the six factors: scope, quality, schedule, budget, risks, and resources for the successful performance of the project. In the literature these factors are identified as shown in Figure 14. The problem of managing is to respect all these factors equally. For example, reducing the timeframe for completion can negatively influence the factors quality and scope; however, it might have a positive impact on resources and budget. All cited authors emphasize three factors: schedule, budget, and scope or alternatively, quality. These combined factors are known as the “magical triangle.” (Aichele, 2006; Cleland & Gareis, 2006; Dobiéy et al., 2004; Harrison & Lock, 2004; Kerzner, 2009; Lester, 2007; Litke, 2007; Lock, 2007; T. Mayer et al., 2008; Stackpole et al., 2008; Verzuh, 2008). Only PMI states the above-mentioned six factors, which are known as the magical hexagon (Stackpole et al., 2010).
Figure 14: Balancing the magical hexagon (developed by author)

The ability to balance these factors is founded on experience. PM must operate proactively, not reactively. The latter is acceptable only in unexpected events or accidents.
For this purpose, management must know the targets and borders of the project, which should be openly and directly communicated to stakeholders (Jankulik et al., 2005; Pfetzing & Rohde, 2009). PM’s target is also affected by soft factors like guiding and motivating the team in the actual situation and adequate planning (Pfetzing & Rohde, 2009). Lester (2007) suggested the following criteria to support the target of balance (Lester, 2007):

- Clear objectives are stated at the beginning
- Support by top-management and sponsor are given
- Tight financial control
- Comprehensive quality control procedures
- Good contractual documentation
- Good client relationship
- Well internal and external communication

The target of PM should be the satisfaction of the stakeholders, but should also provide support for actions that benefit an organisation (Brandon, 2006).

**Measurement of PM efforts**

Measurement shows whether a project was successful and if the stakeholders and sponsors expectations were met. One of the first methods for measurement was developed in 1978, and is called “site man-hours and costs” SMAC (Lester, 2007). This instrument gauges the number of production hours and the costs that were generated in a given project. Another measurement for PM efforts is a baseline. Specific targets in the past are defined and compared to actual performance. Baselines check cost, schedule, and scope, which are used to determine whether the project proceeded as planned (Sanghera, 2007). For measurement in a project Lester (2007) established KPIs, which can be defined as milestones, requirements, economic figures, etc. (Lester, 2007).

In addition, Lock (2007) introduced milestone trend analysis (MTA) in which single milestones are checked and the actual milestone dates are compared with the original target dates. A divergence in MTA can easily show if the target has been met or not (Lock, 2007).

Another method used to measure successful PM efforts is earned value management (EVM). EVM is defined by the cost performance indicator (CPI) and the schedule per-
formance indicator (SPI). In Figure 15 the setup of the formulas of the EVM are described (Brandon, 2006; Lester, 2007; Lock, 2007; Sanghera, 2007; Stackpole et al., 2008).

**Figure 15: Description of EVM (developed by author)**

In addition to measurement that is calculated with hard data, Brandon (2006) introduced satisfaction factors. These are not always hard measurements, and are more frequently soft measurement factors. They are normally arranged in fixed intervals and typically assessed when the phases end. Satisfaction is not only measured in stakeholders, but also for customers. It influences the decision to go, kill, or hold a project. (Brandon, 2006)

**Result of PM**

Effective PM results in a successful project. Users of PM are guided and are informed as to what they can expect to do and what the result will be. The standards of PM should be reproducible to ensure that they can be applied to different projects. A good PM results in (Bentley, 2010):

- Less time or performing the project in at least the estimated time
- No overrun of costs
- Delivery of the exactly requested product
- Product of adequate and confirmed quality
- Transparency at all stages and actual status known by management
Additionally, PM should account for the expectations of the customers (Verzuh, 2008). In Verzuh’s (2008) view, because the customer is the final judge of a project, customer satisfaction represents success even where the schedule and/or budget have not been executed as planned. PM has to provide the customer with realistic expectations and follow through with those during the course of the whole project (Verzuh, 2008). A good PM results in transforming resources into a product/service for the customer and minimizes the effects and after-effects of setbacks. Everything is done in a planned and coordinated way (Cleland & Gareis, 2006). PM minimizes the effects of disasters by using potential trade-offs of a project and by being aware of when objectives can no longer be met or the execution is impossible (Kerzner, 2009).

**Excursus on the maturity models**

Maturity models benchmarking PMs capability for an organisation. They push the development of target-orientated PM (Pennypacker & Grant, 2003). Maturity models originated in software development and are intended to evaluate the execution of processes (Cooke-Davies, 2007). A clear definition for maturity models is nowhere stated, only a description for usage and a rough structure of the setup (K. Crawford, 2002; Kerzner, 2001). Further details for the rough structure are described in Appendix VIII – Project management method “capability maturity model integration” (CMMI). The maturity model in the appendix is one of the most well-known models in the world and is often the basis for other models worldwide (Cooke-Davies, 2007; Paulk, Curtis, Chrissis, & Weber, 1993).

The benefits of a maturity model as stated by Cooke-Davies (2007) as follows:

- Understanding the necessary processes for successful project management
- Specific improvement on project management processes to get the next level of the maturity model
- Self-evaluation of one’s capabilities and processes as related to project management
- Implementation of project management processes across project portfolios and programmes over the whole organisation

An evaluation of the processes helps to identify their strengths and weaknesses, and lends insight to improve them. As an outcome, maturity models are the basis for benchmarks (Cooke-Davies, 2007; Judgev & Thomas, 2002). Ibbes, Reginato, and Kwak (2007)
identified an increased value of time and cost savings at higher stages of the maturity level. This represents a first step of investing into improving processes, which provide benefits in the future. Additional possibilities for cost savings emerge at a higher level, which will amortise the investment and continue the improvement of processes (Ibbes, Reginato, & Kwak, 2007). This is also a target of the maturity model.

**Project management: Conclusion**

Project management is the planning, delegating, controlling, steering, and organisation of a project intended to achieve a result positioned within agreed criteria, cost, time, and performance. Organisations are motivated to implement PM because they expect to increase the efficiency and decrease the risks of a project; simultaneously, PM binds different stakeholders together. This enables an improved capacity to survive in the global economy. PM is implemented in an existing organisation by a functional, matrix, or projectised orientation. The project itself is orientated on a PLC with the four phases of initiating, planning, executing, and closing. Knowledge groups represent the structure of the project, which is managed by a project manager with special characteristics and competences. The overall target of a project is to balance the magic hexagon using the factors of scope, quality, schedule, budget, resources, and risks. The successful performing of those tasks results in the satisfaction of sponsors and stakeholders involved with the performing and benefiting organisation. The success of PM can be measured by hard facts like KPIs, MTA and EVM; it can also be measured by soft facts like the satisfaction of the customer and the sponsor. The standards of PM are replicable methods.

**4.2.4 SUMMARY OF MULTI PROJECT MANAGEMENT**

The basis of MPM is the same as the original definition of management. Like management, MPM is also subdivided into three levels but is based on projects. In the field of management, the divisions are: top-level management (strategic), middle-level management (tactical), and first-level management (operative). The same level is valid for MPM: top-level management represents the strategic approach of PPM, middle-level management represents PgM, and first-level management represents PM. All three levels depend on and profit from the competences of MPM: resource planning, optimization of projects, definition of processes, procedures, and the development of professional competences.

PPM (see Appendix II – Project Portfolio Management (PPM) – strategic approach) consists of programmes and projects that must not directly be linked together. It manages
multiple programs and provides a synergy across all managed projects (Leonard & Swanepoel, 2010; Levine, 2005; Maizlish & Handler, 2005).

PgM (see Appendix III – Programme Management (PgM) – bonding strategic with operational) is situated at the mid-level of the MPM pyramid and manages a bundle of projects. These projects can each have a different approach. For example, a project might: relate to one specific objective, have a consolidated approach, have one final customer, or have a cooperative objective.

PM is the planning, delegating, controlling, steering, and organisation of a project that is designed to achieve the result within agreed criteria, cost, time, and performance. PM organizes the process using the PLC to continually control the success. PM represents methods that apply to different projects.

4.3 COMPARISON OF PROJECT MANAGEMENT STANDARDS
As already mentioned, management is the key for handling difficult, complex projects. There are different levels of project management, and standards vary globally. Project management skills are not used in the same way everywhere (Stackpole et al., 2008). Agile project managements such as scrum will not be discussed in this thesis because those methods do not include the traditional role of project manager. Furthermore, no standardized certification program exists for those methods. They cannot be viewed as representing a PM standard, rather they signify a complementary method for traditional PM (Lehmann, Mikulaschek, & Oestereich, 2013).

Four main certificates exist worldwide: Association for the Advancement of Cost Engineering (AACE), AIPM, IPMA, PMI (Giammalvo et al., 2005). However, after an examination of these programmes, AACE focuses more on financial topics and will not be considered here. Here PM standards, often used in the field of industry, were taken into account: AIPM, IPMA, PMI, PMSGB by the SAQA, Prince2 by the office of government commerce (OGC), CMMI by the Software Engineering Institute (SEI), and Project and Programme Management for enterprise innovation (P2M) by the Project Management Association of Japan (PMA). The model for levelling the maturity like CMMI is included. As a close link from the maturity model CMMI to project management standards is given, CMMI is also listed in the table for comparison of PM standards worldwide, but many processes from CMMI cannot be linked to PM standards.
PM standards, which are described in detail in the appendix, were selected and compared. The criteria used were based on the following key factors: membership volume worldwide distribution and completeness of the process steps. The key facts of each standard are illustrated in Table 4. The PM standards listed have an international accepted certification programme and relate to an ISO norm. The oldest standards have been in existence for more than 40 years. Their published handbooks are offered in different languages and are practiced in many countries worldwide. The newer standards are distributed less and are primarily based on the older PM standards; they frequently require further development.

<table>
<thead>
<tr>
<th>Standards Facts</th>
<th>PMP (PMI)</th>
<th>CMMI (SEI)</th>
<th>Prince2 (OGC)</th>
<th>P2M (IPMF)</th>
<th>ICB3.0 (IPMA)</th>
<th>NCSPM (AIPM)</th>
<th>PMSGB (SAQA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country of origin</td>
<td>USA</td>
<td>USA</td>
<td>UK</td>
<td>Japan</td>
<td>Switzerland</td>
<td>Australia</td>
<td>South Africa</td>
</tr>
<tr>
<td>Int. accepted certification</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Certification owner/world</td>
<td>&gt;520,000</td>
<td>&gt;4,000</td>
<td>270,000</td>
<td>2,500</td>
<td>&gt;170,000</td>
<td>3800</td>
<td>1,200</td>
</tr>
<tr>
<td>Practising countries</td>
<td>&gt;200</td>
<td>13</td>
<td>70</td>
<td>n.a.</td>
<td>&gt;60</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Languages</td>
<td>Arabic, Chinese, English, French, German, Italian, Japanese, Korean, Portuguese, Russian, Spanish</td>
<td>English</td>
<td>Chinese, Danish, Dutch, English, French, German, Norwegian, Polish, Spanish</td>
<td>English, Japanese</td>
<td>Chinese, Danish, Dutch, English, French, German, Polish, Spanish</td>
<td>English</td>
<td>English</td>
</tr>
</tbody>
</table>

Table 4: Comparison of facts on PM standards (developed by author)

The processes of the standards were examined to determine how comprehensive the content was by thorough analysis and comparison (see Appendix VII – Comparison of processes from worldwide project management standards).

The variance in practice of the process steps and the characteristics of specific PM standards are described in the following:
PMI PMBoK 4th edition

- Data management is not covered, the possibility to track requirements is not mentioned
- Business Case is only recognized at the beginning
- Tailoring of criteria and guidelines are mentioned once at the beginning of the project
- PMI states that a project is always established on the existing structure and not defined in a new manner

CMMI

- As it is a maturity model and not a real PM standard, it does not cover the creation of a project charter at the beginning of a project
- A closing phase is not mentioned
- CMMI is focused on products that are integrated inside the company. Therefore clear conceivability and preparation for interfaces exist – CMMI mentions specific processes for a product
- A focus on operational process performance, which is primarily covered in other standards by baselines

Prince2

- Is a product based planning, the product is the central point
- Great focus on business case that is checked on a regular basis, at the end of each phase at the latest
- Stakeholder expectations are not mentioned because it is focused on the product
- No mention of procurement, data management, and process improvement
- Strong involvement of management because management plans ad-hoc instructions and must release each phase

P2M

- Procurement is not mentioned as a part of PM
- No mention of data management
- Human resource development is not considered
ICB3.0

- Does not cover processes for technical solutions of the product
- Strong focus on behavioural competence and contextual competence (integration into management, organisation, health, environment, and legal)

AIPM/NCSPM

- Parallels can be seen to PMI in its origin
- No mention of the process for technical solutions of products

PMSGB/ SAQA

- Standards consist of fundamental, core, and elective components
- Mentions Africa specific problems like handling of HIV infected people
- PM certification is established on different levels and prerequisites are necessary (previous certification levels)
- Origins of PMI can be seen

In conclusion, Table 19 (see Appendix VII – Comparison of processes from worldwide project management standards) shows that worldwide, the processes of the frequently used standards do not differ greatly. All initial listed phases (initiating, planning, executing, monitoring/ controlling and closing) are handled by the standards listed above. The older standards (PMI, ICB3.0) list more process steps for the single phases. The newer standards (PMGSB, NCSPM and P2M) are less detailed and refer more to the older standards. Product specific validation and process steps are mentioned more in the CMMI and Prince2 standard because they include product based planning.

4.4 **SELECTION OF A PROJECT MANAGEMENT STANDARD**

For selecting the most appropriate standard for this research, the criteria from Table 4 were used: example of associated companies, international accepted certification, memberships worldwide, practising countries, availability of different languages, and compliance with official norms.

PMI standard was selected. It is associated in a variety of highly successful companies and shows a close relationship to practical application. Their certification is accepted worldwide. Furthermore, it is used the most worldwide and has more than 520,000 certified members in over 200 countries (Lehmann et al., 2013). Providing the standards in
more than ten languages increases the international use of the approach. The content of The PMI standard has been in existence for longer than 40 years. This standard covers most of the aspects included in the other standards, and based on its history provides the most practical experience. For these reasons PMI standard appears suitable for researching management in complex projects.

Investigations were performed within the PMI group of Germany. Here the IPMA standard ICB3.0 is used more with over 30,000 certified people vs. >9,700 people certified in PMI standard PMP (Project Management Professional). However, from a global view, PMI’s standard PMP is used more than the ICB3.0 (Lehmann et al., 2013). This thesis will focus on a specific geographical area because a worldwide survey would be difficult to execute and very time consuming.

A comparison conducted by the Global Alliance for Project Performance Standards (GAPPS) resulted in another rating of PM standards. However, the credibility of the report is highly questionable because the organisation created the criteria for the study.
5 Complexity

The introduction of this chapter defines the term and theory of complexity. The origin of complexity with its strengtheners and root causes are described. Different forms and its impacts to the value chain are shown. The visualization and the management of complexity by controlling, reduction or elimination follow. Finally, the degree of complexity and resulting costs are measured.

5.1 Complexity Definition

Complexity is derived from the Latin root *complexus*, which means entwined or twisted together. Ireland (2007) interpreted complexity as system with two and more components or variables.

The detection of complexity depends on the observer’s standpoint. Therefore, the estimation of complexity is subjective and different for each observer (Flückinger & Rauterberg, 1995).

Therefore, no common agreed upon definition exists for complexity. Edmonds (1998) stated: “property of a language expression makes it difficult to formulate an overall behaviour of complexity, even when given almost complete information about atomic components and their inter-relations” (Edmonds, 1998, p. 6). Language here includes diagrams, atomic components, and irreducible signs in chosen language of representations. It corresponds to undefined functions, signs, predicates, and constants in a formal logic (Edmonds, 1998). This definition of complexity is actually quite complicated Alisch, Winter, and Arentzen (2004) provided a more comprehensible definition: Complexity is the characteristic of a system whose overall behaviour cannot be described and explained, even not when all information of single components and their behaviour is available (Alisch, Winter, & Arentzen, 2004).

In the literature, authors relate complexity to different fields as illustrated by the following definitions:

*Computational Complexity, Kolmogrov Complexity and Bennetts Logical Depth* – they refer to information technology and are not further explained here (Edmonds, 1998).

Löfgrens *Interpretation and Descriptive Complexity* – refer to the process of description and interpretation. The interpretation process is the translation from the description to
the system and the descriptive process is the other way around (Löfgren, 1973). Kauffmans (1993b) *Number of Conflicting Constraints* – is more concerned with order than with complexity. He defines complexity as number of conflicting constraints.

Complexity is described generally in theory, but there is no explicit definition. Definitions in the literature are polymorphic. Complexity is characterized by the features: continuous motion/ momentum, increasing complexity/ non-transparency, spontaneity of hierarchy, adaption, large amount of different elements, irreversible and considering given restrictions (Ehrlenspiel, 2009; Feess, 2013; Pruckner, 2005; Riedl, 2000; Schwarz, 2011; Valle, 2000). This is summarized in Table 5.

![Table 5: Characteristics of complexity (summarized from Valle, 2004; Riedl, 2000; Pruckner, 2005; Ehrlenspiel, 2009; Schwarz, 2011 and Feess, 2013)](attachment:image)

### 5.2 **Theory**

Theories describe and explain the different phenomena of complexity.

#### 5.2.1 **System theory**

The system theory developed in different disciplines, and many of the principles are indistinguishable. However, in several disciplines a divergence exists (Szent-
Györgyi, 1964). To explain this, Bertalanffy (1969) defined the targets of the system theory:

- Support for more integration in different disciplines
- Exact theories and science beyond physics
- Development of integrative science and system theoretic world view
- Simplification and abstraction of an explanatory model
- Support of scientific teaching and creation of scientific generalists

Several authors have demonstrated that while system theory originated in the earliest scientific disciplines, it continues to be a significant part of the modern sciences including: biology, chemistry, psychology, engineering and economics. Those fields influenced system theory. Two significant paradigm changes in the theory are discussed (Pulm, 2004): First, the cybernetic order moves from externally controlled and monitored to a self-controlled encircled system emerging from the environment. Appropriate methods can influence the system and also imply the potential to control the system. The second cybernetic order changes the system to a reflexive and self-referential one. It is self-developed and sustained by the environment. Externally it is not controllable and results or events are not predictable – but an intervention is possible. Checkland and Scholes (1999) described cybernetics by a controllable “hard system” and non-controllable “soft system” (Checkland & Scholes, 1999, p. A9).

System theory develops continuously. Different theories have been derived from it. Similarities between system theory and the following complexity theory are hard to define. System theory appears earlier in the timeline than complexity theory; however, the management of complexity in practice is the target of both (Van Gigch, 1987; Vemuri, 1978). In system theory, complex systems are generally described by their characterizing features. The complexity of a system escalates with the addition of more elements or with an increase in the relationships of elements (Milling, 1981). System theory can consist of different complex systems.

According to Pleitgen, Saupe, and Jürgens (1992), chaos theory is also a sub category of system theory, which will be discussed further in this thesis.

5.2.2 Complexity theory
Complexity theory describes neither a linear, nor a back coupling relationship between elements of a system. The system illustrates an asymmetric structure that is partially non controllable. Furthermore, elements can be irreducible. The reaction of the system is difficult to predict (Casti, 1986; Flood, 1987). Therefore, complex systems must be controlled in a decentralized manner. A manipulation of variables is destined to fail and could lead to a breakdown of the system (Johns, 2008).

Grossmann (1992) and Purle (2003) defined the following characteristics of complex systems:

- Large amount of elements that are related
- Non-linear with internal and external back couplings
- Lapse of time can change
- Possibility to change to many different statuses in a certain time
- Relying on the past, but not analytically definable
- Definable and measurable by variety

Complexity theory leads to a system that requires a minimum quantity of resources to be managed. If the quantity of available resources falls below that minimum, then difficulties cannot be solved. In advance the system predicts that success might not appear, but its results can still influence practical applications (Wegener, 2003).

Complexity theory stands between order and chaos theory. Order theory moves in regular relationships (Mittelstrass, 1984). Kauffmann (1993a) argued that complexity appears as a transition phase between order and chaos. He also spoke of a controlled/proper complexity.

5.2.3 Chaos Theory

Complexity can evolve into chaos. Chaos theory is a subcategory of the system theory that reveals internal instabilities and can result in a loss of organisation; however, it can also lead to reorganisation as a “module of organisation” (Peitgen, Saupe, & Jürgens, 1992).

There are many possible definitions of chaos. However there is no general agreement in the scientific community what characterizes a chaotic system (Devaney, 1992; Fradkov & Pogromsky, 2008).
Chaos theory arose from research conducted in academic fields that include the life sciences, physical sciences, and mathematics (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007).

According to Kellert (1993) and Bedford (1998), chaos theory is a qualitative study of a deterministic nonlinear dynamic system with unstable aperiodic behaviour (Bedford, 1998; Kellert, 1993). Valle (2000) described the following characteristics of a chaotic system: it is dynamic (changes over the time) and behaves in an aperiodic and unstable manner (not repeating itself). Although it is a complex system, it can contain simple causes. In chaotic systems the element of nonlinearity results in the fact that inputs and outputs are not proportional and the principle of additivity is non conforming. The deterministic character of chaotic systems means that chaotic behaviour is not random despite their instability and aperiodicity (Valle, 2000). Similar characteristics were found by Beyerchen (1992), Kellert (1993), and Williams (1998) (Beyerchen, 1992; Kellert, 1993; G. Williams, 1998). Nonlinearity, sensitivity, and aperiodicity were also confirmed by Namrata (2011) and J. Zimmermann (2010). Valle (2000) concluded that these characteristics lead to an unpredictable system, but only where the output of the system is used as an input for the next (Valle, 2000). Probst (1987) added to those descriptions: chaotic systems do not behave randomly (Probst, 1987).

The problem of a chaotic system is unpredictability. In order to calculate the future behaviour of a system, all parameters must be known with infinite accuracy. This is almost impossible. Defined predictions are possible for only a limited time period (Werndl, 2009).

Chaos theory gained recognition with the introduction of the “butterfly effect”. This was presented in 1979 by Edward Lorenz in a paper published by the American Association for the Advancement of Science. He described how minute changes could influence nonlinear systems in an unpredictable way (Cooke-Davies et al., 2007). The “Lorenz Attractor” is a graphic illustration of this concept that is visually similar to the image of a butterfly. The image reveals the intricate structure that is hidden within a disorderly stream of data. In 3D space a point is fixed by three variables. Changing the system, this point represents the motion and continuous changing variables. It is a system whose trajectory cannot exactly be repeated and never intersects with itself (Gleick, 2011).
Can a flap of a butterfly influence the weather on the other side of the earth? Paradoxically, in the long-term, weather is not predictable; however, it should be possible to explain its behaviour or at least to understand it (Cooke-Davies et al., 2007).

5.2.4 SUMMARY OF THEORIES

All three described theories are linked. Complexity and chaos theory are derived from system theory with an increasing grade on difficulty. With reference to Snowden’s (2005) “cynefin”, framework the three theories are summarized and illustrated in Figure 16 (Snowden, 2005).

Figure 16: Differences of System-/ Complexity- and Chaos-Theory (summarized by author)

The figure above shows order or system theory and includes Snowden’s (2005) approaches of simple and complicated. People first observe a situation, than start to categorize or analyze it before responding.

Complexity or complexity theory can only be understood after the problem is solved. Therefore, situations are first investigated and/ or tested, and then analyzed and responded to.
Chaos theory states that a chaotic situation is not manageable because it is unstable and a-periodic. Snowden (2005) asserted that people generally act first, and then analyze a given situation.

5.3 **PARADOX ON COMPLEXITY**
Paradox is derived from the Greek words *para* – against and *doxa* – doctrine, and means an unsolvable situations (Duden, 1996). A paradoxical situation is characterized by the occurrence of contrary events. According to Howard (2010), the concept of paradox indicates that world should be viewed as black *and* white, not black *or* white. Today, the paradox has been increased by the growing amount of available information that cannot be confirmed. This phenomenon leads to a rise in complexity. Therefore, in the commercial environment, constant management of paradox is necessary (Howard, 2010).

In relation to complexity, Bandte (2007) mentioned two paradoxes: information and term. Complexity that results from the paradox of information is caused from a lack of information. To control a system, complete information is necessary and requires the constant collecting and handling of information, which is almost impossible, (Bandte, 2007; Kirchhof & Specht, 2003; Malik, 2003). Complexity caused by the paradox of term occurs because humans have a limited ability to absorb and handle information (Dörner, 1998). The paradox can be only solved by the connectivity of single elements to the system, not by syntheses to a cohesive whole (Luhmann, 2002).

5.4 **ORIGIN OF COMPLEXITY**

5.4.1 **ROOT CAUSE**
Complexity can originate from the internal side (endogenous) and/or the external side (exogenous). Endogenous factors can include the increasing variance of products; customer demands are considered exogenous aspects (Datar, Kekre, Mukhopadhyay, & Srinivasan, 1993; Schuh, 2005a).

Complexity arises from a multitude of targets that require attention as requested by a system with its different plans (processes) and signals (influences, e.g. environment). Everything is related to each other and reacts with each other (Flückinger & Rauterberg, 1995; Frese, 1987; Richter, 2008). Back coupling, nonlinearity, accumulation, and delays generate complexity in a system (Grösser, 2011).

Free trade facilitates the exchange of goods, people, knowledge, and capital (Maznevski, Steger, & Amann, 2007). The expansion of free trade has the potential to grow further.
As free trade escalates, complexity will increase because of growing external and internal requirements; companies react to environmental influences by implementing changes in the organisation, product, or process (Schuh, 2005a).

U. Lindemann, Braun, and Maurer (2009) categorized the root cause for complexity into the following sections:

- Market (external) with demands for multi-functional products, globalization/competition, norms, customer diversity and competitors.
- Product (internal/external) with demands for variant diversity, decreasing batch sizes, component interfaces, make or buy parts and functionalities.
- Process (internal) with increased linkage of processes, iterations, concurrent engineering, multi-disciplinarity and development time.
- Organisational (internal/external) with involved parties, organisational requirements, employee fluctuation, employee size and organisational structure.

The majority of the root causes listed above have been confirmed by Krause, Franke, and Gausemeier (2007). Other roots for complexity are: technologies and changes in politics and society (Franke, Hesselbach, Huch, & Firchau, 2002; Krause, Franke, & Gausemeier, 2007). Those aspects are not shown in Figure 17.
The internal and external root causes for complexity influence today's projects. Externally, market demands impact projects because in a globalized market customers change their requirements as market demands change. Internally, project and company processes change constantly, which reduces development time because product lifetime is shortened and information technology is accelerated. Internal and external influences in a product or an organization affect the product/project such as the interfaces or make/buy-part decision and change the structure of organization. All of these factors can cause complexity when the original planning of a project is changed.

5.4.2 Complexity Strengthener
Complexity strengtheners are mainly powered by cross-linking, change and diversity. When all three characteristics are combined, and possess a high ratio in particular; they create a highly complex system (Klaus & Buhr, 1975; Schuh, 2005a). If the dynamic is low in a given project, the project will be minimally complicated. When the dynamic is high, projects become highly complex. This concept is independent from diversity and only partly related to cross-linking (see Figure 18).
In his Phalinza model, Schwarz (2011) outlined the following components of complexity: various elements in different constellations, strongly cross-linked with an intensive communication, highly self-dynamic. This model demonstrates the difficulty of predicting the next step in a given project or task (Schwarz, 2011).

The Phalinza model is more or less abstract. However, several authors and experts have addressed the main strengtheners of complexity in tangible situations:

- Size of project or organisation by people and assets
- Internal and external interfaces for system, companies, environment and projects
- Customer requirements as well as country specifics, functions and individualization
- Market dynamics
- Organisational changes
- Amount of cooperation with stakeholders and other companies
- Technical/ product diversity
- Communication/ decision process and use of information
Laws, norms, and regulations

The literature offers an almost endless number of strengtheners for complexity as mentioned earlier. In Table 6, all strengtheners are broadly listed, and sorted according to their occurrence (Bohne, 1998; Chronéer & Bergquist, 2012; Faller & Kracht, 2006; Franke et al., 2002; Hass, 2007; Hass & Lindbergh, 2010; Ireland, 2007; Kersten, Lam- mers, & Skirde, 2012; Klaus & Buhr, 1975; Koch, 2008; Krause et al., 2007; Leybourne, Kanabar, & Warburton, 2010; U. Lindemann, Braun, & Maurer, 2009; Lösch, 2001; T. Mayer et al., 2008; Maznevski et al., 2007; C. Meyer, 2007; Schuh, 2005a; Ward, 2005).

Table 6: Complexity strengtheners from the literature (developed by author)

With the IT revolution and intertwined systems, access to information is enhanced and frequently actualized (Sargut & Gunther McGrath, 2011), which increases the dynamic nature of markets. Companies must be flexible and establish their projects with a global perspective. The trend is to speed up the implementation of all available data (Scheiter
et al., 2007). Project managers that operate in the international arena should be prepared to deal with the complexity strengtheners that are listed in the literature.

5.4.3 IDENTIFYING COMPLEXITY

In order to identify complexity, the elements of the system need to be monitored, differentiated, described, evaluated, and correlated to each other. Several monitoring standards and tests provide unique perspectives. They focus on specific elements, reactions or topics. Furthermore, they still solve the complexity by possible observations (H. Lindemann, 2008).

Enlargement of the observation perspective promotes the recognition of complexity. Here variables outside of the system must be taken into account like the environment (H. Lindemann, 2008).

The following questions are helpful to identify complex systems (H. Lindemann, 2008):

- Is there another possibility of being?
- The perception of the system by others?
- Are there any other possibilities and which might emerge?
- Who or what could support the solution?

In summary, the recognition of complexity depends on a variety on perspectives and also by the exchange of the perceptions or the “twisting of perspectives” (H. Lindemann, 2008).

5.5 FORMS AND IMPACTS OF COMPLEXITY

Complexity is manifested in different forms and impacts a system in a variety of ways.

5.5.1 FORMS OF COMPLEXITY

The researcher analyzed the forms of complexity in the work of fifteen authors (Blockus, 2010; Bosch-Rekveldt, Hermanides, Mooi, Bakker, & Verbraeck, 2010; Bozarth, Wasing, Flynn, & Flynn, 2009; Christen, 1996; Fleig, 2009; Grösser, 2011; Hanisch, 2011; Heidegger & Weerda, 2008; Johns, 2008; Maurer, 2007; McKinley, 1987; Schweiger, 2005; von der Eichen & Stahl, 2003; Weber, 2005; Zolin, 2010).

42 forms of complexity were identified. These forms are arranged into the following groups: environmental, time related, technical, organisational, production, process, technology, and market. Those groups are then divided into the subcategories of objective/ subjective view and internal/ external view. This is summarized in Figure 19.
5.5.2 IMPACTS OF COMPLEXITY

In the 1990s, the behaviour of 29 organisations was investigated over a ten-year period. The products offered rose up to 130%, the variants increased by approximately 420%. The lifecycle was shortened by about 80%, and the delivery time decreased by approximately 90% (Schuh, 2005a; Wildemann, 1991). This caused a surge in complexity. To avoid negative effects and impacts it is necessary to manage complexity.

The impacts of complexity have been pointed out by several authors: Denk (2007), Franke (1998), Franke et al. (2002), Hanisch (2011), Kaiser (1995), Rathnow (1993), and Schweiger (2005). These impacts are best explained along an organisation’s value chain with its process steps of research & development, purchasing, production, sales, service/ recycling, and overall processes such as planning and accounting (see Figure 20) (Denk, 2007; Franke, 1998; Franke et al., 2002; Hanisch, 2011; Kaiser, 1995; Rathnow, 1993; Schweiger, 2005). Costs incurred in one department can potentially affect a different department by causing a time delay (Blockus, 2010).
During all phases of a project, whether a phase focuses on the development or on the span of a product, complexity can influence the project and cause negative impacts in different areas. Management needs to be able to counteract those effects in different areas including: time, costs, scope, risk, communication, and procurement.

5.6 MANAGEMENT OF COMPLEXITY
Management has become more complex due to accelerated development cycles, the continuous growth of globalization, and the emergence of new markets (H. Frank & Schmidts, 2007). Many companies have a difficult time competing in emergent markets and rather than implementing new measures to improve performance, they copy developments from other organisations. Managing complexity helps to avoid copying (Maurer, 2007; Wildemann, Ann, Broy, Günthner, & Lindemann, 2007). In a complex system, single development cycles of modules are isolated and must be managed. In the future, this process will be performed more frequently due to a rise in system-oriented thinking (Krumm & Rennekamp, 2011). Modules are later consolidated and introduced in an overall structure and network (H. Frank & Schmidts, 2007). Figure 21 shows examples in the automobile industry - movement towards module, platform in general.
Increasing customer demands turn mass production from a low complexity enterprise into to high complexity enterprise (Maurer, 2007). Brandes (2002) used a statement made to congress by a representative of Stafford Beer to illustrate that principle. We have learned to break down information into small bits. Systemic thinking is not popular. Since 200 years science also works according that scheme. Also managers think in reduced, simplified terms; with fatal outcomes for the companies. If fractioned skills of employees are estimated, essential information and know-how is lost. Systemic management reckons the overall structure and relations in an organisation (Brandes, 2002). The ability to manage instead reducing complexity is a real advantage. That particular core competence, which is the basis for the further development of new products, is difficult to copy (Maurer, 2007). However, the notion that complexity can be controlled in entirety is false (Weyer & Schulz-Schaeffler, 2009). According to Schuh (2005a), it is better to reduce “over-complexity” and to manage “rest-complexity”. Complexity management relates to exogenous (external, market demands) and endogenous (internal, to comply with demands) interfaces (Schuh, 2005a; Wildemann, 1998). This division is necessary because the human ability to understand the totality of complexity is limited (Christen, 1996).

Complexity in a project can be planned like any other function or process. This results in a planning of an uncertainty that will occur in the future (Curlee & Gordon, 2011; Titcomb, 1998). Planning for complexity is often difficult and leads to changes. Continu-
ous and pre-emptive planning is suggested as solution to manage complexity (Curlee & Gordon, 2011; O’Toole, 1996).

In the following, the methods of handling of complexity are described, including: inter-dependencies, visualizations, reductions, and measuring methods.

5.6.1 Visualization of complexity

Visualisation enables a better understanding of complexity. However, a poorly designed visualization can lead to ambiguity and incorrectness if a complex system is poorly and inaccurately presented, not outlined in the correct diagram, or if key features/processes are omitted, such as explanatory icons or symbols (Flood & Carson, 1993). Three rules designed to avoid those traps are developed (Checkland, 1979):

1. Define the type of diagram that is appropriate to the system and the situation.
2. State clearly the entities and relations within the diagram and which elements are portrayed by specified symbols.
3. Provide a legend, so that others who will read the diagram are able to interpret it in the same way.

In the following, the different visualisation methods for complexity are listed. These are oriented to variations of handling complexity: understand, reduce, and manage. For completeness, only a descriptive method is mentioned. Table 7 shows the visualisation methods that are all explained in more detail in the appendices.

<table>
<thead>
<tr>
<th>VISUALISATION METHODS FOR COMPLEXITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understand complexity</strong></td>
</tr>
<tr>
<td>- Mapping</td>
</tr>
<tr>
<td>- Mind map</td>
</tr>
<tr>
<td>- Rich picture method</td>
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<tr>
<td>- Scenario analysis</td>
</tr>
<tr>
<td>- Fuzzy Logic</td>
</tr>
<tr>
<td><strong>Reduce complexity</strong></td>
</tr>
<tr>
<td>- Graph theory</td>
</tr>
<tr>
<td>- Network (arrow) diagrams like value stream mapping (VSM) and value network mapping (VNM)</td>
</tr>
<tr>
<td>- GANTT/ PERT/ CPM</td>
</tr>
<tr>
<td>- Portfolio</td>
</tr>
<tr>
<td>- Mapping</td>
</tr>
<tr>
<td>- Concept map</td>
</tr>
<tr>
<td><strong>Manage complexity</strong></td>
</tr>
<tr>
<td>- Balanced Score Card (BSC)</td>
</tr>
<tr>
<td>- Data structural matrix (DSM)</td>
</tr>
<tr>
<td>- Component, people, activity and parameter based DSM</td>
</tr>
<tr>
<td>- Domain Mapping Matrix (DMM)</td>
</tr>
<tr>
<td>- Multiple Domain Matrix (MDM)</td>
</tr>
<tr>
<td>- Portfolio</td>
</tr>
<tr>
<td>- Fuzzy Logic</td>
</tr>
</tbody>
</table>

*Table 7: Overview visualization methods for understanding, reducing, and managing complexity (developed by author)*
5.6.2 Handling Complexity

Managing complexity can be described as the attempt to decouple external from internal variety (e.g. products, projects etc.). Complexity can unlock many new possibilities, but it can also be very costly (Hofer, 2001). It permits flexibility in a certain level of process structures, which can be specified when the environment changes and results in a competitive advantage (Maurer, 2007; Puhl, 1999). A target of the majority of organisations is to align complexity with the requirements of environment (Purle, 2003). According to Schuh (2005b), optimal complexity is gained when internal complexity equals external complexity. An imbalance must be adjusted (Schuh, 2005b). Therefore, the ability to control, adjust, and steer complexity is equivalent to the successful management of it (Malik, 2007). Successful handling requires a wide view of the performance of the system and its principles (Malik, 2003).

The handling of complexity is a continuous process that identifies unexpected developments in every phase of a process. To maintain continuity, complexity management should be set up within the strategic management division. Here the products must be defined and standardized for a correct setup of variants (Blockus, 2010; Franke et al., 2002). On operational level, particularly for projects, the following factors are necessary: target definition, component strategies, limitations, early documentation, build-up of system suppliers, limitation in parts, robust planning, and prioritization (Franke et al., 2002).

Schuh (2005b) conducted survey of several organisations and found that if the following conditions are in place, a company is better able to handle complexity:

- Clear definition of customers and their requirements. This means a mix of big and small customers and standard products that have the potential to be adapted to customer specific needs
- Strategic planning of a product’s variety and its lifecycle; although variants will increase with a mostly regular strategic planning
- Transparency of process costs and impact on the value chain; process costs will influence the offer proposals
- Active handling of complexity in organisation belongs to the daily tasks of operative management
Although maintaining simplicity is effective in some fields, it can also be precondition for crises and collapse. According to Malik (2007), it is better to cope with complexity as it results in a better perception of the environment. However, this technique should not be limited to financial indicators because they are too reductive. Prosperity and values would not be generated and instability could be caused (Malik, 2007). This principle is also stated by the natural law in cybernetics: the law of requisite cybernetics or Ashby’s Law. This concept states that only variety can destroy variety (Ashby, 1956).

The limitation of human knowledge also impacts the prediction of events and the identification of significant influences (Malik, 2003). Therefore, change should be managed in small steps, and those steps should be thought through and acted upon in a systematic manner (Maurer, 2007). Handling complexity requires an awareness of different perspectives, cognition of relationships, strengths and speed, effective intervention when required, and perseverance in uncertainty, and being prepared for surprises (Richter, 2008). Individuals need to be able to think in complex terms, to engage in open communication, and to cope handling of complexity needs thinking in own complex processes, free communication, and to retain composure when coping with unpredictability and paradoxical outcomes (Cooke-Davies et al., 2007). A pre-condition for handling complexity is the clear definition of roles, responsibilities, targets, and communication like in project management (Johns, 2008). The quality of the outcome on handling complexity depends on resources and a precise data analysis that is performed when the requirements are defined (Maurer, 2007). Hereafter, the performance variance must be kept in mind. During all proceedings, the optimal internal value chain should be attended to for an ideal structure in market orientation, product mix, value creation, and organisation (Schuh, 2005b).

The ability to handle complexity can be adversely impacted by a lack of coordination and interaction between different departments within an organisation. This can lead to cannibalization in departments, markets, resources and products. Communication can prevent that situation (Schuh, 2005b). This and the assimilation of information support the handling of complexity (Hoole, 2006; Schrader, 2009). Grösser (2011) addressed the necessity of permanent communication and suggested the following tactics to maintain it: investing in relationships, storytelling, providing hard facts, and giving feedback (Grösser, 2011; Schaub, 1996). The feedback communication culture is also confirmed by others (Blockus, 2010; Erdi, 2008; Norman, 2011). In a control loop, this provides
new information and data that begins a new process for controlling chaos and complexity (Erdi, 2008). Leybourne, Kanabar, and Warburton (2010), expanded this aspect by defining the specific communication processes: plan, skills, and groups. The authors divided factors into groups using the typical communication channel formula, which implies a simplification (Leybourne et al., 2010). This is shown in Figure 22.

![Communication formula](Image)

**Figure 22: Communication formula (source: derived from Leybourne et al., 2010)**

There are three various ways to handle complexity. These are controlling, reducing, and eliminating (George & Wilson, 2004; Kersten et al., 2012; Sander, 2007; Schoeller, 2009; Schuh, 2005b; Schweiger, 2005). These handling methods are valid for the product and process level (Sander, 2007).

**Controlling complexity**

The control of complexity first requires acceptance, then norms and guidelines can be implemented. In general, decisions are made primarily on the strategic level (Sander, 2007; Schoeller, 2009).

Controlling complexity occurs in steps: incremental planning that uses lessons learned from former projects, a rolling wave planning, and different multiple estimating methods like a Work Breakdown Structure (WBS). These are controlled by gate reviews on a regular basis. These steps are already well known in management, but are not widely applied to controlling complexity (Hass, 2007). In a survey of organisations in the distribution business, Kersten et al. (2012) analysed the methods used to control complexity. Those are used for controlling, and they are also used to reduce complexity. They found the following methods were the most often used: reporting from electronic systems, meeting structures with a defined target, time limitations, efficient process management, and adapting processes to customers’ needs. Further methods for controlling complexity
were: ABC Analysis, best-practice workshops, bottleneck analysis, defined interfaces, benefit analysis, standardization, analysis on value creating, target definition and business intelligence. Business intelligence concentrates all necessary data on a central server (Kersten et al., 2012). Other special methods in the field of distribution will not be discussed in this thesis.

Malik (2003) established an approach for managing that is also valid for controlling complexity. He made a distinction between constructivistic-technomorph and systemic-evolutionary managing. Managing complexity in the constructivistic-technomorph way means to create a distinctive arrangement by a planned human act. Managing complexity in the systemic-evolutionary way also creates an arrangement by human act but in a spontaneous, self-generating mode (Malik, 2003).

Using this approach, methods for controlling complex situations were categorized. These methods describe process steps for controlling complex situations that are categorized by arrangement and problem solving.

Methods of arrangement are mainly dominated by a heuristic process (Stüttgen, 2003), the theory of creating order (Malik, 2003), and a steered order or taxis (Malik, 2003). The single process steps or restrictions of these three approaches of arrangement are shown in Table 8. Here the “heuristic process” and the “theory of creating order” have similarities in the beginning. Both start from a simple perspective. They continuously control the simple situations and repeat that process until those situations become stable. After the initial step, the approaches diverge. The “heuristic process” moves forward by continually adding new small steps, and then this is repeated till the steps are stable. The “theory of creating order” defines rules for gaining flexibility and order in complex situations. Contrary to these methods, the “steered order” has an intuitive approach. Nothing is planned, and actions are decided upon intuitively. Malik compares this approach with a soccer team; however, general valid rules are still followed. In summary, each method possesses fundamental requirements to control complexity.
Handling can be defined by six different methods/ conditions designed to solve the problem of complexity:

- Vesters sensitivity model requires describing the system, identifying influencing factors, proofing the relevance, questioning interactions, defining the internal roles and checking the networking/ back coupling (Fisch & Beck, 2004; Hetzler, 2010; Vester, 2000)
- Analytical reductive handling is based on questioning the side effects (what can be gained and influenced) and how can it be realised (Malik, 2003)
- Constructivist handling enables rational decisions for problem solutions by target definition, develops a problem solving process and analysis alternatives/ stable evaluation criteria (Malik, 2003)
- The evolutionary method is based on making decisions with cognitive knowledge (too less information available) and closes gaps without knowing it (Malik, 2003)
- Cognitive mechanism employs the principles of reality consideration, simplification, abstraction, and implication to handle complexity (Malik, 2003)

Table 8: Theoretical methods for handling complexity - arrangement (developed by author)
The situation awareness model is founded on environment awareness, workload, and available tools. The actual situation is observed and projected into the future (Endsley, 1995; Hetzler, 2010).

Those methods are summarized in Table 9 and Table 10. These six methods/conditions foster handling complexity by distinct instructions like process steps or defined conditions on how to proceed. If applied, they actively deal with the current problem: complexity.

The GAMMA and the Heraklit methods are similar in approach to Vesters sensitivity model. Both are discussed by Fisch and Beck (2004). An alternative problem analysis form Flood and Carson (1993) will not be discussed further because it bypasses complexity, rather than controlling or reducing it.

<table>
<thead>
<tr>
<th>Vesters sensitivity model</th>
<th>analytical reductive</th>
<th>constructivist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. System description:</strong> Where are the problems?, What can we do against it?, What is linked to it?, What are the limitations?, What are the restrictions? and Who is against it?</td>
<td>Which results can be expected by the system? Which side effects are caused? What can be gained with this approach and what not? What can be influenced? How can the impact be realised on the system?</td>
<td>Core Idea based on rational decision</td>
</tr>
<tr>
<td><strong>2. Identification of influencing factors:</strong> Identify intersection, describe the system roughly, documentation of variables</td>
<td></td>
<td>Strongly based on mathematical quantitative approach</td>
</tr>
<tr>
<td><strong>3. Proofing system relevance:</strong> Physical-, dynamical criteria, Environment (involved people/resources etc) and system relationships</td>
<td></td>
<td>Method tries to identify principles, techniques and methods to make rational decisions</td>
</tr>
<tr>
<td><strong>4. Questioning interactions:</strong> Impact of variables inside the system (impact matrix) to their under-, over-proportion</td>
<td></td>
<td>Constructivist method can not be realised in reality (\rightarrow) better decision than evolutionary method</td>
</tr>
<tr>
<td><strong>5. Defining roles inside the system:</strong> definition along their activity or passivity</td>
<td></td>
<td>Developing rational prob. solutions</td>
</tr>
<tr>
<td><strong>6. Overall relationship</strong></td>
<td></td>
<td>Developing rational prob. solutions</td>
</tr>
<tr>
<td>Outlining the network and back coupling effects inside the system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Theoretical methods for handling complexity – steered problem I (summarised by author)
Table 10: Theoretical methods for handling complexity – steered problem II (summarized by author)

Reduction of complexity

The reduction of complexity is made possible by the standardization of products. This occurs by modularization, optimizing assembly processes, scale effects, or the reduction of product/part variants. Standard products are focused, but fulfil the maximum of market demands and decrease costs (Schoeller, 2009). The characteristics and advantages of standard products are as follows: the optimization of products and processes, a focus on core competences, limited part varieties, an improvement of the supply chain, the reduction of quality problems, and decreased cost (Bick & Drexl-Wittbecker, 2008). The “tearing approach” or the elimination of the worst products from the portfolio was mentioned as an additional benefit of standard products (Grimm, 2009; Maurer, 2007). Generally, model kits, modules or platforms exist for reducing complexity (Abdelkafi, 2008; Bick & Drexl-Wittbecker, 2008; Englen, 2006; Franke et al., 2002; Marti, 2007; Pahl & Beitz, 2007; Pine, 1993; Ulrich & Tung, 1991). Also, a definition of variants later in the process can still help to reduce complexity (Abdelkafi, 2008; Firchau, 2003; Maune, 2002; Rapp, 1999).
In order to reduce external complexity, it is important to be certain that internal complexity is within stable limits. (Marti, 2007).

In theory, the reduction of complexity is executed by shielding, sub-systems, standardization, and structuring.

- “Shielding”, changes can be adopted till a certain level or milestone. Than a freeze will appear and change can no longer be implemented (Geckler, 1997)
- “Sub-systems” by modularization, platform building in products helps to identify potential new synergies, reduce costs, and also increases the lifecycle time, as modules and platforms are uncoupled from development cycles. Additionally, mass production with individualization by customers is still possible (George & Wilson, 2004; Hofer, 2001; Krumm & Rennekamp, 2011; Maurer, 2007). To Maurer (2007) variant management is only partially adoptable for processes
- “Standardization” results in a possible decentralization of processes (globally), enabling a team to work together for a specific project or sub-project (Grösser, 2011; Schaub, 1996). A constraint is the grading and competence of team members for realizing the project (Johns, 2008). This method to reduce complexity is also suitable for components and interfaces resulting in a minimization of interfaces (Kersten et al., 2012; Maurer, 2007).
- “Structuring” with lists, signs, labels, and the observation and replication of best practices (Norman, 2011).

In practice, the following methods are used to reduce complexity.

*Common part use:* similar parts including components, processes, know-how, and people are used in more than one product (Bick & Drexl-Wittbecker, 2008; Marti, 2007; Maune, 2002).

*Model kits:* Maune (2002) described a method of standardization that employs model kits. These can be combined in different ways to create numerous variants (Bick & Drexl-Wittbecker, 2008; Franke et al., 2002). The product structure itself does not change, only the overall system. Model kits require an exact definition of interfaces (Englen, 2006). Pahl and Beitz (2007) distinguished four different types of model kits: basic kits, that fulfill basic functions; support kits, for the realization of connections; special kits, not existing in all products with additional functions; and adoption kits, adoption to other systems or requirements (Pahl & Beitz, 2007).
**Modules:** similar to model kits, but typically more complex in their setup (Bick & Drexl-Wittbecker, 2008; Marti, 2007). Those modules cannot be changed because they have standardized interfaces, but they can be positioned at different locations within a complex system such as a platform. (Englen, 2006; Franke et al., 2002). Modules are defined in an early planning phase and an actualisation can be done by refreshing only the module (Englen, 2006).

**Platforms:** in platforms, the product architecture is divided into standardized parts and custom modules (Marti, 2007). Here other authors differ. For them it is not a standalone system. Platforms operate as a basis on which variants can be created by adding modules. So the platform strongly influences the final system (Bick & Drexl-Wittbecker, 2008; Englen, 2006).

Abdelkafi (2008) also discussed common part use, product modularity, and platforms. However, he did not limit the reduction of complexity to the product level. This process is expanded to include the reduction of complexity in processes (process commonality, process modularity and process platforms (Abdelkafi, 2008).

**Elimination of complexity**

Management typically implements elimination in an early phase to avoid complexity, which usually results in the simplification of the product (Sander, 2007), which can impact the ability to compete in global markets (Malik, 2007). Schoeller (2009) did not address elimination; he described a hybrid method between the control and reduction of complexity. This will not be discussed further in this thesis.

### 5.7 Measurement and Costs of Complexity

The impact of complexity was discussed in 5.5.2. In this section, the measurement, costs, and benefits of complexity management are described.

Variety is the measurement index for complexity. Variety is the amount of possible differentiable status of a system. Combinatorics justifies the variety (Malik, 1998). The measurement of complexity is primarily subjective and partially dependent on the viewpoint of the observer (Flückinger & Rauterberg, 1995). No confirmed and proven index exists for measuring complexity. In general, it depends on the observer and his or her attitude towards the system.
A hard fact-based measuring could be controlled by KPIs. Förster lists different KPIs which combined identify complex systems (Förster, 2003):

- Amount of part numbers
- New part numbers for new developed systems
- Development time / -costs / -changes
- Production time / -costs / -changes
- Procurement time / -costs / -changes
- Amount of order positions and the number of supplier
- Offered products in worldwide markets
- PM effort for new products

Authors have investigated the measurement of complexity, but no tangible solution was found. The same is valid for costs. Management of complexity will improve the return on invest (ROI), or return on sales (ROS), or earnings before interest and tax (EBIT) (Bick & Drexl-Wittbecker, 2008). A survey in 2007 by the A.T. Kearney group confirmed that the active management of complexity improves the EBIT by 3-5%; therefore, a transparency must be given by the complete value chain (Scheiter et al., 2007). In order for complexity management to succeed, it must be continually applied and examined for an extended period of time to show tangible results (Scheiter et al., 2007).

Costs are identified in a variety of fields, ranging from direct costs to opportunity costs. They have been identified and summarized below in the Table 11 (Sander, 2007; Schuh, 2005a).
5.8 SUMMARY OF COMPLEXITY

In the management literature, no common agreement exists for defining how complexity can be identified. But most authors agree that complexity consists of restrictions like a continuous motion/momentum and the increase of non-transparency. The theory of complexity describes a relationship of the elements, but those can change due to varying statuses and are nonlinear due to back couplings that can exist internally and/or externally. Managing complexity succeeds being open minded and being ready to change the course as the situation demands it without a predefined concept. With such restrictions, complexity could be described by using a balloon as an illustrative example. Imagining that a balloon is stretched onto one side, some elements might change their structure more strongly than others. The behaviour of each element will change, when the balloon is stretched into a different direction.

A difference exists between complicated and complex. Complexity differs because the internal dynamic is high. Diversity and crosslinking make a system complicated, but they do not impact complexity to the same degree as a dynamic (Figure 18). An appropriate analogy is the construction of a home. An architect who is building a home for the first time might find the process complex due to the need to coordinate all of the different internal/external interfaces, addressing customer requirements, and attempting to bypass a potential dynamic. With the construction of the second home, the architect knows how to handle and react to specific strengtheners of complexity and the possible upcoming dynamic. It is possible to predict the dynamic to a certain level.
The impact of complexity is not measurable or tangible for management. Costs caused by complexity can only be measured indirectly. Success is realized when managing complexity reduces costs. General methods used for handling complexity are reduction and control. Elimination is rarely used because it endangers the success of the product.
6 RESEARCH QUESTION AND OBJECTIVES

Connection of project management and complexity

The lack of literature related to handling complex projects made it necessary to investigate the field of project management and complexity separately. Project management standards have been in place for over 40 years. When those standards were established, project managers did not have the support of computers and the world was not globally connected through the Internet, as it is today. In the past, projects had different requirements and impacts and the standards were based on those requirements. Projects were based more on the internal or immediate environment, and lacked a global perspective. They were focused on internal, less on external influences.

The challenges of a globally connected world are often named complex. The literature shows that the absence of knowledge about the strengtheners of complexity causes confusion for management and generates complex projects. In the literature, complexity is discussed from a general perspective, and is not focused on project management. Also, different methods of handling complexity are referred to, such as the ability to react to, specific situations where no standard might be applicable.

How can complexity which is not standardisable fit into a standardisable approach like project management? It is necessary to investigate both.

Today projects are more ambiguous and challenging as projects during the last century. Different key-factors like time to market, turnover has to be considered and force projects to become more efficient. A consequence is the more efficient use of existing resources and a shortening of the duration by a parallelization of tasks.

Since the introduction of project management, knowledge in project management further developed. Also other technical scientific areas, for example IT, machinery, materials etc. further developed. These might affect the project. Existing available knowledge needs to be combined and applied in the project. This is the task of management. The challenge for the management is to keep the knowledge in the project up to date with the newest innovations. This process never stops and is in a continuous motion.
For example the development of an aircraft wing is chosen. In the beginning of the 20th century the wing was simple curved and constructed by wood. Streaming influencing flaps were principally developed; varying geometrical shapes were primary discovered. Today, the wing is a complex part of an aircraft. It has a specific aerodynamically optimized form. Different materials are used like plastics, aluminium, carbon etc. to reduce weight and increase the stability. Additionally further different handling procedures are necessary to apply them all together. That causes increasing complexity of projects and products.

These different scientific knowledge need to be brought together. This is the task of management. Current project management methodology might not fully satisfy the current requirements. Are current standards considering complexity sufficiently?

Top-target of project management is the predictability of the project results and a mostly reliable reproducibility of projects. Increasing complexity hinders a reliable planning of projects. Management must actually consider continuously knowledge and status of complexity. For success, management should be checked and if necessary supplemented by additional instruments to identify and overcome complexity.

This research is performed with the intent of combining non standardisable complexity with standardised project management in order to arrive at a workable option.

Research questions/ objective

The literature shows that the management of projects in the past were performed in a much more simple manner than those performed today. Today’s projects are developed in a more difficult environment and are influenced more by quickly changing factors. Those factors of change were examined in the literature that addressed complexity. Furthermore, the origin, impact, and management of complexity were investigated.

It is now essential to investigate how complex projects can be handled adequately. Is traditional project management still adequate for complex projects? Does a combination of managing complexity and an actual project management standard exist? If there is no practical combination, can be an alternative solution be proposed to manoeuvre more securely through complex projects? The impacts and negative aspects in handling complex projects need to be described to provide an awareness of complex projects. For the
future the new challenges in projects for project managers, especially young inexperienced project managers need to be shown.

Basic rules were created to enable project managers to recognize how complexity could affect their projects. Indicators of complexity are outlined and also specific management styles to manoeuvre through this situation. In a final step, the possible adaption of existing project management was investigated.

The literature review led to five fields of research. The research questions were attempted to be answered by using a survey and focus group interviews with experts in project management.

**Research field A**

**Question:** How does complexity (theory) influence the execution of project management (PM)?

**Justification:** Only two books deal in detail with managing complexity in projects so far, and project managers often discuss complexity in projects. This research demonstrates in defined projects (participant’s projects) where and in which form complexity appears. The guide for the demonstration is one selected project management standard.

**Target:** To examine participant’s cognition of the influence of complexity theory on the appearance, treatment, and visualisation of the most appropriate project management standard (selected on its membership criteria, availability, norms and distribution of use).

**Research field B**

**Question:** What are the complexity ‘strengtheners’ in project management?

**Justification:** The literature addressing complexity lists an almost endless number of complexity strengtheners. However, the link to project management was not found. Veteran project managers have the ability to estimate those strengtheners via their experience. Novice project managers might become trapped due to a lack of experience; typically they rely on the veteran project managers to confirm the strengtheners of complexity.
Target: To link project management with complexity and finally provide handling options, participants questioned in complexity 'strentheners' in project management (from the literature) and evaluated in practice with experts.

Research field C

Question: How does project management deal with complexity?
Justification: Assignment of single strengtheners of complexity to different processes in the selected PM standard. This outlines the vulnerability of each process inside the PM standard. Further the degree of complexity (low, middle, high) has not been developed so far. This is generated in form of a cluster. For this the selected PM standard, the identified strengtheners for complexity, ranking of participants projects and field of industry are used.

Target: To connect and demonstrate complexity and project management in a model. The non-predictability of complexity with its strengtheners is regulated in defined processes of project management. With the model, developed by the evaluated input from participants, project managers are able to locate the complexity in a project and to estimate the influence on project processes. Also the possible effect of complexity on currently non-affected processes can be predicted. This provides a more predictable handling in managing complex projects.

