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

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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 Information derived from the published and unpublished work of others has been acknowledged in the text and references are given in the list of sources.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 [redacted]

DATE 11th of November 2015

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ABBREVIATIONS

AACE	Association for the Advancement of Cost Engineering
AC	Actual Costs
ACCI	Australian Chamber of Commerce and Industry
ADM	Arrow Diagram Method
AHP	Analytic Hierarchy Process
AIPM	Australian Institute of Project Management
AMA	American Management Association
ANP	Analytic Network Process
ANSI	American National Standards Institute
ANTA	Australian National Training Authority
APM	Association for project management
AQF	Australian Qualification Framework
BAC	Budget At Completion
BCA	Business Council of Australia
BCG	Boston Consulting Group
BEC	British Electrotechnical Committee
BoK	Body of Knowledge
BS	British Standard
BSB	Business service training package
BSC	Balanced Score Card
BSI	British Standard Institute
CAPM	Certified Associate in Project Management
CASRO	Council of American Survey Research Organisations
CBA	Cost Benefit Analysis
CCP	Critical Chain Project management
CCTA	Central Computer and Technology Agency

CEO	Chief Executive Officer
CMAJ	Construction Management Association of Japan
CMAP	Concept Map
CMMI	Capability Maturity Model Integration
CNN	Cable News Network
CPD	Continuous professional development
CPI	Cost Performance Indicator
CPM	Critical Path Method
CPO	Chief Project Officer
CPPD	Certified Practising Project Director
CPPM	Certified Practising Project Manager
CPPP	Certified Practising Project Practitioner
CTA	Cost Trend Analysis
CV	Cost Variance
DEST	Department of Education, Service and Training
DIN	Deutsches Institut für Normung
DMM	Domain Mapping Matrix
DNA	Deutscher Norm-Ausschuss
DoD	Department of Defence
DSM	Data structural matrix
EAC	Estimate At Completion
EAM	Enterprise architecture model
EBIT	Earnings before interest and tax
ECV	Expected Commercial Value
ENAA	Engineering Advancement Association of Japan
ESC	Engineering Standards Committee
ESOMAR	European Society for Opinion and Marketing Research
ETA	Estimate To Complete

EV	Earned Value
EVM	Earned Value Management
FGI	Focus group interviews
FMEA	Failure Mode and Effects Analysis
GAPPS	Global Alliance for Project Performance Standards
GPM	Gesellschaft für Projektmanagement
IBM	International Business Machines Cooperation
IBSA	Innovation & Business Skills Australia
ICB	International Competence Baseline
IMSA	International Management System Association
IPMA	International Project Management Association
ISO	International Standardisation Organisation
IT	Information technology
JPMF	Japan Project Management Forum
KPI	Key Performance Indices
LC	Life Cycle
MDM	Multi Domain Matrix
METI	Japanese Ministry of Economic, Trade and Industry
MIT	Massachusetts Institute of Technology
MMAP	Mind Map
MRS	Market Research Society
MPM	Multi Project Management
MTA	Milestone Trend Analysis
NADI	Nationaler Norm-Ausschuss der Deutschen Industrie
NASA	National Aeronautics and Space Administration
NCSPM	National Competency Standard for Project Management
NPV	Net Present Value
NQF	National Qualification Framework

NQSZ	(Normen-Ausschuss, Qualitätsmanagement, Statistik und Zertifizierungs-grundlagen
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 Registrated
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

PROMT	Project Resource Organisation Management Planning Technique
PV	Planned Value
QM	Quality Management
RASCI	Responsible/Accountable/Support/Control/Inform
RegPM	AIPM registration process for project management
ROI	Return on Invest
ROS	Return on Sales
R&D	Research and Development
SAQA	South African Qualification Authority
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SCM	Structural Complexity Management methodology
SEI	Software Engineering Institute
SMAC	site man-hours and costs
SMART	Specific, Measurable, Realistic, time able
SNA	Structured Network Analysis
SPI	Schedule Performance Indicator
SPM	Academic Project Management society
SPMA	Swiss Project Management Association
SPSS	Statistical Package for the Social Science
s.s.	Statistical significance
SV	Shedule Variance
TCO	Total Cost of Ownership
TCPI	Total Complete Performance Indicator
ToC	Theory of Constraints
TQM	Total Quality Management
UK	United Kingdom
US	United States
USAF	United States Air Force

VAR	Variance At Completion
VFM	Value for Money
VNM	Value Network Mapping
VSM	Value Stream Mapping
WBS	Work Breakdown Structure
WP	Work Package
WTA	Work Trend Analysis

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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 temporally 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, 2000). 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.