Research field D

Question: What is the scope for possible modifications in the chosen PM standard for managing complexity?
Justification: Confirmation of existing methods for managing complexity inside the actual PM standard and identification of new methods for managing complexity in projects for a possible enlargement of existing PM standards. These newly identified methods are likely emerge from the management literature of complexity together with cur-
rently applied methods by project managers in their projects that are not listed in the PM standard nor in literature for complexity.

Target: To generate an account of the methods for the treatment of complexity in the chosen PM standard and to explain their application in practice.

Research field E

Question: Are there additional methods to those mentioned in the chosen PM standard for the management of complexity?

Justification: The statements in existing literature disagree as to whether the current PM standards need to be adopted or not. PM experts have expressed their viewpoint of whether an adoption of current standards is suitable or not. The proposed outcome has a range from no modification up to a full reworked PM standard.

Target: To create a more manageable framework for the treatment of complexity in the chosen PM standard through modification.

In this thesis, the findings from project management and complexity are combined and investigated. This synthesis was accomplished using both qualitative and quantitative research. Therefore, strengtheners for complexity were reviewed in order to discover where and how they might impact single project process steps and the management of those steps. Different approaches of managing are discussed for handling complex projects as well as methods for visualization. Several methods already exist in the standards, such as: WBS, checklists, stakeholder analysis etc. Other methods should be considered as necessary additions, such as: moderating techniques, like 6-3-5, and data structural matrices (DSM). From this perspective, experts in the field are working to synthesize the general overview of complexity and the specific linear view of project management standards. That strategy is intended to develop a new viewpoint for managers handling complex projects. This new viewpoint for handling complex projects is focused on aligning with existing models like the Tuckman model, to which the current literature on handling complex projects can already be partly related. Results of Tuckman’s five stages of developing a team are in a same manor unpredictable like the han-
dling of complex projects. Each time a team is set up; it will develop differently as hu-
mans are always acting different. So also a complex project behaves. The approach of
Tuckman’s model is described linear, but in real it is applied cyclic. Phases cannot be
distinctively be defined. Therefore the Tuckman model could serve as a basis for han-
dling complex projects.
7 RESEARCH METHODOLOGY

7.1 RATIONALE FOR MIXED CASE RESEARCH
As mentioned in Chapter 3, today more than two-thirds of all projects do not meet their targets, which results in financial distress for organisations. The researcher's motivation to proceed with this thesis was to generate a change in this unsatisfactory situation. First, the actual state of managing complex projects needed to be investigated. Based on the results of that research, potential improvements on handling complex projects emerged.

The research focuses on the identification of complexity strengtheners that appear in different processes of current projects. The intent is to examine the influence of complexity in project management and to investigate where complexity can affect the execution of project management. Based on the findings, a model will be developed to assist project managers to identify traps of complexity in a project. Additionally, the existing standards were analyzed to determine whether they are effective for handling complex projects. Where those standards were lacking, the missing components were identified. A recommendation will be made for incorporating those. As a contribution to practice, the missing elements will be examined and a proposal will be made to integrate them into the PM standard.

A survey with project management experts was chosen as the most suitable approach for determining the current status. This survey was performed with certified PMI members. The PMI standard was selected because it is the most widely used globally and meets several norms accepted worldwide (see Table 4).

Academic investigations most often use action research, case research, ethnographic research or grounded theory (Wabwoba & Ikoha, 2011). Recently, interest has grown in using a mixed method design. The mixed method design supports increased validity, confidence, and the credibility of results (Easterby-Smith et al., 2012). From the philosophical standpoint of a positivist, the mixed method is ideal and continues to dominate positivist theory and research (Giddings, 2006).

7.2 MIXED CASE RESEARCH
This study uses the mixed method approach – operationalized through case research using a survey (quantitative method) and focus groups (qualitative method). Quantita-
tive principles strongly influenced the research design (Giddings, 2006). The qualitative approach provided further an in-depth knowledge and validated the results from the survey.

7.2.1 **Quantitative Research: Survey**

A survey includes theoretically based and systematically designed questions presented in a questionnaire that justifies the theoretical findings (Porst, 2011).

At the beginning of the development of the questionnaire, the medium for collecting data was defined. Two styles are possible: interviewer administrated interview and self-completed interview. Interview administrated interviews are usually face-to-face interviews, telephone interviews, or computer assisted personal interviews. Paper-based questionnaires and web-based questionnaires are categorized as self-completed interviews (Brace, 2008).

In general, interviews administered by the interviewer have a common disadvantage: they can be affected by the interviewer’s biases, which can directly influence the interviewee. In the face-to-face interview, the interviewer’s presentation can also add bias to the interview. An advantage of direct interviews is that the interviewer is able to present stimulus material that can encourage both the interviewer and interviewee to ask more complex questions on the topic. The evaluation of face-to-face interviews is more time consuming because audio taped or handwritten notes are used. In the second method, the telephone interview given prompts might be unclear to the interviewee and further explanation may be necessary. However, it is not possible to present any kind of stimulus material that could support the interviewee within the interview. An advantage of the telephone interview is that the interview can be kept mostly anonymous. During the evaluation of the telephone interview, it is almost impossible to identify specific given statements by interviewee. This is especially valid for a large number of interviews. The last method listed by Brace (2008) for interviewer-administered interviews is the computer assisted personal interview. Randomized response lists could evolve into more complex techniques that can be applied, but questions would be pre-coded and prompted. Also, the interviewer does not have to prepare as intensively for the interview because the instructions are given by the computer.

In self-completed interviews there is no direct contact between interviewer and interviewee. This non-direct participation is a general advantage. Different scales in the self-
completed interview may elicit different response patterns and evaluation, can hardly be influenced. The interviewer has no influence on the how long it will take for the interviewee to complete the interview; however, an approximate completion time should be determined during the development of the questionnaire. Because spontaneous questions are not possible, the questionnaire can be monotonous and interviewees might not complete the survey. These advantages and disadvantages are valid for both types of questionnaires: paper-based and web-based. In web-based questionnaires it is not possible to integrate any stimuli like touch or smell; however, graphic illustrations can be provided, such as: images, messages, or graphs.

Advantages and disadvantages of these different media are described by Brace (2008) and summarized in Figure 23.

![Figure 23: Media for collecting data (summarized by author from Brace (2008))](image)

In this research, a web-based questionnaire was chosen and completed independently by the participant. It seemed to be the most appropriate choice for this thesis because it eliminated the potential impact of interviewer bias. Also, the anonymity of participants assured that sensitive issues could be addressed, such as the budget for an individual’s project. Scales used inside the questions allowed for eliciting different qualitative and quantitative response patterns. Data provided by the participants were recorded automatically by the server that was used for the web-based questionnaire. Afterward, this information is easily transferred to statistical software for evaluation. The web-based questionnaire made it easy to reach easily project managers from PMI all over Germany.
without extensive and costly travel. Participants were not under pressure to complete the questionnaire, which allowed for calm and balanced responses. The choice to use open questions or half-opened questions was based on the need to gather the most precise data possible.

7.2.1.1 **Developing the questionnaire of the survey**

The questionnaire of the survey was designed according to “Asking questions” (Bradburn, Sudman, & Wansink, 2004), “Questionnaire design” (Brace, 2008), “Der Fragebogen” (Raab-Steiner, 2010), and “Design, evaluation, and analysis of questionnaires for survey research” (Saris & Gallhofer, 2007).

The researcher found no common recommendation for where the acknowledgement for data protection should be placed in the survey (Porst, 2011; Raab-Steiner, 2010). Therefore, the acknowledgement was placed in the glossary on the first page, together with the information about handling and usage of participants’ data. This covered the permission to use data gathered for this research, and protected participants against the misuse of their data. Participants answered the questionnaire after reading and agreeing to the acknowledgement.

Questions were kept short, but an explanation to the specific question was always given. Questions were stated mostly in a closed or half-opened (multiple-choice) form. Open questions were avoided for an easier evaluation. To exclude an interpretation by participants, scales were verbalized whether they were even or uneven.

To assure the validity of the questions, four maxims were followed during the development of the questionnaire (Grice, 1975; Porst, 2011):

- QUALITY – telling the truth, not mentioning statements that are deemed false and cannot be proven
- MANNER – being specific within the question, avoiding ambiguous, complex formulations and confusing expressions
- QUANTITY – providing only the relevant information to the participant that is necessary for answering
- RELATION – assuring that the contribution is relevant for the research target
The questionnaire was arranged into five different sections centred on the field of complexity and management as presented in this thesis. The *PMBok* 4th edition was the basis for the design.

“Seniority and work experience in project management”

The questionnaire began with simple questions to elicit attention and to prevent inaccurate answers. Participants were first queried to reflect about their expert experience. The target of this section was to gain an indication of the seniority and the experience of the interviewees.

The following questions were intended to reach this target. The number of the question correlates to the number as it appeared on the questionnaire.

1. Are you a credential holder of the PMP (PMI)?
2. Since when do you hold the PMP (PMI) certification?
3. Do you hold other certifications for project management except PMP (PMI)?
4. How many years do you work in project management?
5. How many people work in your project team?
6. How many sub-projects has your project?
7. Which field of industry is your project placed in?
8. What is the total value (internal/external) of your project in ‘000 €?
9. How would you categorize the size of your project? (small, medium, large, major)
10. How do you estimate the quality of your project according to the PMI knowledge areas and final success?

With consideration to the motivation and anonymity, the participants were always able to leave out answers. For sensitive questions like question 8, asking the project’s budget, a special note was provided that allowed the participant not to answer.

The field of industries in the questionnaire were defined according to the German Ministry of Statistics (Statistisches Bundesamt, 2008). Terms specific to the PMI standard are easily understood by certified PMI members in Germany.

**Influence of complexity in projects**
In the second part of the questionnaire, participants were confronted with complexity for the first time. The level of difficulty was designed to increase slowly. First, the strengtheners of complexity in projects were addressed, which was intended to familiarize the participants with the concept. This question is designed to answer the research field B about strengtheners for complexity appearing in project management. After being provided with background information about existing complexity strengtheners, participants were asked to estimate the complexity of their own projects.

The following questions focused on those issues:

(11) Which of the following strengtheners (multiplier) for complexity affect your project? Mark your top five items.

(12) How would you rank your project concerning complexity? (1=low and 5 =high)

The questions were semi-structured using multiple-choice. Strengtheners identified in the literature review were listed as possible answers. Participants had to select by minimum zero and maximum five. All five available answers were relevant.

The participants were asked to rank the complexity of their projects using a numerical interval scale. This provided results defined by a single number.

**Handling and management of complex projects**

The third part addressed the handling and management of complex projects by participants. It required the maximum attention of the participants. There they were able to state how they manage complexity in their projects. Depending on the answer of the multiple-choice question, filter questions appeared. To avoid confusion, participants were informed that the filter question was optional and generated by the previous answer. Only one possible answer could be given to each question.

The following questions were intended to achieve this target:

(13) How do you manage complexity?

(14) How do you control complexity? By....

(15) How do you reduce complexity? By...

As a result of this question, the exact method of handling complexity should be identified: not at all, elimination, control and/ or reduce. Possible methods for controlling
complexity were investigated by the literature review. To provide further information to participants and prevent misunderstanding or demotivation, short explanations for each possible answer were given to each participant. The same was done for the management of complexity by reduction.

**Categorization of the complex projects**

To generate further motivation and concentration by participants, they were again confronted with familiar terminology in project management. They had to identify the most and least vulnerable processes in their project. It was the aim to deflect from these question together with already answered questions (specific field of industry, complexity strengtheners and value of project in '000 €) a model to categorise projects concerning complexity and easily identify their specific strengtheners. Such a new model is the objective of the research field C.

The following questions were intended to reach this target:

(16) Name the processes vulnerable to complexity in your project. Mark the 10 most vulnerable processes (PMI standard).

(17) Name the processes vulnerable to complexity in your project. Mark the 10 least vulnerable processes (PMI standard).

Here participants had to assign a rating to most and ten least vulnerable processes using ten as the maximum and using zero as the minimum. So non-meaningful responses did not arise. The offered processes of the PMI standard are familiar to participants because they are certified members of PMI.

To avoid similar answers on vulnerable processes, the processes were not arranged according to the PMI process table where the participant might always choose the first one. This bias “order effects” is avoided by displaying the possible answers by the random listing of all processes (Brace, 2008).

**Handling complexity in the actual PMI standard**

The last section in the questionnaire addressed the topic of complexity in PMI standard, although it is not specifically mentioned in that standard. The target was to identify whether the standard of PMI is still sufficient to manage complex projects or if a modification is needed. For this portion, participants were asked to propose changes to the
current standard. First, an easy question was asked regarding whether or not the PMI standard is still satisfactory. Filter questions were then applied, as noted in the original question. When question 18 was answered with “no,” questions 19 and 20 were hidden. Question 19 and 20 was intended to prompt proposals from participants to manage complexity. Then they directed to the question of whether a separate chapter for dealing with complexity is needed. Finally, the tools and methods to handle complexity, as found in the literature, were offered as selections that could be integrated into the PMI standard (question 22). With the outcome of this section of the survey the research objectives of the fields D and E shall be answered, identifying the satisfactory handling of complex projects with current PM standards or whether an adaptation is necessary in methodology and methods.

The following questions were intended to reach this target:

(18) Does the actual PMI standard satisfactorily describe complexity?
(19) Which tools/ methods in the actual PMBoK guide would you suggest to manage complexity?
(20) Which other tools/ methods do you recommend for managing complexity?
(21) Would you prefer a separate chapter for managing complexity in PM standards?
(22) Which method would you implement in the PM standard to handle complexity?

Finally, participants could state their opinion about the questionnaire in an open question. To gain information about the efficacy of the survey, the participants were asked for explanatory notes about the structure, set-up, understanding and handling of the questionnaire (Porst, 2011).

The online questionnaire is shown in Appendix XXVII – Questionnaire for online survey of PMI members in Germany.

Its ‘understandability’ and completion time were examined in pilot-tests with senior project management consultants (see 7.2.1.4).

7.2.1.2 Survey participants
All participants in the survey were members of the Project Management Institute (PMI). Therefore, the ability to contact possible participants was provided by the institute.
Chapter 4.4 shows that the PMI standard is used most worldwide. The survey was performed exclusively for project managers in Germany.

The data acquisition in this investigation focused on certified members of PMI. This was the main criterion for the selection of participants and ensured a high standard of quality in the answers.

Participants were informed that participation is voluntary and anonymous. If desired, the results of the survey could be provided to participants (Raab-Steiner, 2010).

### 7.2.1.3 Data collection by the survey

Data for the survey were acquired online. Answers to questions could not be controlled. The link to the questionnaire was distributed by the PMI chapters in Germany to their members. The questionnaire was available online for a period of three months from the end of September 2013 until the end of November 2013. During this time, this topic was presented by the researcher at different PMI meetings in Munich, Stuttgart, Heidelberg/Mannheim, Düsseldorf. Furthermore, the survey was announced in the newsletters of PMI chapters and the link online posted on PMI web community pages in Germany via the business platform XING and LinkedIn. This was necessary to inform as many PMI members in Germany about the ongoing survey, and to motivate them to participate in the online survey. In order to alert participants from other countries, a statement was given at the beginning of the questionnaire that only German certified PMI members should participate. The survey involved approximately 4,900 certified project managers in Germany (Lehmann, 2014). A feedback rate of 1-10% was expected.

Closed questions, half-opened questions, and ranking scales provided data in practice of handling the PMI standard and complexity. Data were first numerically coded and investigated to assure completeness. Incomplete questionnaires were rejected. Coded data were imported to a statistic analyzing tool. The Statistical Package for the Social Science (SPSS) was used because it was the most appropriate software for this research. All necessary statistical analyzing methods were provided as freeware from the university. A consistently numerical coding of the questions was checked in the SPSS data table. Then they were analyzed using descriptive and analytic methods. The questions and the findings of the survey are described in detail in chapter 8.1.

### 7.2.1.4 Pilot-test – survey
Before the survey started, a pilot-test with a small group of project management experts was performed. The pilot-test was intended to identify possible obstacles.

Experts in project management tested the questions with regard to content, time duration, technical aspects, and rules for correctly formulating questions (Bradburn & Sudman, 1979; Holm, 1986; H. Mayer, 2004; Porst, 2011; Schnell, Hill, & Esser, 1999; Sudman, Bradburn, & Schwarz, 1996):

- Clear wording understood in the same way by participants
- Avoiding long and complex questions
- Avoiding hypothetical questions
- Avoiding negated and doubled stimuli
- Avoiding assumptions and suggestive questions
- Avoiding questions which require specific information
- Using a definite temporary basis
- Using a clear non overlapping answer possibilities
- Context of question should not refer to the answer
- Definition of unclear terms

The pilot was performed in late August 2013 predominantly with people from the researcher’s place of employment. Those individuals are experts working as project management consultants. They have a minimum of three years’ experience in the specific business and are well versed in the PMI standard. The pilot provided direction making and integrating improvements into the final questionnaire.

Understanding of the questionnaire – typing errors and grammar failures appeared in several of questions and answers. Here single consonants omitted, question marks missed, or words were selected that cannot be translated into English like “enabler” instead of “strengtheners”. These were corrected before distribution. Non-existent words were replaced and questions were modified concerning precise terms for the answering option.

Technical aspects – Most participants had no technical problems in handling the online questionnaire. Question 16 and 17 invite participants to select up to ten relevant valid processes. When a participant selected none, the online survey was halted. The mandatory option was removed in the setting for these questions.
Time duration – all participants of the pilot-test completed the survey in approximately 30 minutes, which seemed to be a reasonable timeframe. Therefore, a reduction of questions was unnecessary.

Helpful hints for the arrangement of the questions were received, so that the setup was rearranged in order to support the logical way of thinking. In particular, significant information was received regarding the ten most vulnerable obstacles concerning complexity in project management and for the ten least vulnerable blocks.

Answer options were randomly changed in the questionnaire. The option of a randomly outlined answer helps to combat a habitual scoring. This randomly changed order for answers was applied to questions that addressed topics that the participants would be very familiar with such as questions 16 and 17 for the most and least vulnerable processes concerning complexity, or question 19 that asked about the tools and methods for managing complexity inside the PMI standard.

The results of the pilot-test optimized the questionnaire. Questions were coherent and technical implementation was well done. Experts received an overall understanding of the research topic. The research questions and goals were viewed as more understandable after the modification (Appendix XXVI – Results pilot-test: online survey)

7.2.2 Qualitative research: Interview

The Interview is a qualitative research method that is intended to understand the world from a subject’s point of view (Kvale & Brinkmann, 2009). The researcher learns about the experience and attitude of the interviewee and the interviewee is made familiar with the topic of research and interview (Kvale & Brinkmann, 2009).

In the narrative interview the context of experience is most important. In the guided interview, open questions are prepared and can be freely answered by the interviewee (H. Mayer, 2004). The guided interview was applied in this thesis.

Prepared questions in the guided interview helped the interviewer to avoid overlooking important topics (Flick, 1999; Friebertshäuser, 1997). Furthermore, a guided interview assures comparability between different interviews. Interviewees will discuss similar questions and this helps the researcher to evaluate the results of the questionnaires (Meuser & Nagel, 2002; Nohl, 2009).
When selecting the scope for interviews, the number of single interviews must be considered because evaluation and transcription is time consuming. Resources are the primary limiting factor for a large number of interviews (Helfferich, 2011). In general, the sample should be representative and allow a statistical interference to the universe, but a reduced mapping of the universe is possible (Kromrey, 1995).

The research interview is established in seven phases (Kvale & Brinkmann, 2009): thematising, designing, interviewing, transcribing, analysis, verifying, and reporting. H. Mayer (2004) recommended at least three phases: development of the guideline, performing the interview, and evaluation. Kvale and Brinkmann (2009) and H. Mayer (2004) have strong similarities in their explanation for executing research interviews. In “thematising,” the research question the why, what, and how is considered. “Designing” explains how to perform the interview. It provides an overview of the entire investigation before starting the interview: subjects, time, resources, improving the quality, spiralling backwards for understanding, and focusing the endpoint (Kvale & Brinkmann, 2009). H. Mayer (2004) discussed similar topics relative to the development of a guideline. The third phase of Kvale and Brinkmann (2009) correlates to H. Mayer’s (2004) second phase. All of the authors describe how to perform and document the interview. After the actual interview is finished, the post interview phase is connected: The transcription, analysis, verification and, reporting of the gathered data (Kvale & Brinkmann, 2009). H. Mayer (2004) combined these elements into a single-phase evaluation.

7.2.2.1 Expert interview: focus group
The focus group interviews added in-depth understanding by exploring the practical experiences of participants. The participants of the focus groups and the survey were anonymous and selected from the population of certified PMI project managers in Germany. The group of participants was reduced based on their specific skills as experts (Flick, 1999; H. Mayer, 2004). It was an investigation into the opinions of similar groups as relevant to the specific research topic, managing complex projects (R. Krueger & Casey, 2009; Kvale & Brinkmann, 2009; Mucchielli, 1973).

The popularity of focus group interviews (FGI) can be explained by a quick turnaround from interview to findings. The information provided by the FGI participants is unique and can be widely used to offer a reflection of expanded knowledge (Baker, 1985; Vaughn, Schumm, & Sinagub, 1996).
The FGIs were carefully prepared by the moderator and had common characteristics. These characteristics are (R. Krueger & Casey, 2009):

- **PEOPLE**
  The focus group interviews were conducted with four to twelve participants. This selected size was small enough to allow participants to comfortably share insights in front of everybody and big enough to provide diverse perceptions (R. Krueger & Casey, 2009; Kvale & Brinkmann, 2009; Mucchielli, 1973; Vaughn et al., 1996). For this research, the existing roundtables of PMI in Germany proved the most suitable venue because PMI members meet at those on a regular basis. Participants of the roundtables receive an invitation 2-3 months in advance including the specific topic that will be discussed. They meet in private areas and each participant has equal status. The head of a chapter moderates the roundtable, but the participants can speak openly. Participants have an inherent motivation to join the round tables because as PMI credential holders must re-certify on a regular basis.

Therefore the FGIs were arranged as PMI round tables. There was no special recruiting or selection of participants. The FGIs – officially announced by PMI – had a number of participants at the upper limit of 9 to 15 participants. All round tables were arranged in the private areas of restaurants.

- **CHARACTERISTICS**
  The members of the focus group share similar characteristics: employment with project management, PMI membership, PMI certification, and long-term experience in project management. The homogeneity of the three focus groups was a pre-condition to present analyzed findings of the survey and to test their validity. Furthermore, the results from focus groups should be compared to each other during the evaluation. Therefore a common familiarity with project management and also complex projects was required for the participants of the focus groups.

- **QUALITATIVE DATA**
  Qualitative data of the interviews are collected and compared later in the process. However, the target was not to gain consensus, but to gather and compare different viewpoints and opinions. This approach is also known as the “phenomenolog-
ical approach,” which is defined as the ability to understand the topic from everyday knowledge (Lindgren & Kehoe, 1981; Vaughn et al., 1996). Different authors recommended that, at the very least, three focus group interviews should be performed (R. Krueger & Casey, 2009; Kvale & Brinkmann, 2009). A limit was not set.

It is assumed that the participants of focus groups were also involved with the online survey. The three performed FGIs with PMI experts took place in Munich, Frankfurt and Stuttgart from April 2014 till June 2014.

— FOCUSED DISCUSSION

The guided interview that was presented by the researcher included predetermined and sequenced questions. Those questions were open ended and arranged in a logical natural sequence, beginning with: opening, introduction, transition, key questions, and closing questions. The goal was to have a maximum of eleven questions and a time limit of 120 minutes (R. Krueger & Casey, 2009).

For the discussions with experts 70 minutes was allowed, and an extra 20 minutes was set aside in the event that the discussion ran long. The discussions required a maximum time of 90 minutes for each focus group.

Open questions were predefined in an interview guide and discussed. During the discussion, the researcher focused on the audience. Interviews were audio recorded after gaining the permission of participants. Prior to conducting the discussion, the interview guide was finalized and agreed upon between the researcher and the head of the PMI chapter. This guide was organized in the sequence according to Krueger and Casey (2009).

Opening
The focus group interview was opened by the moderator of the PMI round table. He welcomed all participants, introduced the researcher and handed over all rights of the moderator with no further influence of the round table.

Introduction
The introduction was planned to last no longer than 5 minutes. Participants were informed about the thesis topic, the general purpose of the focus group, and the findings from the survey. The stages of the focus group interview were explained.

**Transition**

Transition links were presented to shift the topic from the introduction to the key questions of the focus groups. Participants were asked if they were interested in the research topic and whether they had ever been affected by complex projects. The transition phase was planned to last for 5 to 10 minutes.

**Key questions**

The greatest attention from participants was expected for the key questions. Here a minimum duration of 15 minutes for each question was planned. For a faster absorption of the question, the findings of the survey were illustrated together with the relevant key question in a presentation, projected on a screen. Therefore, the participants were provided with comprehensive multi-media information.

**Closing**

During the last 5 minutes, the researcher summarized the outcome of the discussion, reassured the participants of the anonymity of the data and their usage, and asked participants for further questions.

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**SUPPORT IN UNDERSTANDING THE TOPIC**

The interviewer gave a short introduction of the focus group participants, in order to provide a better understanding of the topic of interest (R. Krueger & Casey, 2009).

The introduction allowed participants to gain a common understanding of the topic. The researcher actively worked to engage the participants in the key question portion of the focus group by assigning specific questions to each individual. The participants were encouraged to ask questions, which were answered by the researcher.

The guide applied to the interviews is shown in Appendix XXIX – Guide for the focus group interviews (FGI) with PMI members in Germany.
Later the audio-recorded answers were converted into textual notes. A qualitative content analysis was performed as based on Mayring (2010). The participants’ statements were assigned to the subject matters of the interview guide. Multiple categorizations of the statements were possible when they referred to different subject issues and the context was analyzed and interpreted. The individual textual elements that were categorised into a ‘subject’ were solidified into a connected narrative. The aim was to establish a distinct structure of the available information (Mayring, 2010). A unifying analysis was then performed that compared the results from the survey, the interview, and the literature. Differences were outlined. The findings of the survey were modified by comparison, using the deviating results from the interviews. The reasons for modifications were discussed and outlined (chapter 9). The findings from the focus group interview are described in chapter 8.2.

### 7.2.2.2 Developing the questions for the focus group

The focus group interviews were performed after the survey was completed. Therefore, the findings and ambiguities of the survey were more thoroughly analyzed and clarified in the focus groups. The questions for the focus group were separated into two parts: the questions for transition and the key questions. The quality of the answers to the key question is fundamentally dependent on introductory transition question.

#### Questions for transition

The transition phase was intended to more fully engage the attention of the focus group participants. A question had to be developed that connects the participants’ personal interests in project management to the topic of this thesis, managing complex projects. This question was not meant to be evaluated; it was designed to outline the participant’s view on the topic, how much they are affected by it in their own projects, and how they react to the specific situation of managing complex projects.

Three questions were presented in the focus group guide (see chapter 7.2.2.1). The first addressed the participants’ interest in the topic: How does the topic “optimal handling of complexity in project management” interest you? For this question, the participants should indicate their desire to actively to involve themselves in the discussion. Participants were encouraged to think about complex projects. If so, the in-depth questions begin: Have you ever been affected with a complex project, either as a stakeholder, project manager, or project team member? Participants of the focus group should reflect on
their experiences of being involved in complex projects. In general, people initially remember the positive and negative effects resulting from a complex project. Based on that reflection, the final question for transition was asked: How did you behave within this situation? Participants were prompted to give examples of the way that they handled complex projects, regardless of whether they are aware of the specific methods of handling complex projects.

After focusing the mind-set of participants to the management of complex projects, the key questions were addressed.

**Developing key question #1: Do you agree with the top complexity strengtheners and do you also handle them by control/ reduction?**

The input for the key question #1 was based on the presentation of the results of the online survey for complexity strengtheners and the way to handle them.

This had to be verified with the following question: Do you agree with the top complexity strengtheners and do you also handle them by control/ reduction?

Strengtheners impact projects. The foundation of managing complex projects is based on the potential methods of handling those strengtheners. The top five strengtheners from the online survey were found to be: customer requirements, stakeholders, communication process, division of work, and organisational changes. Typically those areas are the responsibility of the project manager. A project manager must insist on realistic requirements, the involvement of stakeholder, information distribution, and the delegation of specific tasks. The survey showed that more than 85% of the participants choose to control or reduce complexity when it first occurs.

Because the focus group participants belong to the same population as the survey participants, the expectation was that the survey results would be largely confirmed. The researcher also expected to discover additional commentary that could expand understanding and practical applications.

The following key question was developed from the findings of key question 1 and a reflection on today’s failing projects as discussed in chapter 3.
Key question #2: Does project success depend on certified project managers, and do you as a certified project manager manage vulnerable processes using the stated detailed handling methods?

In the online survey, PMI project managers reported that more than 70% of their projects were successful. This success was also analyzed in the survey for each single knowledge area of PMI: communication, cost, human resources, integration, procurement, quality, risk, schedule, and scope. The overall success of projects was also addressed. The success rate might be related to the project management certification of participants. If this could be confirmed by the participants of the focus group, then the complexity of projects could be possibly handled by applying the PMI standard. If the participants did not view certification as the basis for success, then the reasons for that refutation would be investigated.

Furthermore, the applications of the different handling methods on top vulnerable processes for complexity in project management were discussed with participants in the focus group. The handling methods are for controlling complexity the rational and reality approach, and for reducing complexity the learning from others, structuring/labels and standardizing approach.

Therefore, the following question was asked in the focus group: Is a project success dependent on certified project managers and as a certified project manager do you manage vulnerable processes in a project using the stated detailed handling methods?

From the direct discussion with experts, the researcher expected to gain more in-depth knowledge related to project success and the value of PMI certification. Also, a general consensus on handling vulnerable processes in project management was anticipated to emerge from the focus group.

Key question #3: When you think about your own complex project, do you find yourself in the following table with the strengtheners and unimmunized processes in the project? Compare your identified field of the project with strengtheners and vulnerable processes of your project. Are they the same?

From results of the online survey, a classified matrix to identify complexity in projects was developed. This matrix consists of three tables that combine the following variables: complexity strengtheners, the most and least affected processes for complexity in pro-
jects, the participants’ categorization of the level of complexity in their own projects, the size of the projects, and the industry where the participant’s project is located.

The matrix was developed from the online survey and was then be evaluated by the focus group concerning its application to practice.

Therefore, both the participants of the focus group and the online survey participants were asked to categorize their project concerning complexity and size. Afterward, the participants were asked to examine the complexity strengtheners and processes vulnerable to complexity in their own project based on the complexity and size of those projects. The criteria for this evaluation were based on the results of the online survey. Therefore, the matrix developed to identify complexity in projects should be tested in practice to determine whether it is applicable for daily use.

Aimed to the examination of participants’ own project, the key question was formulated as follows, separated into two parts, and supported with the graphic tables:

Part one: When you think about your own complex project, do you find yourself in the following table with the strengtheners and unimmunized processes in the project?

Part two: Compare your identified field of the project with strengtheners and vulnerable processes of your project. Are they the same?

The visualization for the matrix to identify complex projects with its strengtheners/ vulnerable processes and field of industry they appear, should be tested systematically in a broadened community of experts.

**Key question #4: How can an adopted PMI standard support you in manoeuvring a complex project? Spending a separate chapter or explaining new methods for managing it?**

The last key question back couples a link to key question #2. Participants were asked to explain the success of projects as stated in the survey by the certified project managers. In addition, key question 4 asks the participants to discuss whether the PMI standard effectively addresses the handling of complexity in the PMI standard, and if an adaption of the standard is necessary. In the survey, the majority of participants stated that PMI handles complexity effectively, but still requested a separate chapter in the PMI stand-
ard. If focus group participants agree, then the discussion will focus on the implementation of new methods to handle complexity.

The participants then discussed following key question:

How can an adapted PMI standard support you in manoeuvring a complex project? Would a separate chapter on managing complexity be helpful? Should the PMI standard provide an explanation of new methods for managing complexity?

In general, the researcher expected the answers to the key questions to be similar to the results of the survey because the survey participants and the focus group participants were selected from the same population. Therefore, an intersection of the survey participants and focus group participants was possible. The additional information given from the experience of focus group participants and the possibility of deepening questions on focus group answers should provide in-depth knowledge and practical modifications of the standard.

The final guide for the focus group interview is shown in Appendix XXIX – Guide for the focus group interviews (FGI) with PMI members in Germany.

7.2.2.3 **Pilot-test – Focus group**

Like the survey, the focus group interviews were prepared with a pilot-test. So possible obstacles (e.g. structure, understand ability, timeline etc.) were eliminated. The pilot-test for the interview questions was conducted with senior project management consultants and took place in February and March 2014. Those consultants are experts in project management, but not necessarily members of PMI. On a daily basis, they deal with complex situations in engineering, production, and financial projects. These experts identified hidden biases, mistakes, and recommended improvements for the final focus group interview guide.

The pilot test participants considered the guide as overly extensive and difficult to understand. An extended introduction was judged as time-consuming because less time would be available to address the key questions. It was suggested that participants could be overwhelmed by the given information, which would prevent them from engaging in the FGI. Therefore, the timeline for this thesis and the guidelines for the focus group interviews were eliminated. The participants of PMI roundtables are on the same level as the focus group interviewees and need no special instruction. So, the introduction was
shortened. For simplification, the timeline of the thesis and the guidelines of the FGI were eliminated and the action title was renamed.

The unevaluated question intended for initiation and transition was not changed. The experts stated that those questions were easy to understand and would guide participants to the key questions.

*Transition question:* How does the topic “optimal handling of complexity in project management” attract you?

The experts judged the first key question as easy to understand. However, they criticized the excessive information included in this key question (graphs, research target and question). It was suggested that the participants of the FGI could find it difficult to concentrate on the core information in the question. Therefore, the research target and the research question were eliminated. This was also done for the other key questions. Furthermore, the design of the graphics was rearranged according to the flow of the key question 1. That change was intended to allow the participants to read the question first, and then follow the flow of the question in the graphs.

*Key question #1:* Do you agree with the top complexity strengtheners and do you also handle them by control/reduction?

The arrangement of the graphics for the FGI key question 2 seemed was considered illogical to the experts. The participants suggested that the sequence of interpretation and the interrelation of the graphs were unclear. They were rearranged in sequence to be interpreted and separated by lines concerning their context. This should assure a better interpretation and understanding of the key question 2.

*Key question #2:* Is a project success depending on certified PMs and do you as a certified PM manage vulnerable processes in a project by the stated detailed handling methods?

The experts were very confused by key question 3 and could not identify the intent of the context. The question was modified by adding a graphic instruction that explained how the participants should categorize the dimensions (major, high, mid, low) and level of complexity (high, mid, low) of their own projects. This should give the participants guidance and support to better understand the question. In a second step, the results of the connection of vulnerable processes and strengtheners for complexity will be com-
pared with participants experience and the results from the survey. Here experts criticised that the participants would not know what to do on the second part. So the key question 3 for the FGI was repeated for clarification.

Key question #3: **When you think about your own complex project, do you find yourself in the following table with the strengtheners and unimmunized process in the project?**

The final key question 4 of the FGI interview guide was not criticized in the pilot-test: therefore, it was not changed. This was also the case for the interview closing.

Key question #4: **How can an adapted PMI standard support you in manoeuvring a complex project? Spending a separate chapter or explaining new methods for managing it?**

Details of the recommended changes by the experts are shown in Appendix XXVIII – Results pilot-test: focus group interview

### 7.3 Ethics in research methods

All of the participants of the quantitative survey and structured FGI were informed of the methods, risks, and the usage of their data (Silverman, 2009). The questionnaires were anonymous. Interviews started after building a relationship of trust. Confusion and difficulties were addressed and solved cooperatively. The interviews were structured and no names were listed (Simons, 2012).

Data were stored electronically. All physical artefacts were shredded afterwards (McNiff & Whitehead, 2011a). All data were saved in a file that could be compiled for analysis with a statistic tool. No data of survey and interview were used without the prior permission of participants. The security of data was assured and the collected data published with the research findings (McNiff & Whitehead, 2011b).

The following specific ethical issues for questionnaires and interviews were respected.

**Ethics in questionnaires**

Ethical issues in questionnaires are defined primarily in three codes: the Market Research Society (MRS) in the United Kingdom, the Council of American Survey Research Organisations (CASRO) in the United States, and the European Society for Opinion and Marketing Research (ESOMAR) in Europe. Ultimately, the researcher is responsible for
the questionnaire. Consideration must be given to ethical issues and legal mandates must be adhered to (Brace, 2008).

According to the 1998 data protection act of the United Kingdom, the following topics need to be considered in each questionnaire (Brace, 2008):

- Name of organisation conducting the study
- Broad subject area
- Mentioning if the collected data is kept confidential and if collected data is sensitive
- Mentioning by whom and for what purpose gained data are used
- Length of interview
- Possible cost which might appear to the respondent
- Medium with which the interview is recorded

Brace (2008) recommended that the ethical issues should be mentioned in the introduction of the questionnaire, which was followed in this research survey.

**Ethics in interviews**

The interviewer is “researching in private lives and placing accounts in the public area” (Mauthner, Jessop, Miller, & Birch, 2002, p. 1). Ethics must be considered in all phases of an interview process, from development though reporting (Kvale & Brinkmann, 2009).

Researchers must respect four topics in ethics for interviews (Kvale & Brinkmann, 2009):

- Informed consent
  
  Background information should be provided about the interview, risks, and benefits for the participating interviewees. They should be informed about the confidentiality of the interview, and provided information must be weighed carefully. Interviewees should be able to stop the interview at any time if desired.

- Confidentiality
  
  The private data of participants that could identify them are not published. If data are provided to a third party, interviewees must consent. The dilemma of publishing is that some interviewees want to have their private data published for journalistic reasons or to receive credit for the interview.
− Consequences
Outcomes and benefits must be mentioned. However, too much freedom can cause interviewees to change their answers or to withhold relevant information.

− Role of researcher
This regards the moral integrity of researcher and his awareness of moral topics and moral behaviour. The results must be fully checked and validated as soon possible, which proves scientific quality. His independence ensures the unbiased investigation of the phenomena as much as possible. Knowledge, honesty, and fairness of the researcher are essential.

These issues were followed and also always explained before starting the focus groups.
8 RESEARCH FINDINGS

8.1 SURVEY
The online questionnaire as filled in by participants can be seen in the appendix.

8.1.1 SENIORITY AND WORK EXPERIENCE IN PROJECT MANAGEMENT

Questions

The following questions analyzed the seniority and work experience in project management (the number of the question is the same as in the questionnaire):

1. Are you a credential holder of the PMP (PMI)?
2. Since when do you hold the PMP (PMI) certification?
3. Do you hold other certifications for project management except PMP (PMI)?
4. How many years do you work in project management?

Analysis

In order to prove experience, a descriptive statistic method was used. This method was characterized by analyzing the frequency, absolute, and percentage figures. Afterward, standard analyzing methods were used such as: arithmetic mean, the standard error of arithmetic mean, median, variance, minimum, maximum, and standard deviation.

Justification

The analysis gives an overview of the completion of questionnaires. In order to assess the relevant population, only the completed questionnaires were accepted and compared. Furthermore, it was expected that the seniority of the participants should emerge. This was performed by calculating the number of certified project management among the participants. This assured validity for further answers in the questionnaire and emphasis to the research. Differences in the duration of experience were checked by the arithmetic mean in referred PM experience which had to be higher than the minimal time for acquiring a PMP certification. This was planned as a validity check for the experience of participants. However, no difference did appear and falsify the results; the experience was proved. In addition, it was shown that the participants who had certifications (PMP) did not focus on a specific standard, but were open to other PM standards.
Findings

In total, 176 questionnaires were returned. 53 were returned opened, where no questions were answered. 27 questionnaires (22%) were abandoned by the participants and questions were left unanswered. However, a total of 96 questionnaires were completed in full by the participants. This is an acceptable “valid” feedback rate of 78.0% if only completed questionnaires are taken into account (Figure 24). Out of the 22% of abandoned questionnaires (n = 27), 6.5% (n = 8) stopped at the introduction (page 0). 3.3% (n = 4) stopped at the first page and only filled in the questions for “seniority and work experience in project management”. 1.6% (n = 2) stopped at the general introduction into complexity – “influence of complexity in projects”. 8.1% (n = 10) abandoned the questionnaire at the third page. This particular stage of the survey is critical for engaging the interest of the participants in the subject of “handling and management of complex projects”. The majority of participants that did not complete the survey stopped at that point. 2.4% (n = 3) stopped at the second last page where the “categorization of the complex projects” was questioned. This might have happened because the participants had to read and analyze the numerous most and least vulnerable processes of the PMI standard, which is a time consuming effort. When the last page of the questionnaire was finished “handling complexity in the actual PMI standard”, the questionnaire was fully completed. This was performed by 78% (n = 96). For further analysis, only the completed surveys were used and considered as valid feedback. This choice was intended to maintain the integrity of the results, which could have been corrupted by using incomplete surveys.

![Figure 24: Editing of survey by participants](image-url)
91.6% of respondents (n = 87) have passed the PMP test of PMI and maintain the PMP certification (Figure 25). Only 8.4% (n = 8) did not maintain a certification and only one participant did not respond to this question. This is an appropriate basis to make a judgement that the respondents are familiar with the questions about managing complex projects. According to the PMI, these participants have a certain experience in project management practice.

The mean duration of maintained PMP certification is about 5 years (4.87 years +/- 0.428 years) (Figure 26). However, in relation to question 1 regarding PMP certification, only one participant did not reply. For question 2 that addresses maintaining PMP certification, 9.4% of the participants (n = 9) chose “no answer.” This is not as critical as it seems. It is important that a high percentage of participants are credential holders because this certification requires a minimum of three years of practice in project management. 52.9% of participants (n = 46) are first-time credential holders in PMP certification, which has to be renewed each three years. With a minimum of one year and a maximum of 15 years of holding the PMP certification, valuable work experience is gained.

Figure 25: Credential holder of PMP (PMI)

Figure 26: Upstanding PMP (PMI) certification
The average experience in project management was more than seven years. This can be attributed to the PMI requirement of a minimum of a three-year period of work experience prior to gaining PMP certification. This is confirmed by the arithmetic mean of work experience of 14.75 years +/- 0.696 years in project management from the participants (Figure 27), with a span from 2 to 39 years of experience. Every participant in the survey answered this question in the affirmative. Almost 70% of participants have between 2 to 15 years of experience, which is also illustrated in the distribution curve of Figure 27. The upper percentile has experience of 25 years and more, the lower percentile from 4 years and less. The participant who has only two years of experience in project management cannot be a credential holder of PMP, which is also outlined in Figure 25. This has no influence on the results, as the majority of participants is a credential holder.

PMP certification from PMI is not the only certification participants obtain. Some participants hold additional certifications: the Prince2 certification (9.5%/ n = 9) from the OGC is held by the most participants. Few have a broadened view on project management with ICB3.0 (3.2%/ n = 3) from the IPMA, which is more detailed. The BSI 6079 from the British Standard Institute was held by only a few of the participants (2.1%/ n = 2).
Some participants named additional certifications that are not part of the major project management standards or are superseded by a superior grade qualification (Figure 28). These certifications are listed under the collective term “other certifications” (11.6% / n = 11): the Information Technology Infrastructure Library (ITIL) certification, the Australian Institute of Project Management (AIPM) certification like the managing successful project (MSP), a certification of IBM, Certified Scrum Master, internal qualifications of companies, or lower certifications of the listed PM standards like the Certified Associate of Project Management (CAPM) of PMI.

The disparity between the number of certifications (n = 99) and the number of participants (n = 96) is explained by the individuals holding double certification.

![Figure 28: Other certifications than PMP (PMI)](image)

### 8.1.2 Influence of Complexity in Projects

#### Questions

The following questions analyzed the influence of complexity in projects (the number of the question is the same as in the questionnaire):

1. (11) Which of the following strengtheners (multiplier) for complexity affect your project? Mark your top five items.
2. (12) How would you rank your project concerning complexity? (1=low and 5 =high)
3. (13) How do you manage complexity?

#### Analysis

First, all of the questions from this section of the questionnaire were analyzed with descriptive statistics methods. The frequency was analyzed together with the arithmetic mean, minimum, and maximum values. Results are shown in bar charts and histograms.
For a deeper analysis the correlation, according to Spearman (analytic statistic), was then applied. This corresponds to the participants’ estimation of their own projects and the way of handling or appearance of complexity strengtheners (question 12 was correlated with question 11 and 13). This was possible because question 12 was an ordinal ranked scale (1 = low to 5 = high) and correlated to each single answer of the question 11 and 13. Each answer of these questions was ranked in an ordinal manner during the correlation (relevant = 1 and non-relevant = 0).

**Justification**

This section of the questionnaire analyzed the strengtheners of complexity. What type and amount of strengtheners do project managers’ encounter? By categorizing the degree of complexity that participants assigned to their own projects, a ranked variable for the correlation could then be estimated. Furthermore, it had to be identified where the majority of participants ranked the complexity of their projects. By questioning their handling of complex projects, the participants’ generally preferred method was identified.

Afterward, the different categorization of projects with appearing strengtheners and preferred handling method were correlated, which was intended to identify significance significant relationship between the answers.

**Findings**

Participants chose the top items for complexity strengtheners, based on their individual experiences. Generally all participants (n = 96) marked the provided strengtheners. In the mean, participants selected four different strengtheners. The number of different complexity strengtheners that participants assigned to projects follows:

- Selected 1 strengthener by 3.1% (n = 3)
- Selected 2 strengtheners by 9.4% (n = 9)
- Selected 3 strengtheners by 8.3% (n = 8)
- Selected 4 strengtheners by 17.7% (n = 17)
- Selected 5 strengtheners by 52.1% (n = 50)
- Selected 6 strengtheners by 9.4% (n = 9)

This and the standard error are illustrated in Figure 29.
Figure 29: Transformed answers according to respondents for complexity strengtheners

From the offered bundle of strengtheners of complexity, participants selected the most important ones:

1. Customer requirements  (64.6% / n = 62)
2. Stakeholder            (46.9% / n = 45)
3. Communication process  (39.6% / n = 38)
4. Partitionment of work  (38.5% / n = 37)
5. Organisational changes (35.4% / n = 34)

It can be seen that always at least one third of all participants (n = 96) in the survey have concurrently named the same top strengtheners. The top three strengtheners are closely linked together at a very early stage of the project. In a good communication process, all stakeholders are early involved in the project. So customer requirements are clearly considered. These items above should always be on a project manager’s mind. Then complexity in one’s own project will not explode. But also the other strengtheners should be respected in initialising, planning, executing or closing a project. The remaining strengtheners internal/ external interfaces (7.0% / n = 29), project organisation (6.0% / n = 25), technical diversity (5.5% / n = 23), law/ norms/ regulations (5.5% / n = 23), internationality (5.3% / n = 22), change in time schedule (4.6% / n = 19), cultural diversity (4.1% / n = 17), incompatible systems (3.8% / n = 16), limited actuality (3.1% / n = 13), virtual techniques (1.4% / n = 6), market flexibility (1.0% / n = 4) and other (1.0% / n = 4) are listed according to their frequency selected by participants in Figure 30. This does not mean that they are less important, eventually these occur in special projects.
The degree of complexity of their own projects was subjectively ranked by participants in a qualitative scale from 1= low to 5= high. They stated a degree above the Median with 3.31 with a standard error of +/- 0.101 (see Figure 31). The majority of participants (66.7%/ n = 64) estimate their project as medium complex which correlates to level 3 up to light complex correlating to level 4. Projects with a low complexity degree (level 1) almost do not exist (2.1%/ n = 2) and highly complex projects (level 5) are rarely stated (10.4%/ n = 10). Less complex projects equal to level 2, participants marked only seldom in the survey (20.8%/ n = 20). Answers were given by all participants.

Figure 30: ranking of complexity strengtheners appeared in real projects

Figure 31: Participants ranking of their project concerning complexity
Scientists in literature recommend for handling of complexity to control or reduce it. Most project managers in the survey follow this approach – more than ¾ – and gaining so different advantages in markets. The majority of 49.6% (n = 56) tries to control complexity. 36.3% (n = 41) of survey’s project managers follow the approach to reduce it. Only 2.7% (n = 3) in the survey tries to eliminate the complexity. But a high number of 11.5% (n = 13) does not manage complexity at all. This distribution shows that controlling or reducing complexity is the overwhelming handling in practice (Figure 32). Practice is confirming statements in literature. It inspires to implement a method to handle complexity in project management. As participants were able to select more than one handling method, the total number of responses (n = 113) is higher than the number of participants (n = 96). The histogram in Figure 32 relates to responses calculated on 100%.

![Histogram showing managing complexity](image)

**Figure 32: Participants way of handling complexity in their project**

The analysis of the questionnaire correlates the degree of complexity in participants’ own project (question12) to the way of handling complexity (not at all, eliminate, control, reduce) (question 13). The correlation method “Spearman-Rho” is used. The result of the correlation shows no statistical significance. The correlation shows no ensured connection between the degree of complexity in the participants’ projects and the handling of complexity in this survey (Figure 33):
In the following stage, the relationship between the individual degree of complexity in the participants’ projects (question 12) and the strengtheners for complexity (question 11) was investigated. A statistical significance exists (N = 96, r = -.252, s.s. at p < 0.01): this represents a negative relationship, or a higher level of complexity in a project correlates with a lesser impact from the complexity strengthener “cultural diversity.” How can this be explained? In general, strengtheners should not reduce the complexity in complex projects. It can be supposed that in highly complex projects with multinational teams that an increase of varied cultures would not affect the projects complexity. This strengthener “cultural diversity” might have less impact than others and stagnate after certain cultures have joined the project team. All other recorded strengtheners for complexity including the top five strengtheners (customer requirements, stakeholder, communication process, division of work, and organisational changes) showed no significant increase in the degree of complexity in projects in the mind of participants. The statistical significance is shown in Figure 34. Reason for such unexpected result could be that participants had only to name the limited amount of five strengtheners (top) for complexity appearing in their project. Possible that the whole number and ranking of named strengtheners would led to a significant correlation with the estimated degree of complexity. Another explanation for the limited significance between strengtheners and perceived degree of complexity of projects could be the low amount of participants; the majority rank their projects as middle complex (84 participants out of 96 participants). At least the estimation of degree on complexity could impact the significance of complexity.

**Figure 33: Correlation of question 12 and 13**

<table>
<thead>
<tr>
<th>Spearman-Rho</th>
<th>Q13_managing_complexity___not_at_all</th>
<th>correlation coefficient</th>
<th>Sig. (double sided)</th>
<th>N</th>
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<tr>
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<tr>
<td>Q13_managing_complexity___control</td>
<td>correlation coefficient</td>
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<td>.902</td>
<td></td>
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<tr>
<td>Q13_managing_complexity___reduce</td>
<td>correlation coefficient</td>
<td>.010</td>
<td>.920</td>
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</table>

N**. Correlation is on the level 0.01 significant (double sided).**
<table>
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<tr>
<th>Variable</th>
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<th>Q12 (1=low; 5=high)</th>
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<tr>
<td>Sig. (double sided)</td>
<td></td>
<td>0.353</td>
</tr>
<tr>
<td>N</td>
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<td>96</td>
</tr>
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<td>int/ ext interfaces</td>
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</table>

**. Correlation is on the level 0.01 significant (double sided).

*. **. Correlation is on the level 0.05 significant (double sided).

**Figure 34: Correlation of question 11 and 12**
8.1.3 **HANDLING AND MANAGEMENT OF COMPLEX PROJECTS**

**Questions**

The following questions analyzed the handling and management of complex projects (the number of the question is the same as in the questionnaire):

(9) How would you categorize the size of your project? (small, medium, large, major)
(10) How do you estimate the quality of your project according to the PMI knowledge areas and final success?
(12) How would you rank your project concerning complexity? (1=low and 5 =high)
(13) How do you manage complexity?
(14) How do you control complexity? By....
(15) How do you reduce complexity? By...
(16) Name the processes vulnerable to complexity in your project. Mark the 10 most vulnerable processes.
(17) Name the processes vulnerable to complexity in your project. Mark the 10 least vulnerable processes

**Analysis**

All questions were analyzed with a descriptive statistic method according to frequency. Than the analytic $\chi^2$-test was applied for the question 9 and question 10. This was necessary because an ordinal scale was used for question 10 and a nominal scale was used for question 9.

**Justification**

The size of the participant's projects had to be measured (small, medium, large, major). Furthermore, the success of their projects in each single PMI knowledge area and the overall success were researched. Is there a significant correlation between the success and the size of a project? It was then necessary to prove a relationship between these variables. The different handling of complexity by controlling and reducing complexity was investigated to determine the specific approach used by the majority of the participants. Finally, the most and least vulnerable processes were questioned and ranked according their importance for complex projects.
Findings

Most involved PMI members categorized the size of their own project as medium (50% / \( n = 48 \)). The second largest groups were small (19.8% / \( n = 19 \)) and large (19.8% / \( n = 19 \)). The smallest group was that of major projects (10.4% / \( n = 10 \)) (Figure 35). This can be seen as a good mix. The categorization of the projects is a subjective estimation of participants where the arithmetic mean is set slightly above medium sized projects. All participants answered this question; the number of responses (\( n = 96 \)) was equal to the number of the population (\( n = 96 \)).

![Diagram showing project size categorization]

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulated Percent</th>
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**Figure 35: Estimated categorisation of participant’s own project**

Figure 36 (data for the graph in Figure 37) shows how participants rated their project overall success and in specific PMI knowledge areas.
Figure 36: Success of projects according to PMI knowledge areas and in total (developed by author)
Figure 37: Data graph for success of project

Not every knowledge area was chosen by every participant. Therefore, the following knowledge areas were rated as less important than expected: Figure 37 details which areas received no ranking from the participants: only 95 participants chose integration management and scope management; 94 participants chose communication management, cost management, human resource management, quality management, and risk management; 93 participants chose schedule management; and 78 participants chose procurement management.
This could be a result of a specific knowledge area that is outside of a project manager’s responsibility. For example, procurement is often performed by a separate department without the influence of the project manager.

For the overall success of the project, two participants declined to answer. In general it can be said that the ranking for the overall success of the project most participants stated a good standing (52%/ n = 49), or a very good standing (20%/ n = 19). More than two thirds stated that despite weak results in single knowledge areas, the overall view is in good/ very good standing. Although two participants did not respond to the question, the conclusion was not greatly impacted. It should be noted that with a minimum summed poor or weak ranking of >9% (n > 9) in each PMI knowledge area (communication, cost, human resource, integration, procurement, quality, risk, schedule, scope) the overall ranking of the projects is less than 9% (n < 9).

Referring to the mixture of project sizes, the following question arises: is it easier to handle small projects more successfully than major ones? Is there a relation between size and the success of the project/ single knowledge area? The answer is no. In this survey, the non-statistical significance is valid for the relation between size and success of the project (overall knowledge area).

Using the $\kappa^2$-test, the categorization of the projects was transformed to show that only two groups exist (1 – small & medium; 2 – large & major). With the $\kappa^2$-test, no statistical significance is evident (Figure 38). So no relation between the categorization of a project if it is small, medium, large or major and the success is given in this survey. The speculation that smaller projects are easier to handle was refuted. For this question, the original population was downsized to 94 participants because two participants selected the option “no answer.”
As mentioned in 8.1.2, participants voted in the majority to handle complexity by controlling and reducing. The most selected approach to control complexity is constructivist with 14% (n = 13): making rational decisions for problem solutions, target definition, developing the necessary problem solving process, analysis of alternatives, and stable evaluation criteria (Figure 39). The second most used method to control complexity is the approach of situational awareness with 10.8% (n = 10). Than follows with 8.6% (n = 8) the cognitive method: performed by principles of reality consideration, simplification, abstraction and implication.

These top three approaches can be interpreted direct methods, seldom listed methods (sensitivity model (7.5% / n = 7), creating order (5.4% / n = 5), analytic reductive (4.3%/ n = 4), evolutionary (4.3%/ n = 4), heuristic (1.1%/ n = 1) and steered order (1.1%/ n = 1)) were not considered. Projects often change direction, especially in complex systems where the effect can rarely be predicted. Project managers lack the time to stop to create order. They try to manoeuvre the complexity so that it impacts the project with minimum of damage by using a direct method.

Figure 38: Non statistical significance between success and categorisation of project by χ²-test

Figure 39: Method to control complexity
The reduction of complexity follows structured methods (Figure 40). The reduction of over-complexity is primarily followed using a structure that includes lists, labels, and observation. 15.6% (n = 15) use this approach, which helps to penetrate complex relationships and make situations easier to handle. The second most chosen approach for the reduction of complexity is standardization with 12.5% (n = 12). This approach originated in the automobile industry, where the same components/processes/methods etc. are used for more than one product. Other methods were rarely selected by participants like shielding (4.2%/ n = 4), common part use (3.1%/ n = 3), platforms (3.1%/ n = 3), modules (2.1%/ n = 2), modulekits (1.0%/ n = 1), and none of the given options (1%/ n = 1).

Figure 40: Method to reduce complexity

Finally, project managers need to know which processes within a project can be most affected. Participants were asked to name the ten most vulnerable processes for complexity in the 42 PMI processes. Not all processes were selected. The participants did not select the processes of “administer procurements” and “close procurements” as being affected by complexity. A possible reason for this could be that project managers have a separate purchasing department that handles the procurement process. In sum, processes from PMI were nominated 727 times (100%) by 96 participants.

The top ten listed processes vulnerable for complexity are:

- define scope (6.7% of all nominations, n = 49)
- manage stakeholder (6.5% of all nominations, n = 47)
- collect requirements (5.5% of all nominations, n = 40)
- identify risks (4.5% of all nominations, n = 33)
- control scope (3.9% of all nominations, n = 28)
- perform integrated change control (3.7% of all nominations, n = 27)
- estimate duration (3.6% of all nominations, n = 26)
- estimate costs (3.6% of all nominations, n = 26)
- identify stakeholder (3.4% of all nominations, n = 25)
- manage team (3.3% of all nominations, n = 24)

The additional rankings of the remaining processes concerning their vulnerability for complexity are also shown in Figure 41, and include: direct/ manage execution (3.0%/ n = 22), monitor/ control project work (2.8%/ n = 20), create WBS (2.6%/ n = 19), control schedule (2.6%/ n = 19), control quality (2.6%/ n = 19), define schedule (2.5%/ n = 18), distribute information (2.5%/ n = 18), plan communication (2.3%/ n = 17), verify scope (2.3%/ n = 17), develop PM plan (2.2%/ n = 16), perform QM assurance (2.2%/ n = 16), acquire PM team (2.1%/ n = 15), report performance (2.1%/ n = 15), control/ monitor risks (2.1%/ n = 15), project charter (1.9%/ n = 14), define activities (1.8%/ n = 13), estimate resources (1.8%/ n = 13), determine budget (1.8%/ n = 13), plan/ develop QM plan (1.8%/ n = 13), plan risk responsibilities (1.8%/ n = 13), control costs (1.7%/ n = 12), perform qualitative risk management (1.4%/ n = 10), develop PM team (1.4%/ n = 10), sequence activities (1.1%/ n = 8), develop HR plan (1.1%/ n = 8), plan risk management (1.1%/ n = 8), perform qualitative risk management (1.1%/ n = 8), close project phase (0.8%/ n = 6), conduct procurement (0.7%/ n = 5), plan procurement (0.3%/ n = 2).

Those results align with the selection of the top 5 strengtheners for complexity: customer requirements, stakeholders, communication processes, division of work, and organisational changes. The strong correlation reveals that complexity strengtheners appear primarily in processes that involve stakeholders. The most affected processes are in the planning and beginning of execution phase, which means that in these phases the project manager needs to be certain that the project is not overwhelmed by complexity.
The survey also addressed the least vulnerable processes. The participants selected all 42 processes of the PMI at least once. But in sum, fewer processes were nominated (n = 573) by the 96 participants as vulnerable for complexity. In an early stage (initiating phase), the project is not as vulnerable to complexity, when the project charter is created, stakeholders are identified, a team is established, and communication is planned. The same is valid at the end of the project when it is closed, together with the overall managing process for procurement.

At the beginning of a project, everything is new and can be easily set up; tasks are more or less simple and can be easily reviewed. When a project is initiated a rough overview is provided, which allows for potential of adaptations at later stages. A phase or project ends with the closing process. At that point, all relevant documents and evidences must be provided. Although the participants marked complexity seldom in this stage, a closing phase could become complex if many stakeholders must be coordinated and many documents must be submitted to gain clearance. Further investigation is necessary. A separate department in company often handles procurement. In the survey, the project man-

<table>
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<tr>
<th>Frequency most vulnerable processes</th>
<th>response</th>
<th>% of cases</th>
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<tbody>
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<td>manage stakeholder</td>
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<td>collect requirements</td>
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<tr>
<td>control scope</td>
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a. dichotomy group is outlined in a table from with a value of 1.

Figure 41: PM processes most vulnerable for complexity

The survey also addressed the least vulnerable processes. The participants selected all 42 processes of the PMI at least once. But in sum, fewer processes were nominated (n = 573) by the 96 participants as vulnerable for complexity. In an early stage (initiating phase), the project is not as vulnerable to complexity, when the project charter is created, stakeholders are identified, a team is established, and communication is planned. The same is valid at the end of the project when it is closed, together with the overall managing process for procurement.

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</tr>
<tr>
<td>plan procurement</td>
<td>2</td>
<td>0.3%</td>
</tr>
<tr>
<td>total</td>
<td>727</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

a. dichotomy group is outlined in a table from with a value of 1.
agers stated that they do not deal directly with sub-contractors and put it down to the least vulnerable processes for complexity. The top least vulnerable processes are:

- create project charter (4.9% of all nominations, n = 28)
- identify stakeholder (4.5% of all nominations, n = 26)
- close procurements (4.2% of all nominations, n = 24)
- plan communication (4.0% of all nominations, n = 23)
- plan procurement (3.8% of all nominations, n = 22)
- close project phase (3.8% of all nominations, n = 22)
- administer procurement (3.7% of all nominations, n = 21)
- control costs (3.5% of all nominations, n = 20)
- acquire PM team (3.3% of all nominations, n = 19)
- report performance (3.1% of all nominations, n = 18)

According to the rankings, the remaining least vulnerable processes for complexity are:
define activities (3.0%/ n = 17), sequence activities (2.8%/ n = 16), distribute information (2.8%/ n = 16), define scope (2.6%/ n = 15), determine budget (2.6%/ n = 15), identify risks (2.6%/ n = 15), manage team (2.6%/ n = 15), conduct procurement (2.6%/ n = 15), control schedule (2.6%/ n = 15), create WBS (2.4%/ n = 14), develop PM plan (2.3%/ n = 13), define schedule (2.3%/ n = 13), estimate costs (2.3%/ n = 13), develop HR plan (2.1%/ n = 12), develop PM team (2.1%/ n = 12), manage stakeholder (2.1%/ n = 12), plan risk management (1.9%/ n = 11), monitor/ control PM work (1.9%/ n = 11), plan/ develop QM plan (1.7%/ n = 10), plan risk responsibilities (1.7%/ n = 10), verify scope (1.7%/ n = 10), control scope (1.7%/ n = 10), collect requirements (1.4%/ n = 8), estimate resources (1.2%/ n = 7), direct/ manage execution (1.2%/ n = 7), control quality (1.2%/ n = 7), estimate duration (1.0%/ n = 6), perform qualitative risk management (1.0%/ n = 6), control/ monitor risks (1.0%/ n = 6), perform QM assurance (0.9%/ n = 5), perform integrated change control (0.9%/ n = 5), perform quantitative risk management (0.5%/ n = 3). These are also shown in Figure 42.
8.1.4 Categorization of the Complex Projects

Questions

The following questions analyzed the categorization of complex projects (the number of the question is the same as in the questionnaire):

1. How many people work in your project team?
2. How many sub-projects has your project?
3. Your project is placed in... (Selecting a specific field of industry)?
4. What is the total value of your project in €?
5. How would you categorize the size of your project? (small, medium, large, major)
6. Which of the following strengtheners for complexity affects your project? Mark your top five items.
7. How would you rank your project concerning complexity? (with 1 = low and 5 = high)
8. Name the processes vulnerable to complexity in your project. Mark the 10 most vulnerable processes (PMI standard).

Figure 42: PM processes least vulnerable for complexity
Analysis

Data were first analyzed using a descriptive method that identified the frequency and distribution of the answers. Outlining the significance between sub-projects (question 6) and number of involved people in a project (question 5) the Pearson product moment correlation was chosen. For the identification of complexity in a project, cross tables were used (question 7, 8, 9, 11, 12 and 16). It could be applied as all variables (project size/ level of complexity/ field of industry/ strengtheners/ vulnerable processes) were ordinal scaled, metric and could be determined exactly.

Justification

The descriptive analysis was performed to show a frequency analysis of the participants' answers. The later executed Pearson product moment correlation shows a special relationship between the number of members in a project and the number of sub-projects in a project.

The descriptive data analysis showed whether the given answers could be used to establish a valid matrix. Based on the cross table, a classification of the different categories (project size and level of complexity) was possible. In sum, twelve different multiplex answers were queried with SPSS. The twelve queries result from the matrix grid that is created in the graphs (4 different fields for the categorisation of the size on the y axis and 3 different fields for the level of complexity on the x axis). First, the question of project categorization and level of complexity are cross-tabled, providing the information of available responses. Only then multiplex answers are selected for questions on specific field of industry, complexity strengtheners, processes most vulnerable for complexity, value of project in ˈ000 €.

Findings

The arithmetic mean of involved people in a project is 27.97. However, the majority of projects (11.5%) consist of 10 team members. The 25th percentile is 6 team members and 75th percentile is almost 25 team members. As the arithmetic mean for team members is higher than 75th percentile, it can be clearly identified that some of the participants' projects have a large amount of team members, shifting the arithmetic mean above the 75th percentile.
The arithmetic mean for the sub-projects in a project is 3.75 (Figure 43). Most of the participants’ projects (26.0%) have no sub-projects. A formation of groups is given for projects with two to five of sub-projects, which were chosen by half of the participants (50.1%). The detailed analysis of the distribution of people and sub-projects in participant’s projects is outlined in Figure 43.

It could be estimated that with approximately 28 people involved in a project, four sub-projects would exist. This is tested by a correlation.

![Graph](image1)

![Graph](image2)

**Figure 43: Distribution of people and sub-projects in participant’s projects**

The significance was calculated according to Pearson. The correlation showed a strong statistical significance ($N = 96, r = -0.706$, s.s. at $p < 0.001$). This implies that if the amount of people in a project increases, then the number of sub-projects also increases. This is shown in Figure 44. That result is also illustrated in Figure 45. The y-axis defines the sub-projects, the x-axis the number of team members. It can be seen that the majority of
participant’s projects has less than 50 team members and less than 9 sub-projects. The equation for calculating the sub-projects is: \( y = 1.93 + 0.07 \times \text{“number of team members.”} \) Referring to the result from the arithmetic mean, the estimated assumption is confirmed.

\[
\begin{array}{|c|c|c|}
\hline
\text{Spearman-Rho} & \text{Q6_How_many_people_work_in_your_project} & \text{Q6_How_many_sub-projects_has_your_project} \\
\hline
\text{correlation coefficient} & \text{correlation coefficient} & \\
\text{Sig. (double sided)} & \text{Sig. (double sided)} & \\
\text{N} & \text{N} & \\
\hline
\end{array}
\]

<table>
<thead>
<tr>
<th></th>
<th>Q6_How_many_people_work_in_your_project</th>
<th>Q6_How_many_sub-projects_has_your_project</th>
</tr>
</thead>
<tbody>
<tr>
<td>correlation coefficient</td>
<td>.706**</td>
<td>1,000</td>
</tr>
<tr>
<td>Sig. (double sided)</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

**.correlation is on the level 0.01 significant (double sided).

Figure 44: Correlation between team members and sub-projects

Figure 45: Graphical illustration of correlation between team members and sub-projects
For establishing the four different fields of the matrix for categorizing complex projects (field of industry, appearance of top ten strengtheners of complexity, most vulnerable processes for complexity, and project value in ‘000 Euro), the descriptive analysis of strengtheners for complexity and for the most vulnerable processes concerning complexity was completed earlier (see Figure 30 in chapter 8.1.2 and Figure 41 in chapter 8.1.3).

Detailed analyses of the specific fields of industry illustrated that not all twenty offered fields of industry are named (mining, economical services, art/entertainment, real estate/housing, private household, water supply/waste management, hotel/restaurant, extorital organisation). A strong focus is set on finance (44.8%/ n = 43) and information/communication industry (17.7%/ n = 17). For selecting the possibility “other” (10.4%/ n = 10), participant’s quoted: administration, pharmaceutical, automotive, oil and gas, electronics, and program management consulting in engineering. Other possible selected industries were rarely selected: industry (7.3%/ n = 7), public service/defence (4.2%/ n = 4), energy (3.1%/ n = 3), transportation (3.1%/ n = 3), scientific/academic service (2.1%/ n = 2), trade (2.1%/ n = 2), welfare/healthcare (2.1%/ n = 2), education (1.0%/ n = 1), construction/building (1.0%/ n = 1), agriculture (1.0%/ n = 1). As Figure 46 presents, no noticeable problems occurred by the categorization of projects to the field of industry and all participants selected their relevant field of industry for their current project.
Problems occurred in the evaluation of the project’s value. Here is the estimated arithmetic mean value 3.262.290.000 Euro with a standard error of 3.030.866.000 of the arithmetic mean. This extreme mean value is explained by the top four project values (range: from 1.000.000.000 Euro to 200.000.000.000 Euro). The top project is almost equal to the total assets of households in Germany with approximately 295 bn. Euro. A mistake by participants’ answers is supposed, where the project's value had to be nominated in ’000 Euro (not in Euro). Further this top value project was not placed in the financial industry or in a different field of industry that can be cost-intensive. So this question from the survey is declared invalid, and results are not taken into account. Ranges for project values are shown in Figure 47.
The remaining three fields: specific field of industry, complexity strengtheners, and processes most vulnerable for complexity did not show any unexpected noticeable problems. Before starting the use of the matrix graphs, project managers have to determine project categorization (small, medium, large and major) and level of project complexity (low, medium and high). Then they look up if their field of industry is listed. If so, they can proceed with the next matrix graph looking for strengtheners of a project of concern. Or they proceed with matrix graph of vulnerable processes for complexity. For both, only the top ten are listed. The matrix graphs are shown in Figure 48, Figure 49 and Figure 50.

If their field of industry is not listed, the matrix can provide only approximately hints.

The dimension for a correct categorization of projects value (in Euro) is invalid. Therefore it cannot be guaranteed that this matrix will work accurately. However, it can give direction to the factors that should be recognized in order to manoeuvre smoothly through complex projects.
From the twenty-one possible answers in the field of industry where projects are placed, participants selected thirteen. Therefore, a claim of completeness does not exist. Most projects were stated in the field “information and communication.” Statements in this field might be therefore most significant (Figure 48).

![Field of industry projects are placed in](image)

**Figure 48:** First matrix layer for selecting the field of industry the PM’s project shows accordance
The strengtheners for complexity in projects which participants selected are ranked by the top ten hits, minimum marked twice (Figure 49).

**Appearance of top ten strengtheners in projects (at least >2 hits)**

<table>
<thead>
<tr>
<th>Complexity Level</th>
<th>PROJET CATEGORY</th>
<th>Strengtheners</th>
</tr>
</thead>
</table>
| low              | small          | - No° of stakeholder (6)  
                  |                | - Cust. requirements (5)  
                  |                | - Communication process (5)  
                  |                | - Change in time schedule (2)  
                  |                | - Project internationality (2)  
| medium           | medium         | - No° of stakeholder (8)  
                  |                | - Cust. requirements (6)  
                  |                | - Org. changes (6)  
                  |                | - Int./ ext. interfaces (5)  
                  |                | - Communication process (4)  
                  |                | - Partionment of work (6)  
                  |                | - Cultural diversity (3)  
                  |                | - Size of project org (2)  
                  |                | - Incompatible systems (2)  
| high             | major          | - No° of stakeholder (13)  
                  |                | - Cust. requirements (13)  
                  |                | - Org. changes (8)  
                  |                | - Communication process (8)  
                  |                | - Partionment of work (7)  
                  |                | - Int./ ext. Interfaces (6)  
                  |                | - Size of project org. (5)  
                  |                | - Tech./ prod. diversity (4)  
                  |                | - Law/norm/ regulation (5)  
                  |                | - Change in time schedule (4)  

**Figure 49:** Second matrix layer identifying the top ten strengtheners for complexity in your project

The participants’ selection of the most vulnerable processes for complexity in projects are ranked by the top ten hits; at a minimum, they are marked twice (see Figure 50).
**Top ten most vulnerable processes within projects (at least >2 hits)**

- Define schedule (2)
- Report performance (2)
- Define scope (6)
- Control scope (5)
- Collect requirements (4)
- Plan communication (4)
- Manage stakeholder (4)
- Identify stakeholder (3)
- Estimate duration (3)
- Define schedule (3)
- Identify risks (3)
- Direct/ manage exec. (3)

- Define scope (2)
- Estimate duration (2)
- Estimate costs (2)
- Perform integrated CCB (8)
- Verify scope (8)
- Define scope (6)
- Estimate duration (6)
- Manage stakeholder (6)
- Control scope (6)
- Create WBS (5)
- Plan risk mngt. (5)
- Identify risks (5)
- Direct/ manage exec. (5)

- Define scope (8)
- Collect requirements (6)
- Identify risks (6)
- Manage stakeholder (5)
- Create project carter (4)
- Identify stakeholder (4)
- Estimate costs (4)
- Verify scope (4)
- Control scope (3)
- Perform integrated CCB (3)
- Define scope (13)
- Manage stakeholder (12)
- Collect requirements (11)
- Identify stakeholder (9)
- Contr. & monitor risks (8)
- Identify risks (8)
- Control scope (7)
- Control costs (7)
- Perform integrated CCB (6)
- Create WBS (5)
- Collect requirements (4)
- Manage team (2)
- Manage team (2)
- Identify stakeholder (9)
- Collect requirements (6)
- Estimate costs (6)
- Identify risks (6)
- Perform integrated CCB (5)
- Define scope (5)
- Define activities (4)
- Estimate duration (4)
- Distribute Information (4)
- Monitor/ contr. proj. work (4)

- Define scope (5)
- Manage stakeholder (5)
- Direct/ manage exec. (4)
- Collect requirements (3)
- Define schedule (3)
- Develop HR plan (3)
- Control scope (2)
- Create WBS (2)
- Plan communication (2)
- Define activities (2)
- Collect requirements (4)
- Develop PM plan (3)
- Identify risks (3)
- Direct/ manage exec. (3)
- Manage team (3)
- Monitor/ contr. proj. work (2)
- Identify stakeholder (2)
- Create WBS (2)
- Estimate duration (2)
- Define scope (4)
- Develop scope (4)
- Manage scope (2)
- Perform integrated CCB (2)

**Ranking: most hits on top (No° of hits be participants)**

**Figure 50: Third matrix layer identifying the top ten processes within projects vulnerable for complexity**

8.1.5 **Handling complexity in the actual PMI standard**

**Questions**

The following questions analyzed the handling of complexity in the actual PMI standard (the number of the question is the same as in the questionnaire):
(18) Does the actual PMI standard satisfactorily describe complexity?
(19) Which tools/ methods in the actual PMBoK guide would you suggest to manage complexity?
(20) Which other tools/ methods do you recommend for managing complexity?
(21) Would you prefer a separate chapter for managing complexity in PM standards?
(22) Which method would you implement in the PM standard to handle complexity?

**Method for analysis**

First, the frequency distribution was analysed in a descriptive manner. In a second step, the correlation was performed between the satisfactory description of complexity in the PMI standard (question 18) and the wish for a separate chapter (question 21). Here the \( \kappa^2 \)-test was applied as all data were nominal. For outlining the significance between the suggestions for new methods (question 22) and the satisfactory handling of complexity (question 18)/ wish for a separate chapter (question 21) the Spearman-correlation had to be performed because the scales were ordinal. Therefore, the answers from question 22 were judged as correlated.

**Justification**

The descriptive analysis was performed to give a frequency analysis on participants’ answers and also to understand their attitude towards the already existing methods for handling complexity in PMI standards and the possible tools/ methods that could be implemented. Positive answers from question 18 were investigated for their validity to question 21, if the PMI is satisfactory, then no new chapter is required. Furthermore, in the case where the PMI was judged as unsatisfactory, the participants were asked to suggest new methods. The proposed methods for implementation were correlated using Spearman’s rank correlation coefficient.

**Findings**

46 participants (47.9 %) chose “no answer” for the question of whether the PMI standard sufficiently covered the issue of handling complexity. Therefore, only the answers from the remaining 50 participants were taken into account. From that group, 30 participants (60%) showed satisfaction with the PMI PM standard for handling complexity. Enough tools and methods are provided to handle complex projects. The other 20 participants chose “no answer” for the question.
ipants (40%) were not satisfied with standard (Figure 51). Questions 19 and 20 were addressed only to those participants that showed some level of satisfaction with the standard.

Figure 51: Sufficient handling method/ tool for complexity in the actual PMI PM- standard

The actual PMI standard was investigated and tools/ methods were queried for handling complexity. The result is shown in Figure 52.

Figure 52: Methods/ tools used for handling sufficient complexity (listed in PMI standard)

49 methods/ tools were taken directly from the PMI standard and were presented as choices to the group of participants that had expressed satisfaction with the standard. The total sum of all methods chosen was 286. Participants were given the option of choosing multiple methods/tools. The top three choices were:

1. WBS – work breakdown structure (6.3% of all nominations, n = 18)
2. Checklist (5.2% of all nominations, n = 15)
3. Stakeholder analysis  

(5.2% of all nominations, n = 15)

These methods are suitable to manage the top strengtheners for complexity. A WBS helps to identify, check, and track requirements from stakeholders. The checklist facilitates communication between the project team and stakeholders. The checklist often appears as a “list of open points.” Lastly, the stakeholder analysis identifies all of the people involved in the project. These methods help to manage the top three strengtheners for complexity.

Participants named additional methods not listed in the PMI or requested in the survey: enterprise architecture model (EAM), influence diagram, agile management, and montecarlo analysis. 10.4% of the queried 96 participants (n = 10) did not provide an answer on the question if a separate chapter for complexity is necessary. From the valid questionnaires (n = 86), 54% participants (n = 47) recommend implementing a separate chapter for handling complexity. However, only 40.6% (n = 39) stated that PMI is not sufficient for handling complexity. This result is shown in Figure 53.

Figure 53: Separate chapter for handling complexity in PMI PM standard

The relationship between question 18 (PMI PM standard is satisfactorily for complexity) and question 21 (separate chapter for complexity in PMI PM standard) is not significant (N= 96, $\chi^2$= 536). Therefore, the variables for dealing satisfactorily with complexity and the desire for a separate chapter are not congruent. Participants answered questions 18 and 21 in a contradictory manner. The statistical significance of the $\chi^2$-test is outlined in Figure 54.
In question 22, participants were asked to identify which other methods for handling or visualizing complexity should be implemented in the PM standard of PMI. Participants were able to nominate multiple methods to be implemented. In sum 182 nominations were stated.

These proposed methods are similar to already listed methods/tools in the actual PMI standard like the scenario analysis (22.0% / n = 40), mindmap (21.4% / n = 39), graph theory - PERT (6.0% / n = 11) and graph theory - network (5.5% / n = 10). Several little-known were selected less (concept map (8.2% / n = 15), balanced score card (8.2% / n = 15), portfolio (7.7% / n = 14), fuzzy logic (4.4% / n = 8), data structural matrix (3.8% / n = 7), and rich picture (2.2% / n = 4). The option “no need for a method to be integrated in the PMI standard” was selected by participants 6.6% (n = 12). This ranking is shown in Figure 55.

![Graph showing the ranking of suggested methods](image)

**Figure 55: Suggested methods for handling complexity to be implemented in PMI standard**

In question 22, participants were asked to identify which other methods for handling or visualizing complexity should be implemented in the PM standard of PMI. Participants were able to nominate multiple methods to be implemented. In sum 182 nominations were stated.

These proposed methods are similar to already listed methods/tools in the actual PMI standard like the scenario analysis (22.0% / n = 40), mindmap (21.4% / n = 39), graph theory - PERT (6.0% / n = 11) and graph theory - network (5.5% / n = 10). Several little-known were selected less (concept map (8.2% / n = 15), balanced score card (8.2% / n = 15), portfolio (7.7% / n = 14), fuzzy logic (4.4% / n = 8), data structural matrix (3.8% / n = 7), and rich picture (2.2% / n = 4). The option “no need for a method to be integrated in the PMI standard” was selected by participants 6.6% (n = 12). This ranking is shown in Figure 55.

<table>
<thead>
<tr>
<th>method for managing complexity to be implemented in PMI</th>
<th>valid</th>
<th>missing</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>percent</td>
<td>N</td>
<td>percent</td>
</tr>
<tr>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scenario analysis</td>
<td>40</td>
<td>22.0%</td>
<td>41.7%</td>
</tr>
<tr>
<td>mindmap</td>
<td>39</td>
<td>21.4%</td>
<td>40.6%</td>
</tr>
<tr>
<td>concept map</td>
<td>15</td>
<td>8.2%</td>
<td>15.6%</td>
</tr>
<tr>
<td>balanced score card</td>
<td>15</td>
<td>8.2%</td>
<td>15.6%</td>
</tr>
<tr>
<td>portfolio</td>
<td>14</td>
<td>7.7%</td>
<td>14.6%</td>
</tr>
<tr>
<td>none</td>
<td>12</td>
<td>6.6%</td>
<td>12.5%</td>
</tr>
<tr>
<td>graph theory (pert/ gantt/ cpm)</td>
<td>11</td>
<td>6.0%</td>
<td>11.5%</td>
</tr>
<tr>
<td>graph theory (arrow/ network)</td>
<td>10</td>
<td>5.5%</td>
<td>10.4%</td>
</tr>
<tr>
<td>fuzzy logic</td>
<td>8</td>
<td>4.4%</td>
<td>8.3%</td>
</tr>
<tr>
<td>data structural matrix</td>
<td>7</td>
<td>3.8%</td>
<td>7.3%</td>
</tr>
<tr>
<td>other</td>
<td>7</td>
<td>3.8%</td>
<td>7.3%</td>
</tr>
<tr>
<td>rich picture</td>
<td>4</td>
<td>2.2%</td>
<td>4.2%</td>
</tr>
<tr>
<td>total</td>
<td>182</td>
<td>100.0%</td>
<td>189.6%</td>
</tr>
</tbody>
</table>
Methods for handling complexity like the data structural matrix or both different graph theories were infrequently marked. These are not common known by project managers.

There is no statistical significance between the answers of question 22 (implementation of additional methods for handling complexity) and question 18 (actual PMI standard is sufficient) – (N = 50, \( r = -0.050 \), no s.s. at \( p < 0.731 \)). In addition, no statistical significance exists in the correlation with question 21 (necessity of separate chapter) – (N = 86, \( r = 0.211 \), no s.s. at \( p < 0.052 \)). People who requested a separate chapter for complexity inside the standard did not prefer the additional methods for handling complexity listed in the standard. This is stated in Figure 56 and Figure 57.

**Figure 56: Correlation of question 22 and 18**

**Figure 57: Survey result: Correlation of question 22 and 21**

### 8.1.6 Feedback from Participants on Questionnaire

Participants judged the questionnaire differently. Some felt that it was difficult because the definition of complexity was not precise. Most participants who noted separate comments judged the questionnaire as clear understandable and well structured. Sometimes too many possible answers were available. It could be assumed that the answers on the most/least vulnerable processes are meant, where participants were able to select from more than 40 different choices.
Finally, the most valuable comment from the participants was: it is urgent to put more effort in researching complex projects. This reinforces the importance of the research topic.

8.2 INTERVIEW
Three focus groups were performed in Germany with at least 09 - 15 participants each. They took place in Munich, Stuttgart, and Frankfurt in April and May 2014. Where no projector was available, participants received handouts. Afterward, they were collected to ensure confidentiality. All interviews were recorded for the evaluation of the results. The records were deleted according to ethics guidelines after completion.

The interview consists of five questions complexes. The first question was the transition from the introduction. It engaged the participants with past and current projects, and particularly addresses whether they have been impacted by complex projects.

**How does the topic “optimal handling of complexity in project management” attract you?**

All participants were interested in this topic.

**Have you ever been affected with a complex project, no matter if as a stakeholder, project manager or project team member? How did you behave within this situation?**

In two of three focus groups people immediately began talking about complex projects that they had already performed and also stated their methods. One group discussion focused intensely on the word complex project and its meaning. A question arose regarding how to determine when a project becomes complex. This group had a very different perspective compared to the other groups. Ranking a project as complex is always relative and depends on viewpoint of the project manager. For instance, when an individual is accustomed to performing a given task, that project is not perceived as complex. As example it was mentioned that if people used to perform a project e.g. to build a house, the planning and the building of a house is not complex for them. An individual with experience in a specific field understands how to structure a project and is aware of potential obstacles that need to be avoided or prevented. However, when an individual is unfamiliar with a given task, then that project is perceived as complex. For them it is something new and unknown. Participants’ interpretation is that complicated projects
have many requirements and stakeholders. The project becomes complex when these requirements and stakeholders change frequently, but the project is still perceived as manageable. Chaotic projects are those that exceed an individual’s ability to manage the situation, and are caused by constantly changing requirements and stakeholders.

All three groups outlined different behaviours when handling complex projects. Participants of FGI I handled complexity by a sufficient staffing, a close tracking of all tasks, and well prepared planning. However, in FGI I, costs and expenses were not very relevant because the most important factor was time to market and a zero defect tolerance. Participants in FGI II followed project management methodology for assistance with handling complex projects. While the preparation of a fully detailed planning would cause complexity at the outset of the project, the implementation of a rough master plan that becomes more detailed in the project life cycle, would help with handling complexity. They suggested unrestricted communication to achieve clear recognition of all dependencies because adequate tests cannot be performed when requirements are not correctly analyzed and reported. According to the FGI II participants, a complex project is more successful when the project manager/ project team possesses methodology and experience. In addition, FGI III deemed experience as the most important component for handling complexity. Frequently, project managers and the team do not sufficiently respect each other at the beginning. They tackle the task and seldom are frightened of the challenge; they more show a positive attitude towards the challenge. So at the beginning, people tend to start with little knowledge of the overall project and tend to push through. Meeting unknown fields in the project, they consult experts to find the best way out of the challenging situation.

After the “warming up” question for the participants, the focus groups were presented with the first results from the survey, which outlined the strengtheners of complexity and how they were handled in projects.

**Do you agree with the top complexity strengtheners and do you also handle them by control/ reduction?**

The top five strengtheners from the survey were: customer requirements, stakeholders, communication, division of work, and organisational changes; which are handled by reduction, control, elimination or not at all.
All focus groups agreed with the top five complexity strengtheners and also the remaining strengtheners, with the exception of the participants from FGI III. They stated that these strengtheners for complexity are only correctly expressed when the prefix “change of” is placed before each strengthener (e.g. change of customer requirements). FGI III participants asserted that because consistency is not a challenge, the complexity would not increase. Only changes will challenge the project and the project team, because appropriate reaction is demanded. Complexity increases as the occurrence of changes increase within the project.

In general, the interpretations of the strengtheners were different between the focus groups, but some intersections occurred. The strengthener “customer requirement” should be distinguished into user and customer requirements; those characteristics should then be divided into hidden and non-functional requirements. All groups agreed that eliminating requirements was best performed at the beginning of a project. Because after the scope is defined, a reduction is almost impossible. At that point, only an attempt for flexible control is feasible. The scope creep, an uncontrolled increase of the requirements/ scope should be avoided. FGI III categorized market flexibility as one of the top strengtheners. This strongly influences the scope of a project because customers want their product to be state-of-the-art, which can influence changes to their requirements.

The complexity strengthener “stakeholder” was confirmed by all groups. Even when methods and tools exist for analyzing and handling stakeholders, it is an extremely significant topic. An analysis is often performed only once at the beginning and then never repeated. During organisational changes, stakeholders change, or other business targets gain a higher priority and the project interests’ change. Groups FGI I and FGI II rank this strengthener differently. Participants from FGI I rated this topic as most important if sponsors are included. Having powerful sponsors on board is the most important component as they can break down barriers for the project. In contradiction, FGI II stated that it is important to involve all stakeholders equally; however, stakeholders that are not closely associated with the project should be given precedence. This helps to extinguish several small fire sources in advance and to make the project run more smoothly.

The “communication” appears everywhere in the project process. If tasks and advices are not correctly addressed, the team does not know what to do. The PM standards outline some tools and methods to improve communication. The increase of complexity
only appears when there is a high rate of changes according to the FGI III group. The “partitionment of work” is listed as one of the top five strengtheners. The project team must have an overview of the task to identify has to see how everything on a higher and lower level fits together in total. The deliverables must be clearly stated. If the sub groups of the project team are not included, then only a small part of the project is meaningful. Possible results include extended timelines and poorly matched interfaces. Therefore the strengtheners “partitionment” and communication on work are important and must be taken in to account, changes in these areas have a major impact on complexity.

According to the environments of the focus groups, the single top strengtheners were weighted differently. FGI I estimated that “organisational changes” were rated too high. FGI II rated other impacts like the “cultural diversity” higher as a strengthener for complexity. “Cultural diversity” does not only cover the different cultures; also time zones, religions, habits, languages, etc. FGI II considered this strengthener as underrepresented and made the assumption that the majority of survey respondents did not work in a multi-cultural environment.

Overall, FGI I mentioned the omission of industry specific fields. However, that is outlined in the detailed analysis of the survey in Figure 48, Figure 49, and Figure 50.

A basic approach for controlling complexity was discussed in the third focus group. Participants agreed that complexity must first be perceived by managers. Managers, who are afraid of and averse to change, tend not to observe complexity. Problems are blocked out and controlling complexity is shifted to the future. When managers have a combination of an open mind-set and methodology/ experience, managers handle complexity quite well over the course of a project. They are able to absorb the impact of change and show flexibility in decision making. This proactive approach to controlling change would result in a more predictable and successful conclusion to the project.

**Does project success depend on certified project managers, and do you as a certified project manager manage vulnerable processes using the stated detailed handling methods?**

The question was intended to discover whether a connection exists between the success of a project and the certification of a project manager. More than 90% of the survey participants were certified in PMI or another standard. All focus groups expressed that cer-
tification does not directly impact the success of project; however, it could be a supporting factor. The connection between certification and project success cannot be proven. To prove a connection it would be necessary to have a certified project manager and a non-certified project manager execute two identical projects. This proposition in practice is not possible; by definition, every project is unique. Therefore, it is unwise to trivialize this topic. Managers, certified or not, have the potential to conduct successful projects.

According to the first two focus groups, the success of a project is based more on the methodology employed, which can be independent of an official project management standard. It is common for large companies to develop an internal methodology that administers the performance of the different areas of project management. The PMI standard demonstrates how to organize a project more efficiently and provides reasons for using that procedure. When problems occur in projects, customers are more willing to accept the arguments and advices stated by an official standard. Project management standards outline the advantages, solutions, and effects if a methodology is not applied.

In contradiction to pure methodology, FGI III proposed another element of successful project management methodology: a project manager’s level of experience. The group agreed that success is connected more to the combination of methodology and experience. Managers learn by performing projects and by applying methods learned in training. As managers’ experience increases, so does the success of the projects. PMI and other institutes request a certain level of experience before getting certified in a PM standard. Nevertheless, non-certified project managers who gained experience from work and training can successfully execute projects. A certification by an official standard is just an “official stamp” showing that someone has experience and has learned methodology related to conducting projects. Therefore, the focus should be more on training and experience, instead of certification.

However, the overall success of a project should not be limited to one or two single factors, like methodology and experience of the project manager. The success of a project is also based on the team, customer, sponsor, and technical skills.

If the sponsor, stakeholder, or a team member does not accept the applied methodology, then the project could be disrupted. Without agreement on how to proceed, trust will be broken between team members, departments, etc. and overall performance will suffer.
For the team, it is important to keep in mind the shared target and the plan to achieve that target. If one team member diverges from the common processes and plan, then team solidarity can be damaged.

The most vulnerable processes in a project should be constantly observed; implementing this process represents another component of success. Survey participants named the following ten most important vulnerable processes: define scope; manage stakeholder; collect requirements; identify risks; control scope; perform integrated change control; estimate duration; estimate costs; identify the stakeholder; manage the team. These were not fully agreed upon by the focus groups because not all processes are listed here.

The most vulnerable process listed was “defining scope,” which depends on the specific industry. Furthermore, the vulnerability and success of the project depends on the contractual details. If the scope is clearly defined and agreed upon in advance, the project should be not vulnerable to complexity as changes should be official requested. This appears in the processes “control scope” and “integrated change control” for gaining an overview on all changes and their effects in the project.

The pure identification of risks can be performed quickly and identification by itself has no influence on project’s success. But the management of dependencies in risks is one of the most critical steps. Until risks are mitigated, it can be difficult to manage and track them on a regular basis. Discounting risk could have a negative impact on the project’s success. The responsibility of managing specific risks could be delegated to an internal department or outsourced.

According to the focus groups, one of the most vulnerable and critical processes is the overall communication process, termed knowledge area communication according to PMI. This process is the biggest share of the project managers work and affects processes listed above like “manage stakeholder”, “estimate duration”, “estimate costs”, “identify stakeholder”, and “manage the team”. The stakeholder and the team must be informed in time so that the delivery of sub-packages is in harmony and not delayed. If communication is not performed adequately, complexity in a project can increase dramatically. However, different styles of communication are necessary. Communication in the public sector must deal more with politics; however, the communication in the economic sector is more objective and focuses on scope and requirements.
When you think about your own complex project, do you find yourself in the following table with the strengtheners and unimmunized processes in the project? Compare your identified field of the project with strengtheners and vulnerable processes of your project. Are they the same?

The focus group discussions revealed that two factors had to be defined in order to successfully identify complexity strengtheners and vulnerable processes. These definitions were: the exact rating of a project concerning its value as a low, medium, large and major project, and the rating of the level of complexity using low, medium, high. The definition can vary for every project manager, company, and specific field of industry. It is a matter of interpretation.

The industry specific categorization was performed but not shown as a lack of time during the interview.

For the participants, the complex graph was accepted as an indication, but was too difficult to read. A suggestion to change the “hits” to a percentage of the total would help to interpret the graph. But still a reduction of the tables and a combination of all tables in one could help to improve comprehension. Different proposals like a scatter diagram, which would be too confusing as to many dots would appear; or a 3D/ 4D bubble diagram reducing it to maximum ten listings would too strongly simplify the matrix were given. Totally different from the already mentioned proposals, in the third focus group was stated that a kind of timeline in project size and complexity over the specific fields of industry could help. It was suggested that previously mentioned strengtheners and vulnerable processes once mentioned, should not be mentioned again for larger and more complex projects. This could greatly improve the intelligibility of the matrices.

It was pointed out that small projects are not really managed because they are too unimportant to a company and run alongside the large projects. Therefore, project managers could have many small projects that cannot be managed with full attention, which causes overall complexity. In general, major projects in gain more attention in governance and management, which increases complexity as stakeholders and sponsors want to get more involved in decisions.

How can an adopted PMI standard support you in manoeuvring a complex project? Spending a separate chapter or explaining new methods for managing it?
First, the discussion addressed the diagram that listed possible methods/tools for handling complexity (Figure 55). Focus groups agreed that the answers from the survey were contradictory. Participants could not explain and agree how a balanced scorecard or the fuzzy logic would support manoeuvring through a complex project. Further, they agreed on listed methods like brainstorming. It is useful for gaining an overview on complex situations, gaining different views by stakeholders on the actual situation. For brainstorming, their preferred tool is the mind map. Participants mentioned methods that were not brought up in the questionnaire, such as the Ishikawa diagram and project management methods like creating a project charter or performing a requirements analysis.

The second focus group stated that it is good for a project manager to choose from a big bundle of multi different methods. Therefore, basic moderating techniques should also be listed such as working with a white board with Post-it® notes. Depending on situation, project managers should choose the best method for handling complexity. In general, project managers must know how to handle complexity in their specific situation: reducing, managing, eliminating, or not at all. Before these thoughts about the right handling methods are done, it can be helpful to choose a tool that can improve an unsatisfactory situation.

The second part of the question of the FGI focused on the actual PM standard of PMI and how it addresses complexity. The first two groups agreed that the standard helps to overcome complexity. Methods and the processes support the project managers to overcome complexity, but complexity is not specially mentioned in the standard. Methods and processes are explained well in know-how areas like communication management. Here detailed ideas are necessary, in order to implement and realize these processes without allowing complexity. Therefore, a separate chapter is not necessary from the viewpoint of the FGI I and FGI II. Specific symbols in the standard could focus a manager’s attention on the typical places where complexity appears. But also the handling is depending on experience. So it would be supportive in using a possible correct method, underpinned by an example.

Participants in FGIs were surprised that the survey answers indicated that the PMI handles complexity satisfactorily, and expressed the need for a separate chapter inside the standards. This was not confirmed by the focus groups.
In contradiction, the third focus group does not agree to describe the handling of complexity inside the actual project management standard. This would lead to state an explicit definition for complexity, gaining a consistent meaning. It is questionable if complexity can be standardized. Complexity depends on the situation and the specific viewpoint of the project manager. Additional symbols in the standards that give advice for danger of complexity as stated in the second focus group are no solution. The standard would be overcrowded by symbols. They recommend a separate chapter. This should not be an element of the PM standard; but listed in a separate paper. Finally complexity is a viable trend and the PMI should address that. It is a topic that impacts project managers. PMI should provide guidance in how to overcome complexity, but not as a general standard.

9 Discussion

9.1 Seniority and Work Experience in Project Management

The survey was introduced with questions to identify the experience of participating project managers. This is basis for the quality of the survey. From the original 176 responses, only 96 were used because they were fully executed. This assures a reliable level of data (basis) on evaluation and correlation of questions, because the feedback is comparable for each questionnaire (Lienert & Raatz, 1998).

The expected response rate of 1-6% of the basic population cannot be precisely evaluated. As mentioned in the report for standard definitions from the American Association for public opinion research the rate is estimated (The American Association for public opinion research, 2011). The approximately 4.900 PMI members in Germany were contacted via the different PMI chapters and online PMI platforms on LinkedIn and XING. For data security reasons, the PMI did not provide the addresses of the project managers and individually distributed the link for this questionnaire. A response rate of 1-5% was assumed.

Still the feedback of the survey can be seen as meaningful. From the used 96 responses, 91% of the participants hold PMP certification. Here PMI requires an experience of three years in project management before participation. The professionalism of participants is also reinforced by additional certifications that are held by one fourth of the population. On average, the participants were credential holders for four years, which implies that
their work experience is approximately seven years. As confirmation, respondents noted that their average experience in the field of project management was approximately 14 years.

More than 91% of project managers are certified. Therefore, errors resulting from the participation of non-PMI members can be viewed as low. The online questionnaire could not be manipulated because data were coded and tracked in a system, transferable to the statistical evaluation software SPSS.

According to standard definitions, no ideal response rate exists. However, the seniority level and professionalism of the survey participants can be viewed as high based on the number of participating top-class experts in project management. The existing 96 valid responses serve for satisfactorily evaluation.

9.2 INFLUENCE OF COMPLEXITY IN PROJECTS
The influence of complexity is based on distinct strengtheners. As mentioned in chapter 8.1.2 a limited statistical significance was found between the strengtheners and the degree of complexity in projects. The non-significance raises questions. Why are the strengtheners for complexity not significant? Reason for such results in evaluation can only be suggested. Possible that significance would have appeared if participants have to name all strengtheners of complexity instead of ranking only the top five strengtheners for complexity.

Has each project really to deal with different strengtheners? In that case it is possible to develop a method/tool which can support project managers adequately. In the evaluation of the survey in chapter 8.1.2 a tendency of the main strengtheners is obvious. It was shown that a few numbers of distinct strengtheners often create complexity in projects. These were derived from recently published literature related to the management of complexity, which were used in the survey and interviews. Table 12 shows the top strengtheners as identified by the different data acquisition methods in the survey, focus interviews, and literature. Those findings answer the research objective B strengtheners of complexity that appear in projects. And yet even with the limited significance, the strengtheners can be related to projects with low, middle and high complexity.
Table 12: Research findings on strengtheners for complexity (developed by author)

Similar strengtheners in survey, focus interviews and literature cause complexity. Project managers assume that complexity influences their projects, especially the top strengtheners. The project manager can rarely eliminate those factors. They often are closely linked and must be scrutinized in detail. Participants from the survey and the interview described corresponding strengtheners, but focus groups emphasized “change”. Change causes more complexity. The listed strengtheners are mainly affected. This might also depend on the specific relationships. Customers and stakeholders define the requirements. With progress of the project, requirements can change frequently due to alterations in market demands or environmental conditions. The stakeholder and the requirements must be communicated to other groups of the company such as the project team and management. When changes take place, work must be reorganized. Internal changes of the organisational setup and new arrangements of work and team must be communicated. The focus groups listed also cultural diversity as a strengthener for complexity which appears especially in multinational project teams.

In general, the same strengtheners were mentioned in the literature, the survey, and the focus interviews. The literature expands on those concepts with the addition of urgency and flexibility (Hass, 2009). Those factors could not directly cause complexity in a project. However, they might increase the impact of the existing strengtheners.

Strengtheners quoted in the survey, focus interviews, and literature are not randomly acquired. Projects normally are initiated and sponsored by specific stakeholders like customers. These define the requirements to be realized in the project. As defined by the existing project management standards, 90% of the project manager's work consists in communication, portioning, and tracking of tasks; the project team has to perform.
Summarized strengtheners like customer, requirements, communication, partitionment of work, and organisation, cause and foster the complexity of a project. Especially when these strengtheners are randomly and often changed.

9.3 HANDLING AND MANAGEMENT OF COMPLEX PROJECTS

More than two-thirds of the participants (69.8%) estimated their projects as small/medium size. 72% of the participants named the overall success of projects (incl. large and major) as “good” and “very good”. An assumption that all small and medium sized projects are always in “good”/“very good” standing is not supported by a statistical analysis (see Figure 38).

50% or more in the detailed process areas that are directly controlled by the project manager stand in a “good” or “very good” success. Only the knowledge area of procurement is less successful. Procurement is often outsourced to a separate department and not directly influenced by project managers. Generally the success of the other detailed knowledge areas and the overall knowledge area is conforming (see Figure 36 and Figure 37).

This result raises questions. The chaos report stated that most projects fail or are not successful (The Standish Group, 2010). Did participants of the research have a specific way to manage complex projects? Is this success based on the structured approach in projects by the PMI standard? Or can a project be declared as successful if it met customer requirements and quality demands, even if it was not completed on time or within budget?

Management of complex projects

The management of the complexity differs slightly. All (survey, focus interview and literature) suggested not eliminating or ignoring the complexity of a project. An elimination of complexity might not be the best solution as it could afford too many disadvantages for the project. In the survey, 85.9% of participants stated that immediate actions must be undertaken when complexity is recognized. This could be a controlling or reduction of complexity. This conforms to scientific method. Scientists recommend that the only way to meet market demands and protect their goods against plagiarism is to manage or control complexity and reduce the “over-complexity” (Maurer, 2007; Schuh, 2005a).
For controlling complexity participants mostly choose a rational (constructivistic) and reality (cognitive) referring method. Project managers base their decisions for controlling complexity on the actual situation. These approaches are suitable because complexity is characterized by many different interrelations, a spontaneously changing status, and are difficult to control. Depending on the situation and the problem, most participants try to define the target and describe the solution process with possible alternatives – rational, constructivistic approach. The cognitive approach for controlling complexity consists of reality consideration with a subsequent simplification, abstraction and implication.

The method of reducing complexity is a planned method, not a fast reaction in spontaneous situation. The latter could cause mistakes like reducing a product by eliminating significant features, which could decrease market viability or inferior products. It is a long lasting learning process, what can be reduced for simplifying the complexity. Managers try to structure the complex situation: by learning from others, structuring with labels, or standardizing existing complexity. For example, the “model kit” technology is introduced was recently introduced in the automobile industry. OEMs (original equipment manufacturer) develop “model kits” that can be used in more than one type of car. The range can start with simple parts like steering wheels or entertainment systems up to complex “model kits” such as complete platforms that can be used for different brands. In other industries project managers also rely on existing “model kits” to simplify management.

Feedback from the focus groups on managing complexity was similar. All focus groups agreed that the handling of complex projects should first be performed on the particular situation of the project. They just suggested handling them by a situative approach – analyzing the situation before focusing and taking actions. Because an overall management method does not exist, handling of the vulnerable process is always depending on the topic itself and all approaches should be considered (rational/ situative/ summarized/ standardized). A main proposition for the FGI’s was to stay flexible, the expression of any concerns, and a continuous observation of the vulnerable process and strengtheners that cause the complex situation.

As opposed to the literature and survey, the focus groups did not prefer a reduction for handling complexity, different to the survey and literature. Fixed and contractual signed scope by the sponsor is difficult to be reduced. Focus groups propose no general formula for handling complexity. It can appear in too many different ways and result in too
many different impacts. Rather, it should be controlled by creating manageable sub packages and informing sponsors in time where potential risks can appear. The focus interview participants also mentioned that the attitude of the project manager is relevant in handling problems. Methodology, experience, and proactive action are essential for performing a project successfully and predictably. Hass (2009) suggested the “eXtreme model”, which is described as the approach of situational flexibility and the experience of the project managers.

In ambiguous situations, the managers should consult their team and sponsors, so they could base a decision on a common agreement while maintaining the support of the team/management.

In summary, the approach of controlling and reducing of complexity seems logical, but this was confirmed by all participants of the research. An adaption to the specific situation of the project and the conservation of flexibility is necessary. Otherwise the benefit of the project might not be given and the basement for the project might be detracted. This is shown in Table 13.

**Table 13: Analysis on management of complex projects by survey/ interview/ literature (developed by author)**

**Handling of complex projects**

Where should project managers expect complexity in their projects? The participants of the survey and interview named top vulnerable processes (define scope, manage stake-
holder, collect requirements, identify risks and control scope). They appear mainly in the planning and execution phase of a project. These processes correlate with the previously defined top 5 strengtheners for complexity (customer requirements, stakeholder, communication process, division of work, and organisational changes). Rarely vulnerable processes appear in the projects initiation and closing phase. In the initiation phase, the project has not started yet. In the closing phase, the product/project is so far developed that it can be accepted and inspected by the stakeholders. There is a clear connection between strengtheners and affected processes.

Strengtheners of complexity have a larger effect on projects farther along in the development process. The later those strengtheners are recognized, the greater their impact. Therefore, strengtheners of complexity must be immediately identified and managed from the beginning. 66.7% of participants in this survey think that their project is more or less complex, if even not highly complex. Participants in the survey estimated their projects as 8% as unsuccessful; however, the literature stated that more than 60% of today’s projects are unsuccessful (Amberg et al., 2009; M. Frank et al., 2011; The Standish Group, 2010). Focus interview participants did not mention any unsuccessful projects. How can such a difference in the success of projects appear?

An explanation for this phenomenon could be that over 90% of the participants are PMP credential holders and better know how to structure and manage a complex project. They have proven experience. A direct relation between the certification of project managers and success of the project is not confirmed by the focus groups nor by the survey. So the PMI standard was not confirmed as a method to solve complexity. But successfully certified project managers positively influence projects results. Literature (chaos report) has a broadened view on all projects that are not explicitly executed by certified project managers.

The literature and the focus interviews demonstrated that the success of a project relies on methodology, experience, and the mind-set of the project manager. The success relays more on the methodology and can be expressed in standards. Big companies have established methodologies and their own standards for performing large projects successfully. The methodology is also taught when gaining the PMP. Furthermore, the experience of project managers is relevant. Haas’ (2009) approach confirmed the findings of the focus groups. They require for complex projects the experience of project managers,
equipped knowledge/ skills and exceptional level of leadership. The quality of leadership is grounded on soft skills (Hass, 2009). FGI participants named this experience and seniority of project managers. PMI’s “Navigating Complexity” does not list experience, but it does list leadership, project management techniques, and strategic business management (Project Management Institute, 2014). Skills for leadership and project management techniques are gained through experience. This was expressed by the participants of the FGIs. The strategic business management is not part of this research.

With their experience, project managers learn to apply and methodology in real projects. A project management standard can assist with creating standards for customer service and with outlining advantages, as long as those are applied and accepted by the team. However, it is not a guarantor for success. Also, proactive action in complex situation fosters success. Experience alone will not bring the project to a successful end if there is no defined methodology that people can follow. Furthermore, both methodology and experience cannot support the project if it is insufficiently staffed. So, the success of projects in survey was explained by the focus interview.

In summary, the successful handling of complex projects is influenced by the manager and the applied methodology. The success does not depend on any specific project management standard like PMI, but the implied methodology. The greater the skill set of manager, the greater his or her ability will be to handle a complex project. That skill set includes; experience in practical implementation of a project, the abilities in soft skills, leadership, strengthening interpersonal relations, and proactive action. This is shown in Table 14.
9.4 CATEGORIZATION OF COMPLEX PROJECTS

The original target of this thesis was to create an accurate matrix for every field of industry in order to identify the most typical strengtheners of complexity and vulnerable processes (research field C). For an exact evaluation, the monetary values are missing. The reason for this is the different, partly unrealistic declaration of project budgets by the participants that showed budgets up to 200 bn. €.

Project management experts estimated the categorization and level of complexity of projects. On one hand, project managers have different experience; on the other hand, a strict comparison between each project and field of industry is not possible. The matrices show possible strengtheners of complexity and vulnerable processes, listed to category of project and level on complexity. However, the matrix does not predict them exactly. The listed fields of industry are named on which experience this matrix is based.

The three matrix graphs (Figure 48, Figure 49 and Figure 50) defined commonly appearing complexity strengtheners and vulnerable processes in projects, depending on field of industry. They can provide a guide to the strengtheners of complexity that should be observed single project processes in specific fields of industry, particularly for inexperienced managers. This is the first time that these tables have been established.
Focus groups accepted the matrix as an indicator, but suggested that it was difficult to understand. In discussions, they pointed out and suggested that it would be good to have strengtheners and vulnerable processes listed only the first time that they were identified. Otherwise, the result from the survey could not be applied in practice. These concerns from focus groups were respected. The matrices were transformed into a newly created clear funnel model, useable in practice.

The transition from the three matrices to the funnel model was performed in this way that doubled nominations are eliminated. Single nominations are listed in light grey to exposure their less importance, they are only valid in their stage. Normal printed data for strengtheners of complexity, vulnerable processes, and field of industry are not only valid in the first mentioned stage of complexity, but also in the following higher stages. So the funnel model is easier readable.

With the input from the FGIs, the following graph was framed (Figure 58). Such a funnel model achieves the original objective of research field C, whereas the output of the survey incorporating a three-layer matrix is too complicated to apply. The funnel model is now a controllable model where project managers can easily indicate complexity in their projects.
Figure 58: Funnel model for identification of complexity (developed by author)

The funnel model was developed as follows: in the upper part, strengtheners for complexity are listed. In the lower part, vulnerable processes for complexity are listed. The arrow in the middle shows the field of industry relevant to the strengtheners of complexity and vulnerable processes. On the y-axis, the size of the project is listed, starting in the middle moving to the outside from small to major project. The x-axis demonstrates an increase of the level of complexity from low to high.

Strengtheners and processes listed under the category low complexity are additionally valid in the categories middle and high complexity. The same is relevant for the field of industry. Light grey listed processes that are vulnerable for complexity are processes that were listed only in one of the categorized fields for the size. Processes and strengtheners listed in black are intersections of all listed affected project sizes.

The adapted funnel model is a simplified illustration of the matrices and should indicate where and how complexity can affect a project. The ranking of project size and the level of complexity depends on the user’s perspective. This conforms to an earlier statement.
of the third focus group: the complexity of a project depends on the attitude and experience of the project manager and/ or project team. When projects are done for the first time they can be complex. However, the experience gained from similar projects creates a decrease in complexity.

An agreement for a correct indication of the matrixes and also the new funnel model was the statement that low complexity does not appear in large or major rated projects and that high complexity is listed in small projects.

This newly developed funnel model is not intended to be a complete guide for handling of complexity in practice. It only indicates where and how complexity can emerge in a project. Two focus group participants suggested offering specific tools and methods for handling complexity. However, the other participants rejected this recommendation. A real handling and managing of complex situations was not expected from this thesis because the process should always specific to the situation. If tools and methods are offered, it could be a book for methodology in the form of project management standards.

The categorization of projects by a matrix is not possible. Project size and level on complexity are strongly based on interpretation of the user. It is dependent on the field of industry and project budget. Simplified matrices could give an indication and is illustrated by a funnel model (Figure 58). This new funnel model shall focus on vulnerable processes and strengtheners of complexity, as relevant to the field of industry, the size of project (small, middle, large, major), and the estimated level on complexity (low, middle, high).

This funnel model is based on the processes of PMI standards, but an adaptation to other similar standards is possible. A comparison of standard processes has been performed (Appendix VII – Comparison of processes from worldwide project management standards) to assure validity of the standard. But the selection was performed according to criteria like the example of associated companies, international accepted certification, membership worldwide, practicing countries, availability in different languages, and compliance with official norms (Table 4). As the selected standard is used world-wide and considers already the different cultures, cross-cultural habits don’t need to be further investigated. It indicates where complexity strengtheners can appear in complex projects and affect processes in project management that are vulnerable for complexity.
A greater number of participants in the survey would have been desirable. A specified categorization of the projects could be possible. Even a survey not focused on Germany and also not focused on one specific standard could have broadened the perspective. This approach was not intentionally followed because the scope of the research was limited by time and topic. This thesis places for the first time the relation of strengtheners and level of complexity and processes and sizes of projects in different fields of industry, in a clearly laid out pilot matrix.

A similar approach was not found in the literature. The literature provided only a basis for a model of handling complexity. Haas (2009) described the following aspects of handling complexity: selecting the right project management cycle, the right project manager, and the right management style. There was no mention of where possible strengtheners of complexity and vulnerable processes for complexity can appear. In “Navigating Complexity”, a book from PMI, no relation to the project management processes of the PMBoK is given. PMI provides only a basic outline relevant to reducing the complexity in projects. The mentioned assessment does not result in a categorization, it shows the user how to think and reflect on complexity inside the project (Project Management Institute, 2014).

9.5 Handling Complexity in the actual PMI Standard

A narrow majority of the participants (60%) in the survey consider the actual PMI standard sufficient for handling complexity, but 54% request a separate chapter for handling. This must be reflected. Even participants who stated that PMI standard is sufficient would appreciate more advice to manoeuvre projects safely in complex situations. Indications for a structured chapter can be inferred from the survey.

Participants from interviews were astonished by the answers in the survey that on the one hand PMI handles complexity satisfactorily, but on the other hand they would like to have a separate chapter inside the standard. This was not confirmed in the focus groups. They consider complexity as a trending state of affairs that should be addressed by the PMI. It is a topic that affects project managers. The PMI should give guidance for overcoming complexity, but a general standard should not be created. Some participants suggested that notes should be integrated into the standards, where the reader’s attention has to focus on complexity. A separate book was suggested because of the multitude of factors inherent in complexity. This was recommended as complexity cannot be standardized like project management. For a sufficient handling of complexity an ampli-
fication of PM standard with possible instructions is not recommended. A new widespread guide for handling complexity in project management is the solution.

In the literature, the traditional PM standards are considered valid and effective. This is reinforced by Gary Gingrich as cited by Hass, 2009, “... [the] science of complexity, however, does not yield answers, at least not in the sense that we have typically sought to describe our world and predict its events since the beginning of the Scientific Revolution. What it does yield is a new way of thinking about the world...” Also PMI did not integrate their new release “Navigating Complexity” into the actual standard. For them it was worth to generate a separate book to manage complexity (Project Management Institute, 2014).

In summary, the focus interviews and literature revealed that existing standards for project management are considered valid. The PMI standard PMBoK V4 and the PMBoK V5 deal satisfactorily with complexity. An introduction of a new separate chapter for complexity was shown as needed in the survey, but was rejected by the focus groups. It should not be integrated in standards, as handling complexity cannot be standardized, (Hass, 2009). Additional advisories inside the PM standards could cause confusion. The common desire for a separate guide to manage complex projects was obvious, and is therefore also suggested as a finding for the research field E. This analysis is shown in Table 15.

<table>
<thead>
<tr>
<th>Survey</th>
<th>Focus interview</th>
<th>Literature</th>
<th>Resulting in…</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMI is sufficient for managing complex projects (60% of participants)</td>
<td>PMI is sufficient for managing complex projects</td>
<td>Actual PM standards are sufficient for managing complex projects</td>
<td>PMI and the actual traditional PM standards are still valid</td>
</tr>
<tr>
<td>Separate chapter for managing complexity</td>
<td>Separate chapter for managing complexity</td>
<td>Separate chapter for managing complexity</td>
<td>A separate chapter should not be integrated as complexity cannot not be standardised</td>
</tr>
<tr>
<td>Give advisory in the PMI standard where complexity can appear</td>
<td>Give advisory in the PMI standard where complexity can appear</td>
<td>Give advisory in the PMI standard where complexity can appear</td>
<td>Standards would be overcrowded with hints and would cause babel</td>
</tr>
<tr>
<td>Separate guide for managing complex projects including methods, tools, cases etc.</td>
<td>Separate guide for managing complex projects including methods, tools, cases etc.</td>
<td>Separate guide for managing complex projects including methods, tools, cases etc.</td>
<td>Separate guides exist, further investigation for practical application needs to be scrutinised</td>
</tr>
</tbody>
</table>

Table 15: Analysis on handling complexity in actual PMI standard (developed by author)
Multiple tools and methods for handling complexity should be outlined in this separate guide. Project managers should be able to select the appropriate tool and/ or method (research field D). Existing methods like WBS, checklists, and stakeholder analyses should be integrated to overcome complexity. These are stated methods/ tools in the PMI standard. The additional tools that were mentioned in the survey for handling complexity should be critically scrutinized.