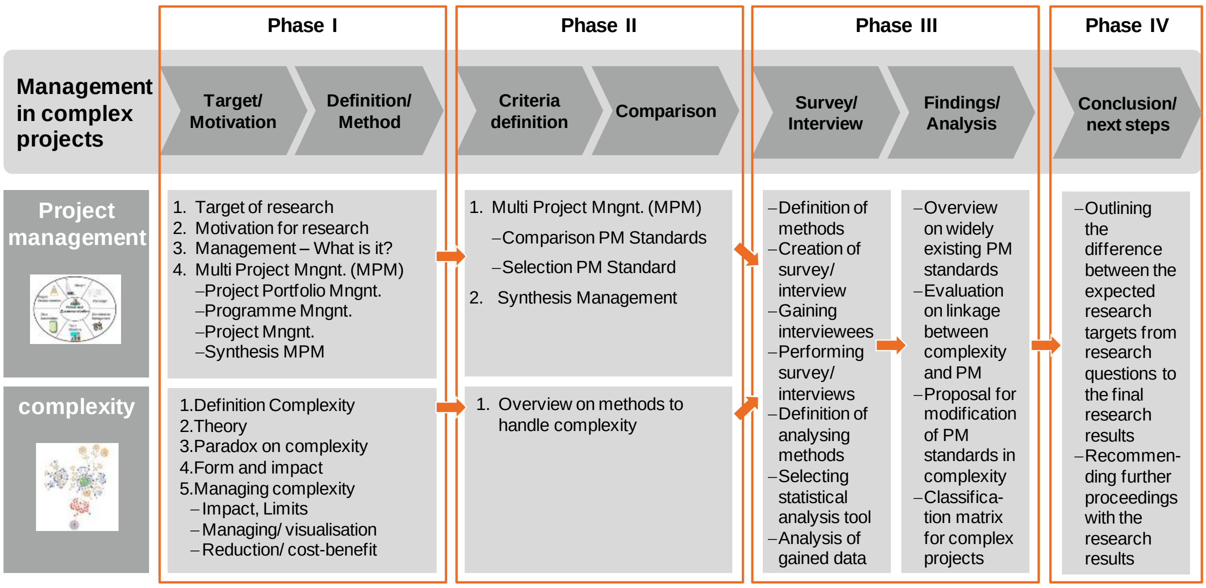


Figure 1: Phases for execution of thesis (developed by author)

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 evaluation 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 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).