The enterprise architecture model (EAM) is a specific model demonstrating the relationship of information technology and business activities in the company. The Montecarlo analysis, also known as a scenario analysis, was addressed in the survey. Participants ranked it on the first position for handling complexity. The “influence diagram” can be interpreted with a fish bone diagram (Ishikawa diagram). It could be a method to analyze the reason for complexity and is similar to the arrow diagram. A typical “influence diagram” (Ishikawa) shows only the reason for complexity, but not a method for handling. Some use the method “agile management” to control complexity with a situational approach.

In the literature, the balanced score card (BSC) is mentioned for handling complexity. However, this method was not supported in the survey or the focus groups. It is typically used for tracking KPIs, as described in Appendix XXII – Balance score card (BSC). This approach would be more useable for programme or portfolio management and is only partially suitable for project management.

New methods for the research field D were rarely proposed for handling complexity. Unusual methods researched in the literature on handling complexity were not familiar to project managers, who focus more on project management literature. For a new chapter, other methods like the DSM should be proved and integrated. Focus groups fostered an adoption by general moderating techniques like 6-3-5 or working on a white board with Post-it® notes.
10 RESEARCH CONCLUSION

Research field A

How does complexity (theory) influence the execution of project management (PM)?

The research target was to examine the influence of complexity theory on the appearance, treatment, and visualisation of the most appropriate project management standards (selected on its membership criteria, availability, norms and distribution of use).

Project management standards worldwide were analyzed according their processes and objective facts like distributed countries and memberships. This overview is shown in Table 4. A comparison of the knowledge areas and processes in project management phases was investigated by the GAAP before, but should be viewed as a subjective interpretation. Therefore, the comparison is listed in the Appendix and only the fact-based comparison is consulted for the selection of the most appropriate PM standard. However, the comparison with most common worldwide standards (PMI, CMMI, Prince2, P2M, ICB3.0, NCSPM and PMSGB) was done for the first time in an exceptionally extended range. Worldwide, PMI is the most used standard in project management with more than 520.000 members, adhering to general ISO norms (ISO 9001, ISO 1006, ISO 21500), offering the standard in several different languages (Arabic, Chinese, English, French, German, Italian, Korean, Portuguese, Russian and Spanish), having been established for longer than 40 years (1969). Therefore, it is basis for this research. In the survey and focus interviews the most vulnerable processes (define scope, manage stakeholder, collect requirements ...) and the least vulnerable processes by complexity (create project charter, identify stakeholder, close procurements ...) in project management were identified and researched. Identified processes, most vulnerable for complexity, appear mostly in the planning phase. Therefore, complexity has the biggest impact on the planning of a project, which is performed continuously during the whole project life cycle. Less impact by complexity in project is given in an early (initialising) or late (closing) stage. The impact itself is discussed in the following research question. To recognize complex situations in project management the following processes were examined: mind map, WBS, and stakeholder analyses. The results were used for the other research questions.
The research confirms that complexity impacts project management. The most vulnerable processes appear in the planning phase, which ranges during the whole project life cycle.

**Research field B**

*What are the complexity ‘strengtheners’ in project management?*

The research target was to identify complexity ‘strengtheners’ in project management from the literature and evaluation in practice with experts.

The strengtheners for complexity were examined first in the literature. These are listed in Table 6. In the literature, identified strengtheners for complexity were investigated for the first time with PM experts (survey). Here strengtheners were proved to have the most impact on project management in general. The identified strengtheners were: customers/ stakeholder, requirements, communication, organisation, and division of work. The findings from the survey were later scrutinized with PM experts in focus interviews. Those experts confirmed the strengtheners from the survey, but added the prefix “change.” These strengtheners are only valid for complexity if they regularly change, not remaining stable. So a main issue of complexity is the frequency of change. Summarised participants from the survey and the focus groups rated the same top five strengtheners: customers/ stakeholder, requirements, communication, organisation and division of work. Identified strengtheners are scientifically proven here and ranked by a survey and interview with PM experts for the first time (Table 12).

These five complexity strengtheners were uniformly named in the survey, focus interviews and literature.

**Research field C**

*How does project management deal with complexity?*

The research target was to evaluate and demonstrate the connection between complexity strengtheners and vulnerable processes in project management.
The relationship between strengtheners for complexity and the processes they affect were detailed analysed. Participants’ projects (concerning size and field of industry) and vulnerable processes in project management were interrelated in the evaluation. The only significance that appeared was: when complexity in projects increases, the complexity strengthener “cultural diversity” decreases. This strengthener “cultural diversity” might have less impact than others and stagnate when many cultures have joined the project team. Other correlations with strengtheners of complexity did not show significance. The possible reason for no other significance might be the number of participants within the survey, which could change if the survey were performed worldwide.

Based on the evaluation, a newly developed funnel model categorises strengtheners and vulnerable processes in projects relative to the size and degree of complexity in the different fields of industry. Such a model was generated for the first time, oriented on the single process steps of the selected PMI standard. But it is possible to project from a limited view of one standard (PMI) onto a broadened view on all standards worldwide, because processes in all standards are similar. However, generalisation still depends on the manager’s interpretation. Indeed, the selected basis for this research (PMI standard) is available in different languages, but this does not always assure the same interpretation. Nevertheless, in general this funnel model provides an indication how the strengtheners for complexity can affect single processes in project management. Project managers can easily orientate themselves where they have to pay attention in a project concerning complexity and estimating difficulties.

The connection between complexity and project management is demonstrated in the funnel model (see Figure 58).

Research field D

*What is the scope for possible modifications in the chosen PM standard for managing complexity?*

The research target was to generate an account of the methods for the treatment of complexity in the chosen PM standard and their application in practice.

Before discussing methods of handling a complex project, managers should know which strategy they should apply to a project: not at all, eliminate, reduce, or manage/control.
An important principle is to remain flexible. The literature and the results from the survey show that complex projects are best managed by reducing or controlling complexity. So project managers gain advantages by managing and controlling complexity. Increasing specification reduces plagiarism and provides better product diversification in comparison to competitors and assures market advantages.

Already mentioned in the PM standard WBS, stakeholder analysis, requirements analysis, and communication management support handling complexity. Participants suggested brainstorming with mind maps and applying scenario techniques in complex situations of a project. In general, they also named applying moderating techniques (6-3-5 techniques or white board with Post-it® notes) for handling complexity, but new approaches were not stated by participants of the survey.

This research target can be confirmed. Methods for the treatment of complexity in a PM standard are outlined from a practical point of view. Participants did not identify new methods that were used in their daily practice. But some participants from the focus group interviews stated that it would be supportive to have a separate guide offering a kind of manual to handle complexity. It would especially support unexperienced project managers. Integration into the existing PM standard was negated as the complexity is not standardisable.

A successful complex project does not only focus on standardized or individually developed methods. All authors engaged with the topic concluded that personal skills (experience, ability for communication, leading and guiding people) are most important for handling complex projects (Hass, 2009; Levin & Ward, 2013; Project Management Institute, 2014). This was also partly confirmed by the focus group interviews. But this should not just be limited to the project manager, also the project team should be considered to improve their personal skills. This can be reflected to a learning organisation/project team. Senge defined the five disciplines that are necessary requirements to improve a learning organisation: personal mastery, mental models, shared vision, team learning, and system thinking (Senge, 1997). These single disciplines can also assist with handling a complex project. The team members have an open mind-set for new approaches and won’t stop to gain new knowledge. Together they create a vision for the future and will follow that vision because all team members created it. Therefore they develop an intuition for a bigger overview and won’t stop at the boarders of the system.
Research field E

Are there additional methods to those mentioned in the chosen PM standard for the management of complexity?

The research target was to create a more manageable framework for the treatment of complexity in the chosen PM standard through its modification.

Handling of complexity in the actual PMI standard is estimated satisfactorily by the survey and focus groups. However, the survey participants proposed modifications of the existing standard that included creating a new chapter dealing separately with complexity. This was not confirmed by the interview participants or recently released literature. Additional advisories inside the PM standards could cause confusion, making the standard too complex. It has also been argued that complexity cannot be standardized (Hass, 2009) and has not to be mentioned in the methodology, explained in a standard. The general desire for more support in handling complex projects was shown by the survey and interviews.

A way out of this problem is the proposal of research participants in focus groups. They suggested the creation of a separate guide focused on managing the complexity in projects. The recently published literature by Haas (Managing Complex Projects: A New Model) and PMI (Navigating Complexity – A practical guide) should be integrated here, as it explains concepts for handling complex projects. Still missing parts would be the acknowledgement and identification of complex projects – which is partly investigated in this research – and also need to be integrated in the new guide. An overall guide would only be supportive and provide ideas of where to focus and how to handle complex projects, but it would address the entire process from the recognition of complexity, identification of complexity at single processes, the possible handling methods, and an assessment to check the progress.
11 Managerial Implications

In today's projects, complexity is still an issue. More than 45% of the survey participants stated that they deal with complexity in their projects. In contradiction to the reviewed literature, complex projects of the certified project managers are often successful. Most of the certified project managers of PMI choose the right handling: control or reduce complexity (>85%). How to do this? The current PMI standard was voted as sufficient for managing complexity, even there is no explicit advice for managing. A result from the focus groups was that complexity could not be standardized. This might be a reason why no standard has integrated a chapter for dealing complexity. But newly released literature, also from PMI, discusses this specific topic. Here a comprehensive guide supports managers in complex projects.

This research attempts to address this dilemma and provides a proposal. The approach follows a model developed in 1965 by the psychologist Tuckman that outlined developmental sequences in small groups. The Tuckman model is known for an integrative set-up of a team which performs successfully a project. Such a synonym should also be applied to handle complex projects. Project managers should find easily themselves in such a model and remember each of the five phases. Also experienced managers simply accept this model (Tuckman), here transferred for handling complexity. The problem of handling complex projects can be solved using the Tuckman technique setting up a team. This structure shall support project managers better in applying the new proposed guide, as it relies on a model that is based on current project management literature. The developmental sequences in small groups are arranged in five phases (Tuckman & Jensen, 1977): forming, storming, norming, performing, and adjourning. These five phases could be the foundation for creating a guide in “optimal handling of complexity in project management” by dealing with the recognition of a complex project, the identification of complexity at single processes, the possible handling methods, and an assessment to check the progress.

Phase 1 – Forming/ recognition of a complex project

Tuckman defines the forming phase as follows:

“Groups initially concern themselves with orientation accomplished primarily through testing. Such testing serves to identify the boundaries of both interper-
sonal and task behaviours. Coincident with testing in the interpersonal realm is the establishment of dependency relationships with leaders, other group members, or pre-existing standards. It may be said that orientation, testing and dependence constitute the group process of forming” (Tuckman, 2001, p. 78).

The forming phase is where the team members have first contact. It is often characterised by uncertainty. Team members need to become familiar with each other.

In the “forming” phase, the project manager must gain self-awareness and discover that a problem exists. He or she must be aware of complexity and gains an understanding for needing support to overcome the newly identified problem. This could be accomplished by talking with other project managers about the own project, reflecting about the current situation with his or her project management team, or by reviewing the latest status reports of the project. Here a first idea of strengtheners for complexity comes up in the focus of the project manager/ team and possible affected project management processes should be outlined. The project manager should be responsible for acknowledging and identifying the complexity of the project. This phase ends when the project manager has identified a problem and assume that complexity could be the origin. This can be performed by the manager on its own in discussion with the team. Complexity is than analysed in the next phase (storming).

**Phase 2 – Storming/ identification of complexity at single processes**

Tuckman’s definition of the storming phase as follows:

“The second point in the sequence is characterized by conflict and polarization around interpersonal issues, with concomitant emotional responding in the task sphere. These behaviours serve as resistance to group influence and task requirements and may be labeled as storming” (Tuckman, 2001, p. 78).

In this phase, team members of a project generally discuss their own targets. Often such discussions end in power struggles, which cause tension in the relationship of team members. However, in this phase, the first agreements by single team members are accomplished. The performance of the team might have not started yet, because the team is still becoming oriented.

In the second step of this guide for successful management of complex projects, managers must confront complexity in a manner similar to the “storming” phase, where the
team must address a given task. Is the running project complex? A complex project is characterised by a temporarily limited endeavour in a continuous irreversible and spontaneous motion, where by given restrictions and large amount of elements a non-transparency is created.

Often the project manager does not know how to start managing his or her complex project successfully. Necessary knowledge of different strengtheners of complexity might be present, but is not manifested (Table 6 and Figure 19). The newly developed funnel model from this thesis shall support project managers to identify the indicators for complexity of their own projects (Figure 58). Managers first analyze their own project by their own internal subjective categorization of the project range. They rank their project to its size (small/ large/ medium/ major). Looking at the newly developed funnel model from this thesis, they get an indication where the real problems exist. In the phase 1 they already gained an idea of possible strengtheners of complexity which showed up in their project. With the available information of their subjective categorisation of the project size and the clue of strengtheners for complexity in the project, the project manager is able to categorise the project. Often the strengtheners of complexity are linked to the project size. The amount of potential strengtheners for complexity increases with the size of the project. At the same time with a higher number of strengthener within a project, more processes inside a project are affected by complexity.

The possible strengtheners for complexity should be always considered, if they really impact the complexity inside the project. Further the processes should be evaluated if they are the reason for the “problem” of complexity.

Complexity on currently non-affected processes but possible in future can be predicted. So handling of complex projects is more projectable.

Identified strengtheners and relevant processes are best analysed in the project team. The complex project is observed by different viewpoints. The common analysis underpins the understanding of the complex project in the project team and strengthens the acceptance of the derived actions which are defined in „norming“ phase.

The PMI standard is the basis for this model; it can be applied to other standards, as they are also constructed in single process levels. The model can be applied and modified worldwide as a model, with respect to cultural mannerisms beyond specific German virtues as the survey was performed in Germany. In summary, the funnel model supports
managers and indicates processes in project management that are affected by complexity.

The gap for identifying complexity in a project shall be closed with the new funnel model inside the five-phase model.

After the application of the funnel model, the project manager knows the main strengtheners for complexity and most vulnerable processes in his or her project. With this short evaluation he or she can select the most appropriate tools to handle complexity from PMI’s *Navigating Complexity* or Haas’s *Managing Complexity: A new model*.

**Phase 3 – Norming/ possible handling methods**

Definition of the norming phase to Tuckman is as follows:

> “Resistance is overcome in the third stage in which in-group feeling and cohesiveness develop, new standards evolve, and new roles are adopted. In the task realm, intimate, personal opinions are expressed. Thus, we have the stage of norming” (Tuckman, 2001, p. 78).

In the third phase of the guide of complexity (“norming”-phase), the team has agreed upon the actions that need to be done. Team members have settled into their roles, accepted each other, and developed their own ideas.

In this stage, the findings of the researched literature on managing complexity can be combined, used, and adapted. The manager of a complex project must determine and arrange actions in project cycles. For this Haas (2009) proposed nine different project cycles related to the different levels of complexity – low, middle, high (Figure 2). These must be selectively identified and applied. Managers choose the tools and methods for handling complexity as offered by PMI’s *Navigating Complexity*. However, a complete synthesis cannot be provided based on PMI’s *Navigating Complexity*, Haas’s *Managing complexity*, or this thesis. This thesis further provides a proposal to apply methods in addition to the existing project management standards like the Data Structural Matrix (DSM).

The qualifications of the project team and the style of management should be examined for potential factors that could improve a complex situation. Hass (2009) and PMI’s *Navigating Complexity* require specific soft skills of the manager and set-up of the team.
Support in this could come from the following disciplines as outlined by Senge (1997):

- **Personal mastery** – discipline of continually clarifying and deepening the personal vision, focusing on one’s own energies, developing patience, and seeing reality objectively.

- **Mental models** – deeply ingrained assumptions, generalizations, or even pictures of images that influence understanding of the world and how actions are taken.

- **Shared vision** – practice of unearthing shared pictures of the future that foster genuine commitment and enrolment rather than compliance.

- **Team learning** – dialogue where team members suspend assumptions and enter into genuine thinking.

Additionally, these disciplines explain which soft skills are supportive for the team and the manager on an abstract level to handle complex projects and improve the norming phase.

**Phase 4 – Performing/ assessment to check the progress**

Tuckman defines the performing phase as follows:

> “Finally, the group attains the fourth and final stage in which interpersonal structure becomes the tool of task activities. Roles become flexible and functional, and group energy is channeled into the task. Structural issues have been resolved, and structure can now become supportive of task performance. This stage can be labeled as performing” (Tuckman, 2001, p. 78).

In the fourth phase of the new guide on handling complexity (“performing” phase), the team shows performance and defined actions are realized. Team members know what to do and have a common open mind-set. They accept and appreciate each other and work together successfully. The success of a team is established.

In a similar manner, the manager of a complex project would have selected and implemented tools, methods, and management styles and assessed himself/ herself and the team. For a sustainable success, a critical reflection should be performed to the achieved outcome. PMI’s *Navigating Complexity* supports an assessment and provides a picture of the complex project by questioning 48 questions.
Tuckman’s five phase model of the “developmental sequences in small groups” is a linear model, but theorists like Bales have proposed cyclic models. Bales argued that team members seek a balance between finishing a task and the interpersonal relationship within the team. This results in a movement between norming and performing (Bales, 1965). The “performing”-phase should be iteratively repeated together with the norming and storming phase. As the process on managing complex projects proceeds, projects might be categorised differently and adaption concerning the applied methods might become necessary.

**Phase 5 – Adjourning/ project successfully ended**

For the fifth phase of Tuckman’s model, no real definition exists. He explained it in an article as follows:

“We reviewed 22 studies that had appeared since the original publication of the model and which we located by means of the Social Sciences Citation Index. These articles, one of which dubbed the stages the ‘Tuckman hypothesis’ tended to support the existence of the four stages but also suggested a fifth stage for which a perfect rhyme could not be found. We called it *adjourning*” (Tuckman, 1984)

The fifth phase was supplemented by Tuckman in 1977. It describes that the team members will move onwards to a different endeavour when the original task is completed.

The fifth, “adjourning”-phase is not needed for the complexity guide. The project hopefully ended successfully.

The following graph is the proposal for a cohesive guide on handling complex projects (see Figure 59). It shows the single phases derived from the results of this research.
Figure 59: Five phases to successful complex projects (developed by author)

This new guide supports project managers of handling complex projects from the beginning. In addition, the literature mentions the handling of complex projects in different cycles and provides support for project management by offering tools, methods, and an assessment. The reflection of the project manager, which is the first step to detect complexity, is a necessary component. This component appears to be absent from current research. Furthermore, the “storming” phase is missing: here the project manager gains the knowledge of where to start in the complex project (funnel model). The funnel model uses the PMI Standard as a basis and is so cross-cultural approved. It disposes results of survey and interviews with PM experts in Germany and is a generalized model. It indicates where complexity strengtheners can appear in complex projects and how they affect processes in project management that are vulnerable to complexity.

In addition to the existing project management standards, this guide should enable project managers to handle professionally complex projects.
12 RECOMMENDATION FOR FURTHER RESEARCH

In the future, the existing guide of PMI, the model for managing complex projects (Hass, 2009), and the findings of this thesis could be integrated into an overall guide for handling complex projects. All three have a different focus, and if combined, could give project managers confidence in handling complex projects. My suggestion is to use methodology and models from Hass (2009); methodology and skills (leadership, PM techniques and strategic/business management) from PMI guide “Navigating Complexity”; the funnel model (complexity strengtheners affecting vulnerable processes in the existing PM standard), and tools for handling complex situations from this thesis. Additional tools and methods for handling should be investigated. This could then be a complete guide for handling complex projects (Hass & Lindbergh, 2010).

A first step for integration could be done by PMI, where a survey is set up with all PMI members worldwide. The motivation for a new worldwide survey would be the integration of the different cultures and outlining possible differences to the outcomes of this research. Participation in the survey could be motivated by earning credits for renewing the project management certification.
13 REFLECTIVE THOUGHTS FROM THE AUTHOR

I was motivated to research handling complex projects based on my daily work as a consultant for challenged projects.

Everything else was reduced during this scientific work. During this work I learned a lot about scientific methods in theory. This theoretical knowledge was strengthened by putting it into practice using the survey and interviews. This also was performed for the knowledge concerning project management of complex projects.

During data collection in the survey, I leaned to have a second viewpoint, validating and scrutinizing the results. Comparing the survey and focus interviews I noticed that no common agreement existed for handling complexity with an actual PM standard. Discussions with direct feedback showed that it is better to have a separate guide. Also for an adjustment of the findings to practice, participants of the interview mentioned that the explanations for the matrices were too complicated. So, this was discussed and a new funnel model developed.

Further discussions with other researchers from my university broadened my perspective. A single answer rarely exists; different viewpoints must be considered.

Finally, all the gained knowledge about project management and complexity management supported me in my actual job. I became more confident in national and international projects and my ability to debate was improved.

During the course of my studies, I was convinced that I could handle this thesis and my job. I planned on completing the thesis in three years, but it took a bit longer than four.
## APPENDIX

### APPENDIX I – APPROACHES OF HANDLING DIFFERENT TYPES OF COMPLEX PROJECTS

<table>
<thead>
<tr>
<th>Large, long-duration projects</th>
<th>Planning and structuring the project:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason:</td>
<td>• Select appropriate mngt. approach</td>
</tr>
<tr>
<td></td>
<td>• Progressively elaborate the plan</td>
</tr>
<tr>
<td></td>
<td>• Use systematic, reliable approach to estimating</td>
</tr>
<tr>
<td></td>
<td>• Perform rigorous time and cost mngt.</td>
</tr>
<tr>
<td></td>
<td>• Use stage-gate mngt.</td>
</tr>
<tr>
<td></td>
<td>• Conduct rigorous risk mngt.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Large, dispersed, culturally diverse project teams</th>
<th>Developing and delivering the solution:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason:</td>
<td>• Structure your project to develop and deliver the solution incrementally</td>
</tr>
<tr>
<td>Team leadership:</td>
<td>• Minimize scope</td>
</tr>
<tr>
<td></td>
<td>• Delay design decisions until the last responsible moment</td>
</tr>
<tr>
<td></td>
<td>• Use rapid application development</td>
</tr>
<tr>
<td></td>
<td>• Use lean development techniques</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highly innovative, urgent projects</th>
<th>Sustaining a high performing team/ selecting team members:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason:</td>
<td>• Select team members for the long haul</td>
</tr>
<tr>
<td>Team collaboration, communication + coordination:</td>
<td>• Pay close attention to team health</td>
</tr>
<tr>
<td>Team leadership:</td>
<td>• Share resources</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ambiguous business problems, opportunities and solutions</th>
<th>Ambiguous business solution:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason:</td>
<td>• Form a special “innovation team”</td>
</tr>
<tr>
<td>Ambiguous business problem or opportunity:</td>
<td>• Use edge-of-chaos management to bring the solution into view</td>
</tr>
<tr>
<td>Ambiguous business solution:</td>
<td>• Become adept at facilitating teams to make innovative decisions</td>
</tr>
<tr>
<td></td>
<td>• Conduct a feasibility study to identify and analyse solution options</td>
</tr>
<tr>
<td></td>
<td>• Conduct value-chain analysis for cross-functional enterprise solutions</td>
</tr>
<tr>
<td></td>
<td>• Conduct root-cause analysis to ensure the solution will solve the business problem</td>
</tr>
<tr>
<td></td>
<td>• Become adept at using tools and techniques that foster creativity and innovation</td>
</tr>
<tr>
<td></td>
<td>• Lead your team into “the zone”</td>
</tr>
</tbody>
</table>
## Poorly understood, volatile requirements

### Reason:
- Deficient requirements practices
- Insufficient stakeholder involvement
- Requirements interdependencies

### Rigorous enterprise analysis:
- Complete rigorous analysis prior to project funding
- Secure executive approval for the project scope and approach

### A framework for managing requirements complexity:
- Establish requirements integration teams
- Recruit a professional business analyst
- Insist on adequate customer, end-user, and technical involvement
- Establish a requirement knowledge management system

### Agile methods:
- Agile, iterative requirements definition and analysis techniques
- Sophisticated requirements visualisation techniques
- Incremental solution development techniques

## High-visibility strategic projects

### Reason:
- Political maneuvers and power struggles
- Changing strategies and expectations

### Executive support:
- Enlist the support of a strong executive sponsor
- Establish a steering committee
- Focus on business benefits

### Political management strategy:
- Create a political management plan
- Promote yourself and your project
- Leverage the formal authority of functional managers

### Stakeholder management:
- Establish positive relationships with key stakeholders
- Involve customers and users in every aspect of the project
- Establish and manage virtual alliances
- Establish and manage expectations

## Large-scale change initiatives

### Reason:
- Resistance to change
- Emotional responses to change
- Common change management mistakes
  - Allowing too much complexity
  - Failing to create sufficient guiding coalition
  - Underestimating power of vision
  - Under communication of the vision
  - Permitting obstacles to block new vision
  - Failing to create short-term wins
  - Declaring victory too soon
  - Neglecting to anchor changes firmly in culture

### Change management framework:
1. Create a sense of urgency
2. Build a guiding team
3. Get the vision right
4. Communicate for buy-in
5. Empower action
6. Deliver short-term wins
7. Don’t let up
8. Make change stick

### Internal motivation for change:

### Groundbreaking commercial practices:
- Conduct rigorous industry analysis
- Threat of substitute products
- Threat of established rivals
- Threat of new entrants
- Bargaining power of suppliers/customers
- Conduct prototyping to obtain market feedback
- Investigate commercial practices rules and regulations
- To enhance consumer rights
- To protect consumer health and safety
- Prevent exploitation of vulnerable consumers
- Make it easier to carry out global transactions
- Outlaw unwanted practices
<table>
<thead>
<tr>
<th>Significant, dependencies and external constraints</th>
</tr>
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<tbody>
<tr>
<td><strong>Reason:</strong></td>
</tr>
<tr>
<td>• Complex behaviours and reactions to changes</td>
</tr>
<tr>
<td>• Unintended consequences of interventions</td>
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<tr>
<td>• Outsourced products, services or solutions</td>
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<tr>
<td>• Cross-functional and cross-project dependencies</td>
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<tr>
<td>• Regulatory and environmental constraints</td>
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<tr>
<td>• Integration issues</td>
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<td><strong>Risks and uncertainties:</strong></td>
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<tr>
<td>• Managing risks</td>
</tr>
<tr>
<td>• Supportive organisation</td>
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<tr>
<td>• Competent people</td>
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<tr>
<td>• Appropriate methods, tools, techniques</td>
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<tr>
<td>• Simple, scalable processes</td>
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<tr>
<td>• Managing uncertainties</td>
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<tr>
<td>(1) Identify uncertainties</td>
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<tr>
<td>(2) Consider the impact of your uncertainties</td>
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<tr>
<td>(3) Consider monitoring and research</td>
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<td>(4) Consider mitigation and exploitation</td>
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<tr>
<td>(5) Clarify alternative future outcomes</td>
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<td>(6) Make risk-aware plans</td>
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<tr>
<td>(7) Design internal control systems</td>
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<tr>
<td><strong>Dependencies and external constraints:</strong></td>
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<tr>
<td>• Identify inter-group and cross-project dependencies</td>
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<tr>
<td>• Assign ownership to dependencies</td>
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<tr>
<td>• Manage your project in the midst of changes in your IT environment</td>
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<tr>
<td>• Use edge-of-chaos management to adapt to changes on the external environment</td>
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<tr>
<td><strong>Complex outsourced projects:</strong></td>
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<tr>
<td>• Establish positive supplier partnerships</td>
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<tr>
<td>(1) Clear defined scope</td>
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<td>(2) Evaluate like an employee</td>
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<tr>
<td>(3) Specific experience fit</td>
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<td>(4) Don’t choose vendor on price</td>
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<tr>
<td>(5) Review portfolios</td>
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<tr>
<td>(6) Start small</td>
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<tr>
<td>(7) Payment to defined gates</td>
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<tr>
<td>(8) Clear ownership of work</td>
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<tr>
<td>(9) Support after the project</td>
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<tr>
<td>(10) Get it in writing</td>
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<tr>
<td>• Create an integrated project management team</td>
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<tr>
<td>• Establish a framework for managing outsourced projects</td>
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<td>• Governance layer</td>
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<td>• Management layer</td>
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<tr>
<td>• Technical layer</td>
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<td>• Communication layer</td>
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</table>

Table 16: Examples of complexity thinking in different project types (adapted from: Hass (2009))
APPENDIX II – PROJECT PORTFOLIO MANAGEMENT (PPM) – STRATEGIC APPROACH

Definition of PPM

The strategic approach (top-level management) of MPM is PPM. PPM has its origin in PM. PM handles projects separately, PPM manages multiple programs and provides a synergy across all managed projects (Leonard & Swanepoel, 2010; Levine, 2005; Maizlish & Handler, 2005). In the United States, terminology PPM is often mentioned, but in the United Kingdom, the terminology is rarely used. PPM in US terminology is responsible for the process of selecting programs. In UK terminology this function is performed by the PgM, other processes of PgM remain the same (Reiss et al., 2006). This is shown in Figure 60.

![Figure 60: Differences between US and UK terminology for PPM and PgM (developed by author)](image)

Jenny (2009) stated that PPM leads all projects within one division. PPM prioritizes, coordinates, controls, and supports all projects current and in immediate future, as well as the necessary resources (Jenny, 2009). The Project Management Body of Knowledge (PMBoK) defines PPM as a selection and support with investments of programs or projects in alignment with the organisation’s strategic plan and its available resources (Stackpole et al., 2008). Morris (2007b) compared approaches from Pennypacker, Platjie, Lundin and Stablein, which provided the same conclusion; PPM is a collection of projects, managed in a coordinated way. As these projects are linked together, it is not possible to manage them separately. The bundling of skills, tools, and techniques supports the alignment of an organisation’s strategy (Morris, 2007b). All definitions of PPM show
it at a much higher strategic level than PgM and PM (see Figure 5). This is also shown inside the structure of an organisation (see Appendix V – Matrix organisation of a MPM/PPM/PgM/PM environment).

**Motivation for implementing a PPM**

By setting up a PPM, the problems of a single project are the focus. But problems increase through global overlapping, interdependent projects, and resource allocation. Here PPM supports projects in gathering data from the monitoring progress and in providing estimates for activities selected to future projects (Morris, 2007b). It traces the evolution of projects and programmes and speeds up the organisation’s learning (Pennypacker & Dye, 2002). Operating in an interwoven organisation, the decisions have to be accepted inside the portfolio. Which project takes second place, priority, and resource allocation must be balanced inside an environment with a multitude of conflicting goals (Müller et al., 2008). PPM does not have a defined end like a project; it has a periodic life cycle. Therefore, projects, targets, and scope need to be checked and adapted to the existing strategy of the organisation. It is important to state clear objectives for all relevant projects in order to obtain the attention of top management (Pennypacker & Dye, 2002). The motivation for implementing PPM is to subdivide the strategic goals of the organisation for programmes and projects and to state a clear business vision and target. PPM has therefore gained prominence for a number of reasons (Pennypacker & Dye, 2002):

- **Financial**: maximizing return on research, development and technology spending
- **Resources**: Allocation of lack resources
- **Linking**: Linkage between programme/project and the business strategy
- **Communication**: Communication of project priority horizontally and vertically
- **Objectivity**: achieving a greater degree of objectivity on project selection

The factors mentioned above need to be balanced against the programme/project’s supporters within the organisation, and their competitive position. Accordingly, stakeholders, both internally and externally, need to understand why some programmes/projects receive higher prioritization and why resources are allocated in a specific manner (Dinsmore & Cabanis-Brewin, 2011). On the other hand, PPM also helps the organisation to improve its performance externally. When it is performed successfully with the right project mix and scope, PPM can produce the following advantages (Dinsmore & Cabanis-Brewin, 2011):

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- 20-30% improvement in time to market for projects or programmes
- 25-50% shortening of programme or project’s duration
- Up to 90% success rate of the programme or project
- Increasing research and development productivity by up to 50%

**Method of PPM**

PPM is a top-down approach, and defines its strategy on the basis of the organisation’s targets and visions (Goette, 2005). It is the guide for the complete project environment because it focuses on the overview of all affected programmes/ projects within the portfolio (Lomnitz, 2001; T. Mayer et al., 2008). The main task of PPM is planning programmes and projects in alignment with the strategic goal of the organisation (Jenny, 2009). In the first stage, PPM evaluates the current programmes and projects by according them the status “GO”, “KILL” or “HOLD” (Pennypacker & Dye, 2002). Morris (2007b) defined selection criteria for these difficult decisions assigning a final status. Common measures like risk analysis, cost benefit, and economic return are compared against each other. The scoring model weights the decision criteria such as weight, cost/ financial, workforce, scope, resources, duration of project, satisfaction of stakeholder etc., so the finally decision can be taken and the merit recalculated (Morris, 2007b). These portfolio matrices can be shown clearly in a bubble diagram. This is helpful for top management as it is self-explanatory. Users of such a model must be aware that, since it uses probability of success vs. net present value (NPV) it might only focus on profit maximization. For focusing on factors other than profit maximization, this tool should be used with other methods for balance. Figure 61 demonstrates an example of measuring benefit over two dimensions (NPV and strategic evaluation).
Market research can be helpful. It demonstrates the demand for a new product in future, presented in the form of a “clinic” to potential customers gauging the potential market (Morris, 2007b). Having clear selection criteria, PPM does not deal with minor projects and programs. A good mixture of programmes and projects is important, with variation by size – big or small – and by risk – high and low (Pennypacker & Dye, 2002). Selection of projects and programmes leads to a further task of PPM: prioritization- this is one of its main tasks. Prioritization of programs and projects is essential for the allocation of financial and personal resources and gaining the attention of top-level management. Programme and project managers administer their own budgets. PPM does not have a responsibility for these budgets. PPM controls the overall budget. As a result of prioritization, resources are balanced internally in a fair way; different portfolios don’t compete for resources (T. Mayer et al., 2008; Pennypacker & Dye, 2002). All of these methods are helpful when it comes to preparing reviews and gates of PPM. This is an internal audit for tracking and adjusting the PPM to the organisation’s strategy. The PPM reviews are performed two to four times a year: projects and programmes are analyzed according to schedule, budget, quality of deliverables, business cases, and other defined criteria. They are then compared with each other and ranked again, which establishes a new resource.
allocation (Pennypacker & Dye, 2002). If the existing projects and programmes no long-
er fit into the portfolio, they are killed; otherwise up- or downgrading might occur. New
projects and programmes will be calculated during such reviews and, if necessary, se-
lected and prioritized (Pennypacker & Dye, 2002). T. Mayer et al. (2008) described this
situation, but also showed the potential problems and risks, especially those for the fu-
ture. In general, T. Mayer et al. (2008) positioned the portfolio review team on the sec-
ond top level of management.

In addition to PPM reviews, PPM cooperates with the top-level management responsible
for strategic orientation. This is performed in portfolio gates. These gate-meetings occur
once or twice a year, and check the priorities that have been set among projects and
programmes. If the mix or balance is not correct, the PPM must modify it. It is a strategic
snapshot for top management, which also receives an overview of the portfolio. Morris
(2007b) referred to the portfolio gates as portfolio reviews, and termed the portfolio
reviews as board meetings. The meaning is the same (Morris, 2007b). Pennypacker and
Dye (2002) also stated that the portfolio gate checks the correct execution of the review
guidelines. Top management is also involved too because PPM directly incorporates the
organisation’s strategy into programmes and projects (Pennypacker & Dye, 2002).

**Targets of PPM**

PPM’s goal is to coordinate programmes and projects. This can only be achieved if all
parts of the portfolio are balanced, not only parts of it. Thus, a focus on specific projects/
programmes is necessary using the methods described above (Dinsmore & Cabanis-
Brewin, 2011; Morris, 2007b). The optimization of the system is only possible if the ob-
jectives are clear to everybody. Another target of PPM is to communicate the organisa-
tion’s strategy and the meaning to all programmes and projects. Projects and pro-
gramees with a similarly defined scope are linked together when they follow the same
strategy of PPM (Morris, 2007b; Pennypacker & Dye, 2002). In accordance with PPM
criteria and decisions, programmes and projects delivering the highest value have to be
prioritized. On the other hand, top-level management expects that an effective PPM will
produce a better competitive position and an overall improvement in effectiveness. This
results in the lower cost of projects and programmes (Morris, 2007b; Rad & Levin,
2008).

**Measurement of PPM efforts**

The effort of PPM can be measured. One scale is the value maximization. The indicator is
the net present value (NPV) or the expected commercial value (ECV). Another indicator for value maximization is a scorecard for customer or stakeholder satisfaction. All of these should increase when a project/ programme is integrated into PPM. Another effective measuring tool for PPM is the balancing of projects/ programmes. Appropriate balance can be observed when projects/ programmes improve in risks, duration, technologies etc. Finally, the controlling of the organisation’s business strategy makes the PPM efforts observable. Do projects/ programmes still correlate with the business strategy (Pennypacker & Dye, 2002)? This has to be proven by PPM.

**Result of PPM**

As an outcome of PPM, top-level management is enabled to make correct decisions. Resources are allocated among the prioritized list of programmes/ projects and the strategic targets are communicated and understood by everybody (Müller et al., 2008).

**Summary of PPM**

PPM is a strategic approach of multi-project management. It stands at the top level of the MPM pyramid, as previously mentioned. It consists of programmes and projects that must not be directly linked together. PPM manages multiple programmes and provides a synergy of all managed projects (Leonard & Swanepoel, 2010; Levine, 2005; Maizlish & Handler, 2005). By coordinating programmes and projects, PPM increases the performance of the organisation. PPM is a higher level than operational project management. Mentioning PPM is necessary for understanding the overall context of managing projects. The next level that needs to be discussed is the “bonding” level of management: programme management.
APPENDIX III – PROGRAMME MANAGEMENT (PgM) – BONDING STRATEGIC WITH OPERATIONAL

Definition of PgM

PgM bonds the strategic approach of PPM and the operational approach of PM. Military and governmental institutions were the first organisations that defined the boundaries of programme management. The United States Air Force (USAF) defined it as an integrated, time-phased task, necessary to accomplish a particular purpose. NASA’s definition is similar. NASA defined PgM as a series of undertakings continued over a period of time, designed to accomplish a broad scientific or technical goal (Kerzner, 2009). These approaches are more specific to governmental institutions, and financial benefits are not mentioned. Industry has several definitions of PgM in economy like: “A group of related projects managed in a coordinated way to obtain benefits and control not available from managing the individually. Programmes may include elements of related work outside the scope of the discrete projects in the programme. Projects within a programme are related through the common outcome or collective capability” (Stackpole et al., 2008, p. 9). This definition is confirmed by other authors like Pennypacker, Krueger and Lester. Pennypacker, Krueger and Lester state: PgM coordinates a group of projects related together by an identifiable theme. This ensures he best use of resources and the ability to deliver the project in the specified time, cost, quality, and other performance criteria, and so meet organisation’s strategic goals. Milosevic, Martinelli, and Waddell (2007) disagreed with the strong timeframe of the programme. From their point of view, the programme must not have a definite end of time OGC (Office of Government Commerce) and also PMI, define PgM as a coordinated management of projects to achieve benefits of strategic importance (Reiss et al., 2006).

In summary, PgM is a timely undertaking, bundling projects with identifiable themes, for achieving the business strategy’s goals and benefits.

Motivation for implementing a PgM

In the field of the short-term strategy, PgM divides their missions into smaller better manageable tasks for the projects (Dobiéy et al., 2004; W. Krueger, 2009). PgM assures that an organisation’s strategic targets – formulated by PPM – are well executed by PM. PgM is the alignment between organisation’s strategy and its execution (Milosevic, Martinelli, & Waddell, 2007). Changes within the environment of the programme, portfolio, project, and organisation are fundamental, as they can change the complete business strategy. It is necessary to observe the environment regularly (Reiss, 1996). All projects
inside a programme are individual, but have at least one common objective, linking and focusing them on a corporate goal (Lester, 2007; Morris, 2007b; Reiss, 1996). Project interfaces in a programme enable a horizontal collaboration. For e.g. they share rare resources without impeding and must manage tasks with increased value by common purchasing for all projects (Milosevic et al., 2007; Morris, 2007b; Verzuh, 2008). The motivation for defining a programme is clearly stated; it adds an increased efficiency to all projects within a theme-orientated organisation (Dobiéy et al., 2004). So the benefit of the programme is maximized. Prioritization of projects in a programme is allocated to those with the greatest benefit to the programme. Projects that are not beneficial will be eliminated from the programme (Reiss et al., 2006). This can be done in the early stages. It is possible when a bad idea for the project or the programme is recognized or when the environmental factors have changed dramatically (Reiss et al., 2006). Otherwise a programme supports the organisation when it is allocated limited resources (Lester, 2007), and coordinates and manages them in an optimized way. Changing e.g. costs, resources, procurement or standard procedures of one project the PgM, will influence the other projects (Lester, 2007). Other motivating factors for strengthening PgM are increased financial performance, stability, future growth, increased customer satisfaction, and effective communication inside the programme between the projects (Kerzner, 2009). PgM will be helpful by accelerating the projects (prioritising), and by providing necessary resources (Dobiéy et al., 2004).

**Method of PgM**

All programmes are planned and executed in a programme life cycle (LC). The life cycle provides the steps that a programme will follow. Checkpoints will prove the success of the programme. It is defined in four phases: mandated, preparation, execution, and completion phase. These phases are partitioned into stages: start-up programme, define programme, establish programme, manage, and close the programme. All have defined sub-processes (Reiss et al., 2006). The same approach is followed by Milosevic et al. (2007) and uses a similar scheme by describing following stages: define, plan, implement, launch and sustain stage. The authors describe these stages in two phases – programme definition/planning phase and programme execution phase Those stages are also defined with several sub-processes (Milosevic et al., 2007). In contrast, Dobiéy, Köplin, and Mach (2004) described only the four phases in their programme life cycle definition. Those are as follows: initialisation, mobilisation, realisation, and integration, which are closely aligned with the phases of Reiss et al. (2006). Processes are directly
assigned to the phases and are not further subdivided into stages.

Furthermore several sub processes support the program life cycles. The major sub processes are schedule, financial and accounting, risk and issues, change and configuration, benefit and stakeholder management, and ongoing support life cycle support (Milosevic et al., 2007; Reiss et al., 2006). The mentioned programmes vary in size, duration, etc.; therefore, they must be adapted to their specific use. Such a case for example could be an international merger like integrating Wella with Procter and Gamble. Programme life cycles are limited in time and do not proceed in a linear manner later in the process. However, the guiding principles remain the same. The programme life cycle should be used as a decision framework for the programme. Estimates and assessments will become more accurate and reliable as the programme proceeds forward (Reiss et al., 2006).

A comparison of the different life cycle definitions from Reiss et al. (2006), Milosevic et al. (2006) and Dobiéy et al. (2004) is shown in Figure 62, where also the sub processes and supporting processes are mentioned (see Figure 62).
One important step during the life cycle is the selection of single projects in each programme. Selection criteria have to be carefully chosen and stated officially inside programme, portfolio, and organisation. As an example, Pennypacker and Dye (2002) listed

1. Analyse impact
2. Organize groups (defined work)
3. Plan next stage (plan time + cost)

Reiss (Gower)

1. Analyse impact
2. Organize groups (defined work)
3. Plan next stage (plan time + cost)

Milosevic

1. Define concepts
2. Business Case

Support process:
- change management
- schedule management
- risk management
- finance management
some of these criteria:

- Project duration – similar to others, as unusually long projects might afford more attention
- Interfaces – should have same interfaces like the other projects within the programme
- Resources – the quantity of resources needed for implementation and whether they can be shared together with other projects
- Customers/ Stakeholders – can they be grouped and the relationship strengthened, which would reduce conflicts, as not each single project manager contacts them
- Logical fit – projects should be logical fit for the product, technology, or used resources
- Priority – prioritization of projects should be similar, otherwise low prioritized projects might never be successfully be finished
- Location – projects should be closely located together, because this ensures effective management
- Life cycle – project life cycle should be similar in length, otherwise less efficiency and more problems might be caused.

In general, projects within programmes tend to be simple; therefore, they are predictable to a certain degree. So it is possible to use an almost 'standardized' plan for most projects inside the programme (Dobiéy et al., 2004).

The programme structure is organized like the PPM in a matrix inside the organisation. In Appendix V – Matrix organisation of a MPM/PPM/PgM/PM environment and in Figure 63, the organisational structure of PgM is shown. Most times, PgMs are supported by programme offices as the PgM must be adapted on a regular basis with respect to changes concerning internal and external, environmental factors, and strategies. In addition to adapting to change, programme offices support with regular reports, meetings, workshops, and escalations (Dobiéy et al., 2004).
Target of PgM

The benefits of a programme can be abstract and/or material. They are related to different areas like customer, financial, internal, learning, and innovation (Obeng, 1994, 1996; Reiss et al., 2006; Sanghera, 2007). A programme is normally unique in its organisation and structure. The structure must be clear cut, well understood by the team and embedded within the company to ensure the success of a programme (Reiss et al., 2006). There are procedures, processes, and policies established. They help to standardize core competencies of programmes, such as resource and task identification, draft versions of plans, and planning files etc. (Reiss et al., 2006). Clear-cut instructions of programmes can manage the interfaces of various projects by prioritizing them and balancing resources (Morris, 2007b). Programmes distribute limited sources in a very cost effective manner (Lester, 2007). Standardization of programmes helps to increase the efficiency of development. Furthermore, it improves the communication channels and the messaging with customers etc., which results in increased satisfaction (Milosevic et al., 2007). Another target of PgM is monitoring all aligned projects by reports. Those reports are standardized and communicated in a defined way and cycle (Lester, 2007). For effective monitoring, these reports must be actual and accurate. The content should show a real-
istic picture of the reported project. It must be readable and comparable with other projects. Overviews must be presented with an appropriate level of detail. A summary of benefits, the target, actual and remaining cost, time, and effort should be mentioned as well as the expected variation of the budget. Therefore, most reports include trend charts, risk register, and milestone reports (Reiss et al., 2006). The report enables management to make funding decisions (Milosevic et al., 2007). Therefore, programmes increase the satisfaction of customers, boost the efficiency of the organisation, increase knowledge about projects and their status, and reduce the waste of resources (Reiss, 1996). In general, invested capital is better used due to increased efficiency and effectiveness. PgM creates a long lasting and sustainable advancement of the organisation (Obeng, 1996).

**Measurement of PgM efforts**

The effort of the programme can be measured and monitored. Therefore, the measured performance data (actual) of the PgM are compared with the target (planned) metrics (Bolles & Hubbard, 2007; Lester, 2007; Milosevic et al., 2007; Reiss et al., 2006). Different methods measure the outcome. On the strategic basis (programme level), all projects of a programme are aligned together and compared with other programmes. On the operational level (project level), each project of a programme is measured and compared with other inside projects. The result of measurement on the strategic basis confirms or rejects the business case and its benefit. An alignment matrix can show the degree of deviation of organisation’s strategy. This is a qualitative scale where the outcome of each programme is compared with its strategic goal (see Table 17).

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<tr>
<th></th>
<th>PgM1</th>
<th>PgM2</th>
<th>PgM3</th>
<th>PgM4</th>
<th>PgM5</th>
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<td>y</td>
<td>n</td>
<td>n</td>
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<td>organisation objective 2</td>
<td>y</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>y</td>
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<tr>
<td>organisation objective 3</td>
<td>n</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
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<td>organisation objective 4</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
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<td>organisation objective 5</td>
<td>n</td>
<td>y</td>
<td>y</td>
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<td>organisation objective 6</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
</tr>
</tbody>
</table>

n = no    y = yes

Table 17: Alignment matrix (developed by author)

Another strategic measurement compares the time phases in programmes in a roadmap. In that process, planned and the realized time phases including completions are shown.
A further measurement on strategic basis is a portfolio map in form of bubble diagrams. The x/y- axes represent key parameters of the programme (NPV, success, business objectives etc.). The size demonstrates the quantity and the colour the state of completion of the programme (dark – close to the end; bright – at the beginning) (see Figure 64) (Milosevic et al., 2007).

![Probability of success](image)

**Figure 64: Portfolio map with a programme (developed by author)**

The performance measurement on operational level is focused on projects. It shows whether components are delivered on time and if the budget agrees to standards (Reiss et al., 2006). For operational tools Internet based dashboards can be used. They briefly report the status on progress of financial achievement, risk, time, and changes. A programme map clearly illustrates all critical interdependencies and deliverables. So each member of the team understands the dependencies in each project of the programme. In addition, at a specific stage in the programme, a formal review is generated and the status of the programme will be evaluated (Milosevic et al., 2007). Dobiéy et al. (2004) also discussed a budget analysis where the difference is calculated: Deviation = actual costs – planned costs.
Another very effective operational method is the earned value method (EVM). EVM is rarely used because it necessitates very strict planning. This method measures the improvement of progress including the costs and time tracking (Dobiéy et al., 2004; Sanghera, 2007). This analysis estimates the probable deviation of costs and time in progress (see Figure 65).

![Figure 65: Earned Value Method graph (source: (Dobiéy et al., 2004))](image)

**Result of PgM**

The result of PgM is a constant link of organisation’s strategy and the realization of that strategy. The implementation time can be greatly decreased (Dobiéy et al., 2004). In operative difficulties, the benefit is evident. By prioritizing and merging small projects, limited resources are efficiently used according to business strategy (Dobiéy et al., 2004; Lester, 2007). The top-level management like chief executive officer (CEO) or the portfolio manger are enabled to make their decision on proven data. Wrong individual perceptions and false subjective criteria are prevented. This leads from an individual and limited overview of project performance to a larger view by sharing information of the whole programme team (Pennypacker & Dye, 2002). As a result of sharing information in the programme team, the communication channels quality – internal (company) and external (to customer) – and the satisfaction on both sides increase (Milosevic et al, 2007).
Summary of PgM

It is shown that programme management bonds strategy with the operational approach. In the beginning, it was placed at mid-level of the MPM pyramid. Several monitoring tools help PgM to manage a bundle of projects. PgM manages those different projects if they have one specific objective, a consolidated approach, one final customer, or a cooperative objective. The PgM LC assures that projects are reviewed regularly at gates to gauge whether they still match with the PgM's target. PgMs are measurable with different methods where the planned target is compared to the actual status.

PgM is more focused on managing than performing operational project management. However, the approach of project management has not yet been discussed. The next level that has to be discussed is the operative level of management: project management.
Appendix IV – PgM Life Cycle Comparison

Figure 66: Comparison of PgM Lifecycles (developed by author)
The arrangement of life cycles in programme management of Dobiey et al. (2004), Reiss et al. (2006), and Milosevic et al. (2007) are compared in Figure 66. All life cycles begin with a concept that is transformed into business practice. This needs to imply a vision – the programmatic idea of the programme, a mission – what is promised to the customer, and a target – which is set up SMART (specific, measurable, attainable, realistic, time able). Then a programme plan is defined and set up. Afterward, during realization and execution; deliverables are created, checked, and released. Once the deliverables have been created and released, a review is conducted, and management executes the official programme closure. The authors above agree on the content of setup; however, the phases are described differently. Milosevic et al. (2007) mentioned only two phases: the definition and planning phase, and the execution phase, which includes the closing of the programme. In that model, five stages are included in the programme life cycle Milosevic et al., 2007). This is aligned with the programme life cycle model of Reiss et al. (2006), that is divided into five stages that are subdivided into four phases: mandate phase, which contains the initialisation of the program; preparation phase, which contains the complete planning and setup of the program; execution phase, where the programme produces its deliverables; the completion phase, where the programme is closed down by management. Those four phases are similar to the model of Dobiéy et al. (2004). In that model, the process steps of the programme are arranged in four phases: initialization, mobilization, realization, and integration All life cycles for establishing programmes are quite similar. However, the life cycles are differentiated. Reiss et al. (2006) and Milosevic et al. (2007) include support processes like schedule management, risk management, finance management etc. during the whole programme. Dobiéy et al. (2004) did not include support processes in the programme life cycle.
Figure 67: Matrix organisation of a MPM/PPM/ PgM/PM environment (developed by author)

This diagram shows the structure of a MPM/ PPM/ PgM/ PM organisation. This structure is based on several models (Dinsmore & Cabanis-Brewin, 2011; Lester, 2007; Milosevic et al., 2007; Morris, 2007b). It is a normal matrix organisation. The project’s axis is horizontally orientated on resources; the vertical axis is oriented on departments like development (R&D), production, or sales and marketing. The projects are again summarised in programmes and then combined into portfolios. It is possible that a programme contains one single project, just as a portfolio may contain one single programme. Staff functions such as a project management office (PMO), programme management office (PgMO), or a project portfolio management office (PPMO) can support each respective department inside the MPM area (see Figure 67).
**APPENDIX VI – ISO 21500 GUIDANCE ON PROJECT MANAGEMENT**

**ISO – FACTS**

<table>
<thead>
<tr>
<th><strong>YEAR OF DEVELOPMENT</strong></th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LANGUAGE</strong></td>
<td>English, French, German, Spanish</td>
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<tr>
<td><strong>LEGAL RIGHTS BY</strong></td>
<td>International Organisation for Standardization</td>
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<tr>
<td><strong>CERTIFICATION</strong></td>
<td>None</td>
</tr>
<tr>
<td><strong>STANDARDS</strong></td>
<td>ISO 21500</td>
</tr>
<tr>
<td><strong>MEMBERS WORLD WIDE</strong></td>
<td>162 counties world wide as a member of the ISO committee</td>
</tr>
<tr>
<td><strong>ASSOCIATED COMPANIES WITH CMMI</strong></td>
<td>PMI, IPMA, OCG and BSI use the ISO 21500 norm as a reference for their project management standard as the ISO norm does not offer methods or tools</td>
</tr>
</tbody>
</table>

In 2006, a need was identified to establish an overall guideline for project management. This proposal was presented to members of the international organisation for standardization (ISO) in more than 160 countries. The majority voted for a new guideline and work started in 2007 for the ISO 21500 norm, a guide for project management. Big organisations for project management standards (PMI, OCG, IPMA and BSI) supported work on the ISO 21500 norm. It was released for the first time in 2012 (Zandhuis, Stellingwerf, & Newton, 2013).

The basis for the ISO 21500 norm was the DIN 69901 (Deutsche Industrie Norm), BS6079 and PMBoK 3rd edition. Reference materials were the ICB version 3.0, PRINCE2, ISO 9001, ISO 10006, and ISO 31000 (Zandhuis et al., 2013).

This norm does not replace the existing standards; it serves more as a reference for all existing standards and combines the best practices of each standard. This reference supports project management with a highly detailed description of concepts and processes (Zandhuis et al., 2013).

As similar to the PMI, The ISO 21500 norm offers five process groups with ten different subject groups existing on thirty-nine different processes Table 18.
Table 18: ISO 21500 process groups, subject groups and processes (source: International organisation for Standardization)

Finally it has to be mentioned that the ISO 21500 does not offer any certification, it serves only as a guide for project management without offering tools or techniques like the project management standards (Zandhuis et al., 2013).
APPENDIX VII – COMPARISON OF PROCESSES FROM WORLDWIDE PROJECT MANAGEMENT STANDARDS

In analyzing and comparing each investigated standard, the specific processes need to be checked for completion of their content. Their processes were sorted according to the standard with the most worldwide use. This is the standard of PMI; its process groups are the basis for this comparison. Those are: initiating, planning, executing, monitoring and control, and closing. All processes of each standard were arranged in the process groups of PMI and processes missing in PMI, but mentioned in other standards. Table 19 shows the process steps in project management for each standard. Because excessive detail would overwhelm the table, only the shortcuts and identifiers of each process are shown. Details are given in the appendix. During the research, new releases of some standards were published. The research is performed on the table of mentioned standards. A delta analysis of the new releases is also outlined in the appendix of the relevant standards.
<table>
<thead>
<tr>
<th>Standards Process</th>
<th>PMI PMBoK 4th ed</th>
<th>CMMI</th>
<th>Prince2</th>
<th>P2M</th>
<th>ICB3.0</th>
<th>AIPM/NCSPM</th>
<th>PMSGB/SAQA</th>
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<tr>
<td>Create project carter</td>
<td>4.1</td>
<td>PI-SP1.1; PI-SP1.2; PI-SP1.3; OPM-SP1.1; QOM-SP1.1;</td>
<td>SU5; SU4; SU6; DP1; DP2; DP3; IP8; Theme: Business case</td>
<td>1.2; 1.3; 3.1; 6.1,6.2,6.3,6.4</td>
<td>1.01; 1.19</td>
<td>2 – 2.2; 3 – 3.2</td>
<td>Prerequisite (level 4)</td>
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<tr>
<td>Identify stakeholder</td>
<td>10.1</td>
<td>PP-SP2.6</td>
<td>Principle: defined roles and responsibilities</td>
<td>1.1</td>
<td>1.02</td>
<td>2 – 2.2; 18 – 18.3</td>
<td>CC5.12</td>
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<td><strong>PLANNING</strong></td>
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<tr>
<td>Develop project management plan</td>
<td>4.2</td>
<td>PP-SP2.7; OPD-SP1.7; OPM-SP1.2</td>
<td>SU5; SB1; SB2; Theme: plans</td>
<td>3.3,3.6; 7.2; 10.1,10.2</td>
<td>1.06; 1.11</td>
<td>2 – 2.3; 2.4; 3 – 3.1; 4 – 4.1; 4.2; 15 – 15.4</td>
<td>CC5.7; CC5.9</td>
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<td>Determine process improvement</td>
<td>1)</td>
<td>OPF-SP1.1; OPF-SP1.2; OPF-SP1.3</td>
<td>-</td>
<td>-</td>
<td>1)</td>
<td>4 – 4.4</td>
<td>-</td>
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<tr>
<td>Collect requirements</td>
<td>5.1</td>
<td>REQM-SP1.1; RD-SP1.1; RD-SP1.2; RD-SP3.5</td>
<td>Principle: focus on products</td>
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<td>1.02; 1.03</td>
<td>6; 7 – 7.1; 8 – 8.1; 30 – 30.1;</td>
<td>CC5.6</td>
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<td>Define scope</td>
<td>5.2</td>
<td>CM-SP1.1; PP-SP1.1; PP-SP1.4; RD-SP2.1; OPP-SP1.1; OPP-SP1.3; OPP-SP1.5; OPP-SP1.9; OPP-SP1.5</td>
<td>Principle: manage by exceptions</td>
<td>3.2</td>
<td>1.03</td>
<td>6; 7 – 7.1; 7.3; 8 – 8.1</td>
<td>CC5.5; CC5.6</td>
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<td>Work breakdown structure (WBS)</td>
<td>5.3</td>
<td>CM-SP1.1; PP-SP1.1; PP-SP1.4; RD-SP2.1; RD-SP2.3; RD-SP3.2; OPP-SP1.1; OPP-SP1.3; OPP-SP1.5; OPP-SP1.9; OPP-SP1.5</td>
<td>Theme: progress (product based); Principle: defined roles and responsibilities</td>
<td>3.2</td>
<td>1.08; 1.10</td>
<td>6; 7 – 7.1; 18 – 18.1;</td>
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<td>Define activities</td>
<td>6.1</td>
<td>PP-SP1.2</td>
<td>Principle: manage by stages</td>
<td>3.4</td>
<td>1.09; 1.10</td>
<td>9 – 9.2</td>
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<td>Sequence activities</td>
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<td>Principle: manage by stages</td>
<td>3.4</td>
<td>1.09; 1.10</td>
<td>9 – 9.1</td>
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<td>Estimate resources</td>
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<td>Principle: manage by stages</td>
<td>8.1; 8.2</td>
<td>1.12</td>
<td>9 – 9.1</td>
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<td>CMMI</td>
<td>Prince2</td>
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<td>PMSEGB/ SAQA</td>
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<tr>
<td>Estimate duration</td>
<td>6.4</td>
<td>-</td>
<td>IPE: Principle manage by stages</td>
<td>3.4; 5.6</td>
<td>1.09; 1.10; 1.11</td>
<td>9 – 9.1</td>
<td>-</td>
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<td>Define schedule</td>
<td>6.5</td>
<td>PP-SP1.1; OPP- SP1.1; OPP- SP1.2; OPP- SP1.3; PP-SP1.4; OPP-SP1.5</td>
<td>SUS, IPE: Principle manage by stages</td>
<td>3.4; 5.6</td>
<td>1.11</td>
<td>2 – 2.4; 9 – 9.3; 10 – 10.1</td>
<td>CC5.8</td>
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<td>Estimate costs</td>
<td>7.1</td>
<td>PP-SP1.4</td>
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<td>3.3</td>
<td>1.15; 1.19</td>
<td>12 – 12.1</td>
<td>Prerequisite (level 4)</td>
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<td>Determine budget</td>
<td>7.2</td>
<td>PP-SP1.1; OPP-SP1.1; OPP-SP1.2; OPP-SP1.3; PP-SP1.4; OPP-SP1.5</td>
<td>SUS, IPE: Theme: plans</td>
<td>3.5; 3.6; 3.7</td>
<td>1.18; 1.19</td>
<td>2 – 2.3; 12 – 12.2; 13 – 13.1, 13.2; 13.3</td>
<td>CC5.7</td>
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<tr>
<td>Plan quality/ develop quality plan</td>
<td>8.1</td>
<td>MA-SP1.1; MA-SP1.2, QPM-SP1.2, QPM-SP1.4</td>
<td>SUS, IPE: Theme: plans</td>
<td>3.3</td>
<td>1.05</td>
<td>1; 2 – 2.3; 15 – 15.1, 15.2; 15.3; 15.4; 16 – 16.3</td>
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<tr>
<td>Develop human resource plan</td>
<td>9.1</td>
<td>PP-SP2.4</td>
<td>SUS, IPE: Theme: plans/ organizations, Principles defined roles and responsibilities</td>
<td>7.1; 7.3; 8.1</td>
<td>1.12</td>
<td>7 – 2.3; 18 – 18.2, 18.3; 20 – 20.6</td>
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<tr>
<td>Plan communication</td>
<td>10.2</td>
<td>PP-SP2.6; RD-SP3.3</td>
<td>SUS, IPE: Theme: risk</td>
<td>5.1; 7.2; 11.1, 11.2</td>
<td>1.07; 1.17; 1.18</td>
<td>2 – 2.3; 20 – 20.3; 22 – 22.1, 22.2; 24 – 24.2</td>
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<tr>
<td>Plan risk management</td>
<td>11.1</td>
<td>RSKM-SP1.3</td>
<td>SUS, IPE: Theme: risk</td>
<td>2.2; 4.1, 4.2</td>
<td>1.04</td>
<td>2 – 2.3; 26 – 26.3, 26.4</td>
<td>CC5.7</td>
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<tr>
<td>Identify risks</td>
<td>11.2</td>
<td>PP-SP2.2; RSKM-SP2.1</td>
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<td>4.3</td>
<td>1.04</td>
<td>26 – 26.1</td>
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<td>Perform qualitative risk management</td>
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<td>DAR-SP1.2; DAR-SP1.3; DAR-SP1.4; DAR-SP1.5; DAR-SP1.6; RSKM-SP1.1; RSKM-SP1.2</td>
<td>IPE: Theme: risk</td>
<td>4.3</td>
<td>1.04; 1.08</td>
<td>26 – 26.2</td>
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<td>Perform quantitative risk management</td>
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<td>DAR-SP1.2; DAR-SP1.3; DAR-SP1.4; DAR-SP1.5; DAR-SP1.6; RSKM-SP1.1; QPM-SP1.4</td>
<td>IPE: Theme: risk</td>
<td>4.3</td>
<td>1.04; 1.08</td>
<td>26 – 26.2</td>
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<td>Plan risk responses</td>
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<td>-</td>
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<td>4.3</td>
<td>1.04; 1.08</td>
<td>28 – 28.3</td>
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<td>CMMI</td>
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<td>P2M</td>
<td>ICBS.0</td>
<td>AIPM/ NCSPM</td>
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<tr>
<td>Plan procurement</td>
<td>12.1</td>
<td>SAM-SP1.1; TS-SP2.4</td>
<td>-</td>
<td>-</td>
<td>1.14</td>
<td>30 – 30.2</td>
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<td>Plan data collection</td>
<td>-</td>
<td>MA-SP1.3; MA-SP1.4; PP-SP1.3</td>
<td>-</td>
<td>-</td>
<td>1.17</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**EXECUTING**

<p>| Direct an manage project execution | 4.3 | IPM-SP1.1; IPM-SP1.2; PI-SP1.1; PI-SP1.2; PI-SP1.3; PI-SP1.4; QPM-SP2.2 | CS1; CS2; CS3; CS4; MP2; MP3; SP2; Theme: change; Principle: tailor to suit the project environment | 3.8; 10.3 | 1.16 | 3 – 3.1; 4 – 4.2; 4.3; 5 | CCS.14 |
| Implement process action | 2 | OPF-SP1.2; OPF-SP2.2; OPF-SP3.1; OPF-SP3.2 | Principle: tailor to suit the project environment | - | 1.15; 1.16 | 2 – 2.5; 3 – 3.1; 4 – 4.4; 5 | ECS.7 |
| Perform quality assurance | 8.2 | PMC-SP2.2; PMC-SP2.3; MA-SP1.1; MA-SP1.2; PPQA-SP1.1; PPQA-SP1.2; OPF-SP1.1; PI-SP3.1; PI-SP3.2; QPM-SP2.3 | SB2; Theme: quality; change | 5.19 | 1.05 | 16 – 16.1; 16.2 | - |
| Deploy process improvement | - | OPM-SP1.2; OPM-SP1.3; OPM-SP2.2; OPM-SP2.3 | Theme: quality | 5.10 | 1.12; 1.19 | 4 – 4.4; 5; 16 – 16.3; 17 – 17.1; 18 – 18.4 | - |
| Acquire project team | 9.2 | IPM-SP1.5 | SUS, SB2; Theme: organisation | 8.2 | 1.12; 1.19 | 4 – 4.4; 5; 16 – 16.3; 17 – 17.1; 18 – 18.4 | FC5.2; ECS.23 |
| Develop team | 9.3 | PP-SP2.3; OT-SP1.1; OT-SP1.2; OT-SP1.3; OT-SP1.4; OT-SP2.1; OT-SP2.2; OT-SP2.3 | Theme: organisation | - | 2.01; 2.02; 2.03; 2.04; 2.05; 2.06; 2.07; 2.08; 2.09; 2.10; 2.11; 2.12; 2.13; 2.14; 2.15 | 19 – 19.1; 19.2; 20 – 20.1 | CCS.10; ECS.4; ECS.15; ECS.39 |
| Manage team | 9.4 | PMC-SP2.2; PMC-SP2.3; PPQA-SP1.1; OPF-SP5.4 | SB2; Theme: organisation; change; Principle: tailor to suit the project environment | 7.4; 8.3; 8.4 | 1.01; 2.02; 2.03; 2.04; 2.05; 2.06; 2.07; 2.08; 2.09; 2.10; 2.11; 2.12; 2.13; 2.14; 2.15 | 3 – 3.1; 4 – 4.2; 4.3; 5 | CCS.10; ECS.5; ECS.38 |
| Distribute information | 10.8 | MA-SP1.4; PPQA-SP1.1; PPQA-SP2.1; PP-SP2.2; PP-SP3.3; REQM-SP1.2; IPM-SP2.1; OPF-SP5.4 | Theme: plans | 3.11; 11.1; 11.2 | 1.17; 1.18 | 10 – 10.4; 13 – 13.4; 16 – 16.2; 19 – 19.1; 22 – 22.3; 23 – 23.1; 23.3 | CCS.12 |</p>
<table>
<thead>
<tr>
<th>Standards Process</th>
<th>PMI</th>
<th>CMMI</th>
<th>Prince2</th>
<th>P2M</th>
<th>ICB3.0</th>
<th>AIPM/ NCESSPM</th>
<th>PMSEGB/ SAQA</th>
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</thead>
<tbody>
<tr>
<td>Manage stakeholder expectation</td>
<td>10.4</td>
<td>PMC-SP1.5; PMC-SP2.2; PMC-SP2.3; PROA-SP1.1; IPM-SP2.2; IPM-SP2.3; OPF-SP3.4;</td>
<td>-</td>
<td>5.2; 5.3</td>
<td>1.02; 1.17; 1.18</td>
<td>2 – 2.1; 3 – 3.1; 9 – 9.2; 20 – 20.4; 23 – 23.3</td>
<td>CCS.12</td>
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<tr>
<td>Conduct procurement</td>
<td>12.2</td>
<td>PMC-SP1.5; PMC-SP2.2; SAMP-PP1.1; SAMP-PP2.1; SAMP-PP2.2; SAMP-PP2.3</td>
<td>-</td>
<td>-</td>
<td>1.14</td>
<td>51 – 51.1; 51.2; 52 – 52.1; 52.2; 52.3</td>
<td>CCS.33</td>
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<tr>
<td>Execute data mgmt. By storing data</td>
<td>-</td>
<td>MA-SP2.3; PRQA-SP2.3; REQM-SP2.4</td>
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<tr>
<td>Tailoring criteria and guidelines</td>
<td>2)</td>
<td>OPD-SP1.3</td>
<td>Theme: organisation; Principle: tailor to suit the project environment</td>
<td>-</td>
<td>-</td>
<td>1.05; 1.09</td>
<td>-</td>
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<tr>
<td>Implement and establish process assets</td>
<td>4)</td>
<td>OPD-SP1.3</td>
<td>-</td>
<td>-</td>
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<td>Select product component solution</td>
<td>3)</td>
<td>TS-SP1.1; TS-SP1.2</td>
<td>-</td>
<td>3)</td>
<td>1)</td>
<td>1)</td>
<td>-</td>
</tr>
<tr>
<td>Develop/ establish design of product</td>
<td>3)</td>
<td>TS-SP2.1; TS-SP2.2; TS-SP2.3; TS-SP2.4</td>
<td>-</td>
<td>3)</td>
<td>1)</td>
<td>1)</td>
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<tr>
<td>Implement product design</td>
<td>3)</td>
<td>TS-SP3.1; TS-SP3.2</td>
<td>-</td>
<td>3)</td>
<td>1)</td>
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**MONITORING AND CONTROL**

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<th>PMI</th>
<th>CMMI</th>
<th>Principle: manage by stages</th>
<th>ICB3.0</th>
<th>AIPM/ NCESSPM</th>
<th>PMSEGB/ SAQA</th>
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<tr>
<td>Monitor and control project work</td>
<td>4.4</td>
<td>PMC-SP1.1; PMC-SP1.4; PMC-SP2.2; PMC-SP2.3; IPM-SP1.4; OPF-SP3.3; OPF-SP3.1</td>
<td>Principle: manage by stages</td>
<td>10.4; 11.3</td>
<td>1.16</td>
<td>5 – 5.1; 5.2; 10 – 10.2; 10.3</td>
</tr>
<tr>
<td>Perform change control</td>
<td>4.5</td>
<td>PMC-SP1.1; PMC-SP2.2; PMC-SP2.3; CM-SP1.2; CM-SP1.3</td>
<td>Theme: change; Principle: manage by stages</td>
<td>8.11</td>
<td>1.15</td>
<td>8 – 8.2; 8.3; 10 – 10.3; 17 – 17.3</td>
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<td>Verify scope</td>
<td>5.4</td>
<td>PMC-SP1.4; PMC-SP2.2; PMC-SP2.3; CM-SP1.2; CM-SP1.3</td>
<td>Principle: manage by exceptions</td>
<td>10.4</td>
<td>1.02; 1.03; 1.10</td>
<td>7 – 7.2</td>
</tr>
<tr>
<td>Standards Process</td>
<td>PMI</td>
<td>CMMI</td>
<td>Prince2</td>
<td>P2M</td>
<td>ICB3.0</td>
<td>AIPM/NECSPM</td>
</tr>
<tr>
<td>-------------------</td>
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<td>-------------</td>
</tr>
<tr>
<td>Control scope</td>
<td>5.5</td>
<td>PMC-SP1.3; PMC-SP1.4; PMC-SP2.2; PMC-SP2.3; CM-SP2.1; CM-SP2.2; CM-SP3.2; REGM-SP1.3; REGM-SP1.5; OFF-SP3.4</td>
<td>Principle: manage by stages</td>
<td>10.4</td>
<td>1.16</td>
<td>8 – 8.2; 8.3</td>
</tr>
<tr>
<td>Control schedule</td>
<td>6.6</td>
<td>PMC-SP2.2; PMC-SP2.3; OFF-SP3.4</td>
<td>SB2</td>
<td>3.9; 3.13; 3.15</td>
<td>1.11; 1.16</td>
<td>10 – 10.2; 10.3</td>
</tr>
<tr>
<td>Control costs</td>
<td>7.3</td>
<td>PMC-SP2.2; PMC-SP2.3; OFF-SP3.4</td>
<td>SB2</td>
<td>3.7; 3.25</td>
<td>1.11; 1.16</td>
<td>13 – 13.4</td>
</tr>
<tr>
<td>Control quality</td>
<td>8.3</td>
<td>PMC-SP2.2; PMC-SP2.3; CM-SP2.2; REGM-SP1.5; OFF-SP3.4; OPM-SP1.3; OPM-SP2.1; OPM-SP2.2; OPM-SP3.3; OPM-SP2.4</td>
<td>SB2; Theme: quality</td>
<td>3.14</td>
<td>1.05; 1.06</td>
<td>16 – 16.2</td>
</tr>
<tr>
<td>Validation of product</td>
<td>8</td>
<td>VAL-SP1.1; VAL-SP3.1; VAL-SP2.1; VAL-SP2.2</td>
<td>MP3; Theme: quality</td>
<td>3.12</td>
<td>3.12</td>
<td>5</td>
</tr>
<tr>
<td>Verification of product</td>
<td>7</td>
<td>VER-SP1.1; VER-SP1.2; VER-SP1.3; VER-SP1.4; VER-SP2.1; VER-SP2.2; VER-SP2.3; VER-SP2.4; VER-SP3.2</td>
<td>MP3; Theme: quality</td>
<td>3.12</td>
<td>3.12</td>
<td>5</td>
</tr>
<tr>
<td>Report performance</td>
<td>10.5</td>
<td>PMC-SP1.5; PMC-SP1.7; PMC-SP2.2; PMC-SP2.3; OFF-SP3.4</td>
<td>CS5; Theme: progress; Principle: manage by stages</td>
<td>3.11; 11.3; 11.4</td>
<td>1.16</td>
<td>1.17</td>
</tr>
<tr>
<td>Control and monitor risks</td>
<td>11.6</td>
<td>PMC-SP1.2; PMC-SP2.2; PMC-SP3.1; RSIM-SP3.1; RSIM-SP1.2; OFF-SP3.4</td>
<td>CS6; CS7; CS8; SB2; Theme: risk</td>
<td>2.1; 4.3; 4.4; 1.04; 1.16</td>
<td>28 – 28.1; 28.1</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 19: Overview content of PM standards worldwide (developed by author)

In Table 20 are some specific processes of standards listed for completion which are generally non-significant for PM.

Table 20: PM standard specific processes (developed by author)
APPENDIX VIII – PROJECT MANAGEMENT METHOD “CAPABILITY MATUREITY MODEL INTEGRATION” (CMMI)

CMMI – Facts

<table>
<thead>
<tr>
<th>Year of Development/Foundation</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>English</td>
</tr>
<tr>
<td>Origin in</td>
<td>Software Development</td>
</tr>
<tr>
<td>Legal rights by</td>
<td>Software Engineering Institute (SEI), Carnegie Mellon University</td>
</tr>
<tr>
<td>Certification</td>
<td>A company is certified not a single person. SCAMPI Assessment (Standard CMMI Appraisal Method for Process Improvement) by authorised SEI consultants or a BOX Business which is afterwards audited</td>
</tr>
<tr>
<td>Standards</td>
<td>ISO9000, ISO15504</td>
</tr>
<tr>
<td>Country</td>
<td>USA</td>
</tr>
<tr>
<td>Members Worldwide</td>
<td>More than 4,000 (certification of companies)</td>
</tr>
</tbody>
</table>

CMMI - History

The development of CMMI began in 1987 by the software engineering institute (SEI), that was founded in 1984 by the Carnegie Mellon University (Software Engineering Institute, 2011). CMMI was further developed together with the Department of Defense of the United States (DoD): The target was to define and develop successful and predictable processes. The result was the maturity model, which explained to users how to to docu-
ment, communicate, control, and live processes (Newsham, 2005). Experts from industry, government, and the SEI developed it further (Software Engineering Institute, 2011). Therefore the CMMI approach is not only theoretical; people with practical experience are involved in development.

By the SEI three constellations of CMMI were developed:

1. CMMI – DEV (approach for development)
2. CMMI – ACQ (approach for acquisition)
3. CMMI – SVC (approach for service)

Here only CMMI – DEV will be outlined because the other constellations ACQ and SVC were derived from it. The latest CMMI – version 1.3 was publicised in November 2010, (Software Engineering Institute, 2011). Figure 68 shows the development of CMM models in the past.

![History of CMMs](image)

**Figure 68: The History of CMM's (Source: CMMI-DEV (V1.3))**

**CMMI – MOTIVATION**

The motivation of SEI is to support companies in effective handling of processes. With their maturity model, CMMI, they follow the approach of process improvement (Balani & Jujjuru, 2008). CMMI is closely linked to the ISO 9000, an international standard that specifies a quality system for development and maintenance. ISO 9000 only defines a
minimum of processes; CMMI establishes a detailed framework for the continuous improvement of processes and their meanings (Kay, 2005). Essential elements are provided in the field of development, service, and acquisition (Persee, 2007). The CMMI models act as a guide for projects, departments, or entire organisations structuring their processes in an efficient and effective way (Balani & Jujuru, 2008). CMMI shows the organisation where their processes should be installed, but not how to implement them. Processes always must be adapted to their specific surrounding (Kay, 2005; Software Engineering Institute, 2010).

**CMMI – Method**

There exists no certification for manager to a certain CMMI standard like the project management institute (PMI) has done it with its Project Management Professional (PMP). It is only possible for the organisation to be audited or assessed of CMMI by a SEI consultant. Prior to an assessment, the company must be prepared by a hired consultant or a box business (Newsham, 2005). Those consultants work according to CMMI regulations and processes; they are SEI authorized evaluators. They arrange the final assessment test Standard CMMI Appraisal Method for Process Improvement (SCAMPI). The test demonstrates a detailed rating of strengths and weaknesses related to the CMMI models (Kay, 2005). SCAMPI also shows risks and weaknesses associated with the development of particular systems (Chick, 2006). On the other side is the box business. Companies can purchase a “CMMI in a box.” The box contains several templates and processes to be implemented into the organisation. Typically, the templates have to be adapted to the specific organisation. The box business does not guarantee the success of an assessment because of the potential for the incorrect adaption of templates and processes by the individual user (Newsham, 2005).

CMMI has two basic approaches: staged and continuous (Kay, 2005). The staged approach of CMMI is better known by its five levels of maturity: initial, managed, defined, quantitatively managed, and optimized (Persee, 2007), which are also shown in Figure 69.
The continuous representation of CMMI focuses only on selected specific improvements that best fit into organisation’s objectives and that minimize risk. This can make it easier to compare processes internally along projects and other quality standards (Kay, 2005). CMMI is a process driven method. How is a good process set up? It contains explicit described conditions, defined responsibility, specified output, and stated measures. Those procedures should be performed for each single step in order to receive a connected line of the processes (Persee, 2007). Table 21 shows what must be defined for a process.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Objective of the process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actors</td>
<td>Roles needed to perform the activities of the process</td>
</tr>
<tr>
<td>Entry criteria</td>
<td>Conditions that need to be in place before the process activities can begin</td>
</tr>
<tr>
<td>Inputs</td>
<td>Documents or products that need to be in place or referenced before the process activities can begin</td>
</tr>
<tr>
<td>Steps</td>
<td>Step-by-step sequence of the process</td>
</tr>
<tr>
<td>Output</td>
<td>Documents or products to be produced by process activities</td>
</tr>
<tr>
<td>Exit criteria</td>
<td>Condition(s) that will exist once the process is completed</td>
</tr>
<tr>
<td>Measures</td>
<td>Measures that need to be collected once the process is completed</td>
</tr>
</tbody>
</table>

Table 21: CMMI process definition (Source: Persee)

The CMMI handbook (version 1.3 from 2010) lists the same defined process contents of Persee (2007). However, two criteria are added: purpose and activities: purpose, or why the process is needed; and activities, or what needs to be performed during a spe-
cific process stage (Software Engineering Institute, 2010)?

Each of the 22 processes – including related sub-processes of which there are more than 100, are described in the CMMI-DEV handbook. For the organisation implementing the CMM, a short introduction states a clear purpose of the process. The processes themselves are divided into “specific goals” broken down by the already mentioned sub-processes. The sub-processes are described by the following:

– examples of work products which can be gained out of the described sub-process
– possible methods of how to generate the required work products
– how to use and proceed on with the established work products

Processes at CMMI are categorized in project management, process management, engineering, and support (Software Engineering Institute, 2010). CMMI-DEV functions a guide. The concept of CMMI-DEV is general. Organisations must adapt the processes to their specific environments and needs. The following Table 22 to Table 24 (based on the CMMI handbook version 1.3) illustrates the CMMI-DEV's four process groups with it 22 processes and more than 100 sub-processes.

<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>Project Management</th>
<th>Process Management</th>
<th>Engineering</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity Level1</td>
<td>Project Monitoring and Control (PMC)</td>
<td>related to defining, planning, monitoring, controlling</td>
<td>related to developing, planning, deploying, implementing, monitoring, controlling, appraising, measuring and improving process</td>
<td>related to development process improvement</td>
</tr>
<tr>
<td>Maturity Level2</td>
<td>SG1-Monitor the Project against the Plan</td>
<td>SP1.1-Monitor Project Planning Parameters</td>
<td>SP1.2-Monitor Commitments</td>
<td>SP1.3-Monitor Project Risks</td>
</tr>
<tr>
<td></td>
<td>SP1.4-Monitor Data Management</td>
<td>SP1.5-Monitor Stakeholder Involvement</td>
<td>SP1.6-Conduct Progress Reviews</td>
<td>SP1.7-Conduct Milestone Reviews</td>
</tr>
<tr>
<td></td>
<td>SP2.2-Manage Corrective Action to Closure</td>
<td>SP2.1-Analyse Issues</td>
<td>SP2.2-Take Corrective Action</td>
<td>SP2.3-Manage Corrective Action</td>
</tr>
<tr>
<td></td>
<td>SP2.1-Track Change Requests</td>
<td>SP2.2-Control Configuration Items</td>
<td>SP3.1-Perform Configuration Audits</td>
<td>SP3.2-Test Configuration Items</td>
</tr>
<tr>
<td></td>
<td>SG2-Track and Control Changes</td>
<td>SG3-Establish Integrity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Maturity Level3 | | | | | |
| Maturity Level4 | | | | | |

239
<table>
<thead>
<tr>
<th>Project Planning (PP)</th>
<th>Measurement and Analysis (MA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG2 - Establish estimates:</td>
<td>SG1-Align Measurement and Analysis Activities</td>
</tr>
<tr>
<td>SP1.1-Establish the Scope of the Project</td>
<td>SP1.1-Establish Measurement Objectives</td>
</tr>
<tr>
<td>SP1.2-Establish Estimates of Work and Product and Task Attributes</td>
<td>SP1.2-Specify Measures</td>
</tr>
<tr>
<td>SP1.3-Define Project Lifecycle Phases</td>
<td>SP1.3 Specify Data Collection and Storage Procedures</td>
</tr>
<tr>
<td>SP1.4-Estimate Effort and Cost</td>
<td>SP1.4 Specify Analysis Procedures</td>
</tr>
<tr>
<td>SG2-Develop a Project Plan</td>
<td>SG2-Provide Measurement Results</td>
</tr>
<tr>
<td>SP2.1-Establish the Budget and Schedule</td>
<td>SP2.1-Obtain Measurement Data</td>
</tr>
<tr>
<td>SP2.2-Identify Project Risks</td>
<td>SP2.2-Analyse Measurement Data</td>
</tr>
<tr>
<td>SP2.3-Plan Data Management</td>
<td>SP2.3-Store Data and Results</td>
</tr>
<tr>
<td>SP2.4-Plan the Projects Resources</td>
<td>SP2.4-Communication Results</td>
</tr>
<tr>
<td>SP2.5-Plan Needed Knowledge and Skills</td>
<td>Process and Product Quality Assurance (PPQA)</td>
</tr>
<tr>
<td>SP2.6-Plan Stakeholder Involvement</td>
<td>SG1-Objectively Evaluate Processes and Work Procedures</td>
</tr>
<tr>
<td>SP2.7-Establish the Project Plan</td>
<td>SP1.1-Objectively Evaluate Processes</td>
</tr>
<tr>
<td>SG3-Obtain Commitment to the Plan</td>
<td>SP1.2-Objectively Evaluate Work Products</td>
</tr>
<tr>
<td>SP3.1-Review Plans That Affect the Project</td>
<td>SG2-Provide Objective Insight</td>
</tr>
<tr>
<td>SP3.2-Reconcile Work and Resource Levels</td>
<td>SP2.1-Communicate and Resolve Noncompliance Issues</td>
</tr>
<tr>
<td>SP3.3-Obtain Plan Commitment</td>
<td>SP2.2-Establish Records</td>
</tr>
<tr>
<td>Requirements Management (REQM)</td>
<td></td>
</tr>
<tr>
<td>SG2-Manage Requirements</td>
<td></td>
</tr>
<tr>
<td>SP1.1-Understand Requirements</td>
<td></td>
</tr>
<tr>
<td>SP1.2-Obtain Commitment to Requirements</td>
<td></td>
</tr>
<tr>
<td>SP1.3-Manage Requirement Changes</td>
<td></td>
</tr>
<tr>
<td>SP1.4-Maintain Bidirectional Traceability of Requirements</td>
<td></td>
</tr>
<tr>
<td>SP1.5-Ensure Alignment between Project Work and Requirements</td>
<td></td>
</tr>
<tr>
<td>Supplier Agreement Management (SAM)</td>
<td></td>
</tr>
<tr>
<td>SG2-Establish Supplier Agreements</td>
<td></td>
</tr>
<tr>
<td>SP1.1-Determine Acquisition Type</td>
<td></td>
</tr>
<tr>
<td>SP1.2-Select Suppliers</td>
<td></td>
</tr>
<tr>
<td>SP1.3-Establish Supplier Agreements</td>
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<tr>
<td>SG2-Satisfy Supplier Agreements</td>
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<tr>
<td>SP2.1-Execute the Supplier Agreement</td>
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</tr>
<tr>
<td>SP2.2-Accept the Acquired Product</td>
<td></td>
</tr>
<tr>
<td>SP2.3-Ensure Transition of Products</td>
<td></td>
</tr>
</tbody>
</table>

Table 22: CMMI-DEV processes, Maturity Level 1-2 (developed by author derived from CMMI)
<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>Project Management</th>
<th>Process Management</th>
<th>Engineering</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>related to defining, planning, deploying, implementing, monitoring, controlling, appraising, measuring and improving process</td>
<td>related to defining, planning, deploying, implementing, monitoring, controlling, appraising, measuring and improving process</td>
<td>related to development process improvement</td>
<td>provide objective evaluation of processes and work products described in the project</td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td><strong>Integrated Project Management (IPM)</strong></td>
<td><strong>Organisational Process Definition (OPD)</strong></td>
<td><strong>Product Integration (PI)</strong></td>
<td><strong>Decision Analysis and Resolution (DAR)</strong></td>
</tr>
<tr>
<td>SG1-Determine Process Improvement Opportunities</td>
<td>SG1-Identify Alternative Solutions</td>
<td>SG1-Prepare for Product Integration</td>
<td>SG1-Evaluate Alternatives</td>
<td></td>
</tr>
<tr>
<td>SP1.1-Develop Alternative Solutions</td>
<td>SP1.2-Identify Risk Parameters</td>
<td>SP1.1-Establish an Integration Strategy</td>
<td>SP1.1-Establish Guidelines for Decision Analysis</td>
<td></td>
</tr>
<tr>
<td>SP1.2-Identify Risk Parameters</td>
<td>SP1.3-Identify a Risk Management Strategy</td>
<td>SP1.2-Develop a Product Integration Environment</td>
<td>SP1.2-Establish Evaluation Criteria</td>
<td></td>
</tr>
<tr>
<td>SP1.3-Identify Risk Parameters</td>
<td>SG2-Identify and Analyse Risks</td>
<td>SP1.3-Identify Product Integration Procedures and Criteria</td>
<td>SP1.3-Identify Alternative Solutions</td>
<td></td>
</tr>
<tr>
<td>SP1.4-Resolve Coordination Issues</td>
<td>SP2.1-Identify Risks</td>
<td>SP2.4-Develop a Product Experiences</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>Risk Management (RSMK)</td>
<td>SP2.2-Resolve Risks</td>
<td>SP2.4-Develop a Product Experiences</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>SG3-Identify and Analyse Risks</td>
<td>SP2.3-Resolve Risks</td>
<td>SP3.1-Identify Risk Mitigation Plan</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>SP4.1-Identify Needs</td>
<td>SP3.2-Resolve Risks</td>
<td>SP3.2-Implement Risk Mitigation Plan</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>SP4.2-Resolve Risks</td>
<td>SP3.3-Resolve Risks</td>
<td>SP3.3-Identify Risk Mitigation Plan</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>SP4.3-Resolve Risks</td>
<td>SP3.4-Resolve Risks</td>
<td>SP3.4-Implement Risk Mitigation Plan</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>SP4.4-Resolve Risks</td>
<td>SP3.5-Resolve Risks</td>
<td>SP3.5-Implement Risk Mitigation Plan</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>SP4.5-Resolve Risks</td>
<td>SP3.6-Resolve Risks</td>
<td>SP3.6-Implement Risk Mitigation Plan</td>
<td>SP1.4-Select Evaluation Methods</td>
<td></td>
</tr>
<tr>
<td>Organisational Training (OT)</td>
<td>Technical Solutions (TS)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>SG1-Establish and Organisational Training Capability</td>
<td>SG1-Select Product Component Solutions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP1.1-Establish Strategic Training Needs</td>
<td>SP1.1-Develop Alternative Solution and Selection Criteria</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SP1.2-Determine Which Training Needs Are the Responsibility of the Organisation</td>
<td>SP1.2-Select Product Component Solutions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP1.3-Establish an Organisational Training Tactical Plan</td>
<td>SG2-Develop the Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP1.4-Establish a Training Capability</td>
<td>SP2.1-Design the Product or Product Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG2-Provide Training</td>
<td>SP2.2-Establish a Technical Data Package</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP2.1-Deliver Training</td>
<td>SP2.3-Design Interface Using Criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP2.2-Establish Training Records</td>
<td>SP2.4-Perform Make, Buy or Reuse Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP2.3-Assess Training Effectiveness</td>
<td>SG3-Implement the Product Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.1-Perform Verification</td>
<td>SP3.1-Implement the Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.2-Analyse Verification Results</td>
<td>SP3.2-Develop Product Support Documentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.3-Package and Deliver the Product Components</td>
<td>Validation (VAL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.4-Validate Requirements into Customer Needs</td>
<td>SG1-Prepare for Validation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.5-Validate Requirements</td>
<td>SP1.1-Select Products for Validation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.6-Identify Interface Component Requirements</td>
<td>SP1.2-Establish the Validation Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.7-Confirm Readiness of Product Components and Deliver the Products</td>
<td>SP1.3-Establish Validation Procedure and Criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.8-Assemble Product Integration</td>
<td>SG2-Validate Product or Product Components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.9-Integrate the Organisation</td>
<td>SP2.1-Perform Validation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP4.1-Design the Product or Product Component</td>
<td>SP2.2-Analyse Validation Results</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG5-Perform Reuse Analysis</td>
<td>Verification (VER)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5.1-Prepare for Verification</td>
<td>SG1-Prepare for Verification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5.2-Conduct Peer Reviews</td>
<td>SP1.1-Select Workproducts for Verification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5.3-Analyse Peer Review Data</td>
<td>SP1.2-Establish the Verification Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG2-Verify Selected Work Products</td>
<td>SP1.3-Establish Verification Procedures and Criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP2.1-Prepare Peer Reviews</td>
<td>SG2-Perform Peer Reviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP2.2-Conduct Peer Reviews</td>
<td>SP2.3-Perform Make, Buy or Reuse Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP2.3-Analyse Peer Review Data</td>
<td>SG3-Implement the Product Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.1-Perform Verification</td>
<td>SP3.2-Assemble Product Integration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP3.2-Analyse Verification Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 23: CMMI-DEV processes, Maturity Level 3 (developed by author derived from CMMI)
### Table 24: CMMI-DEV processes, Maturity Level 4+5 (developed by author derived from CMMI)

#### CMMI – TARGET

The primary target of CMMI is to help companies document and improve processes within an organisation and to transform those into best practises (Newsham, 2005). It is the CMMI’s mission to ensure the development and operation of systems and to make the costs, schedule, and quality predictable (Software Engineering Institute, 2011).
APPENDIX IX – PROJECT MANAGEMENT METHOD “PROJECT MANAGEMENT INSTITUTE” (PMI)

PMI – Facts

<table>
<thead>
<tr>
<th>YEAR OF DEVELOPMENT/ FOUNDATION</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANGUAGE</td>
<td>ENGLISH, GERMAN, ITALIAN, SPANISH, ARABIC, FRENCH, RUSSIAN, PORTUGUESE, KOREAN, CHINESE, JAPANESE</td>
</tr>
<tr>
<td>ORIGIN IN</td>
<td>SOFTWARE DEVELOPMENT</td>
</tr>
<tr>
<td>LEGAL RIGHTS BY</td>
<td>PROJECT MANAGEMENT INSTITUTE (PMI)</td>
</tr>
<tr>
<td>CERTIFICATION</td>
<td>SINGLE PEOPLE CAN BE CERTIFIED AS A PMP (PROJECT MANAGEMENT PROFESSIONAL). RECERTIFICATION IS REQUIRED EACH THREE YEARS BY GAINING A CERTAIN AMOUNT OF CREDITS. LOWER LEVEL OF CERTIFICATION IS THE CAPM (CERTIFIED ASSOCIATE IN PROJECT MANAGEMENT)</td>
</tr>
<tr>
<td>STANDARDS</td>
<td>ISO9001, ISO10006, ISO21500</td>
</tr>
<tr>
<td></td>
<td>ANSI/PMI 99-001-2008,</td>
</tr>
<tr>
<td></td>
<td>IEEE Standard 1490-2003</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>USA, NEWTOWN SQUARE (PA)</td>
</tr>
<tr>
<td>MEMBERS WORLDWIDE</td>
<td>&gt;430.000 ACTIVE MEMBERS/ &gt;600.000 CERTIFIED PMP HOLDERS IN OVER 200 COUNTRIES WORLDWIDE</td>
</tr>
<tr>
<td>ASSOCIATED COMPANIES WITH CMMI</td>
<td>BANK OF AMERICA, BOOZ ALLEN HAMILTON, BOSTON UNIVERSITY, IBM, LOCKHEED MARTIN, PRICE WATERHOUSE COOPERS, U.S. DEPARTMENT OF DEFENCE</td>
</tr>
</tbody>
</table>

PMI – History

The PMI organisation was established in 1969 in the USA (Giammalvo et al., 2005). The Body of Knowledge (BoK) was published in 1976, and is a predecessor of “A guide to the Project Management Body of Knowledge” (PMBoK) published in 1987. PMI decided in
1981 that a standard had to be developed according to ethics, norms, and accreditation. As a final result, the abovementioned PMBoK was published in 1987. The first PMBoK was approved by the American National Standards Institute (ANSI) (Brandon, 2006). The PMBoK was reworked several times; the last version was published in 2013 as the “A Guide to the Project Management Body of Knowledge (PMBoK GUIDE) fifth Edition” (Violette et al., 2013). For assuring actual PM standards, PMI decided in 1984 to establish a certification programme. This certification “project management professional” (PMP) was awarded only to people who successfully passed a test. In 1999, the PMI received the ISO9001 certification standard. This was the first time an organisation received an ISO certification for PM standards (Brandon, 2006; Harter, 2007)

**PMI – Motivation**

There are several reasons to pursue PMI’s PMP certificate. The PMBoK can be viewed as a medium to communicate with colleagues in the project management domain and serves as knowledge source for managing projects (Yang, 2007). There are six reasons to pursue a PMP:

- **Interpersonal skills/ team skills:**
  Project managers acquire by PMBoK of PMI a balance of technical, interpersonal, and conceptual skills for analyzing the situation and acting appropriately. These interpersonal skills like leadership, team building, motivation, communication, influencing, decision making, political and cultural awareness, and negotiation can be a motivation for gaining the PMP: PMP holders learn to interact with others (Stackpole et al., 2008). People are trained for various situations and procedures and gain the ability to endure critical situations by correct behaviour.
  Team skills are improved, providing by fundamental project management skills including process standardization and communication to each member. With improving the skills of the project team in methodology (e.g. interpersonal and communicational) efficiency increases (Harter, 2007).

- **Career:**
  PMP holders have better defined career paths and will rise faster in their in the company (Harter, 2007). Cable News Network (CNN) states based on growths prospects and salary, that project manager role is placed among the top five positions (Project Management Institute, 2009)
– **Earnings:**
Salaries of PMP credential holder is higher than for non-credential holder. A survey in the PMI PMBoK shows that those who have held the PMP credential for about 2 years have a salary of $64,400, which is approximately 16% higher than those who did not hold PMP credentials (Harter, 2007). At the final stage, the income of PMP credential holder can have a salary of 100,000 $ up to 300,000 $ annually in America (Giammalvo et al., 2005).

– **Pass rate of PMPs:**
The PMI standard requires a good knowledge. An excellent set of learning materials is offered. People who want to perform the test must be well prepared. The percentage of passing the PMP exam is about 74% and more than 82% of the test answers must be correct (Giammalvo et al., 2005).

– **Language:**
The PMI applies to the international project management standard, the PMBoK and provides learning materials in many languages (like Arabic, Chinese, English, French, German, Italian, Japanese, Korean, Portuguese, Russian and Spanish). This makes it easy for PMP examinees to learn the facets of project management (Giammalvo et al., 2005; Project Management Institute, 2011c).

– **Appliance of PMI’s PMP and project management standards:**
PMI’s PMP is rated as the top one in global market for project management. It is a professional stand-alone credential. Therefore, it is used worldwide in public and private sectors by project leaders, project team leaders, project team members, PMO’s, and project schedulers (Giammalvo et al., 2005). This offers the PMP holders various application areas worldwide.

**PMI – Method**

PMI is certified by international standards: ISO 9001, ISO 10006, IEEE Standard 1490-2003 and the ANSI/PMI 99-001-2008 (Brandon, 2006, 2006; Harter, 2007; Rivard & Dupré, 2009). This standard is guaranteed worldwide by the PMI’s certification programme. For project managers, are two certificates available: Certified Associate in Project Management (CAPM) and PMP. CAPM is a pre-step for the PMP certification; it is not a pre-condition (Giammalvo et al., 2005). PMI requires a certain time of professional and educational experience for the certificate. Candidates must have a high school diploma, associate degree, or the equivalent. The CAPM test requires 1,500 hrs. of PM experience...
and 23 hours of formal education. The requirements for a PMP test are much higher: 60 months of PM experience, 7,500 hours in a leading role inside PM and 35 hours of education (Giammalvo et al., 2005). The certification is valid for three years. Afterward, a renewal must take place. This is achieved by completing collecting 60 credits within three years (Giammalvo et al., 2005).

PMI is divided into five main process groups (phases) and nine knowledge areas. The five main process groups (phases) are: initiating, planning, executing, monitoring and control, and closing (Stackpole et al., 2008; Yang, 2007). An arrangement of the main process groups with the knowledge areas in a matrix is shown in Table 25.

<table>
<thead>
<tr>
<th>Process group</th>
<th>Initiating</th>
<th>Planning</th>
<th>Executing</th>
<th>Monitoring &amp; Controlling</th>
<th>Closing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration Management</td>
<td>develop project charter</td>
<td>develop project management plan</td>
<td>direct and manage project execution</td>
<td>monitor and control project work perform integrated change control</td>
<td>close project or phase</td>
</tr>
<tr>
<td>Scope Management</td>
<td>collect requirements define scope create work breakdown structure</td>
<td></td>
<td>verify scope control scope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Management</td>
<td>define activities sequence activities estimate resources estimate duration define schedule</td>
<td></td>
<td>control schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Management</td>
<td>estimate costs determine budget</td>
<td></td>
<td></td>
<td>control costs</td>
<td></td>
</tr>
<tr>
<td>Quality Management</td>
<td>plan quality</td>
<td>perform quality assurance</td>
<td></td>
<td>control quality</td>
<td></td>
</tr>
<tr>
<td>Human Resource Management</td>
<td>develop human resource plan</td>
<td>acquire project team</td>
<td>develop project team manage project team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication Management</td>
<td>identify stakeholder plan communication distribute information manage stakeholder expectation</td>
<td></td>
<td>report performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Management</td>
<td>plan risk management identify risks perform qualitative risk management perform quantitative risk management plan risk responsibilities</td>
<td></td>
<td>control and monitor risks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement Management</td>
<td>plan procurements conduct procurements</td>
<td></td>
<td>administer procurements close procurements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 25: PMI process groups and knowledge areas mapping – PMBoK 4th edition (source: PMI)

The process groups (phases) are arranged in a PLC (project life cycle). At the end of each phase, project deliverables must be finished. Cost and staffing levels increase at the beginning of the PLC and decrease in the last third, as deliverables are almost completed, which is shown in Figure 70 (Stackpole et al., 2008). Each phase has a definite beginning, end, and deliverable. The deliverable, output of a predecessor group is an input for
the next successor phase. If deliverables are not completed, phases can overlap (Brandon, 2006).

**Figure 70**: PMI PLC - Cost-/staffing Level and Deliverables (source: PMI)

Between the process groups an interaction takes place. If stages are not completed in time or if they require iterative loops they will be passed again. Figure 71 shows such an interaction (Brandon, 2006).

**Figure 71**: Interaction of process groups (source: derived from PMI)
The knowledge areas of PMI are the key for organizing and grouping the processes into a specific field of management and are shown in combination with the five process groups in Table 25. The following knowledge areas exist (Stackpole et al., 2008):

- **Project Integration Management:**

  Integration management helps to identify, define, combine, unify, and coordinate the project in the process groups. It includes characteristics of unification, consolidation, articulation, and integrative actions. These are crucial for project completion in order to meet requirements and manage stakeholders’ expectations.

  Stakeholder management is quite important as shown in Figure 72. The costs of changes increase dramatically if they are realized at a late stage. Therefore, stakeholders should be involved at an early stage (Stackpole et al., 2008).

![Figure 72: Impact of variable based on project time (source: PMI)](image)

However, not only internal stakeholders must be managed. External stakeholders like customers, government, environmental activists etc. must be involved. This can also dramatically increase the complexity of a project. Figure 73 shows an example of stakeholders that need to be involved into the project (Stackpole et al., 2008).
Figure 73: Relationship between stakeholders and the project (source: PMI)

- **Project Scope Management:**
  This knowledge area ensures that all necessary work is required and performed. It helps to define and control what is included in the project.

- **Project Time Management:**
  Supporting the project with processes required to complete it within the requested timeframe.

- **Project Cost Management:**
  Cost management involves processes of estimating, budgeting, and controlling costs. It helps and supports to complete the project in the budget approved by top-level management.

- **Project Quality Management:**
  The organisation determines quality policies, objectives, and responsibilities. A quality management system is implemented for continuous process improvement, appropriate for the project.

- **Project Human Resource Management:**
Assigns roles and responsibilities to appropriate team members in order to complete the project smoothly. It supports management to organize, manage, and lead the project team.

- **Project Communication Management:**
  Communication is one of the most important knowledge areas within a project because more than 90% of the project is done by communication. This ensures a timely appropriate generation, collection, distribution, storage, retrieval, and distribution of project information.

- **Project Risk Management:**
  Identifies and analyzes risks. Responses for each risk are planned, monitored, and controlled inside the project. It is the objective to increase the probability and impact of chances (positive risks) and to decrease risks (negative risks). Therefore, risk management planning should be included in each project.

- **Project Procurement Management:**
  Defining the processes that are necessary to purchase and acquire products, services, and results from external to perform or complete the work/project. Contract management and change control processes help to develop and administer contracts or purchase orders. Normally a purchasing manager is responsible; the project manager is only informed.

**THE NEW PMI PMBoK 5TH EDITION**

Shortly after the release of the ISO21500 norm on project management in 2013, by end of 2013 PMI released their new PMBoK 5th edition. This was necessary in accordance to the new ISO norm. The major difference to PMBoK 4th edition appeared in a new knowledge area “stakeholder management.” Formerly, this area was partly integrated in the knowledge area “communication.” An overview of the new knowledge areas is outlined in Table 26. Here also the ISO 21500 is listed as a reference (Stackpole et al., 2008; Violette et al., 2013).
The processes “identify stakeholder” and “distribute information” from the knowledge area “communication” were moved to the newly created knowledge area “stakeholder management” and later renamed to “manage stakeholder management.” This new knowledge area was expanded by two new processes: “plan stakeholder management” and “control stakeholder engagement” (Stackpole et al., 2008; Violette et al., 2013).

Another change appeared in the knowledge area “communication” by renaming processes. The process for distributing information and reporting performance was combined and is now called “manage communications.” The gap for the process of reporting performance is replaced by the process “control communication” (Stackpole et al., 2008; Violette et al., 2013).

Three new processes for planning the scope, schedule, and costs were introduced; the new PMBoK 5th edition has now 47 processes.

All processes of the new PMBoK 5th edition are outlined in Table 27.
The targets of PMI can be seen from two points. The first involves the credential holder and the organisation supporting the credential holder. PMI provides projects with organisational methods, which result in better outcomes. This is assured by an increased support of project management maturity inside the organisation (Harter, 2007). Furthermore, research by the Berkley University showed a benefit on the ROI (return on invest). Companies investing in PMP credentials gained 20% - 30% more than the invested sum in a year (Giammalvo et al., 2005). Secondly, PMI has the target to improve the knowledge of credential holders in various fields.

These are defined by the PMI’s core values that provide continuity, a moral compass, and best practise guidance (Project Management Institute, 2011b):

Table 27: PMI process groups and knowledge areas mapping – PMBoK 5th edition (source: PMI)

**PMI – TARGET**
– Project Management Impact
  “Project management is a critical competence that has a positive influence on organisation results and society”

– Professionalism
  “Accountability and ethical behaviour ensures our commitment to PMI stakeholders”

– Volunteerism
  “Volunteers and effective volunteer partnerships with staff are the best way to accomplish the Institute's goals and objectives”

– Community
  “Bringing members of the global project management community together is the best way to advance the project management profession and facilitate their growth”

– Engagement
  “Encouraging diverse viewpoints and enabling individuals to contribute to the project management profession and to the Institute”

PMI focuses on the code of ethics that is included in each credential. The code of ethics contains areas like: vision of applicability, responsibility, respect, fairness, and honesty (Project Management Institute, 2011a).
APPENDIX X – PROJECT MANAGEMENT METHOD “PRINCE2”

PRINCE2 – FACTS

<table>
<thead>
<tr>
<th>YEAR OF DEVELOPMENT/Foundation</th>
<th>1989 BY THE CCTA (CENTRAL COMPUTER AND TELECOMMUNICATIONS AGENCY) FOR IT. SINCE 1996 PUBLISHED AS AN OVERALL APPLICABLE PM STANDARD</th>
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<tr>
<td>LANGUAGE</td>
<td>CHINESE, DANISH, DUTCH, ENGLISH, FRENCH, GERMAN, NORWEGIAN, POLISH, SPANISH</td>
</tr>
<tr>
<td>ORIGIN IN</td>
<td>SOFTWARE DEVELOPMENT</td>
</tr>
<tr>
<td>LEGAL RIGHTS BY</td>
<td>ROYAL CROWN – ADMINISTERED BY CCTA REPLACED BY OGC (OFFICE OF GOVERNMENT COMMERCE)</td>
</tr>
<tr>
<td>CERTIFICATION</td>
<td>FOUNDATION LEVEL FOR PROJECT TEAM</td>
</tr>
<tr>
<td></td>
<td>PRACTITIONER LEVEL FOR PROJECT MANAGER</td>
</tr>
<tr>
<td></td>
<td>(ACCREDITING BODY IS THE APM GROUP)</td>
</tr>
<tr>
<td>STANDARDS</td>
<td>ISO9001, ISO21500</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>UK, NORWICH, NORFOLK</td>
</tr>
<tr>
<td>MEMBERS WORLDWIDE</td>
<td>500.000 CERTIFIED PEOPLE ON FOUNDATION LEVEL AND 270.000 PEOPLE ON PRACTITIONER LEVEL SINCE 1996</td>
</tr>
<tr>
<td>ASSOCIATED COMPANIES WITH PRINCE2</td>
<td>UK GOUVERNEMENT, FRAPORT AG, IBM, SUN MICROSYSTES GMHB, THYSSENKRUPP AG, BRITISH TELECOM, DEUTSCHE POST AG,</td>
</tr>
</tbody>
</table>

PRINCE2 – HISTORY

PRINCE2 is derived from PProject IN Controlled Environments (PRINCE) and Project Resource Organisation Management Planning Technique (PROMPT). PROMPT was developed in 1975 by Simpact Systems Ltd. (Bruns & Scholles, 2008; Koehler, 2006). This standard was adopted by the CCTA (Central Computer and Technology Agency) in 1979 and used as a standard in all UK government based projects (Office of Government Commerce, 2011). In 1984, as based on PROMPT, it was planned to establish PRINCE as
a standard only for IT projects (Buhr, 2002). The first version of PRINCE was released in 1989 by the CCTA. It started successfully and superseded PROMPT (Office of Government Commerce, 2011). Over the years, PRINCE was reworked and released as PRINCE2 in 1996. This version did not only focus on IT projects. The PRINCE2 standard is applicable in all fields of project management (Bruns & Scholles, 2008; Office of Government Commerce, 2011). It became a generic standard for project management in United Kingdom and is in common usage in governmental projects in the Netherlands (Buhr, 2002).

In 2009, PRINCE2 was completely refreshed by the Office of Government Commerce (OGC), which owns the legal rights of PRINCE2. The major change in the new version is that it was divided into two manuals: ‘Managing successful projects with PRINCE2 – 2009 Edition’ and ‘Directing successful projects with PRINCE2 – 2009 Edition’ (Office of Government Commerce, 2009b). The name of PRINCE2 methods remains unchanged. OCG wanted to express that the methods remain unchanged as well as the underlying principles (Murray, 2009).

**PRINCE2 – Motivation**

Companies can be motivated by various to use PRINCE2. It is a free project management method, there is for usage, and all materials are available on the Internet (de Klerk, 2008). Top-level management can easily make the decision to use this system. Only the certification (foundation level or practitioner level) must be paid with a small fee.

For a project manager, PRINCE2 is a suitable approach and follows the statement “management by exception.” In daily business, project managers can perform decisions independently. The board or project leader is involved in only exceptional cases and defined milestones. Management does not interrupt continuous operative business, which means that time use is more efficient (Maethner, 2005; Office of Government Commerce, 2009c; Rother, 2009). This led to an individual adaption of PRINCE2 to the specific project. Unnecessary features are not implemented and bureaucracy is reduced (Maethner, 2005). PRINCE2 is a practically evaluated approach and consists of “Best-Practice” knowledge from experience, and is strongly based on PMBoK of PMI and others (Bentley, 2010; Linssen & Rachmann, 2010; Office of Government Commerce, 2009c; Siegelaub, 2006). The further motivation for PRINCE2 is the simple implementation to projects. In daily business, many project managers do not have time to study process
methods. PRINCE2 provides them with a recipe for setting up the PM method in a correct manner (Linssen & Rachmann, 2010). PRINCE2 equates a checklist for executing the project. Siegelaub (2006) termed it a "plug-and-play" version among PM methods.

As highlighted by the OGC, PRINCE2 provides the team a common understanding of the projects’ vocabulary and communication. The team is managed in a defined and structured way (Office of Government Commerce, 2009c).

From an organisation’s perspective, the PRINCE2 method can be integrated into specific models of each industry. Projects quality and quantity are insignificant; the philosophy will remain always the same (Bentley, 2010; Office of Government Commerce, 2009c; Siegelaub, 2006). PRINCE2 is flexible and can be applied at each level appropriate to the project (Office of Government Commerce, 2011). Typically, it is used in product-based planning; the linkage to the company will not get lost (Maethner, 2005; Office of Government Commerce, 2011). Reorganisation of the company is not necessary; PRINCE2 can be integrated in the existing structure. Conflicts between project management and line departments cannot be totally avoided, but are solvable (Rother, 2009).

**PRINCE2 – Method**

PRINCE2 creates a management environment for the purpose of delivering one or more business products according to a specified business case (de Klerk, 2008). The abbreviation PRINCE stands for “projects in controlled environments”. Maethner (2005) described the PRINCE2 method as a scalable model derived from successful and collapsed projects. Parts of the model which are not used can be rejected and will not be implemented into the project (Bentley, 2010; Maethner, 2005). The two outputs of the PRINCE2 method are: specialist based products (business products), which are requested by the customers; and management products like schedules of time, structure, and quality, which are created by the management team (Maethner, 2005).

The basis of the PRINCE2 method is the magic hexagon. This magic hexagon consists of the six performance variables costs, time, quality, scope, risks, and benefits of a project. Cost, time, and quality are identified as the magical triangle (American Project Management Group, 2011; Bentley, 2010; Office of Government Commerce, 2009a).

In 2009, OGC decided to enhance PRINCE2. The following identifies the the major differences between the old and new version (Murray, 2009):
Seven basic principles are now defined in PRINCE2
- Process “planning” was cleared and integrated into the other processes and themes
- Configuration management and change control are now combined under the topic change
- For reviewing the benefit of the project at the end, a benefit revision plan is introduced
- Only two specific PRINCE2 techniques will exist in future: product based planning and quality testing technique
- The original shortcuts for the processes like SU1, SU2 etc. are not used anymore

The following outlines the new PRINCE2 method.

The daily business of a project is delegated to a project manager. Project leading is performed by a steering committee and is precisely scheduled by PRINCE2 (Rother, 2009). It is not possible to initiate a project with a PRINCE2 method without the steering committee. The steering committee involves people from the top-management level, customers, suppliers, and external consulting agencies if required. Involved entities can come from different organisations (Buhr, 2002).

Generally the OGC defines the work of the steering committee by initiating and releasing a project, release of single phases or an exception plan, ad-hoc instructions and project closure (Office of Government Commerce, 2009a).

Anderson, Grude and Haug (1999) described the competences and room for decisions for the steering committee with:
- Confirmation of performed milestone reviews (at the end of each phase)
- Performing quality assurance
- Creating documentation of milestone planning, activity planning and responsibilities
- Encouraging motivation and teambuilding activities

The steering committee is assembled at the end of a phase and then releases the next one. This only happens when the planned benefits of a phase are fulfilled and the business case is still positive. Buhr (2002) termed this principle as the “gating method.” PRINCE2 follows the “management by exception” approach: Management will always be
informed of the actual project status but will only be active when decisions are necessary (Buhr, 2002; Maethner, 2005; Office of Government Commerce, 2009a; Siegelaub, 2006).

The method of PRINCE2 contains four major linked elements:

- Principles
- Themes
- Processes
- Project environment

Those elements are shown in Figure 74.

![Figure 74: The structure of PRINCE2 (source: PRINCE2 Pocketbook, OGC)](image)

The element principles are the basis for the complete PRINCE2 method. They cannot be reduced or eliminated. Seven principles exist (Bentley, 2010; Office of Government Commerce, 2009a, 2009c):

- **Continued business justification:**
Each project needs a justification for starting or moving on. The benefit of the business case must be assured. Therefore, the business case must be set up in a document and approved. It will be the basis for all decisions. If justification is no longer valid, then the project should be stopped. Normally, the business justification is checked at the end of each phase, before starting the next.

- **Learn from experiences:**
  Lessons learned from previous projects as well as experienced team members will be used in the project. At the beginning of a project knowledge should be engaged and integrated. At the end of a project, a “lessons learned” workshop should be performed to transfer the experience to the next project.

- **Defined roles and responsibilities:**
  Responsibilities of an organisation are defined. The interested groups in a project are partitioned in business, user, and supplier.

- **Manage by stages:**
  For the total project, a rough plan exists. For the actual phase, detailed planning must be available. The steering committee approves only one stage at a time. The new phase is released when the status of the actual phase ends and a continuation is agreed.

- **Manage by exceptions:**
  For each performance variable, limits are defined. Within these limits, the scope of action is unrestricted.

- **Focus on products:**
  The method of PRINCE2 is focused on the delivery of products, particularly its requirements of quality. It can also be described as a benefit-orientated method.

- **Tailor to suit the project environment:**
  The method of PRINCE2 is always tailored to the project’s environment. This must be done by reacting to the specific needs of a project concerning size, risk, complexity, importance, and the capability of involved people and environment.