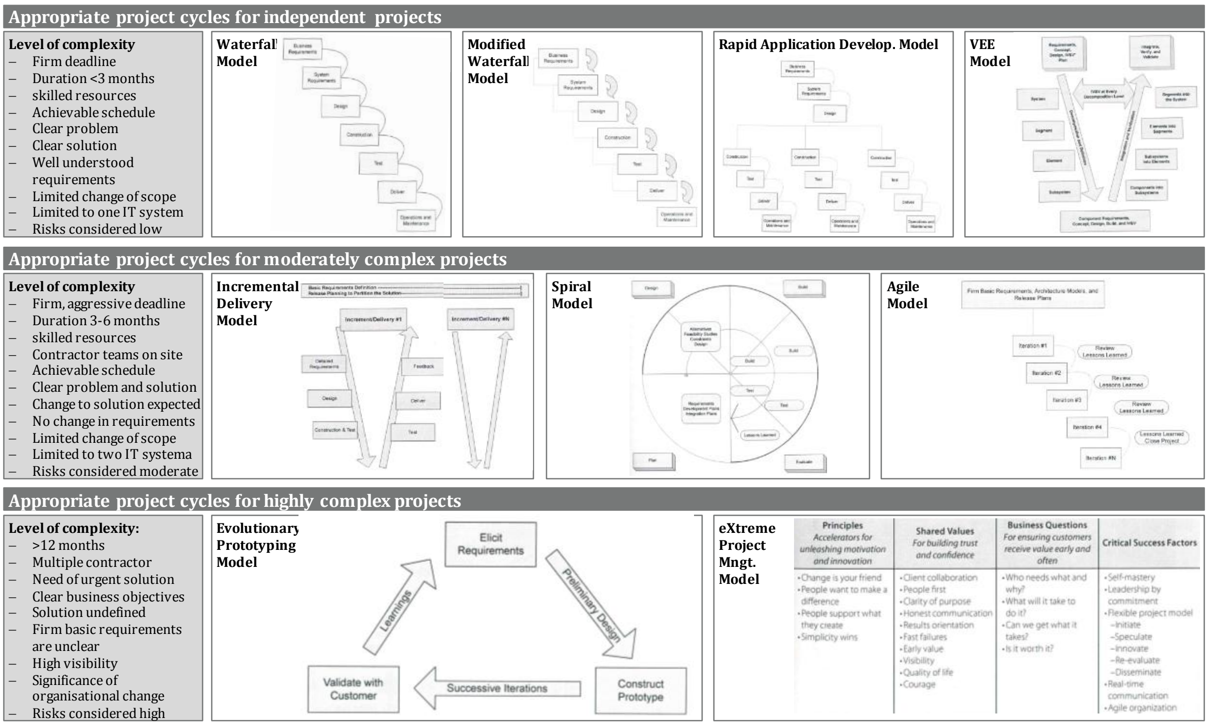


Figure 2: Project cycles by Hass (source: derived from Hass (2009))

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.

In February 2014, PMI published *Navigating Complexity – A Practice Guide* (Project Management Institute, 2014).

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 a 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 virtualization of projects (Scheiter, Scheel, & Klink, 2007), which has occured 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.

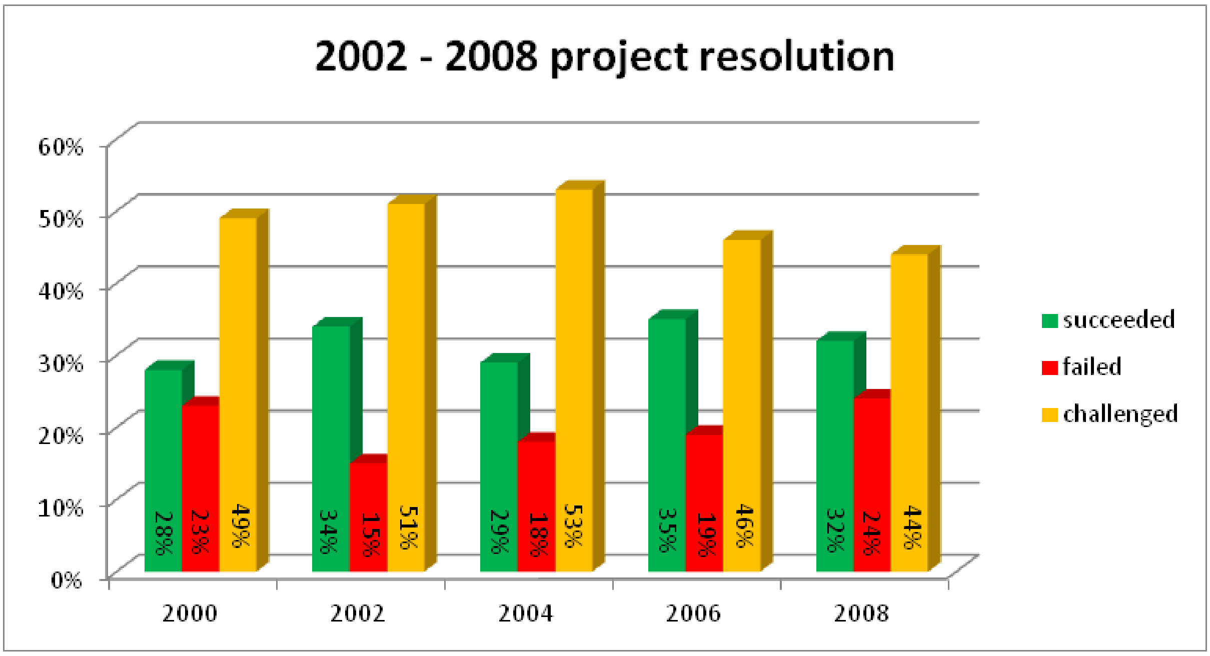


Figure 3: 2002 - 2008 project resolution (source: The Standish Group - Chaos Report (2009))

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%
– Monteral 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%
– Bangkok 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 complex 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 hierarchal 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 & Hawker, 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.