Themes are the second element of PRINCE2. Themes try to explain the philosophy of various project aspects and are implemented by processes. They are used continuously throughout the total project (Bentley, 2010). Following themes exist (Bentley, 2010; Office of Government Commerce, 2009a et seq, 2009c):

1. **Business Case:**
The business case can answer the question: Why? It is developed at the beginning of a project and will be proved several times during the project life cycle (PLC) by the steering committee. Figure 75 shows checkpoints (milestones) over the PLC where the business case is regularly checked.

![Diagram of Business Case Development](image)

**Figure 75: The development path of the Business Case (source: PRINCE2 pocketbook, OGC)**

2. **Organisation:**

The organisation will provide an answer to the question: Who? Work packages are delegated to appropriate people performing the work and who are responsible for the final results. Generally, projects are not organized in linear function, but in in a matrix organisation. Figure 76 shows the relationship between the responsible managers of a project. These change when roles are combined or shared depending by size and complexity of a project.
3. Plans:

Plans are tailored to the size of the project and to the informational needs of the different hierarchy levels. PRINCE2 plans are based more on products rather than on activities. It is a guideline for communication and steering over the complete project lifecycle. Figure 77 shows the different planning levels like project, stage, and team. If an exception occurs, exception plans can be created that must be released by the steering committee.
Figure 77: PRINCE2’s planning levels (source: PRINCE2 pocketbook, OGC)

4. **Progress:**

   Theme progress provides answers to the following questions: Where are we now? Where we want to go and on how shall we proceed? Therefore, continuous control is established. It measures the actual status of the six performance variables or the magic hexagon. It enables decisions to proceed to project’s target and allows the escalation of topics if processes and events are not proceeding according to plan.

5. **Risk:**

   Risks are divided into opportunities or positive risks, and threats or negative risks. PRINCE2 defines how to review, manage, and track risks during the whole process. The communicated procedure of risks is: identify and assess risks, plan and implement countermeasures – see Figure 78.
Figure 78: The risk management procedure (source: PRINCE2 pocketbook, OGC)

6. **Quality:**

   PRINCE2 projects are product based. Quality management activities must be included in the project plan. Each team member must know the created product and its requested quality. Planning begins with customer's quality expectations, and a company's quality standards and inspection methods are considered. Afterwards, the planning of cost and timescale can be started. The quality audit trail with planning and control is shown in Figure 79.
7. Change:

Change requests – a failure in quality endangers the project’s effort. These influences are evaluated and handled by PRINCE2 in the theme change. For example, a special focus is on schedules and completed products. Change includes the topics change management and configuration management. Change management is enforced by a control procedure and considers the status quo. The configuration management prerequisites recorded baselines result in the correct delivery of the product to the customer. Figure 80 shows the procedure for managing changes inside the PRINCE2 project.
Processes are the third element of PRINCE2 principles. They assure that a project has a controlled start, progress, and closure. Furthermore they are a guideline for what should happen and when it should happen. In PRINCE2, all processes are subdivided into the four main phases: pre-project, ignition stage, subsequent delivery stage, and final delivery stage. Those processes and their phases to are shown in Figure 81.
Each major process is subdivided into single process steps. In the following, each process is briefly described including its sub-processes (Bentley, 2010; Office of Government Commerce, 2009a, 2009c).

**"Starting-Up project"** checks whether the project is realizable and profitable. It starts as a pre-process before project initiation and ensures useful continuing with project planning. Following sub-processes are included:

- Nominate sponsor and project manager
- Note down the existing knowledge
- Create and nominate project management team
- Create business case
- Merge project description
- Plan project initiation

**"Directing project"** defines the work and function of the steering committee. Ideally, the steering committee is involved only in milestone decisions such as starting the next phase. The steering committee acts according to the “management by exception” principle. Following sub-processes are included:

- Release initiation
- Release project
- Release phase- and exception plan
- Define ad-hoc instructions
Release project closure

"Initiating a project" is the foundation of the project. The project plan is created (product based planning) and the project start document is initiated. Finally, the contract between the project manager and the steering committee is executed. The following subprocesses are included:

- Create risk management strategy
- Create quality management strategy
- Create configuration management strategy
- Create communication management strategy
- Implement project steering tools
- Create project plan
- Rework and detail business case
- Merge project initiation documentation

"Controlling a stage" describes project manager’s daily work. Progress is reported to the steering committee. If necessary, countermeasures are implemented in the project. If the current stage is successful, the next stage plan can be approved. In addition to those duties, the project manager directs tasks and work packages. The following subprocesses are included:

- Release work packages
- Approve status of a work package
- Approve closed work packages
- Check phase status
- Report on actual project status
- Engage and investigate open tasks and risks
- Escalate open tasks and risks if necessary
- Implement countermeasures

"Managing product delivery" explains the basic principle of a product-orientated planning. The project manager is responsible for the creation and delivery of the product. It contains the following sub-processes:

- Accept work package
- Execute work package
- Finish and deliver work package

“Managing a stage boundary” is used at an end of each phase. The project manager collects all information and actualizes the business case and project plan. These results enable the steering committee to close the current phase. The next phase can be released. The following sub-processes are included:

- Plan the next phase
- Update project plan
- Update business case
- Report about phase closure
- Create exception plan if necessary

“Closing a project” is the process where the acceptance of a project is defined and where the product delivery occurs. The project manager records the experience of the project and makes certain that open tasks are closed. Finally, he or she recommends project closure to the steering committee. The following sub-processes are included:

- Plan scheduled project closure
- Plan premature project closure
- Handover of final product
- Evaluation of project
- Recommendation of project closure

A closure for the third element and overview of all processes in each phase is shown in Table 28.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Shortcut</th>
<th>Pre-Project</th>
<th>Initiation stage</th>
<th>Subsequent delivery stage</th>
<th>Final delivery stage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starting up a project</strong></td>
<td>SU1</td>
<td>nominate sponsor and project manager</td>
<td>release project initiation</td>
<td>release phase- and exception plan definition</td>
<td>release phase- and exception plan definition</td>
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<tr>
<td></td>
<td>SU2</td>
<td>note down the existing knowledge</td>
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<td></td>
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<tr>
<td></td>
<td>SU3</td>
<td>create and nominate project management team</td>
<td></td>
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<tr>
<td></td>
<td>SU4</td>
<td>create business case</td>
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<tr>
<td></td>
<td>SU5</td>
<td>merge project description</td>
<td></td>
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<tr>
<td></td>
<td>SU6</td>
<td>plan project initiation</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Directing a project</strong></td>
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<td>release phase- and exception plan definition</td>
<td>release phase- and exception plan definition</td>
<td>release phase- and exception plan definition</td>
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<td></td>
<td>DP2</td>
<td>release phase- and exception plan definition</td>
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<tr>
<td></td>
<td>DP3</td>
<td>define ad-hoc instructions</td>
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<tr>
<td></td>
<td>DP4</td>
<td>create risk management strategy</td>
<td></td>
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<tr>
<td></td>
<td>DP5</td>
<td>create quality management strategy</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>DP6</td>
<td>create configuration management strategy</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>create communication management strategy</td>
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<td></td>
<td></td>
<td>implement project steering tools</td>
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<td></td>
<td></td>
<td>create project plan</td>
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<td></td>
<td></td>
<td>reread and detail business case</td>
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<td></td>
<td></td>
<td>merge project initiation documentation</td>
<td></td>
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<tr>
<td></td>
<td>IP3</td>
<td>create quality management strategy</td>
<td></td>
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<tr>
<td></td>
<td>IP4</td>
<td>create configuration management strategy</td>
<td></td>
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<tr>
<td></td>
<td>IP5</td>
<td>create communication management strategy</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>IP6</td>
<td>implement project steering tools</td>
<td></td>
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<tr>
<td></td>
<td>IP7</td>
<td>create project plan</td>
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<tr>
<td></td>
<td>IP8</td>
<td>merge project initiation documentation</td>
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<td><strong>Controlling a stage</strong></td>
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<td>approve status of a work package</td>
<td>approve status of a work package</td>
</tr>
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<td>approve closed work packages</td>
<td>approve closed work packages</td>
<td>approve closed work packages</td>
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<td>CS6</td>
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</tr>
<tr>
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<td>implement countermeasures</td>
<td>implement countermeasures</td>
<td>implement countermeasures</td>
</tr>
<tr>
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<td>CS8</td>
<td>approve status of a work package</td>
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<td><strong>Managing product delivery</strong></td>
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<td>accept work package</td>
<td>execute work package</td>
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<td>execute work package</td>
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<td>update project plan</td>
<td>update project plan</td>
<td>update project plan</td>
<td>update project plan</td>
</tr>
<tr>
<td></td>
<td>SB3</td>
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<td>update business case</td>
<td>update business case</td>
<td>update business case</td>
</tr>
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<td>create exception plan if necessary</td>
<td>create exception plan if necessary</td>
<td>create exception plan if necessary</td>
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<tr>
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<td>SB5</td>
<td>update project plan</td>
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<td><strong>Closing a project</strong></td>
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<td>plan scheduled project closure</td>
<td>plan scheduled project closure</td>
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<td>CP2</td>
<td>plan premature project closure</td>
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<td>plan premature project closure</td>
<td>plan premature project closure</td>
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<td></td>
<td>CP3</td>
<td>handover of final product</td>
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<td>handover of final product</td>
<td>handover of final product</td>
</tr>
<tr>
<td></td>
<td>CP4</td>
<td>Evaluation of project closure</td>
<td>Evaluation of project closure</td>
<td>Evaluation of project closure</td>
<td>Evaluation of project closure</td>
</tr>
<tr>
<td></td>
<td>CP5</td>
<td>Evaluation of project closure</td>
<td>Evaluation of project closure</td>
<td>Evaluation of project closure</td>
<td>Evaluation of project closure</td>
</tr>
</tbody>
</table>

Table 28: PRINCE2 process overview in phases (developed by author)
The fourth and last element of PRINCE2 method is environment. A changing environment results in a continuous adaption of the project. That circumstance concerns all sizes of projects including small projects and multimillion-dollar projects. The project manager be aware of environmental influences and be able to make appropriate changes to the project according to size, complexity, team knowledge, and project lifecycle (Office of Government Commerce, 2009a).

As similar to many project management standards, PRINCE2 also offers a certification programme. There are two levels of certification: Foundation and Practitioner. Exams are administered worldwide by the Association for Project Management group (APM). The Foundation-Level provides an overview of the processes, roles, and responsibilities of PRINCE2. Those are basic tools for the team. The Practitioner-Level is an advanced certification for implementing PRINCE2 in an organisation. The holder of PRINCE2 certification must recertify every five years. Trainers and Consultants must be accredited for teaching and providing the method by OGC (Bruns & Scholles, 2008; Koehler, 2006; Maethner, 2005; Office of Government Commerce, 2011; Siegelaub, 2006).

**PRINCE2 – Target**

The main target of PRINCE2 is the justification of the business case. The project must be performed in an economical sense. It means, the business case is positive (Linssen & Rachmann, 2010; Office of Government Commerce, 2009b, 2011). This is attained by the structure of PRINCE2. It guarantees accountability, delegation, authority, and communication and defines roles and responsibilities (Linssen & Rachmann, 2010; Rother, 2009). Active stakeholder management is another target. Stakeholders should be present and involved in the planning and decisions in all project phases (Office of Government Commerce, 2009b; Siegelaub, 2006). OGC postulates as a target of PRINCE2, to be the “Best-Practice-Project” inside the company when it is used to support the project. PRINCE2 uses already experienced and established methods. Therefore, it can be repeated and is applicable in the management of different projects (Linssen & Rachmann, 2010; Office of Government Commerce, 2009b).
APPENDIX XI – PROJECT MANAGEMENT METHOD “P2M”

P2M – FACTS

<table>
<thead>
<tr>
<th><strong>YEAR OF DEVELOPMENT/ FOUNDATION</strong></th>
<th><strong>NOV. 2002 BY CONSOLIDATION OF JPMF (JAPAN PROJECT MANAGEMENT FORUM) EST. AS 1998 AND PMCC (PROJECT MANAGEMENT CERTIFICATION CENTER) EST. APR. 2002</strong></th>
</tr>
</thead>
<tbody>
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<td><strong>ENGLISH, JAPANESE</strong></td>
</tr>
<tr>
<td><strong>ORIGIN IN</strong></td>
<td>DEVELOPED BY RESEARCH STUDIES, SUPPORTED BY THE JAPANESE MINISTRY OF ECONOMY, TRADE AND INDUSTRY (METI) AND ESTABLISHING A NATIONAL CENTER OF EXCELLENCE BY THE ENAA (ENGINEERING ADVANCEMENT ASSOCIATION OF JAPAN)</td>
</tr>
<tr>
<td><strong>LEGAL RIGHTS BY</strong></td>
<td><strong>PMAJ (PROJECT MANAGEMENT ASSOCIATION OF JAPAN)</strong></td>
</tr>
<tr>
<td><strong>CERTIFICATION</strong></td>
<td><strong>PROJECT MANAGEMENT ARCHITECT (PMA)</strong>&lt;br&gt;<strong>PROJECT MANAGER REGISTRATED (PMR)</strong>&lt;br&gt;<strong>PROJECT MANAGEMENT SPECIALIST (PMS)</strong>&lt;br&gt;<strong>PROJECT MANAGEMENT COORDINATOR (PMC)</strong></td>
</tr>
<tr>
<td><strong>STANDARDS</strong></td>
<td><strong>ISO10006, ISO21500</strong></td>
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<td><strong>COUNTRY</strong></td>
<td><strong>JAPAN</strong></td>
</tr>
<tr>
<td><strong>MEMBERS WORLDWIDE</strong></td>
<td><strong>4000 QUALIFIED PEOPLE THERE FROM 2500 PEOPLE CERTIFIED</strong></td>
</tr>
<tr>
<td><strong>ASSOCIATED COMPANIES WITH P2M</strong></td>
<td><strong>PME GROUP LTD.</strong></td>
</tr>
</tbody>
</table>

P2M – HISTORY

Until 2005, different standards and organisations for PM existed in Japan, such as: Project Management Certification Center (PMCC), Japan Project Management Forum (JPMF), PMI Tokyo Chapter, SPM (academic PM society) and Construction Management Association of Japan (CMAJ). In October 2005, the PMCC and JPMF decided to merge into the Project Management Association of Japan (PMAJ) (Brandon, 2006; Ohara, 2006; Project 272
Management Association of Japan, 2005). Originally, the JPMF was established in 1998 as a division of the Engineering Advancement Association of Japan (ENAA) for promoting PM inside Japan. The PMCC is intended to spread PM knowledge, to train PM practitioners, to foster public recognition, and to strengthen international competitiveness by certification systems for project managers (Project Management Association of Japan, 2005).

Currently, the PMAJ is the dominant association for project management in Japan. Their standard method is Project and Programme Management for Enterprise Innovation (P2M). The first development already in 1999, when the ENAA got a contract by the Japanese Ministry of Economic, Trade, and Industry (METI) for development and research of P2M (Brandon, 2006; Ohara, 2006; Project Management Association of Japan, 2005). Now it is the representative standard for PM in Japan (Ohara, 2009).

**P2M – Motivation**

For managing projects, P2M follows a different standard as compared to the above-mentioned methods. P2M is characterized by methods of project management meant to increase business value and to promote innovation in an organisation. It adapts project management to business units of the organisation. For reasons of increasing business value and innovation, a company should choose the P2M method (Brandon, 2006).

There is little literature published in English about the P2M method. It is possible that this method is primarily used in Japan. A motivation for others to learn this method could be to acquire knowledge about how their Japanese customers and competitors handle projects.

**P2M – Method**

The structure of P2M is demonstrated as a pyramid in Figure 82.
The P2M is divided into four levels: Entry, project management, programme management, and segment management.

The **ENTRY-level** contains basic information:

- **Mission achievement of professionals** – Four qualities for professionals must be achieved as shown in Figure 83. First, professionals must possess the capability to integrate knowledge. Additionally, they must possess expertise and authority over the involved disciplines. They must have accountability and reliability, which is characterized by focusing on integration, understanding complex situations, and providing optimal solutions. Third, professionals learn continuously for self improvement and practice. Fourth, the professional needs the ability to practice knowledge, competences and attitudes (Ohara, 2006).
- **History and relationship between programme and project management** – P2M underlines the importance of the origin of project management: Why it was developed? Which targets are pursued? The history of the P2M method is included here and also outlines the principals and setup of P2M.

- **Structure and Design of P2M** – Different aspects are described here like the P2M “Tower” (see Figure 82), the relation and difference between project management with operational view and programme management with strategic view *(Ohara, 2006)*. See Table 29.
The structure and design of P2M requires competent judgement capability. It helps to deal with unusual phenomena in project work by providing a “practice frame.” This is a compound pattern of experiencing, memorizing, recalling, and applying lessons learned (Ohara, 2006). Figure 84 shows the structure of judgement capability.

![Figure 84: Structure of judgment capability P2M (source: P2M Guidebook Volume1)](image)

The next level of the P2M tower is **PROJECT MANAGEMENT**.

It contains following topics:
Project and Project Management – these terms are defined for a common understanding. A project is described by specifics: uniqueness, it is not repetitive; temporary nature, a defined start and end point; uncertainty, execution assumes specific conditions and situations. (Ohara, 2006). Project Management is described by three key attributes: due diligence, methods and procedures respect social expectations; ethical standards and the applicable laws; efficiency, ratio output to mobilized resources (e.g. physical productivity indicator); effectiveness, ratio acquired benefit to investment costs (e.g. capability of stakeholder satisfaction or capability of product delivery). The value of project management value can be estimated from a private or public standpoint. Both create the same benefits: asset value, synergy value, and innovation value of a project (Ohara, 2006). The relationships of these factors are shown in Figure 85.

Figure 85: Project, Project Management and Value Creation according to P2M (developed by author)

PM capability framework – here PM tries to harmonize the view of individual stakeholders involved in a project into one common objective. This necessitates a common understanding of project’s basic attributes and pattern. They are always influenced by political (e.g. new laws and political directions like change in energy usage), economic (e.g. banking crises), and natural (e.g. earthquake) factors. The basic attributes are: system approach, project life cycle (PLC), mental space, project stakeholder, and management skills (Ohara, 2006). They are further described in Table 30.
Table 30: Attributes of PM capability framework of P2M (developed by author)

- **PM knowledge and skill** – those aspects consist of the following elements: common management skills (e.g. organisation theories, leadership, use of resources, etc.) and segment management skills (e.g. communication). These elements of PM are arranged in an efficient and effective execution. The single processes of P2M in Figure 86 are arranged to the phases of designing, planning, implementing, coordinating, and delivering. Figure 87 shows the phases of the P2M project cycle (Ohara, 2006).
PM is a temporary and limited endeavour; the project manager has to form an organisation for a specific mission. For project organisation P2M requires: 1) a common mission and objective, 2) principles of collaboration, and 3) communication. The possible forms of organizing a project are: taskforce, matrix, or a projectized organisation with a project office (Ohara, 2006).
The project manager as a team leader is characterized by the ability of team building and competency in objective. These qualities are shown in Figure 88.

Skills for the efficient use of resources are also necessary. P2M differentiates six areas of resources: information, intellectual, human, material, platform, and financial resources. Resources are typically the limiting constraints for PM. Therefore, it is important to arrange them efficiently and try to upgrade them: people by skills and experience; material resources by renewing or recycling them (Ohara, 2006).

The third level of the P2M tower is **PROGRAMME MANAGEMENT**.

A programme is defined as follows: “A programme is an undertaking in which a group of projects for achieving a holistic mission are organically combined. Multiple projects weak connections or without combination are not regarded as programmes” (Ohara, 2006, p. 26). Programme management was discussed in Appendix III – Programme Management (PgM) – bonding strategic with operational and will not be addressed further.
The fourth and last level of the P2M tower is **SEGMENT MANAGEMENT**. The domains of segment management can be used on individually or in combination with discrete tasks or challenges of project management (Ohara, 2006).

Eleven domains exist and are briefly described in the following:

- **Project strategy management** – Here the relation between projects and corporate strategy is clarified. It supports selection and improves project management. Because a project is an investment, poorly selected projects will increase loss and could fail, even if the project goal is achieved. Projects are selected for creating a higher value. To achieve this, project strategies are based on corporate visions. Risks and chances are considered as well as connectivity of projects to realize synergy effects. This helps to select projects and order priorities (Ohara, 2005).

- **Project systems management** – This domain shows the relationships in a system and solves problems based on system concepts. The methods for problem solving are shown in Table 31 (Ohara, 2005).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Sub-classification</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversion technique</td>
<td>Free association method</td>
<td>Brainstorming method</td>
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<tr>
<td></td>
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<td>Card BS method</td>
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<tr>
<td></td>
<td></td>
<td>Brain-writing method</td>
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<tr>
<td></td>
<td></td>
<td>Short coming/wishes enumeration method</td>
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<tr>
<td></td>
<td></td>
<td>Input/Output method</td>
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<tr>
<td></td>
<td>Forced association method</td>
<td>Attribute listening method</td>
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<td>Checklist method</td>
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<td>Matrix method</td>
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<tr>
<td></td>
<td></td>
<td>Morphological analysis method</td>
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<td></td>
<td>Convergence technique</td>
<td>Synectics</td>
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<td>Gordon method</td>
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<td></td>
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<td>NM method</td>
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<tr>
<td></td>
<td>Integration technique</td>
<td>Affinity graph method</td>
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<td>Cross method</td>
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<td>Characteristics factor diagram</td>
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<td></td>
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<td>Card sort method</td>
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<td>Work design</td>
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<td></td>
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<td>High bridge method</td>
</tr>
</tbody>
</table>

Table 31: Problem-solving techniques in project systems management at P2M (source: P2M Guidebook Volume2)

- **Project goal management** – Core task is to identify a roadmap for a balanced accomplishment of the project. This assures completion under predetermined constraints of project, environment, and organisation. It compels transparency, ac-
countability, and arranges the priority of targets. Project goal management assures reliability throughout the period of the performance of the project and make targets definite and concrete. Goal management, according to P2M, is subdivided into the following fields:

- Lifecycle management: managing phases of concept, planning, execution, and termination
- Scope management: plan, manage, and define scope, preparing the WBS, grasping contractual conditions
- Cost management: calculation of costs, setting of budget, and install measures for improving income and expenditures
- Time management: initiate schedule, manage progress of project, analysing trends, and forecasts of progress by precedence using diagram method (PDM) and arrow diagram method (ADM) network, correction of schedule
- Quality management: plan, manage, assure, and improve quality
- EVM: setting baselines, variance and trend analysis (e.g. schedule performance indicator (SPI)/ cost performance indicator (CPI)), measuring earned value
- Report/ change management: report project’s performance and communicate, performing change management with influences and preventions
- Delivering management: process of project turnover, test run and guarantee of performance, turnover and acceptance of project.

Figure 89 shows the correlation of above-mentioned processes.
Figure 89: Interrelations among goal management processes in P2M (source: P2M Guidebook Volume 1)

- **Project risk management** – Methods for managing risks at any project situation are defined. Risks are controlled and opportunities are realized. P2M distinguishes internal, external, static, dynamic, pure, and speculative risks. In the first two phases of the PLC, many risks might occur but the risk impact is low. In the last two phases, risks occur less frequently but have a higher impact. Risk management assumes following processes: planning of risk management (policy formulation), create a risk plan (including preparation of countermeasures), identification of risks, and developing/ installing measures against risks (execution) (Ohara, 2005).

- **Project relationship management** – The relationship between stakeholders must be defined. Management has to achieve satisfaction between the interests of stakeholders and customers. For improving the relationship, P2M employs three processes: Planning, the design of the relationship between stakeholders; maintenance, consisting of proposal, contract (a classification by scope or contract party), negotiations and relationship coordination between contract parties.
and other stakeholders, handling of claim and quick responses; and the restructuring of relationships, e.g. with strategic alliances (Ohara, 2005).

- **Project finance management** – The main target is to procure a financial structure for the planned project. This domain manages risk process (analysing, selecting, sharing, evaluating, coordinating, contracting), business eligibility and economic efficiency (including verification of costs and benefits), and defines requirements (Ohara, 2005).

- **Project organisation management** – The target is to design the organisation and the formation of the project team. Employing human resources, this can be solved in a functional, projectized or matrix organisation. Organisational management also deals with the project manager and the project team. A good team formation is highly significant and results in an increase in team satisfaction (Ohara, 2005).

- **Project resources management** – Resource management improves project results and productivity. Material resources management have already been discussed (second level of the P2M tower: project management), here only human resources are investigated. This management identifies and monitors adequate human resources and ensures that they are implemented as planned. A resource plan must be created for internal and external resources, which enables performing analyses, evaluations, and predictions (as forecast and efficiency comparison against other projects) (Ohara, 2005).

- **Project information technology management** – The use of information technology (IT) is implemented in project work. It improves accuracy in communication and operations, particularly over long distances. Every stakeholder possesses the same information. Management determines the IT systems to be applied in the project, defines the construction and content of information management, and the method of sharing information and communication (Ohara, 2005).

- **Project value management** – is a provision of values to specific stakeholders. Most times project activities are seen as value sources and used as feedback for projects. Project value management first performs recognition and evaluation. It uses methods like Balanced Score Card (BSC), Value for Money (VFM) and Cost Benefit Analysis (CBA). The second process is to identify the value source. It consists of knowledge management and its transformation as shown in Figure 90 by Kaizen, Maintenance (transition from project execution stage to maintenance stage), and total quality management (TQM) activities shown in Figure 91. The last process is
the provision of value with a knowledge transfer of engineering, management, production, finance, etc. (Ohara, 2005).

**Figure 90: Modes of knowledge transformation (source: P2M Guidebook Volume2)**

<table>
<thead>
<tr>
<th>method</th>
<th>abbreviation</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Quality Control</td>
<td>SQC</td>
<td>Quality development and quality list</td>
</tr>
<tr>
<td>Quality Function Development List</td>
<td>QFD</td>
<td>Quality development and quality list</td>
</tr>
<tr>
<td>Failure Mode and Effect Analysis</td>
<td>FMEA</td>
<td>Failure mode and influence list</td>
</tr>
<tr>
<td>Fault Tree Analysis</td>
<td>FTA</td>
<td>Influence analysis</td>
</tr>
<tr>
<td>Design Review</td>
<td>DR</td>
<td>Examination of designing contents and review of design process</td>
</tr>
<tr>
<td>Operation Research</td>
<td>OR</td>
<td>Optimisation method</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>IE</td>
<td>Work analysis, work design, etc.</td>
</tr>
<tr>
<td>Value Engineering</td>
<td>VE</td>
<td>Value analysis</td>
</tr>
</tbody>
</table>

**Figure 91: Methods of P2M TQM activities (developed by author)**

- **Project communications management** – In a project team, members have various backgrounds, value standards, ideas and ages. The promotion of better understanding and communication inside the team is necessary. Communication management allows individuals to stay apprised of situations, to solve various problems, and to manage projects in a proactive manner. It is a way to integrate work effectively. Therefore, the acceptance of each other and respecting differences and cultures is recommended. Communication improves projects in the following manners:
− Mutual understanding of team and motivation towards success
− Control distribution of information
− Coordination of tasks
− Structuring of communications including understanding of issuing, receiving and understanding of messages
− Understanding of own and different cultures by cross cultural communication and coping with differences in cultures and cross cultural exchanges (Ohara, 2005).

An overview of all processes of P2M is shown in Table 32.
<table>
<thead>
<tr>
<th>Process group</th>
<th>Knowledge area</th>
<th>designing</th>
<th>planning</th>
<th>implementing</th>
<th>coordinating</th>
<th>delivering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. project strategy management</td>
<td>1.1 - relationship between projects</td>
<td>2.1 - relationship between projects</td>
<td>2.1 - problem solving</td>
<td>2.1 - problem solving</td>
<td>2.1 - problem solving</td>
<td>2.1 - problem solving</td>
</tr>
<tr>
<td></td>
<td>1.2 - strategy of project according to corporate visions</td>
<td>3.1 - PLC: manage concept</td>
<td>3.2 - scope management (defining, preparing WBS, grasping contractual conditions)</td>
<td>3.7 - cost management (install measures for improving income and expenditure)</td>
<td>3.13 - time management (analyse trends and forecasts of progress, correction of schedule)</td>
<td>3.16 - PLC: manage termination</td>
</tr>
<tr>
<td></td>
<td>1.3 - select project</td>
<td>3.3 - PLC: manage planning phase</td>
<td>3.4 - time management (initiate schedule)</td>
<td>3.8 - PLC: manage execution</td>
<td>3.10 - quality management (manage)</td>
<td></td>
</tr>
<tr>
<td>2. project systems management</td>
<td>2.1 - problem solving</td>
<td>3.1 - PLC: manage concept</td>
<td>3.2 - scope management (defining, preparing WBS, grasping contractual conditions)</td>
<td>3.7 - cost management (install measures for improving income and expenditure)</td>
<td>3.13 - time management (analyse trends and forecasts of progress, correction of schedule)</td>
<td>3.16 - PLC: manage termination</td>
</tr>
<tr>
<td></td>
<td>2.1 - problem solving</td>
<td>3.3 - PLC: manage planning phase</td>
<td>3.4 - time management (initiate schedule)</td>
<td>3.8 - PLC: manage execution</td>
<td>3.10 - quality management (manage)</td>
<td></td>
</tr>
<tr>
<td>3. project goal management</td>
<td>3.1 - PLC: manage concept</td>
<td>3.2 - scope management (defining, preparing WBS, grasping contractual conditions)</td>
<td>3.7 - cost management (install measures for improving income and expenditure)</td>
<td>3.13 - time management (analyse trends and forecasts of progress, correction of schedule)</td>
<td>3.10 - quality management (manage)</td>
<td></td>
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<tr>
<td></td>
<td>3.1 - PLC: manage concept</td>
<td>3.2 - scope management (defining, preparing WBS, grasping contractual conditions)</td>
<td>3.7 - cost management (install measures for improving income and expenditure)</td>
<td>3.13 - time management (analyse trends and forecasts of progress, correction of schedule)</td>
<td>3.10 - quality management (manage)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3 - PLC: manage planning phase</td>
<td>3.4 - time management (initiate schedule)</td>
<td>3.8 - PLC: manage execution</td>
<td>3.16 - PLC: manage termination</td>
<td>3.11 - report/ change management (report performance and communication, perform change management with influences and preventions)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4 - time management (initiate schedule)</td>
<td>3.8 - PLC: manage execution</td>
<td>3.16 - PLC: manage termination</td>
<td>3.11 - report/ change management (report performance and communication, perform change management with influences and preventions)</td>
<td>3.11 - report/ change management (report performance and communication, perform change management with influences and preventions)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.5 - quality management (planning)</td>
<td>3.6 - earned value (EV) management (setting baselines)</td>
<td>3.11 - report/ change management (report performance and communication, perform change management with influences and preventions)</td>
<td>3.12 - delivery management (test run, guarantee of performance)</td>
<td>3.12 - delivery management (test run, guarantee of performance)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.6 - earned value (EV) management (setting baselines)</td>
<td>3.11 - report/ change management (report performance and communication, perform change management with influences and preventions)</td>
<td>3.12 - delivery management (test run, guarantee of performance)</td>
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</tbody>
</table>
Table 32: Overview of processes P2M method (developed by author)

P2M offers also a certification system for their standards. The standard is split up into three levels from high professionals down to project management specialists. These are: Programme Management Architect (PMA), Project Manager Registered (PMR), which is similar to the IPMA level B and AIPM registrated PM, and Project Management Specialist (PMS) (Ohara, 2004, 2009; Ohara & Asada, 2009; Project Management Association of Japan, 2005). These certifications started in 2002. In 2005, PMAJ released a fourth level in 2005: Project Management Coordinator (PMC). PMC covers the basic PM knowledge like PM terms that team members acquire without prerequisites (Ohara, 2009; Project Management Association of Japan, 2005).

In Figure 92 the certification levels of P2M and its requirements are outlined. All levels except the PMC must be renewed each five years (Ohara, 2004, 2006).
The target of P2M method is not precisely described. More or less it shall provide and support project management with knowledge, experience, and the professional lifecycle for products and services. Although the targets of P2M are not exactly described, the standards of the original PMAJ are clearly stated and derived from the two original institutions JPMF and PMCC. Their target is to enhance the knowledge of P2M in diverse industries, collaboration with other PM communities, educate and train project management professionals, and offer a certification system (Ohara, 2009; Project Management Association of Japan, 2005).

In his P2M guidebook, Ohara (2006) stated following benefits of project management: asset value as an outcome of its endeavour; innovation value because the product generates profit or supplies a service to the public; and synergy value because it gives benefit for future collaboration or new business models (cross industry linked).
**APPENDIX XII – PROJECT MANAGEMENT METHOD “ICB 3.0 – INTERNATIONAL COMPETENCE BASELINE”**

**COMPETENCE BASED PROJECT MANAGEMENT – PM3 – FACTS**

<table>
<thead>
<tr>
<th><strong>YEAR OF DEVELOPMENT/Foundation</strong></th>
<th><strong>The association IPMA (International Project Management Association) was initiated in 1965 in Vienna (Austria) by a group of managers under the name International Management Systems Association (IMSA). It was renamed to IPMA in 1979. The project management standard ICB was published in 1998 and is now available in version 3.0</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Language</strong></td>
<td><strong>Chinese, Danish, Dutch, English, French, German, Polish, Spanish</strong></td>
</tr>
<tr>
<td><strong>Origin in</strong></td>
<td><strong>Management/Project Management</strong></td>
</tr>
<tr>
<td><strong>Legal rights by</strong></td>
<td><strong>IPMA (International Project Management Association) with its headquarter in Nijkerk, Netherlands</strong></td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td><strong>A-Level for project directors</strong></td>
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<td></td>
<td><strong>B-Level for senior project manager</strong></td>
</tr>
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<td></td>
<td><strong>C-Level for project manager</strong></td>
</tr>
<tr>
<td></td>
<td><strong>D-Level for project management associate</strong></td>
</tr>
<tr>
<td><strong>Standards</strong></td>
<td><strong>ISO10006, DIN 69901, ISO 21500</strong></td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td><strong>In 2010, the IPMA standard was represented in &gt;60 countries worldwide</strong></td>
</tr>
<tr>
<td><strong>Members worldwide (2010)</strong></td>
<td><strong>A-Level ➔ 350 people</strong></td>
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<td></td>
<td><strong>B-Level ➔ 7,100 people</strong></td>
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<tr>
<td></td>
<td><strong>C-Level ➔ 32,300 people</strong></td>
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<tr>
<td></td>
<td><strong>D-Level ➔ 90,750 people</strong></td>
</tr>
<tr>
<td>** Associated companies with PM3**</td>
<td><strong>Xerox, Disney, IBM, Microsoft, Intel, Ericsson, Citigroup, Siemens, Nextel, ...</strong></td>
</tr>
</tbody>
</table>
ICB 3.0 – INTERNATIONAL COMPETENCE BASELINE – HISTORY

In 1965, a group of managers in Vienna founded the International Project Management Association (IPMA), a platform to exchange and to network on management topics in projects, which later moved to Switzerland. When it was founded, the association was called International Management Systems Association (IMSA) and was renamed as IPMA in 1979. Two years after founding IMSA, the first congress took place. Participants from over 30 countries were present (International Project Management Association, n.d.-b). More than 25 years later, in 1998, the International Competence Baseline (ICB) was released as a standard for project management (Brandon, 2006). In 2007/2008 the Gesellschaft für Projektmanagement (GPM) and the Swiss Project Management Association (SPMA) were developed on basis of the last version of the ICB (2006) the standard ICB in version 3.0: competence based project management. It deals with activities of project work, qualification, and certification (Gessler, 2009). Today IPMA is represented in over 60 countries (International Project Management Association, n.d.-b), mostly located in Europe, Asia, and Africa. In the USA and Canada, the standard of PMI is more common (Giammalvo et al., 2005). There each country has an adopted ICB that is than named National Competence Baseline (NCB). The next release for the ICB is planned for the end of 2014 where the standard is reworked with referring to the in 2012 released ISO 21500 (Zandhuis et al., 2013).

ICB 3.0 – INTERNATIONAL COMPETENCE BASELINE – MOTIVATION

In general, standards like ICB help project managers to enhance their career opportunities. The importance of certified project managers is not only recognized by organisations. The requirements of customers and clients are better fulfilled when certified managers serve on their projects (Giammalvo et al., 2005; International Project Management Association, n.d.-a). It provides a confidence in project management and general business knowledge (Giammalvo et al., 2005). Interactions between organisation and project can be better represented. Certified project managers also are have international acceptance because they have solid knowledge in handling tools and methods for project management, especially with an increased complexity (Giammalvo et al., 2005). Therefore, IPMA’s competency framework ICB provides project managers with more than knowledge: skills and behaviour in various situations are also stated. Other methods like PRINCE2 only provide some technical knowledge and certified PRINCE2 project manag-
ers are supposed to be competent after a four-day-course (Morris, Pinto, & Söderlund, 2010).

**ICB 3.0 – International Competence Baseline – Method**

As most of the project management standards, the ICB 3.0 fulfils the ISO1006 norm, ISO 21500 and the DIN 69901 norm (Brandon, 2006; Gessler, 2009; International Project Management Association, 2012). The ICB 3.0 is fragmented into three parts: technical competence, behavioural competence, and context competence (Gessler, 2009; Rother, 2009). This is shown in Figure 93. According to Gessler (2009) and Rother (2009), 50% of ICB 3.0 contains the technical competence. The relationship between project management and organisations strategy, which was not mentioned in the former ICB (T. Mayer et al., 2008), takes later account in the ICB3.0 standard. All parts of ICB 3.0 standard are described in processes, in requirements for relevant IPMA certification levels and in cross references to other elements (Rother, 2009).

![Figure 93: ICB 3.0 - eye of competence (derived from ICB3.0, IPMA)](image)

In sum 20 official technical competence fields exist. They are enlarged by additional fields that are not separately listed in the ICB 3.0 method. In the following, an overview and explanation of these fields are given. Each relates to target, method, tools, and competence level.
1.01 – Project success criteria (Moeller, 2009)

**Target:** Measure the success of a project; define milestones for measuring the success; description of success controlling by central instruments.

**Method:** Selection of correct and important projects; prioritization of important strategic projects; effective and efficient implementation of PM methods and instruments for increasing economical success and satisfaction of stakeholders; definition of PM activities and executing PM standard methods.

**Tools:** earned value analysis; customer-/team surveys; project benchmark; stakeholder management; feasibility studies

**Competence level:** know (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 94.

**Project success criteria (1.01) analyses the efficiency and effectiveness of topics and influence therefore the PM-processes**

*Project success is the performance of contractual agreed benefit in required quality and quantity of time and finances by caring about claims. For Management effort vs. Benefit concerning development, practice etc. is relevant*

**1. Selection of projects**

2. **Standardised project management**
   1. Procedure and process description
   2. Checklists
   3. Consistent report management
   4. Prompt overviews on projects and familiarisation in project

3. **Success factors**

<table>
<thead>
<tr>
<th>Top Management</th>
<th>Project Manager</th>
<th>Project Team</th>
<th>Stakeholder/ Customer</th>
<th>Project Rival</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Human resource development</td>
<td>• Define, communicate and document targets</td>
<td>• Take over of responsibility</td>
<td>• Clear and realistic visions</td>
<td>• Open information policy</td>
</tr>
<tr>
<td>• Official PM/ project handbook</td>
<td>• Enforce acceptance and identification</td>
<td>• Motivation</td>
<td>• Financial strength</td>
<td>• Direct involvement</td>
</tr>
<tr>
<td>• Knowledge management</td>
<td>• Integration of project team</td>
<td>• Engagement</td>
<td>• Reliability</td>
<td></td>
</tr>
<tr>
<td>• Development of PM</td>
<td>• Strict claim/- risk management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Forcing WIN/WIN situations</td>
<td>• Courage to accept/ decline projects</td>
<td></td>
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<tr>
<td>• Clear interfaces</td>
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</tbody>
</table>

4. **Tools**
   - feasibility study: scenario technique
   - Cost / benefit analysis: sensitivity analysis
   - customer-/ employee questioning (stakeholder)
   - product (management) benchmarking: project excellence (GPM)

5. **Evaluation time (intern/ extern)**

   When is a project successful: at an acceptance by the customer or by probation of the project results in their usage.

   ![Diagram of project success criteria](Motzel, 2006, p.152)

Figure 94: ICB 3.0 - Project success criteria (developed by author)
1.02 – Stakeholder and interested parties (Ellmann, Behrend, Huebner, & Weitlaner, 2009)

**Target:** Involvement of stakeholders in all topics of project management and project life cycle phases.

**Method:** Systematic stakeholder analysis in four phases; analyse and identify relevant people and factors; action plan for decisions/tactics during negotiations; regular status meetings; definition of communication methods.

**Tools:** structured network analysis (SNA) for interaction of stakeholders; analysis on relations and impacts of environmental factors; portfolio planning for prioritization of stakeholders; stakeholder activity matrix; interviews and workshops for analysing the behaviour.

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 95.

**Stakeholder and interested parties (1.02) strongly influences the project – eight tools for handling stakeholder in all four phases**

- **Project-field-factor analysis** – combination of project and environment by information

- **Stakeholder analysis in project** (see Schelle, 2007)

- **Information distribution** – (Clealand, 1998)

- **Analysis of stakeholder behaviour** – by workshops and interviews (Abresch, 1999)

- **Project marketing** – strategy for turning opponent stakeholders to promoter

- **Influence methods** – motivation is intrinsic, it is the aim to overtake PM’s target

- **Stakeholder activity matrix** – who communicates with whom, when and what target is aimed

- **Status meeting** – for monitoring the influence, power and interests from stakeholders

---

**Figure 95: ICB 3.0 - Stakeholder and interested parties (developed by author)**
Objectives and strategies (1.03) describe the planned targets and requirements of the stakeholder

**Target definition:** “Qualitative and quantitative commitment of project contents and constraints like costs, time which need to be followed by target marks with different weighting” (DIN69901-5, 2009)

_A requirement is a description of a constraint or ability, which is necessary to solve a problem or achieving a target_ (IEE E610-12, 1990)

**Competence level:** skill (D-level), skill (C-level), skill (B-level), skill (A-level).

More details of this technical competence field are shown in Figure 96.
1.04 – Risk threats and opportunities (ROHRSCHNEIDER & SPANG, 2009)

**Target:** Preparing the project team on an institutionalized chance and risk process; reduce risks and conduct countermeasures; observe implemented measures.

**Method:** Identification of risks by a stakeholder analysis, Delphi method, FMEA analysis (failure mode effect analysis), nominal group techniques etc.; evaluating risks by a risk portfolio and an impact-/possibility matrix; evaluating and planning measures for a process of elimination.

**Tools:** Checklists and surveys for identification; qualitative and quantitative analysis of risks by a portfolio; measures for a process of elimination reduces stepwise risks.

**Competence level:** know (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 97.

**Risk, threats and opportunities (1.04) exist in all project phases – experience at project's end are fundamental contribution for future projects**

<table>
<thead>
<tr>
<th>Identify and analyse chances and risks</th>
<th>Evaluate chances and risks</th>
<th>Plan and evaluate measures</th>
<th>Integrate, execute and control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chances and risks are identified by: Checklists and closed questions – Questions concerning feasibility, project's targets, contracts, licences etc. – Nominal group technique – Delphi method – FMEA-technique – Simulation methods – Stakeholder analysis</td>
<td>Evaluation can be performed qualitative or quantitative. Qualitative: – Portfolio concerning probability and consequence</td>
<td>Risk monitoring is carried out stepwise: – Measure planning is done by the exclusion-method avoid-handover-reduce-bear on – Minimising by contractual exclusion – Displace risks at contractual negotiations – Evaluation of technical risks through solutions from predecessor projects – Timely risks are evaluated by an arrow diagram with a critical or sub-critical path</td>
<td>Integration: – Planning iteratively in xx day-cycle Execution: – Risk lists – Measure plans – Cost and effort estimations for measures – Human resource operation schedule – Overall evaluation of the project for the project portfolio Control measures: – Regular control check points – Result and event steered control</td>
</tr>
<tr>
<td>Chances and risks analysis takes place by: – Tolerable/ non tolerable (ethical or economical reasons are not tolerable) – EVA- Analysis – Program, Evaluation, and Review Technique (PERT)- Analysis</td>
<td>Qualitative: – Probability and impact matrix</td>
<td>Overall risk</td>
<td>not identified risks</td>
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</table>

Figure 97: ICB 3.0 - Risks, threats and opportunities (developed by author)
1.05 – Project quality  *(Bartsch-Beuerlein & Frerichs, 2009)*

**Target:** Understanding of quality and quality management in projects; usage of knowledge like planning and guiding processes of quality in project management.

**Method:** Assuring product quality by recognizing customer requirements and avoidance of failures; audits and reviews ensure reliability and quality of the product; support of analysis and identification by total quality management (TQM) tools.

**Tools:** FMEA analysis for assuring the product quality; QM (quality management) tools like Pareto analysis and flowcharts for identification of failures/problems, histograms, steering diagrams, control cards for identification of failures and problems.

**Competence level:** know (D-level), know (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 98.

*Project quality (1.05) is part of all modern projects and considers aspects of project result and management*

“*Project quality management must address both, the management of the project and the product of the project. Failure to meet quality requirements in either dimension can have serious negative consequences for any or all of the project’s stakeholders.*” *(PMBoK, 1996, p.83)*

---

**Maximes of quality management according to EN ISO 9000:2000**

1. Customer orientation  
2. System orientated management approach  
3. Leading and guiding  
4. Continuous improvement  
5. Involving and integration of all people on each levels  
6. Issue-related approach for decision making  
7. Process orientated approach  
8. Supplier relationship for each others advantages

---

*Figure 98: ICB 3.0 - Project quality (developed by author)*
1.06 – Project organisation (Kremer & Rohde, 2009)

**Target:** Describing and defining roles within a project; classification of authority and its impact on project success; evaluation of resources appropriation; selection of the project’s organisational form.

**Method:** Recognizing team members and their interest or concern in the project; defining the content and responsibility of each work package; granting authority to team members according to the six steps (see Figure 99, point 4); defining pros and cons of project organisation and selecting the most appropriate one; eventually changing of project organisation between the project phases.

**Tools:** RASCI-chart (Responsible/Accountable/Support/Control/Inform) for defining responsibilities in a work package; critical matrix for defining project organisation.

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 99.

**Project organisation (1.06) enfold development and sustainment of capable roles, organisational structure and skills for project management (IPMA 2007)**

The project organisation consists out of a group of people and associated infrastructure for an agreement concerning authority, relationships and schedule of responsibilities by an alignment on business- and functional processes (IPMA 2007, p.17)

**Roles**

1. Identification stakeholders
   - Interested on course of project or affected by its consequences
   - DIRECT
     - client
     - project team
     - supplier
   - INDIRECT
     - contractor
     - owner
     - project leader
   - owner
   - project leader

2. Job specification for employees
   - A profile description for each employee according to:
     - targets: fulfill project target, human resource development
     - expertise and methods competence: PM methods, knowledge about core processes, moderation and presentation skills
     - social/personal competence: team work, team guiding, able to be criticised, assertive

3. Define responsibilities
   - Responsibilities can be defined according to roles or resources. Visualization by a RASCI-chart (Responsible/Accountable/Consult/Inform/Support/Verify)

4. Authority – authority is given by delegation
   - 1. Report, let me proceed
   - 2. Report, search for alternatives, recommend a solution
   - 3. Report, suggest what you would do, wait for “GO”
   - 4. Report, suggest what you would do, don’t do it if disagreed
   - 5. Execute solution, report what you have decided
   - 6. Execute solution, no other action necessary

**Project organisation**

1. Organisation
   - Pro’s and Con’s as well as other criteria’s define three different types of project organisations

<table>
<thead>
<tr>
<th>Influence</th>
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2. Change of project organisation

<table>
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<th>Matrix</th>
<th>Autonom</th>
<th>Finish</th>
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<tr>
<td>Initial</td>
<td>Start</td>
<td>Plan</td>
<td>Execute</td>
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   Postulations for an optimal organisation in project phases:
   - Suitable communication
   - Active support by top-management
   - Support and motivation of employees
   - Team spirit
   - Reliable and confidential teamwork

Figure 99: ICB 3.0 - Project organisation (developed by author)
1.07 – Teamwork (Prudix & Goerner, 2009)

**Target:** Communication forms for leading teams; generate a room for manoeuvre in the team to gather creative ideas and solutions; development of synergies by binding different technical competencies; prompt reaction on occurrences.

**Method:** Definition of communication; moderation of meetings according to a defined and known process; implementation of processes for reinforcing teamwork; boosting team culture; taking care on team composition; consciousness of the roles of a project manager and team.

**Tools:** Moderation techniques like brainstorming, 6-3-5, etc.; models of phases and process for settlement of communication.

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 100.

**Teamwork (1.07) is the cross-linking of PM-success, resources, finances purchasing as well as the interface of soft skills like communication, motivation...**

---

**Figure 100: ICB 3.0 - Teamwork (developed by author)**
1.08 - Problem solving (PLATZ & PLATZ, 2009)

**Target:** Dominating the project by a more efficient handling of problems; caring on problems of projects and so avoiding the formation of crises and conflicts; prudent, realizable, fast and effective solving of problems.

**Method:** Selection of the problem solving strategy, which is defined by urgency and importance of the problem itself; approach in problem solving phases by single steps – clarify problem, solve problem and realisation of solution.

**Tools:** Cause identification with Pareto diagrams; creative techniques like 6-3-5, mind mapping, etc. for working out solutions; support of selecting a solution with the earned value analysis.

**Competence level:** know (D-level), skill (C-level), manage (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 101.

Problem solving (1.08) describes a possible unknown paths from plan to actual

Figure 101: ICB 3.0 - Problem solving (developed by author)
1.09 – Project scope (Wolff, Rosenthaler, & Knoepfel, 2009)

**Target:** Creation of a structure inside the project; coordinated diagram and logical visualization of all components of a project.

**Method:** Itemization of the project according the top-down approach; generating work packages, which are the smallest unit of a project with only one responsibility.

**Tools:** Work package (WP) for a distinctive description; work breakdown structure (WBS) as an overview on WPs.

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 102.

Project scope (1.09) is a key element for coordinating and defining the structure of project components like schedule and financial tables

Project structuring splits the project in clear components and its relationships between each other. It is a key component structuring work packages

1. **Understanding for aspects of structuring (project) + Dimensions of guiding (company) = aspects of structuring**

2. **Build-up of WBS (work breakdown structure)**
   - Requirements:
     - planning by top-down
     - Work package (WP) is smallest unit

3. **Structuring principles of organisations**
   - **Object orientated**
     - Building a house
       - PM
       - Concept
       - Planning
       - Execution
       - Closure
     - Activities
       - Case
       - infiltration
     - Phases
       - Basics
       - Draft
       - Build
       - Infiltrate
   - **Activity orientated**
     - Building a house
     - PM
     - Concept
     - Planning
     - Execution
     - Closure
   - **Phase orientated**
     - Building a house
     - PM
     - Basics
     - Draft
     - Build
     - Infiltrate

4. **Creation of work packages (WP)**
   - Characteristics:
     - finished performance
     - Defined result
     - Controllable by owner
     - Clear definition by owner
     - Clear ID
   - Description:
     - Content/ performance
     - Tasks/ Range of activities
     - Date and target
     - Interfaces
     - Costs
     - Expected results
     - Identification
     - Responsible
     - WP ID
     - Project name and No*

**Figure 102: ICB 3.0 - Project scope (developed by author)**
1.10 - Product scope *(Wolff et al., 2009)*

**Target:** Description of the project content by project scope and project deliverables.

**Method/ techniques:** The customer describes his requirements in the performance specification; technical realization is described by the contractor in the requirement specification; checking by the customer if the project can be realized, afterward the contractor receives the order; creation of a poster (characteristics of the project) from the wanted project.

Control and monitoring of the scope is handled by configuration management, which is described as a separate technical competence element.

**Competence level:** know (D-level), know (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 103.

**Product scope and deliverables (1.10) describes the limitations and material/immaterial results of a project**

The project’s content is described and defined in the specification: Entirety of product and service which must be presented as a result at the end of a project (DIN 69901-S: 2009)

---

**Process scope of work:** Work which is not directly involved by creation, planning or managing of the project’s product

**Product scope of work:** Exact knowledge of the required product from the project

**Description of scope of work:**
- All requirements defined by customer concerning deliverables within a project contract (DIN69901-S: 2009)
- Requirements for realisation defined by contractor on basis of the specification given by the customer (DIN69901-S: 2009)
- Project order = assignment for executing the project = target, expected results, requirements, responsibilities, planned resources, agreed agreement on volition etc.

**Procedure for defining the scope of work**

1. **Basis of project life cycle (PLC) – Result by a predefined PLC (concept) which grants a structure till creation of the product**
2. **Concerning requirements Scope of work is developed externally and predefined – depending on level of customer**
3. **Exclusion in scope of work**
   - Exclusion are defined in contracts, specifications etc.
4. **Unknown scope of work**
   - Arranged like development studies, relaying on possibility studies – results are open

**Project’s deliverables:**

- Result at the end of a WP, process or project Which has to be handed over (DIN 69901-S: 2009)
- Categories of deliverables:
  - project product
  - main components or subsystems
  - Documents for defining scope of work (e.g. project documentation)
  - Documents for management (e.g. meeting/ status protocols)

---

Figure 103: ICB 3.0 - Product scope (developed by author)
1.11 – Project life cycle and phases *(Kaestner & Rackelmann, 2009)*

**Target:** Integration of subtask to main tasks for a faster orientation and focusing on essential jobs in the project; creation and rough estimation of the schedule.

**Method:** Phase model of the project explains a timeframe of the project’s flow, but does not replace the WBS (see project scope); phase models are the basis for defining work packages in a structure- or network-diagram; milestones are closing and releasing phases and therefore, limit them; structuring is a requirement for generating an activity planning or schedule.

**Tool:** Visualization and calculation is performed by a network diagram; activity planning can be done forward (progressive) or backward (retrograde).

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 104.

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**Project life cycle and phases (1.11) reduces the complexity by a timely grouping and planning of the project – thus a guide for the general course of action**

*A phase is a timely section of the project’s development, objectively separated from other sections (DIN 69901: 1987)*

---

**Figure 104: ICB 3.0 - Project lifecycle and phases (developed by author)**
1.12 – Resources *(Scheuring, 2009b)*

**Target**: Increase of effectiveness and efficiency of the organisation by a stable request and offer of resources.

**Method/techniques**: Understanding, which resources are needed and by criteria of “who, when and what” how they are to apply in a project; awareness for targets and benefits of resources by decreasing bustle and increasing transparency; reliability and safety of planning supported by predictive scheduling of resources; planning and selecting resources by estimating of requirements, analyzing capacity, workload and defining the activity schedule; steering and monitoring resources by determining work effort/s-progress: this takes place by active steering of optimized planning and reduction of workload with an increased capacity.

**Competence level**: skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 105.

---

**The important position of resources (1.12) is implemented by line- and project organisation in the company**

![Diagram](image_url)

**Figure 105: ICB 3.0 - Resources (developed by author)**
1.13 – Cost and finance (SEIBERT, 2009)

**Target:** Analyzing, planning, monitoring, and steering of costs and finances in a project.

**Method/techniques:** Project cost calculation for a proper detecting and structuring of project costs, similar to accounting; estimation of a project’s cost as a basis for future calculations and planning; cost and budget planning by assigning realized costs under given conditions; counteract budget overruns and preventing cost overruns of the project by cost controlling.

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 106.

**Cost and finance (1.13) is the operative and strategic management of profit-ability and finance accounting in projects**

![Cost and Finance Diagram](image)

**Figure 106: ICB 3.0 - Cost and finance (developed by author)**

305
1.14 – Procurement and Contracts (*ESTER, 2009*)

**Target:** Contractually assuring the supply of the organisation, so that the production does not stand still or the delivery of the final product is not prevented; reduction of costs – all costs which are generated until the required material arrives the sheeting location (TCO – total cost of ownership); caring of sustainability: ecological and social targets like environmental safety and labour laws.

**Method/ techniques:** The process of procurement follows nine single steps:

1. Investigation on demands within the organisation
2. Acquisition of suitable supplier
3. Request for quotation at supplier
4. Comparison of available quotations
5. Negotiation of contract and signing of the contract
6. Triggering the order
7. Monitor the order and delivery process
8. Accounting

**Competence level:** know (D-level), know (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 107.

![Procurement and contracts (1.14) increase importance, focusing on the supply, sustainability ... and strengthen organisations own competences](image)

**Figure 107:** ICB 3.0 - Procurement and contracts (developed by author)

306
1.15 – Configuration management (Saynisch, 2009)

**Target:** Smooth and logical results from project processes and product processes; controlling and structuring changes by documentation; making the project deliverable in a tangible manner with controlled and provable records; definition of control, acceptance and change of project deliverables/ documentation; guarantee of tracing product’s development; possibility of reproducible results; transparency of development status and its measurement.

**Method/ techniques:** Identification of content configuration, technically by baselines and formally by numbering, marking, and structuring; controlling of change management is the process which describes, identifies, classifies, evaluates, and accepts changes and deviations; configuration documents trace back the process of changes on status and impact of project/ product; audits for guaranteeing all deliverables being in the same configuration.

**Competence level:** know (D-level), know (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 108.

**Configuration management (1.15) documents the technical realisation of a product, also named level of maturity**

![Diagram: Configuration management plan](image)

Figure 108: ICB 3.0 - Configuration management (developed by author)
1.16 - Project control (Motzel & Felske, 2009)

**Target:** Early warning for project deviations (e.g. project maturity level and project progress monitoring); written comparison of be-is/ as-is state; extrapolation and prognosis for future course of the project.

**Method / techniques:** Awareness and understanding for project controlling and which topics need to be monitored; capturing actual correct real-time data by questioning, observing, or reviewing schedule, work and results; comparison of be-is and as-is data by single or isolated observation; creation of a deviation-analysis and a review of whether the deviation can be eliminated by an one-time measure or if the planned date needs to be adjusted; display of prognosis and trends by milestone trend analysis (MTA), work trend analysis (WTA) or cost trend analysis (CTA), relying on available data and their chronological sequence; controlling by reduction of resources, increase of process quality, productivity, work reduction and change of project’s scope; reporting of actual project status on regular basis to a defined target group.

**Competence level:** know (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 109.

**Project control (1.16) steers all phases of a project – deviations are early located and adequately responded on it**

**Fundament**
- Understanding of project controlling
  - Planned specification of be-is data
  - Controlling – deviation analysis and/ be-is data
- Make decisions, implement measures for achieving planned data and effort
  - Factor of planned, be-is and as-is to be compared
- Observation of people – used for checking soft factors like climate, motivation… not used for hard factors like time, finances.
- Team oriented generated data – by regular team meetings, discussing work packages
- Data definition oriented on required deliverables and performances like:
  1. Project plan / customer contract
  2. Performance / customer contract specification
  3. Work breakdown structure
  4. Schedule / operation plan [result/ performance, schedule, effort, processes]
  5. Contract

**Detect as-is situation**
- Data quality
  - correct content, formally correct, completed
  - Generating data
    - Questioning and feedback – direct by self agreed feedback or indirect by project team members
    - Team oriented generated data – by regular team meetings, discussing work packages
- Observation of people – used for checking soft factors like climate, motivation… not used for hard factors like time, finances.
- Test review – checking of all project results by checklists
- Data definition oriented on required deliverables and performances like:
  1. Project plan / customer contract
  2. Performance / customer contract specification
  3. Work breakdown structure
  4. Schedule / operation plan [result/ performance, schedule, effort, processes]

**Compare as-is/ be-is**
- Dedicated analysis of deviations is a basis for realistic estimations on impacts of the next project phases and evaluation of trends. It is possible to predict the future by well founded forecasts.
  - Two points of view do exist:
    1. Single point of view (isolated comparison)
    2. Integrated point of view (all factors are evaluated)
- Factors of planned, be-is and as-is to be compared
- Results by work breakdown structure
  - Schedule by a gantt diagram and milestone analysis
  - Efforts from people by hours and costs
  - Costs estimated for residual efforts
  - Deviation analysis and checking if deviations can be changed by counter measures

**Prognosis & trends**
- Prognosis: Projections of the actual knowledge of the future by subjective estimations, predictions and extrapolations
- Trends: Displaying data from the past over time, outline the changes over time.
  - Methods for displaying them are:
    - MTA – milestone trend analysis, if requested milestone take place in time or are delayed
    - WTA – work trend analysis, showing if the effort as requested or is increased
    - CTA – cost trend analysis, outlines the planned overall costs according to the performance factor (PF)

**Guiding & reporting**
- Guiding: Aiming that the course of the project is close to the planning. Deviations must be brought up back to the plan without big changes.
  - Possibilities of guiding:
    - Change of resources
    - Reduction on effort
    - Increase of productivity
    - Change on scope of project
    - Improving process quality
- Reporting: Provide information to all people affected by the project
  - Reporting rules:
    - Reporting form (content/ form)
    - Report creator
    - Report requestor
    - Report cycle
  - Content:
    - Costs
    - Time / milestones
    - Results
    - Risks
    - Recommendations

*Figure 109: ICB 3.0 - Project control (developed by author)*

308
1.17 - Documentation, information and reporting (Gleckler, 2009)

Target: Availability of all project information that is relevant for project team and stakeholders; depending on project, archiving all documents of the project; structured documentation for using knowledge in other projects → knowledge management.

Method/techniques: Project team/manager and stakeholders create documents: project specific documents, especially adjusted to the project and general documents, which can also be used for other projects; documents according to defined processes like acquisition of information, decision, verification, release, confirmation, publication and archiving (online e.g. WIKI, Data manager, ... and offline e.g. computer based data bases, paper archives etc.).

Competence level: know (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field for documents, processes and media are shown in Figure 110.

Documentation, information and reporting management (1.17) is the basis with its rules and methods for assuring a satisfying record of the project

An information is a knowledge which reduces or eliminates the uncertainty on realisation of a specific event out of a sum of possibilities (EN DIN 44301-16).

Documents are separating from data (information) as they have a judicial or work relevant content – mostly in the form of texts, graphics, formulas, video or stereo records.

**Figure 110: ICB 3.0 - Documentation, information and reporting (developed by author)**
1.18 – Communication (Goff & Doerrenberg, 2009)

**Target**: Definite, understandable and actual transfer of information; pertinent information to relevant people in a standardized format.

**Method/ techniques**: Verbal or non-verbal communication takes place all the time and everywhere; the flow of communication follows a communication model; the receiver gathers information by listening or reading; the sender transmits it by a speech, presentation, email, or paper; stakeholders of a project must be involved into project’s communication; it can take place formally or informally.

**Competence level**: skill (D-level), skill (C-level), manage (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 111.

**Communication management (1.18) describes tools and methods of information and is the fundamental link for all processes of a successful project**

Confucius: Explain to me and I will forget, show to me and I will remind, involve me and I will understand

![Diagram of Communication Management](image)

**Questions for reading**:
- What is the target?
- First step: roughly identify the content
- Determine if you need to read exactly
- After reading check alignment with original targets

---

Figure 111: ICB 3.0 - Communication (developed by author)
1.19 – Project Start-up (Scheuring, 2009a)

**Target:** Requesting of conceivability and guidelines from the customer; build up of an informed and motivated project team; gain a definite and binding commitment between all project parties.

**Method/techniques:** A project cannot be started without official project start documentation (project charter); project start phase is a process, involving project idea, preparation, feasibility; handover of a project charter with defined content to steering committee.

**Competence level:** skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 112.

**Project start-up (1.19) defines all requirements for a kickoff and permits the realisation of the project**

![Diagram](image-url)

**Figure 112: ICB 3.0 - Project start-up (developed by author)**
1.20 – Project closeout (Burghardt, 2009)

**Target:** Formal handover of the project deliverables by the contractor; acceptance includes: tests by the customer; internal project closeout analysis concerning performance, quality, be-is/ as-is comparison of schedule, and fiscal results; recording and sharing project experience by lessons learned; official project closure.

**Method/ techniques:** Each target runs through single process steps, as documented and aggregated in particular reports: reports of product acceptance, project analysis, and project experience. These combined reports, along with a resource utilization plan is the project closeout report.

**Competence level:** know (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 113.

**Project closeout (1.20) is the phase after finishing the execution of the project and describes the handover and acceptance of the project deliverable**

![Project closeout diagram](image)

**Figure 113: ICB 3.0 - Project closeout (developed by author)**

The last three technical elements are not separately mentioned in the standard of “competence based project management” from ICB 3.0. But for completeness of technical elements, two of them will be named here: IT-software and CCP — Critical Chain Project management. The third part: DIN Norms is shortly described in a separate appendix.
**1.22 – IT-software (M. MEYER, 2009)**

**Target:** Support of daily project work such as the handling of electronic data by workflow systems; optimizing the project using integrative and cross-linked software.

**Method/techniques:** Generally, support of top-level management is necessary; definition of what should be covered by software and software tools, adequately to its specific needs selected and compared on the market; implementation only after a successful pilot test for avoiding risks; training of users; adjusting and tuning of the data concept. Project management knowledge cannot be replaced by software.

**Competence level:** none, as it is additional to the technical competences of ICB 3.0.

More details of this technical competence field are shown in Figure 114.

**IT-software (1.22) supports project’s work and has to be selected carefully today as it has an comprehensive integrative view on all elements**

*PM-software is a software which was developed and designed for supporting one or many projects in planning and steering*

---

**Table: Costs which are not often thought about by implementing/introducing a new software:**

- Consulting
- Maintenance
- Time for training
- Coaching
- Loss of productivity
- Customising
- Licences
- Adaption to existing systems

**Teachware:**
- SW for qualification e.g.: tutorial, training-video

**Working environment of SW e.g.:**
- Office applications
- Small macro programmes

**Specific functional SW are supporting project management:**
- Risk analysis
- Change management
- Risk management
- Configuration management
- Cost management
- Stakeholder management

**Risks:**
- Concept of SW usage does support PM but does not substitute it
- SW supported planning details – as more you want from the software as more it wants from you

**Chances:**
- Analysis of high data volume
- Transparency in projects
- Assuring documentation and success
- Support of communication
- Improve project’s success

---

**Figure 114: ICB 3.0 - IT-software (developed by author)**
1.23 – CCP – Critical Chain Project management (TECHT, 2009)

**Target**: Useful assignment of resources so that projects can be performed from the viewpoint of costs, quality, and schedule according to plan or accelerated to avoid negative impacts. The result is increased customer satisfaction reduced stress, and increase of motivation for resources.

**Method/techniques**: Following the theory of constraints (ToC) with its five steps; the following illustrates the three CCP rules:

- Staggering projects (reduction of work in progress)
- Trussing of project buffers at the end of the project
- Awarding of tasks to resources by priority.

**Competence level**: skill none, as it is additional to the technical competences of ICB 3.0.

More details of this technical competence field are shown in Figure 115.

**Critical Chain Project management (1.23) considers from a super ordinate viewpoint weaknesses of projects – it follows TOC and optimises the overall system**

The experience of the last decades shows that TOC (theory of constraints) increases the reliability of projects up to 100%, available capacity is used for other value creation and the time of projects is reduced up to 25%.

![Diagram showing point of departure, reason, and awareness of TOC]

**Point of departure for CCP/TOC**
- Projects are too late
- Projects are not in budget
- Projects have not the requested quality
- Employees are stressed
- Customers are unsatisfied

**Reason**
- Trying to use capacity of resources by 100% (resources must also rest sometimes)
- Local efficiency (employees and resource manager are judged if employees are charged well with productive work)
- Destructive multitasking (resources are not always available for planned projects)

**Awareness of TOC**
1. Identify the bottleneck
2. Decide in which way the bottleneck can be utilised in an most effective way
3. Subordinate everything else according to that decision
4. Enlarge the bottleneck
5. If bottleneck has changed, start with step one

→ Inertness is not allowed to become the bottleneck of the system/project

Figure 115: ICB 3.0 - CCP - Critical Chain Project management (developed by author)
The second competence field of the ICB 3.0 method is the *behavioural competence*. It describes the power and authority inside the project and the manner in which it can boost or hinder it. Popitz (1992) defined power as: “the ability to prevail over external forces” (Popitz, 1992, p. 22).

Behavioural competence addresses questions about the considerations of handling power and authority: who exercises power over whom and who leads the scope of action. Power is subdivided into: structural power, position, decision competence, project and management rules; and personal power, language, knowledge, charisma, social competence, and information. The methods of power and authority are subdivided into: force, penalty and censure; threat, sanctions and absence of sanctions; and seduction, compelling an individual to do something in the appropriate manner.

The complete competence field” behavioural” consists of following competences:

Leadership, engagement and motivation, and self-control shown as in Figure 116; assertiveness, relaxation, and openness as shown in Figure 117; creativity, results orientation and efficiency as shown in Figure 118; consultation, negotiation, and conflict as shown in Figure 119; reliability, values appreciation, and ethics as shown in Figure 120 (Gessler, 2009).
Power and authority can boost and impede projects – authority is necessary for handling power, supported by different competences: leadership, motivation and engagement, self control

**Power and authority**

- Authority is necessary for handling power.
- Power can boost and impede projects.
- Authority is required for handling power, supported by different competences.

**Leadership (2.01)** shall motivate, inspire and bring the project-team together.

**Motivation and engagement (2.02)** describes the manipulation of people and the way they are in a specific way.

**Self control (2.03)** is a stabilising factor within the project for boosting the team and single team member.

**Figure 116: ICB 3.0 - Behavioural competence: leadership, engagement & motivation and self-control (developed by author)**

**Power and authority can boost and impede projects – authority is necessary for handling power, supported by different competences:**

assertiveness, handling stress and relaxation, openness

**Assertiveness (2.04)** helps to persuade people of the correctness of an action and by this to motivate them.

**Assessing and controlling (2.05)** helps to ensure personal and professional authority. Conviction ability = communicative altercation

- **Assertiveness has three modules:**
  - Communicative ability and negotiation skills
  - Personal behaviour and authority (fine feathers make fine birds)
  - Personal conviction and confidence (skills, ability, honour, behaviour)
- **Handling of exceptions:**
  - Agree: accept weaknesses and become stronger
  - Except by wash away detail information
  - Qualify, by putting the benefit in foreground
  - Change, by turning disadvantages into advantages
- **Accomplishment of targets** follows six process steps:
  1. Analyse situation
  2. Define targets
  3. Collect arguments
  4. Prepare meeting
  5. Perform follow-up meeting
  6. Control and evaluate results

**Handling stress and relaxation (2.05)** for a long-lasting sustaining of resources in high performance phases.

**Openness (2.06)** interferes a feeling of gaining benefit when fears, comments, proposals, concerns are mentioned.

**Figure 117: ICB 3.0 - Behavioural competence: assertiveness, relaxation and openness (developed by author)**

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Power and authority can boost and impede projects – authority is necessary for handling power, supported by different competences: creativity, achievement and orientation, efficiency

**Figure 118: ICB 3.0 - Behavioural competence: creativity, results orientation and efficiency (developed by author)**

Power and authority can boost and impede projects – authority is necessary for handling power, supported by different competences: consultation, negotiation, handling conflicts

**Figure 119: ICB 3.0 - Behavioural competence: consultation, negotiation and conflict (developed by author)**
Power and authority can boost and impede projects – authority is necessary for handling power, supported by different competences:

**Reliability, value appreciation, ethics**

<table>
<thead>
<tr>
<th>Reliability (2.13) affects mainly technical elements from the ICB like project success, targets, quality and risks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human</strong></td>
</tr>
<tr>
<td>Reliability in general is a measure for the trustiness and safety of a unit fulfilling the requested requirements. It is the generic term for aspects of availability, safety and trustiness =&gt; Quality over time.</td>
</tr>
<tr>
<td>➤ Human must have the capability and will to be reliable. Besides this human should be honest, consistent, loyal, engaging and be revealing</td>
</tr>
<tr>
<td><strong>Arbitrary system</strong></td>
</tr>
<tr>
<td>Quality of an unit is the character of the same in terms of its eligibility defined and assumed needs.</td>
</tr>
<tr>
<td>➤ Following components are of note at reliability engineering: reliability, availability, maintainability and safety</td>
</tr>
<tr>
<td><strong>General</strong></td>
</tr>
<tr>
<td>A product is in general reliable, when it does not leave the user high and dry in daily use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value appreciation (2.14) helps to design relationships between people and systems to an advantage for organisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four areas of value appreciation are relevant for project management</td>
</tr>
<tr>
<td>1. <strong>Value appreciation of people</strong></td>
</tr>
<tr>
<td>➤ Skill to respect, understand, be interested in and articulate with sentiments, standpoints, values, emotions and statements from project relevant people.</td>
</tr>
<tr>
<td>➤ Operate on basis clear defined values, acceptance (respect, trust, tolerance, openness).</td>
</tr>
<tr>
<td>2. <strong>Existing value appreciation</strong></td>
</tr>
<tr>
<td>➤ Regardful handling and respect of changed things, systems, structures.</td>
</tr>
<tr>
<td>➤ Confirmation of former and actual strengths, success and potentials.</td>
</tr>
<tr>
<td>➤ Recognition of prime in humans and environment</td>
</tr>
<tr>
<td>➤ Take note on energy spending factors</td>
</tr>
<tr>
<td>3. <strong>Value appreciation on social systems</strong></td>
</tr>
<tr>
<td>➤ Explore, understand and a constructive/target oriented handling of values, interests and viewpoints of social systems (projects).</td>
</tr>
<tr>
<td>➤ Value adding meetings</td>
</tr>
<tr>
<td>➤ Motivation factors</td>
</tr>
<tr>
<td>➤ Delegation of guiding</td>
</tr>
<tr>
<td>➤ Teams as a valuable resource</td>
</tr>
<tr>
<td>4. <strong>Value appreciation in project + management</strong></td>
</tr>
<tr>
<td>➤ Projects as resource of learning and the strategic development of the organisation</td>
</tr>
<tr>
<td>➤ SWOT Analysis (Strength/Weakness/Opportunities/Threats)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ethics (2.15) is the interface to all elements for the ICB and shall avoid bribery, corruption, human rights abuse...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moral</strong> ➤ congeries of rules and norms which shall guide the action and are responsible for feeling guilty and disrespect if oneself by infringe upon them</td>
</tr>
<tr>
<td><strong>Ethic</strong> ➤ can be described in projects as follows:</td>
</tr>
<tr>
<td>➤ Instrumental reason (success) ➤ (technical + pragmatic dimension)</td>
</tr>
<tr>
<td><strong>Managerial responsibility</strong></td>
</tr>
<tr>
<td>➤ Ethical reason (moral) ➤ (moral dimension)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ethic in projects can be illustrated as follows:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 ➤ analysis</td>
</tr>
<tr>
<td>Phase 2 ➤ planning</td>
</tr>
<tr>
<td>Phase 3 ➤ contracting</td>
</tr>
<tr>
<td>Phase 4 ➤ executing</td>
</tr>
<tr>
<td>Phase 5 ➤ closing</td>
</tr>
<tr>
<td>Phase 6 ➤ earnings/use</td>
</tr>
</tbody>
</table>

**Figure 120: ICB 3.0 - Behavioural competence: values appreciation and ethics (developed by author)**

The third and last element of ICB 3.0 is contextual competence. This competence displays the relationship between project management and the strategy of the organisation. This is performed by illustrating the strategy of projects and products. The evaluation of the strategy is performed by earned value analysis and ranking in portfolios. For long-term targets, basic mid-term targets must be defined. These are realized by programmes.

In general there are three major strategies for products:

1. Products on all markets and sustaining the existing image.
2. Boost products on new markets.
3. New products for existing markets and develop an increase of image.

An overview of the content of the “contextual competences” and its methods for norming and evaluating a strategy are shown in Figure 121.
Contextual competence (3.00) in ICB 3.0 links project management with business strategy

A programme is like a project temporally restricted. Is the target fulfilled, the programme manager is released. A project portfolio is without a temporal restriction in principle, but changes its composition, as projects are closed or cancelled and new enterprises are started.

---

**Figure 121: ICB 3.0 - Contextual competence: overview contextual competence (developed by author)**

Project managers can be certified in four different levels on the ICB 3.0 by IPMA:

- Level A for project directors
- Level B for senior project managers
- Level C for project managers
- Level D for project management associates

For each level, a different expertise is needed as mentioned in the competences (technical, behavioural, contextual). These include understanding, knowledge, skill, and the ability to manage. An overview of the fields and the required level of expertise are shown in Table 33 (Gessler, 2009; Rother, 2009).
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<th>certification level</th>
<th>Shortcut</th>
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<td>legal</td>
<td>3.11</td>
<td>understand know skill skill manage</td>
<td></td>
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</tbody>
</table>

understand heard about the topic
know understanding of topic and possibility to follow the cross linking
skill adopt the acquisitioned knowledge to exercise
tasks are delegated and team is supported by execution and tasks might be checked at the end
manage

Table 33: Overview of the processes and the level of required expertise (Source: Gessler, 2009)
No prerequisites are required at the lowest level; however, some experience in project management is helpful. For Level C, at least three years of practical experience in a leading position is required. For the next level ICB 3.0 method, a minimum of five years of practical experience and three years in a leading position (e.g. project leader) are required. The highest certification Level, requires the same as in Level B with the additional requirement of experience in programme or portfolio management (Gessler, 2009; Giammalvo et al., 2005).

Recertification for the lowest level (Level D) is not necessary and is valid for an unlimited time period. The Levels C to A are valid for three and five years respectively and must be recertified (Giammalvo et al., 2005).

**ICB 3.0 – INTERNATIONAL COMPETENCE BASELINE – TARGET**

The goal of ICB 3.0 is to be a tireless advocate of effective project management practice, which should be used throughout all organisations (American Society for the Advancement of Project Management, 2011c). Project management promotes core competence in all professions. Competent performance of project management shall promote human welfare and effect a social change in thinking and acting. All associates holding a D-Level certification will achieve a high standard of ethics, conduct, and education (American Society for the Advancement of Project Management, 2011b).
APPENDIX XIII – IPMA – “NATIONAL COMPETENCE BASELINES (NCB)”

The IPMA has worldwide national member associations. These are allowed to develop their own competence baselines, called: National Competence Baseline (NCB). They base on the ICB (Yang, 2007). All NCB’s and/or their organisations are validated by the IPMA Certification Validation Management Board, they must include the core elements of the ICB (Cleland & Gareis, 2006). Table 34 shows the actual status of all IPMA member associations worldwide. Most of them have developed their own NCB (AFITEP, 2011; American Society for the Advancement of Project Management, 2011a; ANIMP, 2011; APDP, 2011; APOGEP, 2011; Association for Project Management, 2011; Association for Project Management in Bosnia and Herzegovian, 2011; Association for Project Management South Africa, 2011; Australian Institute of Project Management, 2011f; Azerbaijan Project Management Association, 2011; Brazilian Association for Project Management, 2011; Bulgarian Project Management Association, 2011; CPMS & CAPM, 2011; Danish Project Management Association, 2012; Gesellschaft für Projektmanagement, 2012; Institute of Project Management Ireland, 2011; International Project Management Association, 2011; Kazakhstan Project Management Association, 2011; Kuwait Society of Engineers, 2011; Latvian National Project Management Association, 2011; Lithuanian Project Management Association, 2011; MES Egypt, 2011; NFP, 2011; PM Greece, 2011; Project Management Association Finland, 2012; Project Management Association Hungary, 2011; Project Management Association of Canada, 2011; Project Management Association of Iceland, 2011; Project Management Association of Nepal, 2011; Project Management Association of Slovakia, 2011; Project Management Association of Zambia, 2011; Project Management Austria, 2011; Project Management Research Committee, 2011; Project Management Romania, 2011; SMAP, 2011; SMP, 2011; SOVNET, 2011; SPR, 2011; Swedish Project Management Society, 2011; Swiss project management association, 2011; Taiwan Project Management Association, 2011; Turkish Project Management Association, 2011; UPMA, 2011; Wolf, 2011; Yang, 2007; YUPMA, 2011; ZPM, 2011).
<table>
<thead>
<tr>
<th>Country</th>
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<td>lnppa.lv</td>
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<td>Lithuania</td>
<td>LPVA</td>
<td>Vilius</td>
<td>lpva.lt</td>
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<td>Morocco</td>
<td>MPMA</td>
<td>Morocco Association of Project</td>
<td>mpma.ma</td>
</tr>
<tr>
<td>Nepal</td>
<td>IPMAN</td>
<td>Kathmandu</td>
<td>pmn.org.np</td>
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<td>Netherlands</td>
<td>IPMA-NL</td>
<td>IPMA-NL, Netherlands</td>
<td>ipma.nl</td>
</tr>
<tr>
<td>Norway</td>
<td>NTP</td>
<td>Norwegian Association of Project</td>
<td>projektiedelse.org</td>
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<td>Peru</td>
<td>APPC</td>
<td>Lima</td>
<td>appc.pe</td>
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<td>Poland</td>
<td>SPMP</td>
<td>Polish Association of Project</td>
<td>ipmapoland.ni.com</td>
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<td>APOGEP</td>
<td>APOGEP - IPMA PORTUGAL</td>
<td>apec.gp.pt</td>
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<td>Romania</td>
<td>ARPM</td>
<td>Project Management Romania</td>
<td>pm.org.ro</td>
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<td>Russia</td>
<td>SOVNET</td>
<td>Russian PM Association</td>
<td>sovnet.ru</td>
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<td>Serbian Project Management Association</td>
<td>yupma.rs</td>
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<td>SSRP</td>
<td>PM Association of Slovakia</td>
<td>spsr.sk</td>
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<td>ZPM</td>
<td>Slovenia Project Management Association</td>
<td>zpm.si.com</td>
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<td>For Project Management South Africa</td>
<td>apmsa.org.za</td>
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<td>AEIPRO</td>
<td>asian espanola de ingeniera de</td>
<td>apmsa.org.ni.com</td>
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<td>Sweden</td>
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<td>Swedish Project Management Society</td>
<td>projektforum.se</td>
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<td>Swiss Project Management</td>
<td>spm.ch</td>
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<td>Societe suisse de Management de</td>
<td>projectmanagement.ch</td>
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<td>tvpma.org.tw</td>
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<td>Turkish Project Management Association</td>
<td>trpma.org</td>
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<td>UPMA</td>
<td>IPMA community in the Ukraine</td>
<td>upma.kiev.us</td>
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<td>United Kingdom</td>
<td>APM</td>
<td>Association for Project Management</td>
<td>apm.org.uk</td>
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<td>ASAPM</td>
<td>American Society for Project</td>
<td>ascapm.org</td>
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<td>Zambia</td>
<td>PMAZ</td>
<td>Project Management Association of</td>
<td>4cpm.net</td>
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</table>

Table 34: IPMA member associations worldwide with partly own NGB’S (developed by author)
APPENDIX XIV – PROJECT MANAGEMENT METHOD “NATIONAL COMPETENCY STANDARD FOR PROJECT MANAGEMENT (NCSPM) – AUSTRALIA”

**National Competency Standard for Project Management (NCSPM) – Australia – Facts**

<table>
<thead>
<tr>
<th>Year of Development/Foundation</th>
<th>Founded in 1978 as Project Managers Forum (PMF) It converted in 1989 to the Australian Institute of Project Management (AIPM) with the standard NCSPM.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>English</td>
</tr>
<tr>
<td>Origin in</td>
<td>Project Management</td>
</tr>
<tr>
<td>Legal rights by</td>
<td>The rights of the standard are not at the AIPM, but the Government institutions Innovation &amp; Business Skills Australia (IBSA) and National Training Information System (NTIS)</td>
</tr>
<tr>
<td>Certification</td>
<td>CPPD (Certified Practising Project Director)</td>
</tr>
<tr>
<td></td>
<td>CCPM (Certified Practising Project Project Manager)</td>
</tr>
<tr>
<td></td>
<td>CPPP (Certified Practising Project Practitioner)</td>
</tr>
<tr>
<td>Standards</td>
<td>ISO 21500</td>
</tr>
<tr>
<td>Country</td>
<td>Australia (Northern Territory, Western Australia, South Australia, New South Wales, Tasmanian, Queensland)</td>
</tr>
<tr>
<td>Members Worldwide</td>
<td>&gt;10,000 members worldwide, whereas 3,800 are AQF (Australian Qualification Framework) approved</td>
</tr>
<tr>
<td>Associated companies with NSCPM</td>
<td>NSW Public Work, JACOBS, AUREcon, ARUP, BAE Systems Australia, Brisbane City Council, Queensland Rail, Thales Australia, Telstra Corporation, AXA Australia, BOEING, ANZ Banking Group, Fuji Xerox Australia, ...</td>
</tr>
</tbody>
</table>
**National Competency Standard for Project Management (NCSPM) – Australia – History**

The Australian Institute of Project Management (AIPM) was originally founded in 1978 as the Project Managers Forum (PMF). The name was changed in 1989. In 1990, AIPM published a standard registration process for project management (RegPM). It was later transformed into training packages that were aligned to the Australian Qualification Framework (AQF) and the possibility of certification (Australian Institute of Project Management, 2011d; Cleland & Gareis, 2006). In the same year, AIPM added the code of ethics to the standard. With an increasing experience in certified project management, AIPM started in 1992 to develop an Australian National Competency Standard for Project Management (NCSPM), which was endorsed by the Australian government in 1996 (Cleland & Gareis, 2006). Slight modifications of this standard were performed in 2004 and incorporated into the BSB01, a business service training package provided by the governmental institutions; Innovation & Business Skills Australia (IBSA) and National Training Information System (NTIS) (Australian Institute of Project Management, 2011c). In 2007, the new standard of the IBSA and NTIS was published as BSB07 with updates of knowledge groups, processes, and a major modification adding employability skills (Australian Institute of Project Management, 2011c; Innovation & Business Skills Australia, 2008). Those were originally developed by the Business Council of Australia (BCA) and the Australian Chamber of Commerce and Industry (ACCI) in consultation with the Department of Education, Service and Training (DEST) and Australian National Training Authority (ANTA) in 2002. Industry requested that employability skills be integrated into the BSB07 (Innovation & Business Skills Australia, 2008).

A strategic alliance with the IPMA (page 290) was performed in 2010 when the AIPM hosted the 25th IPMA world congress in Darwin, Australia (Australian Institute of Project Management, 2011e).

**National Competency Standard for Project Management NCSPM – Australia – Motivation**

Project managers are motivated to pursue certification from the AIPM in order to improve skills and recognize competencies of project team members, managers, and direc-
tors in Australia. They all have a key role in achieving projects and, therefore business objectives. With a certified expertise it is possible to recognize the excellence of project management and gain awareness and support of project management as a profession (Australian Institute of Project Management, 2011a). Certified project managers help at all levels of industry, government, and the community by demonstrating that project management is a preferred process for achieving objectives (Giammalvo et al., 2005).

In addition to the viewpoint of AIPM, the motivation is to promote and improve the profession of project management in Australia (Giammalvo et al., 2005). AIPM describes itself as the largest project management organisation in Australia. AIPM’s training aligns with a professional recognition body (Australian Institute of Project Management, 2011a).

**National Competency Standard for Project Management (NCSPM) – Australia – Method**

The NCSPM standard is a performance-based competency standard. It describes the field of action as well as knowledge and understanding of one’s occupation, which users can expect for underpinning their role (Morris & Pinto, 2007; Ohara & Asada, 2009). The basis for the NCSPM standard that is integrated in the BSB0, originally comes from the Project Management Institute Body of Knowledge – PMBoK. The PMBoK with its processes groups and knowledge areas as described in Appendix IX – Project Management Method “Project Management Institute” (PMI).

Three different levels of certification exist in the NCSPM standard and are published in the most recent BSB07:

1. BSB41507 Certificate IV (level4), which is the Certified Practising Project Practitioner (CPPP) at the AIPM and useful for project team members (Australian Government - Department of Education and Training, 2010).
2. BSB51407 Diploma of project management (level5), which is the Certified Practising Project Manager (CPPM) at the AIPM and useful for project leader (Australian Government - Department of Education and Training, 2010).
3. BSB60707 Advanced diploma of project management (level6), which is the Certified Practising Project Director (CPPD) at the AIPM and useful for branch section
leader and programme managers (Australian Government - Department of Education and Training, 2010).

The prerequisites as well as the knowledge areas increase with each level (Australian Government - Department of Education and Training, 2010). Both the prerequisites and the different certification levels are shown in Figure 122.

Figure 122: AIPM - Certification level, prerequisites and knowledge areas (developed by author)

The Business Service Training Package (BSB) is controlled and modified by the IBSA and NTIS. They offer many different courses for business and management in fields of sales, project management, and procurement. Therefore, each project management certification level has a coding like BSB41507 or BSB51407 (IBSA (Innovation & Business Skills Australia, 2007).

More than 30 single process steps exist for each certification level covering all knowledge areas in project management. Knowledge areas differ slightly between the certification levels. The process steps in each certification level are distinguished for project practitioners by knowing the techniques, for project managers by managing the
processes, and for project leaders by directing them. An overview of all processes and knowledge areas in the different certification levels of project management is shown in Table 35.

<table>
<thead>
<tr>
<th>No° process</th>
<th>Certification level Knowledge area</th>
<th>No° process</th>
<th>No° process</th>
<th>No° process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 agree and establish life cycle reporting and measurement systems</td>
<td>Certified Practising Project Practitioner (CPPP)</td>
<td>1 direct integration of all function of project management</td>
<td>Certified Practising Project Manager (CPPM)</td>
<td>2 direct the internal programme/project environment to meet external needs and expectations</td>
</tr>
<tr>
<td>2 manage integration of all project management functions</td>
<td></td>
<td>3 guide and direct programme/projects throughout project life cycles</td>
<td>Certified Practising Project Director (CPPD)</td>
<td>4 define, plan and direct programme/project scope throughout life cycle</td>
</tr>
<tr>
<td>3 coordinate internal and external environments</td>
<td></td>
<td></td>
<td></td>
<td>5 direct programme/project scope change activities</td>
</tr>
<tr>
<td>4 implement project activities throughout life cycle</td>
<td></td>
<td></td>
<td></td>
<td>6 direct scope change activities</td>
</tr>
<tr>
<td>5 assess project integration outcomes</td>
<td></td>
<td></td>
<td></td>
<td>7 contribute to quality requirements</td>
</tr>
<tr>
<td></td>
<td>Certified Practising Project Practitioner (CPPP)</td>
<td></td>
<td>Certified Practising Project Manager (CPPM)</td>
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<td></td>
<td>Certified Practising Project Director (CPPD)</td>
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</table>

<table>
<thead>
<tr>
<th>No° process</th>
<th>Knowledge area</th>
<th>No° process</th>
<th>No° process</th>
<th>No° process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 contribute to scope definition</td>
<td>Integration</td>
<td>1 define the project context</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 apply project scope controls</td>
<td></td>
<td>2 guide the development of project scope definition activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 contribute to the development of project schedules</td>
<td>Scope</td>
<td>3 implement scope controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 monitor agreed schedule</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 update agreed schedule</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 contribute to implementation of project schedules</td>
<td>Time</td>
<td>6 participate in assessing time management outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 participate in assessing time management outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 contribute to the development of project budget</td>
<td>Cost</td>
<td>8 determine project schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 monitor project costs</td>
<td></td>
<td>9 implement project schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 contribute to project budget reconciliation process</td>
<td></td>
<td>10 assess time management outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 contribute to quality planning</td>
<td>Quality</td>
<td>11 determine project budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 apply quality policies and procedures</td>
<td></td>
<td>12 monitor and control projects budget and cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 contribute to continuous improvement process</td>
<td></td>
<td>13 conduct project financial completion activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 assist with determination of human resource requirements</td>
<td>Human Resources</td>
<td>14 determine quality requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 establish and maintain productive working relationships</td>
<td></td>
<td>15 implement quality assurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 contribute to team building</td>
<td></td>
<td>16 implement project quality improvements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 assist with human resource control</td>
<td></td>
<td>17 implement human resource and stakeholder planning activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 contribute to conclusion of human resource practices</td>
<td></td>
<td>18 implement staff training and development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 manage the project team and stakeholders</td>
<td></td>
<td>19 manage the project team and stakeholders</td>
<td></td>
<td></td>
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<tr>
<td>20 assess human resource outcomes</td>
<td></td>
<td>20 assess human resource outcomes</td>
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</tr>
</tbody>
</table>
Table 35: AIPM - Guide to NCSPM-Levels (source: derived from AIPM)

Each definition of NCSPM level contains a guideline of the knowledge areas and is described by the following:

- Range statements:
  “The Range Statements adds definition to the unit by elaborating critical or significant aspects of the performance requirements of the unit. The Range Statement establishes the range of indicative meanings or applications of these requirements in different operating contexts and conditions.” (Australian National Training Authority, 2003c, p. 13).

Plans, objectives, activities, tools, and charts are defined in those statements.

- Evidence Guide:
  “Evidence Guide provides advice to inform and support appropriate assessment of this unit. It contains an overview of the assessment requirements followed by identification of specific aspects of evidence that will need to be addressed in determining competence. The Evidence Guide is an integral part of the unit and should be read and interpreted in conjunction with the other components of competency.”

It defines mainly: required knowledge and understanding, skills and attributes, key competences or generic skills, integrated competency assessment, resource implications for assessment, validity and sufficiency of required evidence, and
products/processes that can be used as an evidence (Australian National Training Authority, 2003a, 2003b, 2003c).

- Processes and sub-processes
  Each knowledge group of the certification levels contains processes. These are divided into sub-processes, as shown for the Level CPPM in Table 36 with approximately 97 sub-processes (Australian National Training Authority, 2003b).

<table>
<thead>
<tr>
<th>certification level</th>
<th>Knowledge area</th>
<th>Certified Practising Project Manager (CPPM)</th>
</tr>
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<td>Integration</td>
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<td>Quality</td>
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</table>
Table 36: AIPM - processes and sub-processes of CPPM certification (developed by author)

Since 2008, employability skills have been defined for each certification level as requested by industry. These were defined by BCA and ACCI and incorporated into the BSB07. They contain skills in: communication, teamwork, problem solving, initiative/enterprise, planning and organizing, self management, learning, and technology (Australian National Training Authority, 2003a, 2003b, 2003c).
Since 2005, AIPM has required recertification by CPD every three years. This includes certified practitioners, managers, and directors of project management a recertification (continuous professional development). The key features of CPD are:

- Continuous use of certified project management knowledge in practitioners work life
- Professional and organisational focus
- Broadly based on the development of knowledge, skills, and personal qualities
- Structured – systematic maintenance, improvement, and a broad skill base

CPD activities are rated with credits. Evidence must be proven. Credits are marked by AIPM. Figure 123 displays the recertification for each level (Australian Institute of Project Management, 2011b; Cleland & Gareis, 2006).

![Figure 123: AIPM - recertification requirements in a three-year cycle (developed by author)](image)

To get a higher certification level, an assessor qualified by AIPM must be contacted. (Australian Institute of Project Management, 2011b).

**National Competency Standard for Project Management NCSPM – Australia – Target**

The target of AIPM is to provide managers a valued service in standardized project management in Australia. Therefore, they assist members in becoming informed about making a suitable decision regarding professional development. AIPM supports the mainte-
nance of the standard NCSPM owned by the IBSA and NTIS that are in line with the AIPM competency/recognition framework. They also encourage service providers to embrace best practices in project management and provide professional development activities aligned with the NCSPM (Australian Institute of Project Management, 2011a).
**APPENDIX XV – PROJECT MANAGEMENT METHOD “PROJECT MANAGEMENT STANDARDS GENERATING BODY (PMSGB) – SOUTH AFRICA”**

**Project Management Standards Generating Body (PMSGB) – South Africa – Facts**

<table>
<thead>
<tr>
<th><strong>Year of Development/Foundation</strong></th>
<th><strong>In 1997 the PMSA (Project Management South Africa) was founded by members of the PMI Chapter South Africa. PMSGB (Project Management Standards Generating Body) was released as a standard in 1999 and adopted to the NQF (National Qualification Framework) in 2000 and to SAQA in 2001 (South African Qualification Authority).</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Language</strong></td>
<td><strong>English</strong></td>
</tr>
<tr>
<td><strong>Origin in</strong></td>
<td><strong>Project Management</strong></td>
</tr>
<tr>
<td><strong>Legal Rights by</strong></td>
<td><strong>South African Qualification Authority (SAQA)</strong></td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td><strong>According to National Qualification Framework (NQF):</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Level 3: Project Support Service Certificate</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Level 4: Generic Project Management Certificate</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Level 5: Project Management Diploma</strong></td>
</tr>
<tr>
<td><strong>Standards</strong></td>
<td><strong>ISO 21500</strong></td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td><strong>South Africa with branches in:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Kwa Zulu-Natal, Western Cape, Johannesburg, Tshwane</strong></td>
</tr>
<tr>
<td><strong>Members Worldwide</strong></td>
<td><strong>1,200 (status 2003)</strong></td>
</tr>
<tr>
<td><strong>Associated Companies with PMSGB</strong></td>
<td><strong>-</strong></td>
</tr>
</tbody>
</table>
The Project Management South Africa (PMSA) was founded in 1997 by members of the PMI Chapter South Africa. The reason for founding the PMSA organisation was the high fee for the PMI membership (Morris, 2007a). The South African Chapter of PMI has been in existence since 1982 and is closely related to the recently founded PMSA (Morris, 2007a; Project Management South Africa, 2011b). The Ministry for Public Works in South Africa challenged PMSA in the year of founding to assist the government and country to develop an effective standard of project management. The Project Management Standard Generating Body (PMSGB) was formed (Project Management South Africa, 2011b). The new standard was initiated in 1998 and released in 1999. In 2000, the PMSGB was officially published in the National Standards Body within the rubric: Business, Commerce and Management Skills. Originally a certification system with Levels 4 to 7 (in 2001 enlarged by Level 3) was planned based on the National Qualification Framework (NQF) (Project Management South Africa, 2011a). In the NQF, today only the Levels 3 to 5 exist, but work is currently proceeding for higher levels (South African Qualifications Authority, 2001).

South African users are particularly motivated to pursue one of three levels of certification by the SAQA. They gain valid competences in project management and receive a qualification. Generally, they build up a generic competence covering project management aspects (South African Qualifications Authority, 2001).

Like the NCSPM standard, the PMSGB standard is a performance-based competency standard. It describes the field of action well as knowledge and an understanding an individual’s occupation, which users can expect to improve their role (Morris & Pinto, 2007; Ohara & Asada, 2009).

Founded by members of the PMI Chapter South Africa, the standard contains mainly the knowledge areas of PMI with some modifications (Project Management South Africa, 2011c):
– project management framework
– project integration management
– project scope management
– project time management
– project financial management
– project risk management
– project communication management
– project human resource management
– project procurement management
– project quality management

The PMI was not the only basis for the PMSGB, knowledge was gained from the ICB, AIPM and Association of Project Management United Kingdom (APM UK) was used. PMSGB was influenced by government endorsed standards and qualification framework of the SAQA (Morris & Pinto, 2007). The content of each certification level is weighted in fundamental, core, and elective components. Single components are rated with a specific amount of credits. Contents of the different Levels of the PMSGB are shown in the following (South African Qualifications Authority, 2011a, 2011b, 2011c):
Level 3 – Project Support Service Certificate is the lowest certification (South African Qualifications Authority, 2011a).

A total sum of 136 credits must be achieved from selected components of the Level 3 certification shown in Table 37.

<table>
<thead>
<tr>
<th>Level 3 Fundamental Component</th>
<th>Credits: 36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td></td>
</tr>
<tr>
<td>• Accommodate audience and context needs in oral/signed communication</td>
<td></td>
</tr>
<tr>
<td>• Demonstrate an understanding of the use of different number bases and measurement units and an awareness of error in the context of relevant calculations</td>
<td></td>
</tr>
<tr>
<td>• Describe, apply, analyse and calculate shape and motion in 2- and 3-dimensional space in different contexts</td>
<td></td>
</tr>
<tr>
<td>• Interpret and use information from texts</td>
<td></td>
</tr>
<tr>
<td>• Investigate life and work related problems using data and probabilities</td>
<td></td>
</tr>
<tr>
<td>• Use language and communication in occupational learning programmes</td>
<td></td>
</tr>
<tr>
<td>• Use mathematics to investigate and monitor the financial aspects of personal, business and national issues</td>
<td></td>
</tr>
<tr>
<td>• Write/present/sign texts for a range of communicative contexts</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 3 Core Component</th>
<th>Credits: 88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td></td>
</tr>
<tr>
<td>• Apply basic business ethics in environment</td>
<td></td>
</tr>
<tr>
<td>• Apply health and safety to a work area</td>
<td></td>
</tr>
<tr>
<td>• Demonstrate an understanding of HIV/AIDS and its implications</td>
<td></td>
</tr>
<tr>
<td>• Understand/apply personal values and ethics</td>
<td></td>
</tr>
<tr>
<td>• Demonstrate an understanding of and provide assistance for risk analysis functions</td>
<td></td>
</tr>
<tr>
<td>• Demonstrate knowledge and understanding of the project and the project support services environment</td>
<td></td>
</tr>
<tr>
<td>• Demonstrate understanding of employment relations in an organisation</td>
<td></td>
</tr>
<tr>
<td>• Explain and apply quality control procedures</td>
<td></td>
</tr>
<tr>
<td>• Explain and provide assistance for project estimating service functions</td>
<td></td>
</tr>
<tr>
<td>• Explain the quality, time and cost parameter of project/obtain change request authorisations</td>
<td></td>
</tr>
<tr>
<td>• Gather information and provide assistance for project planning and scheduling functions</td>
<td></td>
</tr>
<tr>
<td>• Manage time and the work process in a business environment</td>
<td></td>
</tr>
<tr>
<td>• Measure and plan own performance and behaviour in line with roles and responsibilities in a project team</td>
<td></td>
</tr>
<tr>
<td>• Provide assistance for cost control functions</td>
<td></td>
</tr>
<tr>
<td>• Describe and apply the management functions of an organization/Function in a team</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 3 Elective Component</th>
<th>Credits: 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td></td>
</tr>
<tr>
<td>• Identify and maintain the types of records required in own industry and understand why it is necessary to create evidence and maintain confidentiality</td>
<td></td>
</tr>
<tr>
<td>• Maintain an existing information system in a business environment</td>
<td></td>
</tr>
<tr>
<td>• Demonstrate basic accounting concepts</td>
<td></td>
</tr>
<tr>
<td>• Plan, monitor and control an information system in a business environment</td>
<td></td>
</tr>
<tr>
<td>• Use a Graphical User Interface (GUI)-based presentation application to enhance presentation appearance</td>
<td></td>
</tr>
<tr>
<td>• Use a Graphical User Interface (GUI)-based spreadsheet application to solve a given problem</td>
<td></td>
</tr>
<tr>
<td>• Use a GUI-based word processor to create merged documents</td>
<td></td>
</tr>
<tr>
<td>• Use a GUI-based word processor to enhance a document through the use of tables and columns</td>
<td></td>
</tr>
</tbody>
</table>

Table 37: PMSGB - content level 3 qualification (source: derived from South African Qualification Authority 2011b)
The Generic Project Management Certificate is a mid-level certification of the PMSGB (South African Qualifications Authority, 2011b). A total sum of 146 credits must be achieved from selected components of the Level 4 certification shown in Table 38.

<table>
<thead>
<tr>
<th>Level 4 Fundamental Component</th>
<th>Credits: n.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td></td>
</tr>
<tr>
<td>• Accommodate audience and context needs in oral communication</td>
<td></td>
</tr>
<tr>
<td>• Interpret/use information from texts</td>
<td></td>
</tr>
<tr>
<td>• Use language and communication in occupational learning programmes</td>
<td></td>
</tr>
<tr>
<td>• Write texts for a range of communicative contexts</td>
<td></td>
</tr>
<tr>
<td>• Apply knowledge of statistics and probability to critically interrogate and effectively communicate findings on life related problems</td>
<td></td>
</tr>
<tr>
<td>• Engage in sustained oral communication and evaluate spoken texts</td>
<td></td>
</tr>
<tr>
<td>• Measure, estimate &amp; calculate physical quantities &amp; explore, critique &amp; prove geometrical relationships in 2 and 3 dimensional space in the life and workplace of adult with increasing responsibilities</td>
<td></td>
</tr>
<tr>
<td>• Read, analyse, respond to variety of texts</td>
<td></td>
</tr>
<tr>
<td>• Use language and communication in occupational learning programmes</td>
<td></td>
</tr>
<tr>
<td>• Use mathematics to investigate and monitor the financial aspects of personal, business, national and international issues</td>
<td></td>
</tr>
<tr>
<td>• Write for a wide range of contexts</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 4 Core Component</th>
<th>Credits: n.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td></td>
</tr>
<tr>
<td>• Provide assistance in implementing and assuring project work is conducted in accordance with the project quality plan</td>
<td></td>
</tr>
<tr>
<td>• Apply a range of project management tools</td>
<td></td>
</tr>
<tr>
<td>• Conduct project documentation management to support project processes</td>
<td></td>
</tr>
<tr>
<td>• Contribute to project initiation, scope definition and scope change control</td>
<td></td>
</tr>
<tr>
<td>• Contribute to the management of project risk within own field of expertise</td>
<td></td>
</tr>
<tr>
<td>• Fulfil procurement activities and supervise procurement administration</td>
<td></td>
</tr>
<tr>
<td>• Identify, organise and co-ordinate project life cycle phases for control purposes</td>
<td></td>
</tr>
<tr>
<td>• Identify, suggest and implement corrective actions to improve quality</td>
<td></td>
</tr>
<tr>
<td>• Implement required project administration</td>
<td></td>
</tr>
<tr>
<td>• Monitor, evaluate and communicate project schedules</td>
<td></td>
</tr>
<tr>
<td>• Participate in the estimation and preparation of cost budgets for an element of work and monitor and control actual cost against budget</td>
<td></td>
</tr>
<tr>
<td>• Plan, organise and support project meetings and workshops</td>
<td></td>
</tr>
<tr>
<td>• Schedule project activities for effective execution</td>
<td></td>
</tr>
<tr>
<td>• Work as a project team member</td>
<td></td>
</tr>
<tr>
<td>• Evaluate/improve the project team’s performance</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 4 Elective Component</th>
<th>Credits: n.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td></td>
</tr>
<tr>
<td>• Supervise a project team of a business project to deliver project objectives</td>
<td></td>
</tr>
<tr>
<td>• Supervise a project team of a developmental project to deliver project objectives</td>
<td></td>
</tr>
<tr>
<td>• Supervise a project team of a technical project to deliver project objectives</td>
<td></td>
</tr>
</tbody>
</table>

Table 38: PMSGB - content level 4 qualification (source: derived from South African Qualification Authority 2011a)
- **Level 5** – Project Management Diploma is the highest certification of the PMSGB (South African Qualifications Authority, 2011c).

A total sum of 247 credits must be achieved from selected components of the Level 5 certification shown in Table 39.

### Table 39: PMSGB - content level 5 qualification (source: derived from South African Qualification Authority 2011c)

The components of each level are summarized in Table 40.
<table>
<thead>
<tr>
<th>Certification level</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core component (CC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.1 - Apply basic business ethics in environment</td>
<td>CC4.1 - Provide assistance in implementing and assuring project work is conducted in accordance with the project quality plan</td>
<td>CC5.1 - Demonstrate knowledge/ application of ethical conduct</td>
<td></td>
</tr>
<tr>
<td>CC3.2 - Apply health and safety to a work area</td>
<td>CC4.2 - Apply a range of project management tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.3 - Demonstrate an understanding of HIV/AIDS and its implications</td>
<td>CC4.3 - Conduct project documentation management to support project processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.4 - Understand/ apply personal values and ethics</td>
<td>CC4.4 - Contribute to project initiation, scope definition and scope change control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.5 - Demonstrate an understanding of and provide assistance for risk analysis functions</td>
<td>CC4.5 - Contribute to the management of project risk within own field of expertise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.6 - Demonstrate knowledge and understanding of the project and the project support services environment</td>
<td>CC4.6 - Fulfil procurement activities and supervise procurement administration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.7 - Demonstrate understanding of employment relations in an organisation</td>
<td>CC4.7 - Identify, organise and coordinate project life cycle phases for control purposes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.8 - Explain and apply quality control procedures</td>
<td>CC4.8 - Identify, suggest and implement corrective actions to improve quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.9 - Explain and provide assistance for project estimating service functions</td>
<td>CC4.9 - Implement required project administration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.10 - Explain the quality, time and cost parameter of project/ obtain change request authorisations</td>
<td>CC4.10 - Monitor, evaluate and communicate project schedules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.11 - Gather information and provide assistance for project planning and scheduling functions</td>
<td>CC4.11 - Participate in the estimation and preparation of cost budgets for an element of work and monitor and control actual cost against budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.12 - Manage time and the work process in a business environment</td>
<td>CC4.12 - Plan, organise and support project meetings and workshops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.13 - Measure and plan own performance and behaviour in line with roles and responsibilities in a project team</td>
<td>CC4.13 - Schedule project activities for effective execution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.14 - Provide assistance for cost control functions</td>
<td>CC4.14 - Work as a project team member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC3.15 - Describe and apply the management functions of an organization/ function in a team</td>
<td>CC4.16 - Evaluate/ improve the project team's performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamental component (FC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC3.1 - Accommodate audience and context needs in oral/ signed communication</td>
<td>FC4.1 - Accommodate audience and context needs in oral communication</td>
<td>FC5.1 - Access, process, adapt and use data from a wide range of texts</td>
<td></td>
</tr>
<tr>
<td>FC3.2 - Demonstrate an understanding of the use of different number bases and measurement units and an awareness of error in the context of relevant calculations</td>
<td>FC4.2 - Interpret/ use information from texts</td>
<td>FC5.2 - Provide and respond to feedback</td>
<td></td>
</tr>
<tr>
<td>FC3.3 - Describe, apply, analyse and calculate shape and motion in 2- and 3-dimensional space in different contexts</td>
<td>FC4.3 - Use language and communication in occupational learning programmes</td>
<td>FC5.3 - Use communication techniques effectively</td>
<td></td>
</tr>
<tr>
<td>FC3.4 - Interpret and use information from texts</td>
<td>FC4.4 - Write texts for a range of communicative contexts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC3.5 - Investigate life and work related problems using data and probabilities</td>
<td>FC4.5 - Apply knowledge of statistics and probability to critically interrogate and effectively communicate findings on life related problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC3.6 - Use language and communication in occupational learning programmes</td>
<td>FC4.6 - Engage in sustained oral communication and evaluate spoken texts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC3.7 - Use mathematics to investigate and monitor the financial aspects of personal, business and national issues</td>
<td>FC4.7 - Measure, estimate &amp; calculate physical quantities &amp; explore, critique &amp; prove geometrical relationships in 2 and 3 dimensional space in the life and workplace of adult with increasing responsibilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC3.8 - Write/ present/ sign texts for a range of communicative contexts</td>
<td>FC4.8 - Read, analyse, respond to variety of texts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FC4.9 - Use language and communication in occupational learning programmes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FC4.10 - Use mathematics to investigate and monitor the financial aspects of personal, business, national and international issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FC4.11 - Write for a wide range of contexts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The current certification levels of PMSGB are similar to the qualification of NCSPM (L. Crawford, 2002; Dinsmore & Cabanis-Brewin, 2011; Morris & Pinto, 2007; South African Qualifications Authority, 2011a, 2011b, 2011c). This is shown in Figure 124.
Targets differ in each level of the PMSGB as well as in the focus groups and the prerequisites. At level 3, the certified person gains an understanding of self-management and the ability to perform support service as a project team member. In level 4, basic skills and competences of project management for executing small and simple projects or assisting project managers of large projects will be achieved. Level 5, the highest level, has the target to educate people to plan and manage complex projects. The project leader has broad knowledge of tools, methods, and skills and is responsible for the output of the project team. Details and target groups as well as prerequisites for each certification level are shown in Table 41 (South African Qualifications Authority, 2011a, 2011b, 2011c).
<table>
<thead>
<tr>
<th>Target of Level 3 qualification</th>
<th>Target of Level 4 qualification</th>
<th>Target of Level 5 qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prerequisites:</strong> none</td>
<td><strong>Prerequisites:</strong> Level 3 or equivalent accepted by the SAQA</td>
<td><strong>Prerequisites:</strong> Level 4 or equivalent accepted by the SAQA</td>
</tr>
<tr>
<td><strong>Primary purpose:</strong></td>
<td><strong>Primary purpose:</strong></td>
<td><strong>Primary purpose:</strong></td>
</tr>
<tr>
<td>• An understanding of self-</td>
<td>• A foundation of basic project</td>
<td>• Plan, establish and manage a simple to moderately complex project and project team whilst using a variety of routine and non-routine processes.</td>
</tr>
<tr>
<td>management and personal</td>
<td>management skills which can be used to build further project management related competencies.</td>
<td>• Select from a wide choice of standard and non-standard procedures.</td>
</tr>
<tr>
<td>behaviour in an organisational</td>
<td>• Competence to be an effective project team member Competence to execute small, simple projects.</td>
<td>• Take full responsibility for the nature, quantity and quality of output.</td>
</tr>
<tr>
<td>environment.</td>
<td>• Competence to provide assistance to a project manager of large projects.</td>
<td>• Take responsibility for group output as required.</td>
</tr>
<tr>
<td>• An understanding of business</td>
<td>• Competence to provide assistance to a project manager of large projects.</td>
<td>• Show possession of a wide range of scholastic and/or technical skills applicable in the field of project management.</td>
</tr>
<tr>
<td>ethics and practices and how</td>
<td>• Competence to provide assistance to a project manager of large projects.</td>
<td></td>
</tr>
<tr>
<td>to function as a team member.</td>
<td>• Competence to perform support service functions in a project team.</td>
<td></td>
</tr>
<tr>
<td>• Competence to perform support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>service functions in a project</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Target group:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• People who work in the Project Support Services environment.</td>
<td>• Working as a contributing team member on a medium to large project</td>
<td>• people with prior project work experience.</td>
</tr>
<tr>
<td>• Understanding and awareness</td>
<td>• Working as a leader in the context of a small project / sub-project involving few resources</td>
<td>• add value to learners operating their own business.</td>
</tr>
<tr>
<td>of challenges facing in the</td>
<td>• person may be working part time or full time with projects</td>
<td>• person to manage, co-ordinate or support simple to moderately complex projects in any sector.</td>
</tr>
<tr>
<td>process of providing support to</td>
<td></td>
<td>• project leaders/coordinators and project managers.</td>
</tr>
<tr>
<td>a project.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 41: PMSGB - Targets and focus groups (source: South African Qualification Authority 2011a, 2011b, 2011c)
The Deutsches Institut für Normung (DIN) organisation was originally founded as Nationaler Norm-Ausschuss der Deutschen Industrie (NADI) in 1917. Seven years later the NADI established their own publishing house, Beuth Verlag, for printing and publishing Norms. During the Nazi Regime, the name was changed to Deutscher Norm-Ausschuss DNA. In 1951, DNA became a member of the International Standardisation Organisation (ISO), which represented a major step in its worldwide acceptance. The DNA (now DIN)
is responsible exclusively for German norms. In 1975 the DNA adopted the former name DIN (Deutsches Institut für Normung, 2011a, 2011b).

In 1987, the original DIN69901-1 and DIN69901-2 for project management were developed and released. A committee for project management expanded the DIN69901 by three parts (methods, data & data model and nomenclature). In 2009, it was released by the NQSZ (Normen-Ausschuss, Qualitätsmanagement, Statistik und Zertifizierungsgesellschaft) (Beuth, 2012b).

**Deutsches Institut für Normung – DIN69900 and DIN69901 – Motivation**

DIN69900/ DIN69901 are valid for small and simple projects, as well as large and complex projects. A common understanding of project management is provided by a universally standardized nomenclature of terms and definitions (Beuth, 2012b). These norms use a common technical language worldwide and serve to decrease obstacles. The DIN norm is a source of technical know-how and assists with the transfer of technology. Therefore, it protects health, safety, and environment (Deutsches Institut für Normung, 2011c).

**Deutsches Institut für Normung – DIN69900 and DIN69901 – Method**

The DIN69901 provides frameworks for handling projects, rather than detailed instructions. Therefore, the DIN69901 is more a outline and guideline and does not offer certifications for project management.