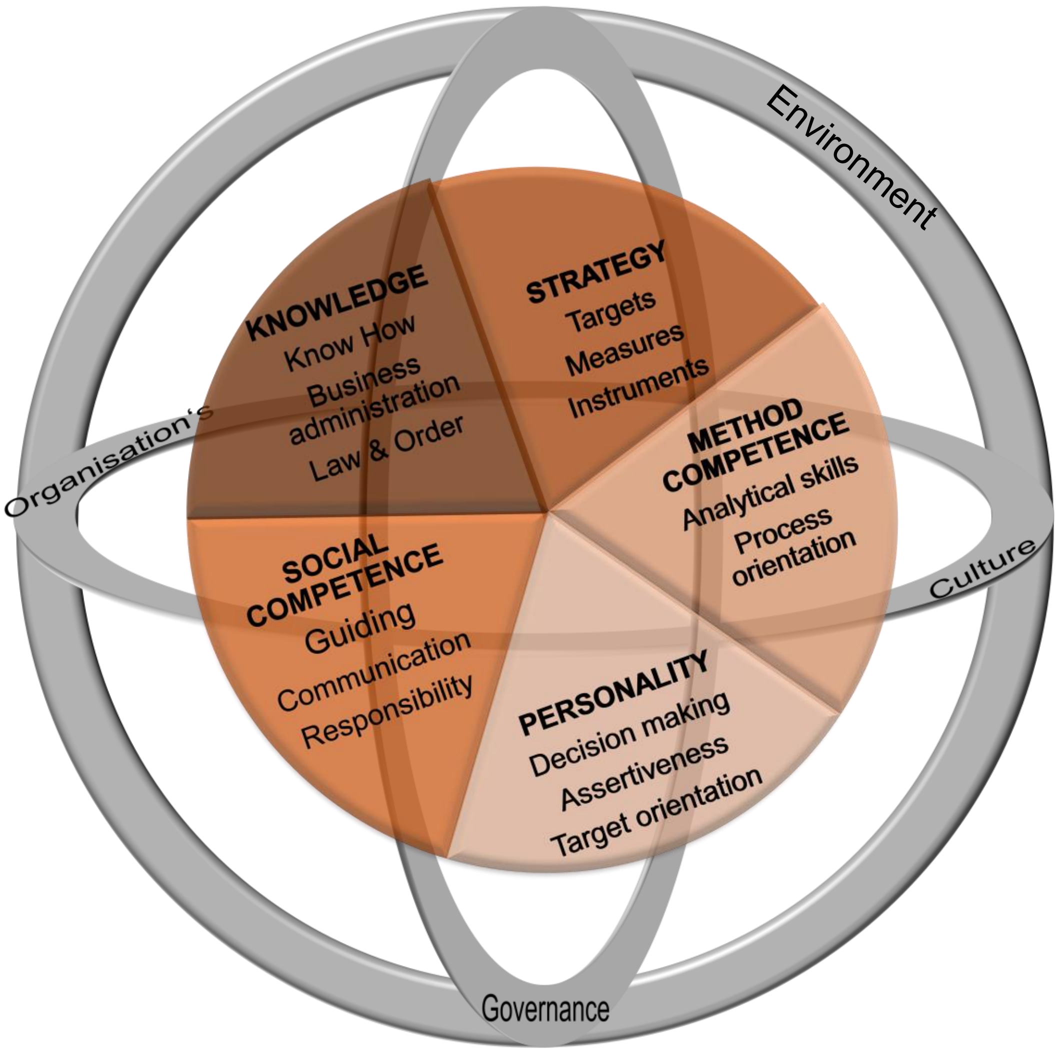


Figure 4: Management virtues and their influencing parameters (developed by author)

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.

Definition by / Level	Kleiman (2009)	Brudney (2005)/ Moore (1995)	challenge
Strategic	top-level management	outward management	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.
Tactical	middle-level management	upward management	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.
Operative	first-level management	downward management	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.

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 areas 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.

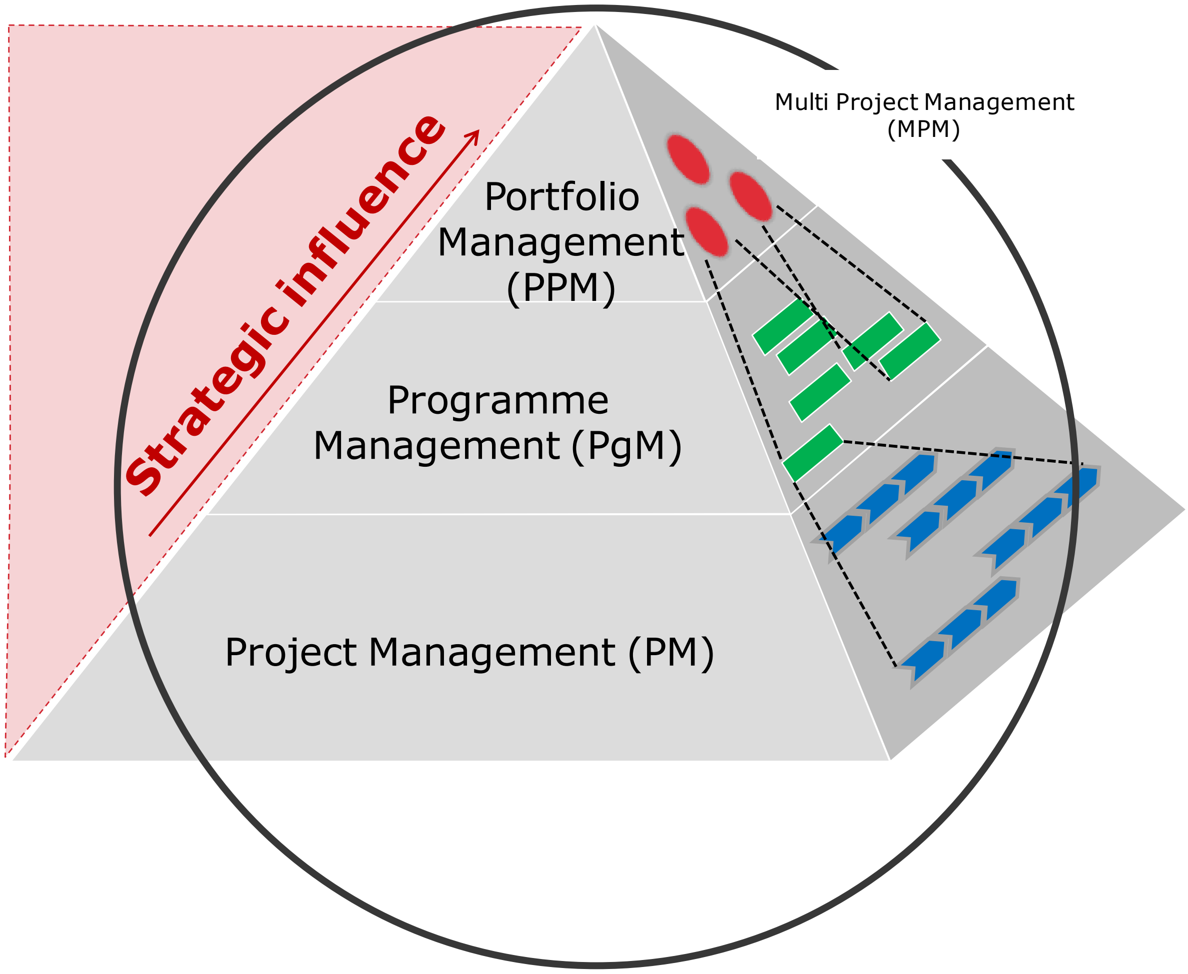


Figure 5: Multi Project Management (MPM) setup hierarchy (developed by author)

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

PM methods training/ coaching)

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).