It is focused on operative project management. It does not observe the strategic viewpoint (T. Mayer et al, 2008). The actual norm consists of five parts: basics, processes, methods, data and data modelling, and nomenclature. They are linked, but the part “processes” is the core element connecting all other parts shown in Figure 125 (Deutsches Institut für Normung, 2009).
Figure 125: DIN69901 - linking of single parts of the DIN (source: DIN, 2009)

The content of each part is briefly described as follows:

- DIN69901-1: Basics (Beuth, 2012a; Deutsches Institut für Normung, 2009)
  - Area of use
  - Project management nomenclature
  - Basics of project management systems (targets of using a system, expectation and support of the responsible organisation)

- DIN69901-2: Processes (Beuth, 2011a; Deutsches Institut für Normung, 2009)
  - Description of all phases within a project: initiating, definition, planning, steering, closure
  - Listing of all necessary processes which are shown in Table 42 (the minimum required processes are shown in bold type)
  - Linking of each process within a project phase
  - Description of each process with its successor, processor, used project management methods, and background information and why the process is performed and the handling of the processes

- DIN69901-3: Methods (Beuth, 2011b; Deutsches Institut für Normung, 2009)
  - All methods and their purpose are described in the field of: cost estimation, project controlling, project benchmark, project organisation/ structuring and field of usage

- DIN69901-4: Data and data model (Beuth, 2011c; Deutsches Institut für Normung, 2009)
Definition of the data model for software of project management

Helpful guideline for developers and organisations that want to implement and improve a software for project management

The basis of project management software contains mainly data of project, product, operating profit, schedule, resources (like personal data, planning and management), reporting, cost management, documents, milestones, and evaluation systems

DIN69901-5: nomenclature (Beuth, 2011d; Deutsches Institut für Normung, 2009)

Definition and explanation of project management terms
<table>
<thead>
<tr>
<th>Process group</th>
<th>Knowledge area</th>
<th>initiating</th>
<th>definition</th>
<th>planning</th>
<th>steering</th>
<th>closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule</td>
<td></td>
<td>0.1.1 define milestone</td>
<td>P.1.1 plan activities</td>
<td>P.1.2 create schedule</td>
<td>S.1.1 start activities</td>
<td>S.1.2 guide and control target dates</td>
</tr>
<tr>
<td>changes</td>
<td></td>
<td>P.1.3 create project plan</td>
<td>P.1.4 plan handling of changes</td>
<td>S.2.1 guide and control changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>information/ documentation/ communication</td>
<td></td>
<td>P.3.1 define information, communication and reporting</td>
<td>P.3.1 plan information, communication and reporting</td>
<td>S.3.1 guide and control information, communication and reporting</td>
<td>A.3.1 create project finalisation documentation</td>
<td></td>
</tr>
<tr>
<td>cost and finance</td>
<td></td>
<td>P.3.2 define project marketing</td>
<td>P.3.2 issue release</td>
<td>S.3.2 issue acceptance</td>
<td>A.3.2 archive project documentation</td>
<td></td>
</tr>
<tr>
<td>organisation</td>
<td></td>
<td>0.4.1 rough estimation of costs</td>
<td>P.4.1.1 create finance and cost planning</td>
<td>S.4.1 guide and control costs and finance</td>
<td>A.4.1 create final project calculation for project closure</td>
<td></td>
</tr>
<tr>
<td>quality</td>
<td></td>
<td>0.5.1 form project core team</td>
<td>P.5.1 plan project organisation</td>
<td>S.5.1 perform project kick-off</td>
<td>A.5.1 perform final project closure meeting</td>
<td></td>
</tr>
<tr>
<td>resources</td>
<td></td>
<td>0.6.1 define success criteria</td>
<td>P.6.1 plan quality assurance</td>
<td>S.6.1 perform quality control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>risk</td>
<td></td>
<td>0.8.1 define handling of risks</td>
<td>P.8.1 analyse risks</td>
<td>S.8.1 control and monitor risks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>project structure (WBS)</td>
<td></td>
<td>0.9.1 create rough structure</td>
<td>P.9.1 create work breakdown structure (WBS)</td>
<td>P.9.2 describe work packages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>contract and claims</td>
<td></td>
<td>P.9.3 describe activities</td>
<td>P.10.1 define content of contracts with customers</td>
<td>S.10.1 conduct contracts with customers and suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>targets</td>
<td></td>
<td>0.11.1 define project content</td>
<td>P.11.1 define project content</td>
<td>S.11.1 manage, control and monitor target achievement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 42: DIN69901 - processes and phases of a project (source: DIN, 2009)

The DIN69900 defines and describes usage and creation of arrow diagrams and flow scheduling in project management. It also states the necessary nomenclature (Deutsches Institut für Normung, 2009).

**Deutsches Institut für Normung – DIN69900 and DIN69901 – Target**

The target of DIN69901 is the successful realization of projects, the satisfaction of customer expectations, and the evaluation of stakeholder requirements. Necessary conditions are the transparency of project structure and the collaboration of processes. It is
achieved by standardized processes, nomenclature, and methods. Additionally, it mandates a complete and target focused communication between all project participants. Systematic project controlling avoids risks and aberrations by early monitoring and implementation of countermeasures. The content of DIN69901 is also continuous improving and assuring the quality of project management processes as described in DIN ISO 10007 too (Beuth, 2012b).
APPENDIX XVII – PROJECT MANAGEMENT METHOD “BRITISH STANDARD INSTITUTE (BSI) – BS6079”

BRITISH STANDARD INSTITUTE (BSI) – BS6079 – FACTS

<table>
<thead>
<tr>
<th>YEAR OF DEVELOPMENT/Foundation</th>
<th>The BSI was originally founded in 1901 as an Engineering Standards Committee by the Institutions of Civil Engineers, Mechanical Engineers, Naval Architects and the Iron and Steel Institute. It became the British Standard Institute (BSI) in 1930, when it was granted a royal charter in 1929. The first standard BS6079 was released in 1996.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANGUAGE</td>
<td>ENGLISH</td>
</tr>
<tr>
<td>ORIGIN IN</td>
<td>-</td>
</tr>
<tr>
<td>LEGAL RIGHTS BY</td>
<td>The legal rights are at the British Standard Institute</td>
</tr>
<tr>
<td>CERTIFICATION</td>
<td>NONE</td>
</tr>
<tr>
<td>STANDARDS</td>
<td>BS6079-1, BS6079-2, BS6079-3, BS6079-4</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>Great Britain but influences other standards worldwide</td>
</tr>
<tr>
<td>MEMBERS WORLDWIDE</td>
<td>-</td>
</tr>
<tr>
<td>ASSOCIATED COMPANIES WITH BS6079</td>
<td>-</td>
</tr>
</tbody>
</table>

BRITISH STANDARD INSTITUTE (BSI) – BS6079 – HISTORY

The British Standard Institute (BSI) was founded in 1901 by the Institutions of Civil Engineers, Mechanical Engineers, Naval Architects, and the Iron and Steel Institute. Initially, it was named the Engineering Standards Committee (ESC). In 1906, the British Electrotechnical Committee (BEC) was established as a sub-organisation of the ESC. The ESC was granted a royal charter in 1929 and in 1930 the ESC was renamed to the BSI, which incorporated the standardized work of the BEC (British Standard Institute, 2011b).
The BSI is also a founding member of the ISO organisation, responsible for international standardization (British Standard Institute, 2011a).

In 1996, the BSI first published the project management standard BS6079. It is now available in the third edition from 2010 (British Standard Institute, 2010).

**British Standard Institute (BSI) – BS6079 – Motivation**

The motivation for using BS6079 is subcategorized into the following groups (Brandon, 2006; British Standard Institute, 2010):

- **Manager**
  
  Raise awareness of challenges in project management and provide an adequate support to sponsors, project managers, and project teams.

- **Sponsors**
  
  Ensure that requested outcomes are achieved and to realize required benefits. Avoid additional work, which was not originally requested.

- **Project managers**
  
  Gain the ability to improve dealing with problems and linking the different project management activities to a cohesive whole.

- **Project team**
  
  Enable teams to understand specific disciplines and to use techniques to increase performance on work packages.

**British Standard Institute (BSI) – BS6079 – Method**

The BS6079 does not provide explicit instructions for project management, but give a framework for handling projects. Therefore, the BS6079 is more a framework and guideline and does not offer any certifications for project management (British Standard Institute, 2010).

The actual version of the BS6079 from 2010 is separated into four parts (British Standard Institute, 2010):

- BS6079-1: Guide to project management
- BS6079-2: Project management vocabulary
- BS6079-3: Guide to the management of business related project risk
- BS6079-4: Guide to project management in the construction industry
The first part “Guide to project management” should be read in conjunction with the second part “Project management vocabulary.” Each part can be adapted to the specific needs of the project. Not all parts of the BS6079 are necessary for a project (British Standard Institute, 2010).

Here only the content of the BS6079-1 is described. The BS6079-2 only defines the project management vocabulary and is not discussed further. BS6079-3 and BS6079-4 will not be described further because they are mentioned briefly in the BS6079-1. The fourth part is only specific for project management in the field of construction.

The BS6079-1: Guide to project management contains five subcategories (British Standard Institute, 2010):

- Project management context
  Different characteristics and types of projects are discussed. The organisational context of projects with regard to legal and regulatory and benefits is outlined.

- Key aspects
  Key aspects handle the principles of project management like balancing the costs, quality, and time of a project (magical triangle), tailoring of processes and methods, and cross-functional working. Roles and people are described in fields of project organisation, project sponsor, steering groups/ project team, project manager, and competences (decision and management). A major key aspect is the project lifecycle with its activities like integration and supporting.

- Project lifecycle (PLC)
  This category describes the PLC, its components like gates, phases and milestones, a possible extension of the PLC, interaction between the PLCs and PLC phases and the relationship between the PLC and management activities.

- Managing of project
  The managing of a project contains the integration and support of activities. Integration activity covers activity flow, preparing a project, approving a project or phase, initiating, directing or managing, and closing a project. Support activities cover the management of scope, schedule, costs, benefits, resources, risks, issues, configuration, documentation, procurement, quality reporting, stakeholder, communication, and controlling changes.
Skills and competencies

Skills and competencies deal with leadership and guidance of project team, stakeholder management, team building activities, resolution of conflicts, education and training, and the development of team, stakeholders, and support staff.

**British Standard Institute (BSI) – BS6079 – Target**

The main target of the BS6079 is to implement a commonly accepted terminology for project management (Brandon, 2006). It helps people to achieve efficient and effective project management outcomes and is not dependent on project size. Therefore, it presents different possible approaches for management dependent on variable challenges and environment.

It supports the project manager, team and senior management in planning and controlling a project and guides it to the requested outcome (British Standard Institute, 2010).
APPENDIX XVIII – MAPPING METHOD: MIND MAP (MMAP)

Mapping is a method for determining and portraying complexity (Fisch & Beck, 2004; Nückles, 2004). The mind map gathers information by reduction, structuring, visualization, and communication. With definition and elaboration of relevant terms – similar terms are closely arranged, the MMAP inspires thinking, not strong schematism (Nückles, 2004). It is a method that reduces the necessity of keeping an overview, but an overview is not eliminated (Della Schiava & Rees, 1999). Maisch (2006) defined MMAP as a method for keeping an overview of the content and the resultant relationships (Maisch, 2006).

Friedrich and Schuster (2004) identified Tony Buzan as the originator of the MMAP. (U. Friedrich & Schuster, 2004). Buzan (1974) developed a brain pattern, which was developed further into the MMAP (Buzan, 1974). According to Haller (2002), Buzan’s concept is based on the spider map, first described in 1971 by Hanf in the Journal of Reading (Haller, 2002).

What is the MMAP? It is a radial centred diagram, represented in a hierarchical way in form of a multi-coloured image (Buzan & Buzan, 2002; Eppler, 2006). Mind mapping is therefore also called “radial thinking” (Buzan & Buzan, 1995). The main topic is in the centre and all subtopics are placed around it in a creative and seamless manner (Buzan & Buzan, 1995; Eppler, 2006). Hierarchies are defined by font, size, icons, or colours (Buzan & Buzan, 2002). The subtopics consist of nouns, verbs, adjectives, and will be further specified in each level (Kirckhoff, 1998). Buzan and Buzan (1995) defined four ground rules for creating a mind map:

1. Use images, colours, fonts, and style variations
2. Make links between associated variations
3. State ideas clearly – use one keyword per line (as the word is closer to the centre as thicker the word and line should be)
4. Develop an individual mapping style, including other forms of coding which can be used as a cross reference on maps

The benefit of the MMAP is that its use can be learned quickly, it can be expanded without restriction, and it makes the illustration of a simple hierarchy possible. The negative aspect of the MMAP is the possibility of inconsistence and that it is hard to read by someone who did not create it. Enlarging the map, it becomes more complex and the
overview of the big picture can be obscured (Buzan & Buzan, 1995; Eppler, 2006). Another handicap of the MMAP is the limited possibility to show only one concept (Bidarra, Guimaraes, & Kommers, 2000). MMAP it is less systematically structured and constructed than a concept map is (CMAP) (Nückles, 2004).

In Figure 126 an example of a MMAP is shown (“Mind maps a powerful approach to note taking,” 2012).

Figure 126: MMAP example according to Buzan’s rules (source: www.mindtools.com)
APPENDIX XIX – MAPPING METHOD: CONCEPT MAP (CMAP)
The CMAP shows a more systematic and structured approach than the MMAP (Nückles, 2004). The CMAP is a strategy to organize and visualize structured know-how (Jospeh Donald Novak & Cañas, 2006). It is possible to portray more than one concept with the CMAP (Bidarra et al., 2000). Novak (1977) developed the CMAP in the 1970s, when increased propositional networks came up. Novak was motivated by Ausubels cognitive learning theory (Joseph Donald Novak, 1977).

The leading concept of the CMAP is listed at the top. All other concepts are subordinated below (Brightman, 2003; Kannicht, 2009). It is a top-down approach, which portrays relationships between the different subordinated concepts (Eppler, 2006; Haller, 2002). These relationships are systematically described by words (Jospeh Donald Novak & Cañas, 2006). CMAP ends in its subordinated concepts with examples at the bottom-line (Eppler, 2006).

The benefit of CMAP is to provide a systematic and rapid overview of different concepts and their relationships. But CMAP requires a time consuming evaluation that necessitates training and is not easily used by novices. Eppler (2006) argued that CMAP tended to be idiosyncratic.

Four steps for creating a CMAP are identified (Brightman, 2003):

1. Listing concepts which are applied to the CMAP subject
2. Ranking concepts from most general to most specific ones
3. First construct a draft CMAP
4. Review draft CMAP concerning correctness and add crosslinks – links between the different subordinated concepts

Figure 127 created by Novak shows an example of a CMAP (Joseph Donald Novak, 2010):
Figure 127: CMAP structure of a NY company illustrating communication problems (source: Novak, 2010)

Bold links indicate weak or missing communications between sectors, or sectors that need strengthening.
APPENDIX XX – RICH PICTURE

Rich pictures seem to look like gigantic cartoons (Flood & Carson, 1993). They offer a subjective interpretation and understanding in messy complex situations (Checkland, 1981; Flood & Carson, 1993). It visualises results of e.g. development processes or changes in management projects (Fassbender & Klein, 2010). This is mostly performed by the use of rich pictures instead of words. Pictures are often plurivalent. Therefore, an additional text often specifies activities, processes, and details. This is necessary to understand annotations and explanations (Fassbender & Klein, 2010; Flood & Carson, 1993). Comparing Figure 126 (MMAP) with Figure 128 (Rich picture), it can be seen that both methods use icons or pictures.

Fassbender and Klein (2010) stated that the creation of a rich picture should follow methodology. First, an extensive discussion with the customer identifies the most important stakeholder groups. In addition to the hierarchy, cross-functional groups are created. Pictured metaphors tell messages by e.g. jokes, stories, wordplay, anecdotes, or puzzles. When the basic metaphor found; it can be than detailed. When the rich picture is finished, the style and communication medium needs to be chosen for transfer.

An example of rich picture is shown from the association for technical collaboration in Figure 128. It displays the collaboration between the central headquarters and the national branch office in Mongolia. The project knowledge is visualized by pictures that are understood by all stakeholders. Therefore, an overall identity is created (Fassbender & Klein, 2010).
Figure 128: Rich picture of the collaboration from the GTZ headquarter with its Mongolian branch office (source: Fassbender & Klein, 2010)
APPENDIX XXI – FUZZY LOGIC

Lotfi Zadeh developed fuzzy logic in 1965 at the University of California in Berkley as a fuzzy set of theories (Lotfi, 1965). The strength of this method is the engagement with complex tasks. In reality, these are characterized as intuitive with definite patterns. It differentiates situations with characteristics that are not fixed. They are differentiated with as-if situations with words like warm, cold, little, medium, much, etc. (Brandes, 2002). During my research, I found no author who confirmed that this method should be used to handle or reduce complexity in projects.
**APPENDIX XXII – BALANCE SCORE CARD (BSC)**

In 1992 Kaplan and Norton developed BSC (Friedag & Schmidt, 2002; Kreimeyer & Lindemann, 2011). The BSC method tries to avoid singular control by using financial key performance indices (KPI) (Kreimeyer & Lindemann, 2011; Morisawa, 2002). To Friedag (2002), the intention is to detect the complexity and reduce it to transparent aspects. This was also stated by Morisawa (2002) and Kreimeyer and Lindemann (2011). They request a balance among short-term, mid-term, and long-term objectives (Friedag & Schmidt, 2002; Kreimeyer & Lindemann, 2011; Morisawa, 2002). Furthermore, Friedag and Schmidt (2002) focused more on the clarity of targets. Employees linked to daily business must understand targets and be able to adapt the BSC when changes appear. The understanding and awareness of BSC should be enforced by a common strategic communication platform. There managers discuss and interpret the KPIs together on a regular basis (Kreimeyer & Lindemann, 2011; Morisawa, 2002).

The basis for BSC is the communication and confidence of all involved people. The final target of the BSC is defined by the vision and mission of the organisation, of the system, of the project etc. and is measured by KPIs (Friedag & Schmidt, 2002). KPIs determine the actual and planned performance, so countermeasures can be taken. Important for the BSC is to have only one responsible person for each KPI, define the relevant KPIs, and to state clearly the method for gaining the basis date (Friedag & Schmidt, 2002). Figure 129 shows the interaction inside a project between four views of a BSC and its linkage of each view and the KPIs (Kapici, 2005).
The incorporators of the BSC suggest four different views for a successful application. These are the financial targets, stakeholder targets, processes targets (internal and external), and the employee targets (development, development perspective, information, systems and knowledge) (Friedag & Schmidt, 2002; Horvath & Kaufmann, 1998; Kapici, 2005; Kaplan & Norton, 1992; Kappler, 2000).
Two approaches exist for using a BSC. The first is a focus on the complexity of the organisational performance, and the second is to focus on complexity factors and reducing those to essential factors (Friedag & Schmidt, 2002).

Kreimeyer and Lindemann (2011) criticized the BSC as too rigid: BSC looks only on incidents, previously modelled in a cause-effect diagram. Furthermore BSC needs processes that provide a common understanding of the KPIs. The authors mention the advantage of the internal control functions of KPIs because they are cross-linked. A manipulation is therefore easy to identify when contradictions in KPIs appear (Kreimeyer & Lindemann, 2011).
APPENDIX XXIII – DATA STRUCTURAL MATRIX (DSM)

The data structural matrix (DSM) was developed by Steward (1981b) for analyzing the design processes of a system (Maurer, 2007; Steward, 1981b). This was originally the main intention of the DSM. But DSM can be also used for projects, focusing on different domains (Kohn & Lindemann, 2010; Steward, 1981b). Steward's development is based on the impact matrix mentioned by Warfield in 1973 (Sander, 2007; Steward, 1981a; Warfield, 1973). Steward's approach from the 1970s was further developed in the 1990s by the Massachusetts Institute of Technology (MIT) and found its way to industry (Eppinger & Browning, 2012).

DSM cope with highly complex and intertwined product architectures (Marti, 2007). Approaching the problem top-down and a stepwise knockdown, DSM generates a classification and cluster (Dömer, 1998; Gausemeier, 2001; Krause et al., 2007). Plotted by a square matrix with identical row and column titles, the relationship between elements inside a system is shown. The reading direction for the square matrix is essential and pre-defined and must be stable during the whole analyzing process. For example, the process begins with vertical columns and acts as an input for the horizontal rows (Eppinger & Browning, 2012). It is a compact, visual, analytical, and advantageous format to display complexity (Browning, 2001; Marti, 2007), showing elements and their interactions in a system by highlighting its architecture (Eppinger & Browning, 2012). The DSM represents the fundamentals of graph theory in a different visualization method (Maurer, 2007). In a DSM, like the graph theory, three relations are possible: sequential, parallel, and coupled as shown in Figure 131 (Browning, 1988; Eppinger, 1991; S. Friedrich, 2008; Yassine, 2004).
Figure 131: Relationships in graph theory and DSM (source: Browning, 1998; Eppinger, 1991)

Furthermore, special characteristics exist in a DSM (Browning, 2001) The matrix can visualize structures with circular logic, hierarchies, and bridges (Browning, 2001; U. Lindemann, Reichwald, & Zäh, 2006). Examples are shown in Figure 132. These structures cannot be recognized by a manual sorting. Sorting algorithms are necessary to sort columns and rows until they are interpretable (U. Lindemann et al., 2006).
The strengths of the relationships can also be displayed. In the original binary DSM, off-diagonal marks indicate the relationship. The strength of relationships can be displayed by different colours, values, symbols, or numbers. Then the DSM is called numerical DSM (Eppinger & Browning, 2012).

DSM sets up processes in a strict way (Steward, 1981b) and helps the user to get an overview on large data volumes (Maurer, 2007). The understanding and gaining of the overview is derived by the division of the system into subsystems, noting the relationship between them, internal/external outputs and inputs and their impact on the system or subsystem (Browning, 2001; S. Friedrich, 2008; Pimmler & Eppinger, 1994). Such a clustering inside the DSM provides an optimized visual identification of closely related groups of elements (Kusiak, 1999; Maurer, 2007; Steward, 1981b).

The strengths of the DSM can be seen in its presentation. A more concise format represents large complex systems that are easily understood by people when they have been once introduced to the DSM. Hierarchy and complexity become transparent when shown in a proper display. It is a well-developed method, and has improved over the decades.
by adding helpful graphics, colours, or other additional data (Eppinger & Browning, 2012).

The taxonomy of the DSM was defined by Browning and cited by various authors. The static based approach of DSMs involves components and people. The time-based approach involves activities and parameters (Browning, 2001; S. Friedrich, 2008; U. Lindemann et al., 2009; Marti, 2007). U. Lindemann et al. (2009) refined the DSM adding the analysis clustering and sequencing algorithms. This is shown in Figure 133.

![Figure 133: Classification of DSMs and algorithms (source: U. Lindemann et al., 2009)](image)

The component-based DSM outlines the interactions between the components inside a system. The focus lies on clustering components so that for new development of components only a single module must be exchanged and not a complete system (S. Friedrich, 2008). For instance this could be subsystems, components, or functions (Eppinger & Browning, 2012).

People-based DSM defines the interface between interacting teams across organisational units. The intensity of interaction is ascertainable. In order to exclude divergences, the DSM must be reviewed from the sender and receiver viewpoint (Browning, 1988, 2001; S. Friedrich, 2008). This helps to assure that the right information is sent to the right people in a timely manner, which prevents an overflow (Eppinger & Browning, 2012).
As an example, Eppinger and Browning (2012) listed departments, teams, or individuals as participants.

The time-based DSMs are designed to omit irrelevant processes and to create iterative processes as efficient as possible. Elements are more timely independent when they are far away from the diagonal in the DSM (Eppinger, 2001; S. Friedrich, 2008). Activity DSMs analyze and optimize processes or activities inside a system along the flow of information (Eppinger & Browning, 2012). In the past, diagrams and Gantt charts were used for common processes (Eppinger & Browning, 2012).

Parameter-based DSMs are split into a detailed level using technical parameters inside a system as a part of the whole development process (Browning, 2001; Browning & Eppinger, 2002; S. Friedrich, 2008). A negative influence of parameter-based DSM can be the dependency of observer’s subjective viewpoint (Eppinger & Browning, 2012).

A general example of the DSM is shown in Figure 134.

![Graphic for a domain structure matrix (DSM)](source: Maurer, 2007)

For handling the component-based DSM first a complex-system must be fragmented. This occurs by listing the subsystems or components into columns and rows of the matrix and outlining the known interactions between them (Eppinger & Browning, 2012). For a people-based DSM the decomposition is performed for the overall organisation into departments, teams, and individuals. That process identifies the desired communication interactions and their intervals (monthly, weekly, daily) (Eppinger & Browning,
In an activity-based DSM the overall process is separated into its activities and their input-output relationships by marks or values (Eppinger & Browning, 2012).

Eppinger and Browning (2012) defined caveats for each type of DSM, which should be considered (Eppinger & Browning, 2012):

![Figure 135: Caveats on DSM types (source: derived from Eppinger & Browning, 2012)](image)

Once a complex system is decomposed using DSM, a methodical analysis is necessary. By moving the empty rows (no mark) to the end and the empty columns to the top, the in-depth analysis can be started (Eppinger & Browning, 2012). Clusters are then formed and interactions outside the cluster as well as the clusters themselves are minimized (Eppinger & Browning, 2012). Minimization of clusters allows an increased number of clusters inside the system, but they should not overlap. In that way, minimization helps to manage complexity (Eppinger & Browning, 2012). The analysis can be iteratively performed using six steps according to Maurer (2007):

1. Selecting a first matrix row
2. Searching for dependencies inside the selected row
3. Searching for dependencies in the rows that correspond to the found dependencies
4. If dependencies exist that link the element that corresponds to the selected row, then a feedback loop is created.

5. Back to step three until no more dependency is found.

6. Select next row until all matrix rows are browsed → back to step two.

For the methodical analysis, the following techniques are possible: sequencing, tearing, banding, and clustering (Kreimeyer & Lindemann, 2011; Maurer, 2007). These are further defined and shown in Figure 136.

Figure 136: DSM analysis techniques (source: derived from Kreimeyer & Lindemann, (2011))

In general, it can be stated for methodical analysis that the user should try to move all elements closely to the diagonal of the DSM. Here the impact of the element is minimized. If it is not possible to move the element above the diagonal of the DSM, the element has a relationship to another element that cannot be removed (Browning, 2000).

Other forms of DSM are the Domain mapping matrix (DMM) and Multi domain matrix (MDM).

Domain mapping matrix (DMM)

The DMM was developed by Danilovic (Danilovic & Browning, 2007). It shows the relationship of elements from two different modules or systems (Kohn & Lindemann, 2010). DMM relates to two DSMs (Browning & Eppinger, 2002; Danilovic & Browning, 2007). Combining an activity-based and people-based DSM, the DMM can replace a RACI-chart (Responsible-Accountable-Control-Information) (Eppinger & Browning, 2012). Figure 137 shows the setup of a DMM (Maurer, 2007).
Figure 137: Graphic for a domain mapping matrix (DMM) (source: Maurer, 2007)

Multi domain matrix (MDM)

The multi domain matrix was developed and named by Maurer (Eppinger & Browning, 2012). He used the basis ideas of Deubzer (Buchenau & Rietz, 2009; Deubzer, Kreimeyer, Herfeld, & Lindemann, 2005). MDM is also known as a structural complexity management methodology (SCM) (Kohn & Lindemann, 2010). It is a further development of Steward’s DSM and Danilovic’s DMM (Buchenau & Rietz, 2009; Maurer, 2007). The MDM interacts on more different levels linking many different systems together (Kohn & Lindemann, 2010; Kreimeyer & Lindemann, 2011) and aggregates two or more DSMs and DMMs (Eppinger & Browning, 2012; U. Lindemann et al., 2009). Therefore, it is a combination of two or more DSMs and DMMs. These can vary on all different types of DSMs including static or time-based approach (Browning, 2001; Buchenau & Rietz, 2009).

An example for a MDM is shown in Figure 138.
The procedure for MDM which is also known as the SCM methodology is described in five steps (Kohn & Lindemann, 2010; Kortler, Helms, Shea, & Lindemann, 2011; U. Lindemann et al., 2009):

1. System definition, defining the MDM
2. Information acquisition, outlining the dependencies of the system
3. Deduction of indirect dependencies
4. Structure analysis, identification of structural criteria
5. Interpretation of structural criteria and its application on product design, understanding of system behaviour

Figure 139 shows the interaction/arrangement between a DSM, DMM and MDM.
Figure 139: Arrangement of DSM, DMM and MDM (source: Eppinger & Browning, 2012)
APPENDIX XXIV – GRAPH THEORY

The graph theory is the basis for many methods in product development: critical path method (CPM), programme evolution and review technique (PERT), project scheduling etc. (Gross & Yellen, 2005; U. Lindemann et al., 2009; Maurer, 2007). It serves as the foundation for analyzing structures and describing large networks (Kreimeyer & Lindemann, 2011). It focuses on the formal modelling and analysis of single nodes and edges of a network and their interactions (Kreimeyer & Lindemann, 2011; Maurer, 2007).

The graph theory describes networks in a generic way as summarized in Figure 140 (Kreimeyer & Lindemann, 2011).

<table>
<thead>
<tr>
<th>Description</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Directed network known as “digraph”</td>
<td><img src="digraph.png" alt="Graph" /></td>
</tr>
<tr>
<td>- Undirected network</td>
<td><img src="undirected_graph.png" alt="Graph" /></td>
</tr>
<tr>
<td>- Combination of a directed and undirected network also named “mixed graph”</td>
<td><img src="mixed_graph.png" alt="Graph" /></td>
</tr>
<tr>
<td>- “weighted graph” by weighting nodes or edges</td>
<td><img src="weighted_graph.png" alt="Graph" /></td>
</tr>
<tr>
<td>- “simple graph” using loops</td>
<td><img src="simple_graph.png" alt="Graph" /></td>
</tr>
<tr>
<td>- Connecting the edge to itself it is called “loop”</td>
<td><img src="loop.png" alt="Graph" /></td>
</tr>
<tr>
<td>- Multiple edges between two nodes named as a “multiple graph” which can also appear with one or none</td>
<td><img src="multiple_graph.png" alt="Graph" /></td>
</tr>
<tr>
<td>- One edge connecting one node to many others – “hyper-edge”</td>
<td><img src="hyper_edge.png" alt="Graph" /></td>
</tr>
<tr>
<td>- Edges not associating with any node called “half-edges” or “loose edges”</td>
<td><img src="loose_edges.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

Figure 140: Basic properties of the graph theory (source: derived from Kreymeyer & Lindemann, 2011)

Three different diagrams from graph theory that assist with visualizing complexity will be discussed:

**Analytic network process (ANP)**

The ANP is based on the analytic hierarchy process (AHP) which was developed in the 1970s (Blockus, 2010; Saaty, 2001). It allows for rational, intuitive, and independent decision making in complex problems (Tschueulin, 2000). The ANP follows four axioms
I. Reciprocity restriction
   The decider must be able to make comparable judgments for the evaluated elements on a reciprocal scale

II. Principle of homogeneity
   All elements are evaluated in pairs by defined criteria. This assures the comparability

III. Principle of structuring
   The decision problem for AHP is structured, for ANP it will be generalized

IV. Postulation for completeness
   All criteria/alternatives for decisions are recognized and considered

The difference between the AHP and the ANP is the structuring of the criteria and alternatives that need to be chosen. This difference is shown in Figure 141 (Blockus, 2010; Dellmann & Diehm, 2002; Peters, 2008; Saaty, 2001; H.-J. Zimmermann & Gutsche, 1991).

Figure 141: Differences between AHP and ANP (source: derived from Blockus, 2010; Dellmann & Diehm, 2002; Peters, 2008; Saaty, 2001; H.-J. Zimmermann & Gutsche, 1991)
The creation of an AHP/ANP diagram starts with splitting system or project into single elements with targets, criteria, and alternatives. Then a comparison of pairs is performed using the weighted advantage in distinct levels (Blockus, 2010; Erdogmus, Kapanolglu, & Koc, 2005). According to Saaty (2001), this weighting can be performed with a stepwise scale (Saaty, 2001). Then evaluation matrices are used to calculate priorities. The consistency of the evaluation of alternatives and decision criteria must be examined because only one factor can emerge as the most important. The impact strength of the element inside the overall system must be shown (Blockus, 2010). An impact matrix defines direct and indirect impacts on the system. Finally, the priorities are checked by the sensitivity analysis (Blockus, 2010).

**Network diagram**

The network diagram was developed in the 1950s. It is a universal tool that does not depend on the size, duration, content, or number of elements (Burghardt, 2002; Kapici, 2005). The Program Evolution and Review Technique (PERT) and the Critical Path Method (CPM) are the best known platforms of the network diagram (R. Bronner, 1999; Eppinger & Browning, 2012). It is a transparent, consistent description by exact information about elements, logical and technical process flow, and a structured display of interactions following a timely relationship (A. Bronner, 2003; Burghardt, 2002; Fisch & Beck, 2004; Kapici, 2005). Therefore, each element has a start and end date and is linked with arrows to other elements (A. Bronner, 2003). All events are defined and described inside a network diagram (Kapici, 2005). The interaction inside a network diagram can arise when coupled tasks are created in a CPM or PERT diagram. This interaction is problematic if the critical path than is not computable anymore (A. Bronner, 2003; Eppinger & Browning, 2012). Coupled tasks can only be shown in a value stream mapping (VSM) diagram, but here tasks are not analyzed (Eppinger & Browning, 2012).

**Value network mapping (VNM)**

Value network mapping (VNM) is strongly related to the VSM. VNMs display the flow of material and information. VNM helps to identify the value adding steps inside the flow and reduces the ones that do not add value. Showing the whole flow from the beginning till the last operation step, a VNM gives an actual status and a future map. Inside the future map, the steps that do not add value are reviewed for possible elimination (Khaswala & Shahrukh, 2001). A VNM is performed in six steps (Khaswala & Shahrukh,
2001): Firstly, a group is formed which aggregates similarities. Secondly, the flow of each element inside the group is visualized. In the third step, the data for process boxes are collected such as handling, time schedule, and responsibilities etc. Fourthly, similar routings are merged. In the fifth step, similar routings are bundled into a component family mentioned as a cluster. In the sixth step, the current state map is created by first selecting key components.

Figure 142 shows a comparison of VSM and VNM from Khaswala & Shahrukh.

Figure 142: Comparison of Value Stream Mapping (VSM) and Value Network Mapping (VNM) (source: Khaswala & Shahrukh, 2001)
APPENDIX XXV – PORTFOLIO

The portfolio was developed in the 1970’s to promote the diversification of organisation’s activities. It uses comparative measures and aims for optimizing the relationship between risks and success, which creates transparency in the organisation’s portfolio (Antoni & Riekhof, 1990; Benkenstein, 2001; Kreimeyer & Lindemann, 2011). The advantage of the portfolio technique is the multiple usability and its many variants. This allows different branches, countries, procurement, and ecological portfolios to interact in market, product, and process-technology fields (Antoni & Riekhof, 1990; Benkenstein, 2001; Hahn, 1990; Hammer, 1992).

Two different techniques are used to display a portfolio: 2D and 3D. For complexity reason it can be used to identify structural runaways and visualize them. An example for both display techniques is shown in Figure 143 (Kreimeyer & Lindemann, 2011).

<table>
<thead>
<tr>
<th>Description</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Two-dimensional portfolio for all nodes</strong></td>
<td><img src="" alt="2D Graph" /></td>
</tr>
<tr>
<td>– e.g. Activity/Passivity</td>
<td></td>
</tr>
<tr>
<td><strong>Three-dimensional portfolio for all nodes</strong></td>
<td><img src="" alt="3D Graph" /></td>
</tr>
<tr>
<td>– e.g. tree criticality</td>
<td></td>
</tr>
<tr>
<td>Also possible as correlation plot of occurrence of a metric for each pair of reference values (e.g., nodes, degrees)</td>
<td></td>
</tr>
<tr>
<td>– e.g., degree correlation (based on nodes)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 143: 2D/ 3D Portfolio (source: Kreimeyer & Lindemann, 2011)

The best-known example of the portfolio is the four-field-product-matrix from the Boston Consulting Group (BCG). It is separated into the fields star, question mark, cash-cow, and poor dog as related to the axes relative market share (x-axes) and market growth (y-axes) (Förster, 2003). Another example is the nine-field-matrix of McKinsey. It shows the advantages of technology as measured by the relative strength of individual platforms/systems.(Förster, 2003).

Portfolios in general are used to derive the strategy for the individual management needs of an organisation (Förster, 2003).

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## APPENDIX XXVI – RESULTS PILOT-TEST: ONLINE SURVEY

<table>
<thead>
<tr>
<th>CTT-1 - project and project manager: Specific questions about the own project and project manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: Typing error … an credential …</td>
</tr>
<tr>
<td>Q6: Understanding Definition of sub-project is missing</td>
</tr>
<tr>
<td>Q7: Typing error Your project is placed in? → is placed in …</td>
</tr>
<tr>
<td>Q8: Typing error … want to answer… → answer</td>
</tr>
<tr>
<td>Q10: Grammar … and finally success? → … and final success</td>
</tr>
<tr>
<td>Q10: Understanding … overall success of project/ knowledge area?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CTT-2 - complexity enablers: Influence and impact of complexity enablers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q11: Typing error … of the …</td>
</tr>
<tr>
<td>Q11: Grammar „enabler“ no BE-word → strengtheners</td>
</tr>
<tr>
<td>Q11: Typing error … time/ schedule → … time schedule</td>
</tr>
<tr>
<td>Q11: Understanding Time limited actuality → ephemerality</td>
</tr>
<tr>
<td>Q11: Typing error Amount of stakeholder → … of stakeholders</td>
</tr>
<tr>
<td>Q11: Logic Question 11 &amp; 12 are not thematically linked</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CTT-3 - Linkage complexity/ PM standards: Linkage and management of complexity with standard PM methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q14: Understanding Cognitive… differentiation → implication</td>
</tr>
<tr>
<td>Q14: Set-up Changed order in answer options</td>
</tr>
<tr>
<td>Q14: Grammar Phrase continuation not logical (e.g. cognitive)</td>
</tr>
</tbody>
</table>
Figure 144: Findings of the questionnaire pilot-test (developed by author)
**APPENDIX XXVII – QUESTIONNAIRE FOR ONLINE SURVEY OF PMI MEMBERS IN GERMANY**

This questionnaire was distributed online to all PMI members within Germany from August 2013 through October 2013, after refining by a pilot-test with PMI professionals and non professionals.

<table>
<thead>
<tr>
<th>CTT-1 - project and project manager: Specific questions about the own project and project manager</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question1:</strong> Are you a credential holder of the PMP (PMI)? Check one of the following answers</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question2:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since when do you hold the PMP (PMI) certification? Check one of the following answers</td>
</tr>
<tr>
<td>Please choose...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you hold other certifications for project management except PMP (PMI)? Check any that apply</td>
</tr>
<tr>
<td>PMUSA (Project Management South Africa) by SAQA (South African Qualification Authority)</td>
</tr>
<tr>
<td>PRINCE2 (Project IN Controlled Environment) by OGC (Office of Government Commerce)</td>
</tr>
<tr>
<td>P2M (Project and Programme Management for Enterprise Innovation) by PMIj (Project Management Association of Japan)</td>
</tr>
<tr>
<td>NCSPM (National Competency Standard for Project Management by API (American Institute of Project Management)</td>
</tr>
<tr>
<td>ICBI.0 (International Competence Base Line) by IPMA (International Project Management Association)</td>
</tr>
<tr>
<td>BS6079 (British Standard for Project Management) by BSI (British Standard Institute)</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

| Question4: |
| How many years do you work in project management? Choose one of the following answers |
| Please choose... |

| Question5: |
| How many people work in your project team? |
| Only numbers may be entered in this field |

| Question6: |
| How many sub-projects has your project? |
| Only numbers may be entered in this field |
CTT-1 - project and project manager: Specific questions about the own project and project manager

Question 7:

Your project is placed in...
Choose one of the following answers:
- Mining
- Construction/building
- Information/communication
- Economical services
- Art/entertainment
- Industry
- Trade
- Finance
- Public service/defence
- Agriculture
- Energy
- Transportation
- Real estate/housing
- Education
- Private household
- Water supply/waste management
- Hotel/restaurant
- Scientific/academic services
- Welfare/healthcare
- Extentional organisation
- Other: [ ]

Question 8:

What is the total value (internal/external) of your project in 000 €?

Only numbers may be entered in this field.

Budget of the project in TEuro; if you do not want to answer - please proceed.

Question 9:

How would you categorize the size of your project?
Choose one of the following answers:
- small
- medium
- large
- major

Question 10:

How do you estimate the quality of your project according to the PMI knowledge areas and final success?

<table>
<thead>
<tr>
<th>Knowledge Area</th>
<th>poor</th>
<th>weak</th>
<th>neutral</th>
<th>good</th>
<th>very good</th>
<th>No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Scope management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Schedule management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Cost management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Quality management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Human resource management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Communication management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Risk management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Procurement management</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Overall project's success</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
### CTT-2: Complexity Enablers: Influence and Impact of Complexity Enablers

**Question 11:**

Which of the following strengtheners (multiplier) for complexity affects your project? Mark your top five items.

<table>
<thead>
<tr>
<th>Item</th>
<th>Max. Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual techniques</td>
<td></td>
</tr>
<tr>
<td>Incompatible systems tools</td>
<td></td>
</tr>
<tr>
<td>Legal norms and regulations</td>
<td></td>
</tr>
<tr>
<td>Size of project/organisation</td>
<td></td>
</tr>
<tr>
<td>Internationality (countries/facilities)</td>
<td></td>
</tr>
<tr>
<td>Int/Ext. interfaces</td>
<td></td>
</tr>
<tr>
<td>Technical-/product diversity</td>
<td></td>
</tr>
<tr>
<td>Amount of stakeholders</td>
<td></td>
</tr>
<tr>
<td>Changes in time schedule</td>
<td></td>
</tr>
<tr>
<td>Partitioning of work/competency/responsibility</td>
<td></td>
</tr>
<tr>
<td>Market dynamics (flexibility)</td>
<td></td>
</tr>
<tr>
<td>Organisational changes</td>
<td></td>
</tr>
<tr>
<td>Time-limited actuality (ephemerality)</td>
<td></td>
</tr>
<tr>
<td>Communication/decision process</td>
<td></td>
</tr>
<tr>
<td>Cultural diversity</td>
<td></td>
</tr>
<tr>
<td>Customer requirements</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

**Question 12:**

How would you rank your project concerning complexity? (with 1 = low and 5 = high)

<table>
<thead>
<tr>
<th>Complexity</th>
<th>1 (low)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (high)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CTT-3: Linkage Complexity/PM Standards: Linkage and Management of Complexity with Standard PM Methods

**Question 13:**

How do you manage complexity?

- Eliminate
- Reduce
- Not at all
- Control

**Question 14 (optional depending on selected answer in question 13):**

How do you control complexity? By...

- COGNITIVE, performed by principles of reality consideration, simplification, abstraction and implication
- CREATING ORDER in a system by regularity, defined rules, reliability by reconstruction which is ob-vously planned
- EVOLVINGARY, a process where too much information can cause uncertainty and decisions are based on cognitive knowledge, closing gaps without knowing it
- SENSITIVITY MODEL, describing the system, identify influencing factors, proving the relevance, question interactions, defining the internal roles and checking the networking and back coupling
- STEERED ORDER, reacting intentional on external influences no matter if it is self-coordinated or hierarchical coordinated
- HEURISTIC, form simple steps without problems before implementing a new level until unproblematic work is assured
- ANALYTIC REDUCTIVE, questioning the side effects, what can be gained and influenced – how can it be realised
- NO ANSWER
- SITUATIONAL AWARENESS, depending on work load and available tools, the environment is realised and the actual situation is observed for involving it into the future
- CONSTRUCTIVISTIC, making rational decisions for problem solutions: targeted definition, developing the necessary problem solving process, analysis of alternatives and stable evaluation criteria

**Question 15 (optional depending on selected answer in question 13):**

How do you reduce complexity in your project? By...

- MODEL KITS - product structure itself is not changed, only the overall system
- SHIELDING - freeze to a defined point of time where nothing can be changed anymore
- STANDARDISATION - same parts are used in more than one product
- NONE
- STRUCTURING - by lists, labels and watching others
- COMMON PART USE - similar parts (incl. processes, know-how etc.) in more than one product
- PLATFORMS - basis on which variants can be created by adding modules
- MODULES - similar to model kits, can not be varied, only differently positioned
## CTT-4 - vulnerable blocks for complexity: Project management vulnerable blocks for complexity

### Question 16

Name the processes vulnerable to complexity in your project. Mark the 10 most vulnerable processes (PMI standard).

<table>
<thead>
<tr>
<th>Process</th>
<th>Vulnerability Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create project charter</td>
<td></td>
</tr>
<tr>
<td>Identify stakeholder</td>
<td></td>
</tr>
<tr>
<td>Develop project management plan</td>
<td></td>
</tr>
<tr>
<td>Collect requirements</td>
<td></td>
</tr>
<tr>
<td>Define scope</td>
<td></td>
</tr>
<tr>
<td>Create work breakdown structure</td>
<td></td>
</tr>
<tr>
<td>Define activities</td>
<td></td>
</tr>
<tr>
<td>Sequence activities</td>
<td></td>
</tr>
<tr>
<td>Estimate resources</td>
<td></td>
</tr>
<tr>
<td>Estimate duration</td>
<td></td>
</tr>
<tr>
<td>Define schedule</td>
<td></td>
</tr>
<tr>
<td>Estimate costs</td>
<td></td>
</tr>
<tr>
<td>Determine budget</td>
<td></td>
</tr>
<tr>
<td>Plan quality/ develop QM plan</td>
<td></td>
</tr>
<tr>
<td>Plan human resource plan</td>
<td></td>
</tr>
<tr>
<td>Plan communication</td>
<td></td>
</tr>
<tr>
<td>Plan risk management</td>
<td></td>
</tr>
<tr>
<td>Identity risks</td>
<td></td>
</tr>
<tr>
<td>Perform qualitative risk management</td>
<td></td>
</tr>
<tr>
<td>Perform quantitative risk management</td>
<td></td>
</tr>
<tr>
<td>Plan risk responsibilities</td>
<td></td>
</tr>
<tr>
<td>Plan procurement</td>
<td></td>
</tr>
<tr>
<td>Direct + manage project execution</td>
<td></td>
</tr>
<tr>
<td>Perform quality assurance</td>
<td></td>
</tr>
<tr>
<td>Acquire project team</td>
<td></td>
</tr>
<tr>
<td>Develop project team</td>
<td></td>
</tr>
<tr>
<td>Manage team</td>
<td></td>
</tr>
<tr>
<td>Distribute information</td>
<td></td>
</tr>
<tr>
<td>Manage stakeholder</td>
<td></td>
</tr>
<tr>
<td>Conduct procurement</td>
<td></td>
</tr>
<tr>
<td>Monitor and control project work</td>
<td></td>
</tr>
<tr>
<td>Perform integrated change control</td>
<td></td>
</tr>
<tr>
<td>Verify scope</td>
<td></td>
</tr>
<tr>
<td>Control scope</td>
<td></td>
</tr>
<tr>
<td>Control schedule</td>
<td></td>
</tr>
<tr>
<td>Control costs</td>
<td></td>
</tr>
<tr>
<td>Control quality</td>
<td></td>
</tr>
<tr>
<td>Report performance</td>
<td></td>
</tr>
<tr>
<td>Control and monitor risks</td>
<td></td>
</tr>
<tr>
<td>Administer procurement</td>
<td></td>
</tr>
<tr>
<td>Close project or phase</td>
<td></td>
</tr>
<tr>
<td>Close procurements</td>
<td></td>
</tr>
</tbody>
</table>

### Question 17

Name the processes vulnerable to complexity in your project. Mark the 10 least vulnerable processes (PMI standard).

<table>
<thead>
<tr>
<th>Process</th>
<th>Vulnerability Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create project charter</td>
<td></td>
</tr>
<tr>
<td>Identify stakeholder</td>
<td></td>
</tr>
<tr>
<td>Develop project management plan</td>
<td></td>
</tr>
<tr>
<td>Collect requirements</td>
<td></td>
</tr>
<tr>
<td>Define scope</td>
<td></td>
</tr>
<tr>
<td>Create work breakdown structure</td>
<td></td>
</tr>
<tr>
<td>Define activities</td>
<td></td>
</tr>
<tr>
<td>Sequence activities</td>
<td></td>
</tr>
<tr>
<td>Estimate resources</td>
<td></td>
</tr>
<tr>
<td>Estimate duration</td>
<td></td>
</tr>
<tr>
<td>Define schedule</td>
<td></td>
</tr>
<tr>
<td>Estimate costs</td>
<td></td>
</tr>
<tr>
<td>Determine budget</td>
<td></td>
</tr>
<tr>
<td>Plan quality/ develop QM plan</td>
<td></td>
</tr>
<tr>
<td>Plan human resource plan</td>
<td></td>
</tr>
<tr>
<td>Plan communication</td>
<td></td>
</tr>
<tr>
<td>Plan risk management</td>
<td></td>
</tr>
<tr>
<td>Identity risks</td>
<td></td>
</tr>
<tr>
<td>Perform qualitative risk management</td>
<td></td>
</tr>
<tr>
<td>Perform quantitative risk management</td>
<td></td>
</tr>
<tr>
<td>Plan risk responsibilities</td>
<td></td>
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<tr>
<td>Plan procurement</td>
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<tr>
<td>Direct + manage project execution</td>
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<tr>
<td>Perform quality assurance</td>
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<td>Acquire project team</td>
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<td>Develop project team</td>
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<td>Manage team</td>
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<tr>
<td>Distribute information</td>
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<td>Manage stakeholder</td>
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<tr>
<td>Conduct procurement</td>
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<tr>
<td>Monitor and control project work</td>
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<tr>
<td>Perform integrated change control</td>
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<tr>
<td>Verify scope</td>
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<tr>
<td>Control scope</td>
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<td>Control schedule</td>
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<td>Control costs</td>
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<td>Control quality</td>
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<td>Report performance</td>
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<tr>
<td>Control and monitor risks</td>
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<tr>
<td>Administer procurement</td>
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<tr>
<td>Close project or phase</td>
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<tr>
<td>Close procurements</td>
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</tbody>
</table>

## CTT-5 - Complexity specific skills and methods: Complexity specific skills and methods for successful management

### Question 18

Does the actual PMI standard satisfactorily describe complexity?

- Yes
- No
- No answer

### Question 19 (optional depending on selected answer in question 18):

Which tools/methods in the actual PMBook guide would you suggest for managing complexity?

<table>
<thead>
<tr>
<th>Tool/Method</th>
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</thead>
<tbody>
<tr>
<td>Critical path method</td>
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<tr>
<td>Mindmap</td>
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<tr>
<td>RBS (resource breakdown structure)</td>
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<td>Scatter diagram</td>
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<tr>
<td>Control flow and run charts</td>
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<tr>
<td>Trend analysis</td>
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<td>Performance reviews</td>
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<td>SWOT analysis</td>
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<td>Risk audits</td>
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<td>WBS + WBS Dictionary</td>
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<td>Change control meetings</td>
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<td>PM information systems</td>
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<td>Benchmark</td>
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<tr>
<td>Benchmark</td>
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<tr>
<td>PERT analysis</td>
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<tr>
<td>Product analysis (breakdown/sytem analysis)</td>
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<td>Stakeholder analysis</td>
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<td>Record mgmt system (cost/schedule/HR/ quality etc.)</td>
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<td>Network diagram</td>
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<td>Maker buy analysis</td>
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<td>Project management plan</td>
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<td>Process analysis</td>
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<td>Variance analysis</td>
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<td>Requirement traceability matrix</td>
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<tr>
<td>Checklists</td>
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<td>Procurement audits</td>
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<td>Quality audits</td>
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<td>Earned value mgmt.</td>
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<td>Rolling wave planning</td>
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<td>Schedule compression</td>
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<td>Project charter</td>
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<td>Resource leveling</td>
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<td>Risk register</td>
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<td>RASi Chart</td>
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<td>Issue log</td>
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<td>Project scope statement</td>
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<td>Precedence diagramming method</td>
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<td>Pareto diagram</td>
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<tr>
<td>Reserve analysis</td>
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<tr>
<td>No Answer</td>
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<tr>
<td>Communication analysis (channels)</td>
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<tr>
<td>Cause-effect diagram</td>
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<tr>
<td>Adjusting leads and lags</td>
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<tr>
<td>Performance reports</td>
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<tr>
<td>Scenario analysis</td>
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<td>Critical chain method</td>
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<td>SWOT analysis</td>
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<td>Monte Carlo analysis</td>
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<tr>
<td>Conflict management</td>
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<tr>
<td>Authorizationsystems</td>
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</tbody>
</table>
CTT-5 Complexity specific skills and methods: Complexity specific skills and methods for successful management

Question 20 (optional depending on selected answer in question 18):

Which other tools/methods do you recommend for managing complexity?
Check any that apply

- Method/tool 1
- Method/tool 2
- Method/tool 3
- Method/tool 4
- Method/tool 5
- No answer

Question 21:

Would you prefer a separate chapter for managing complexity in PM standards?
Choose one of the following answers

- Yes
- No
- No answer

Question 22:

Which method would you implement in the PM standard to handle complexity?
Please select at least one answer

- Balanced Score Card
- Fuzzy logic
- Portfolio
- Mindmap
- Concept map
- Scenario analysis
- Graph theory – network/ arrow
- Data structural matrix
- Graph theory – Gantt/ PERT/ CPM
- Rich picture
- Other:

Question 23:

If you would like to receive my findings on this research, please add your email address. Results are expected by end of 2014.

Question 24:

After finishing the questionnaire I kindly ask you to provide me some feedback about this questionnaire concerning understandability, clearness, structure and evaluation scales. Hints for improvement shall be considered in my dissertation.

Last page of questionnaire

Dear participant of the survey for “complexity in project management”. Thank you for spending your time and effort for this questionnaire.

Kind regards
Christian Tresselt
APPENDIX XXVIII – RESULTS PILOT-TEST: FOCUS GROUP INTERVIEW

This FGI is based on the findings from the survey in 2013 and allows some rules during the interview.

**General Purpose**

This focus group interview is questioning results and interpreted findings from the survey on “optimal handling of complexity in project management” from 2013. Focus is on the main research targets and the findings, if these appear and if they are applicable in the FGI.

Participants for the FGI:

- No specific particular order.
- Do not interrupt anyone else if talking, even in emotional exchanges, try not to jump in.
- As多人ly as participants in the FGI, it is important that each participant’s view is obtained.
- Try not to agree with everyone’s everyone’s statement, but your own statement should be stated and pending someone down.
- An interview held by need and summarise discussions for individual target and next steps of a research.

Research targets are answered by the survey from 2013, but shall be scrutinized with performing/evaluating FGIs.

**Performance FGI in Germany (Munich, Heidelberg, Stuttgart) - Evaluation of (sent data):

- Consolidation of case research data
- Writing-up, reflect case studies and findings

Main intention is to offer a method to handle complexity in PM standard-based projects

- Four main results are expected throughout an survey and FGI

1. Best Practice for handling complex projects
2. Identification of weaknesses caused by complexity in managing projects
3. Matrix for auditing symptoms of complex projects, in strengthens and processes
4. Possible improvements for handling complex projects

Figure 145: Changes in FGI guide - introduction (developed by author)

Opening, making people to talk – intro getting a clue about viewpoints – transition shifting to key questions

Figure 146: Changes in FGI guide – initiation/ transition (developed by author)

Do you agree with the top complexity strengtheners and do you also handle them by control/ reduction?

Figure 147: Changes in FGI guide - key question #1 (developed by author)

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Figure 148: Changes in FGI guide - key question #2 (developed by author)

Figure 149: Changes in FGI guide - key question #3, categorisation (developed by author)

Figure 150: Changes in FGI guide - key question #3, comparison (developed by author)
How can an adopted PMI standard support you in maneuvering a complex project? Spending a separate chapter or explaining new methods for managing it?

Key Question #4

RQ: How does the chosen PM standard consider complexity? Are there further methods than mentioned in the standard for handling complexity?

RT: Investigation of PM standard’s processes and methods for handling complexity in PM. Identifying possible modifications in the PM standard, based on handling complexity in daily practice.

Findings from the survey:

- 45.3% would like a separate chapter for complexity
- 54.7% think the PMI standard is satisfactory for complexity

![Graph showing results](image)

Figure 151: Changes in FGI guide - key question #4 (developed by author)
APPENDIX XXIX – GUIDE FOR THE FOCUS GROUP INTERVIEWS (FGI) WITH PMI MEMBERS IN GERMANY

This guide was used for FGIs at PMI round tables in Germany from April 2014 through May 2014.

Focus Group Interview (FGI) on: „Optimal handling of complexity in project management“
Munich, April 2014
Christian Tresselt
PMI roundtable

Figure 152: FGI guide, page 1 (developed by author)

Agenda

- Introduction 05 min.
- Transition 05 min.
- Key Question #1 10 min.
- Key Question #2 15 min.
- Key Question #3 15 min.
- Key Question #4 15 min.
- Closing 05 min.

70 min.

Figure 153: FGI guide, page 2 (developed by author)
Research targets are answered by the survey from 2013, but shall be scrutinized with performing/evaluating FGIs

This focus group interview is questioning results and interpreted findings from the survey on „optimal handling of complexity in project management“ from 2013. Focus is on the main research targets and their findings, if these appear and if they are applicable in the FGI.

- Performing FGIs in Germany (Munich, Heidelberg, Stuttgart)
- Evaluation of gained data
- Consolidation of case research data
- Write-up, reflect case studies and findings

Next Steps

Main intention is to offer a method to handle complexity in PMI standard based projects

Four main results are expected throughout an survey and FGI:

1. Best Practice for handling complex projects
2. Identification of weaknesses caused by complexity in managing projects
3. Matrix for outlining symptoms of complex projects in strengtheners and processes
4. Possible improvements for handling complex projects

Research target

Beginning: warm up of people – getting a clue about viewpoints and shifting to key questions by transition

1. Informing participants about the target of this FGI (specification of survey results from 2013)

2. How does the topic „optimal handling of complexity in project management“ attract you?

Have you ever been affected with a complex project, no matter if as a stakeholder, project manager or project team member?

How did you behave within this situation?

Figure 154: FGI guide, page 3 (developed by author)

Figure 155: FGI guide, page 4 (developed by author)
3 Do you agree with the top complexity strengtheners and do you also handle them by control/ reduction?

Figure 156: FGI guide, page 5 (developed by author)

4 Is a project success depending on certified PMs and do you as a certified PM manage vulnerable processes in a project by the stated detailed handling methods?

Figure 157: FGI guide, page 6 (developed by author)
When you think about your own complex project, do you find yourself in the following table with the strengtheners and unimmunized processes in the project?

Key Question #3

5. When you think about your own complex project, do you find yourself in the following table with the strengtheners and unimmunized processes in the project?

Findings from the survey:

(1) Rank your actual project concerning size of the project (y-axis)?
(2) Rank your actual project concerning level of complexity (x-axis)?
(3) Reflect if the same complexity strengtheners appear in your project or is there an other ranking valid?
(4) Reflect if complexity appears most in the top ten listed processes in your project or are other processes more affected by complexity?

Remember your field you placed your project in!!!

5. Compare your identified field of the project with strengtheners and vulnerable processes of your project. Are they the same?
How can an adopted PMI standard support you in maneuvering a complex project? Spending a separate chapter or explaining new methods for managing it?

Findings from the survey:

Summary of the FGI @ the PMI roundtable

SUMMARY

Anonymity...

My notes, taken within the FGI were taken anonymous. They will be published without identification of participants in the thesis „Optimal handling of complexity in project management“ to receive the degree as a doctorate of business administration at the University of Gloucestershire (UK).

... final question...

Are there any questions I can answer?

THANK YOU
REFERENCE LIST


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411


The American Association for public opinion research. (2011). *Standard Definitions Final Dispositions of Case Codes and Outcome Rates for Surveys* (p. 62). Derfield, IL, US.


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