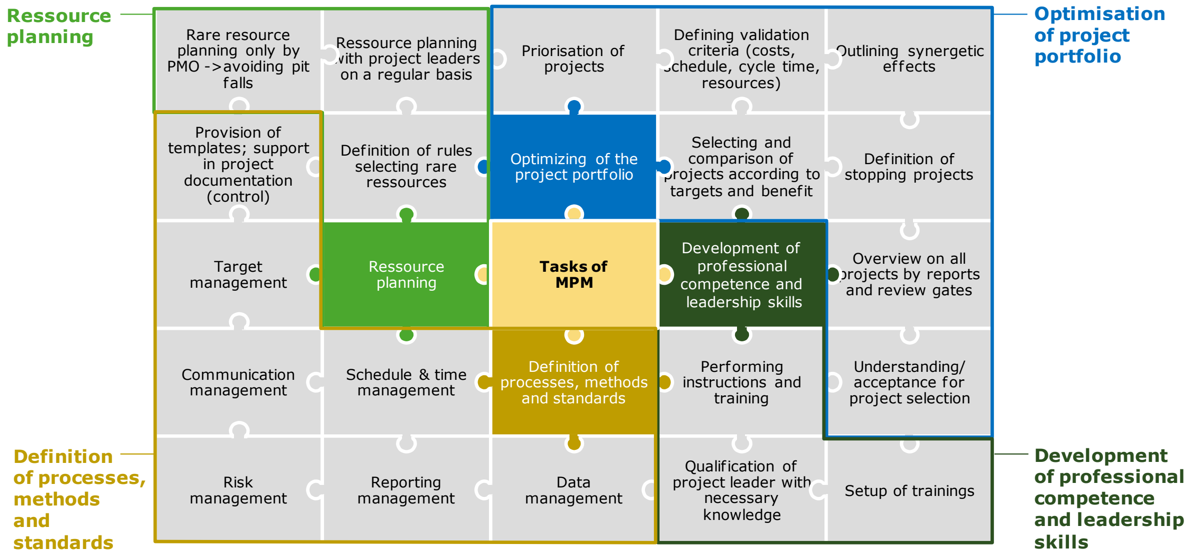


Figure 6: Core competences and tasks of MPM/ PMO (summated by author)

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).

Definition Project

Authors/ organisations	Temporal limited	Unique product	Derived from strategy	Justification by ROI	Funding limits	Certain requirements	Consumes resources	Activity/ work packages	Complexity	Multi-disciplinarity	uniqueness	Comments
PMI/ Brandon	✓	✓										
DIN69901/ Rohe/ Pfetzing	✓	✓			✓		✓		✓	✓	✓	
Verzuh	✓	✓										
Sanghera	✓	✓										Early termination is possible
Cleland	✓	✓										
Dobiey	✓	✓	✓	✓								
Kernzer	✓	✓			✓	✓	✓					
BS6079-1/ Lester	✓	✓				✓		✓				
Gareis/ Jankulik&Kuhlang	✓	✓					✓		✓	✓	✓	Also new and risky contents
Litke	✓	✓					✓					
PRINCE 2	✓	✓	✓								✓	Special environment
Aichele	✓	✓					✓		✓	✓	✓	Specific organisation

Definition Management

Management exists by planning, tracking, guiding and controlling. It orientates on agreed, confirmed targets by a careful use of resources (Weatherly, 2009).

Further definitions of management are described in the chapter management.

Definition Project Management

	Planning	Delegating	Controlling	Steering	Organisation	Skills	Tools	Techniques	Target
Hedeman	✓	✓	✓	✓	✓				→ Realization of targets in time, cost and quality
Dan Brandon/ PMI	✓		✓	✓	✓	✓	✓	✓	→ Meet stakeholder needs/ expectations from a project
Litke	✓	✓	✓	✓	✓	✓	✓	✓	→ Performance concept for executing/ identifying necessary tasks for project realisation
Lester/ Jankulik & Kuhlang	✓		✓	✓	✓				→ Achieve project criteria within agreed criteria, cost, time, performance

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 and justification of ROI (return on invest); in management for example: the delegation of tasks and the required skills, tools and techniques for PM.

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.

Possible organisations for PM				
Authors	Functional	Matrix	Projectised	Comment
PMI	✓	✓	✓	Sub-partition matrix into: weak, balanced, strong
Harrison/ Lock	✓	✓	✓	Sub-partition matrix into: functional, balanced, projectised
Verzuh	✓	✓	✓	
Sanghera	✓	✓	✓	
Kernzer	✓	✓	✓	Sub-partition matrix into: weak, balanced, strong
Lock	✓	✓	✓	Sub-partition matrix into: weak, balanced, strong
Lester	✓	✓	✓	
Lidtke	✓	✓	✓	
Hamilton	✓	✓	✓	

Table 2: Organisations for PM (developed by author)

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).

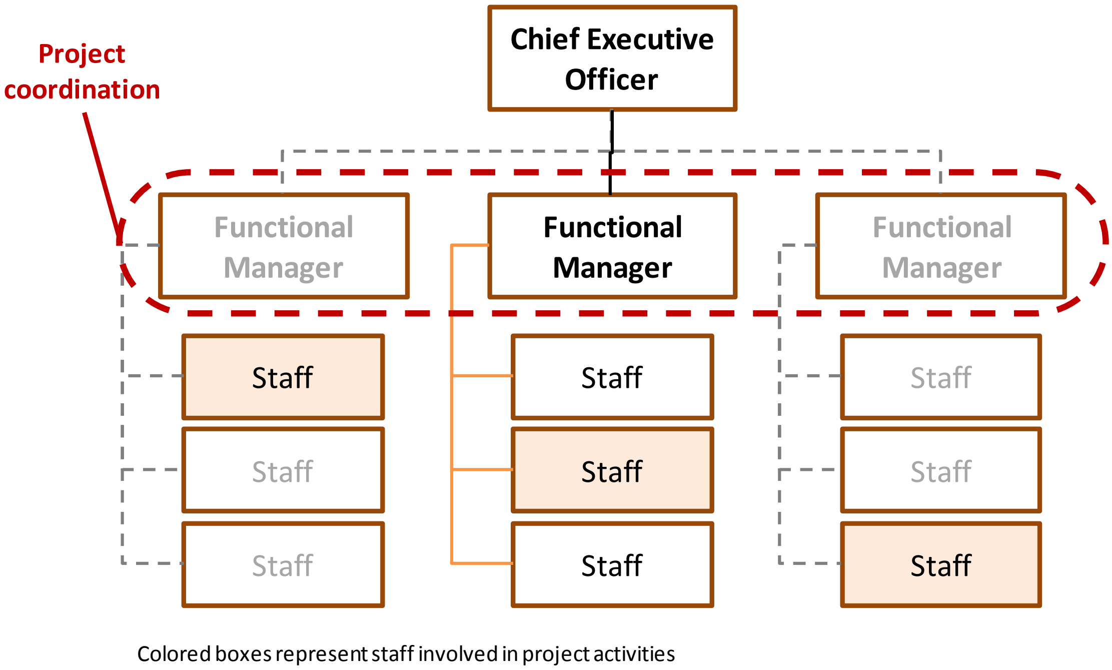


Figure 8: Functional project organisation (Source: A Guide to the Project Management Body of Knowledge, 2008)

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.

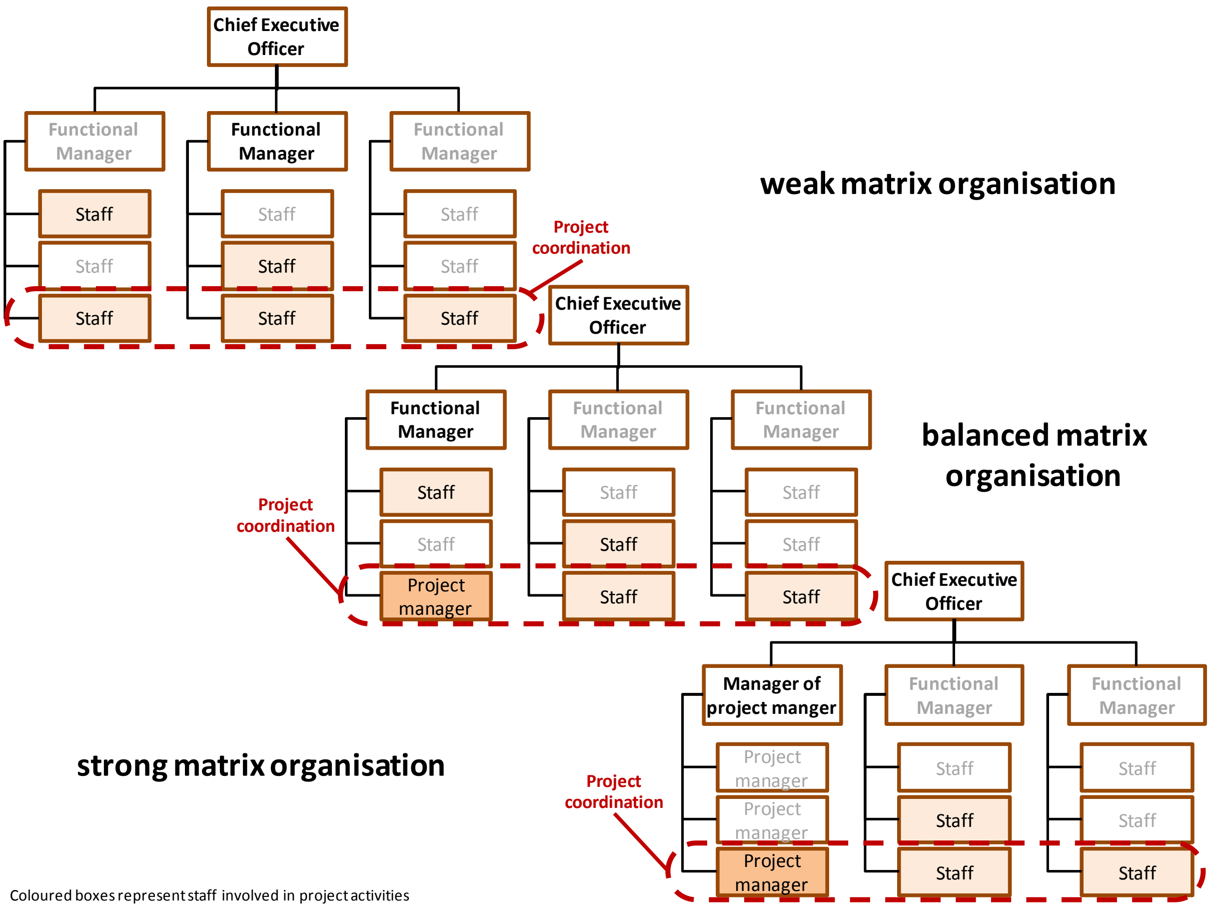


Figure 9: Forms of matrix organisation (source: A Guide to the Project Management Body of Knowledge, 2008)

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 different departments are located far apart from each other. In matrix organisation, more time must 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.

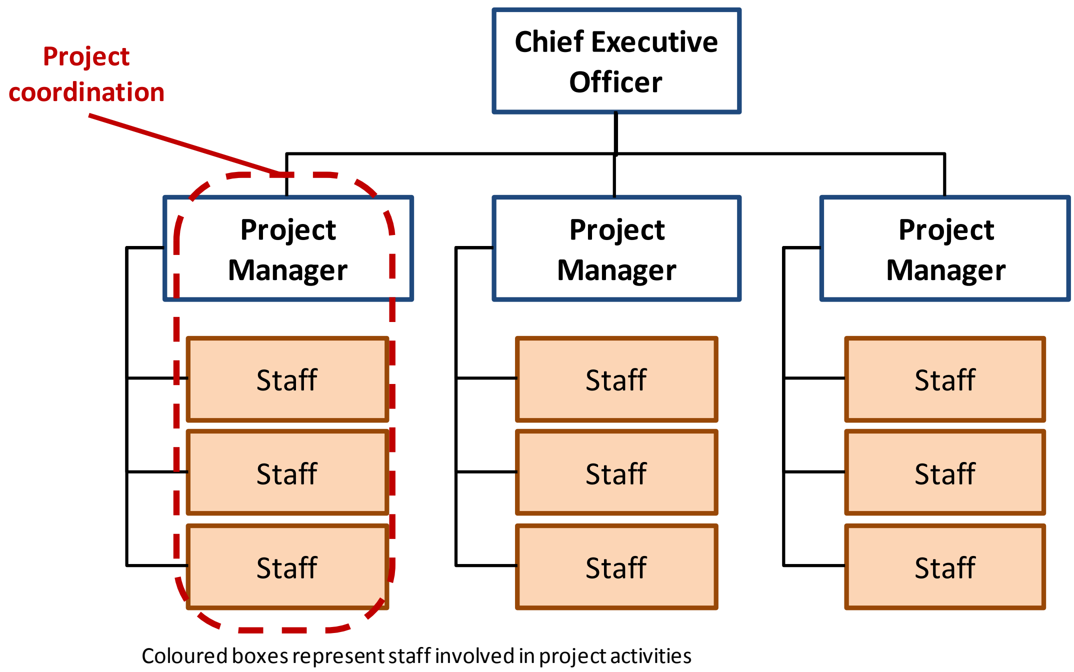


Figure 10: Projectised project organisation (source: A Guide to the Project Management Body of Knowledge, 2008)

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).

Organisation/ structure \ Project characteristics	Functional	Matrix			Projectised
		weak	balanced	strong	
Project managers authority	Little or none	Limited	Low to moderate	Moderate to high	High to almost total
Ressource availability	Little or none	Limited	Low to moderate	Moderate to high	High to almost total
Who controls the project budget	Functional manager	Functional manager	Mixed	Project manager	Project manager
Project managers role	Part-time	Part-time	Full-time	Full-time	Full-time
Project management administrative staff	Part-time	Part-time	Part-time	Full-time	Full-time

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.

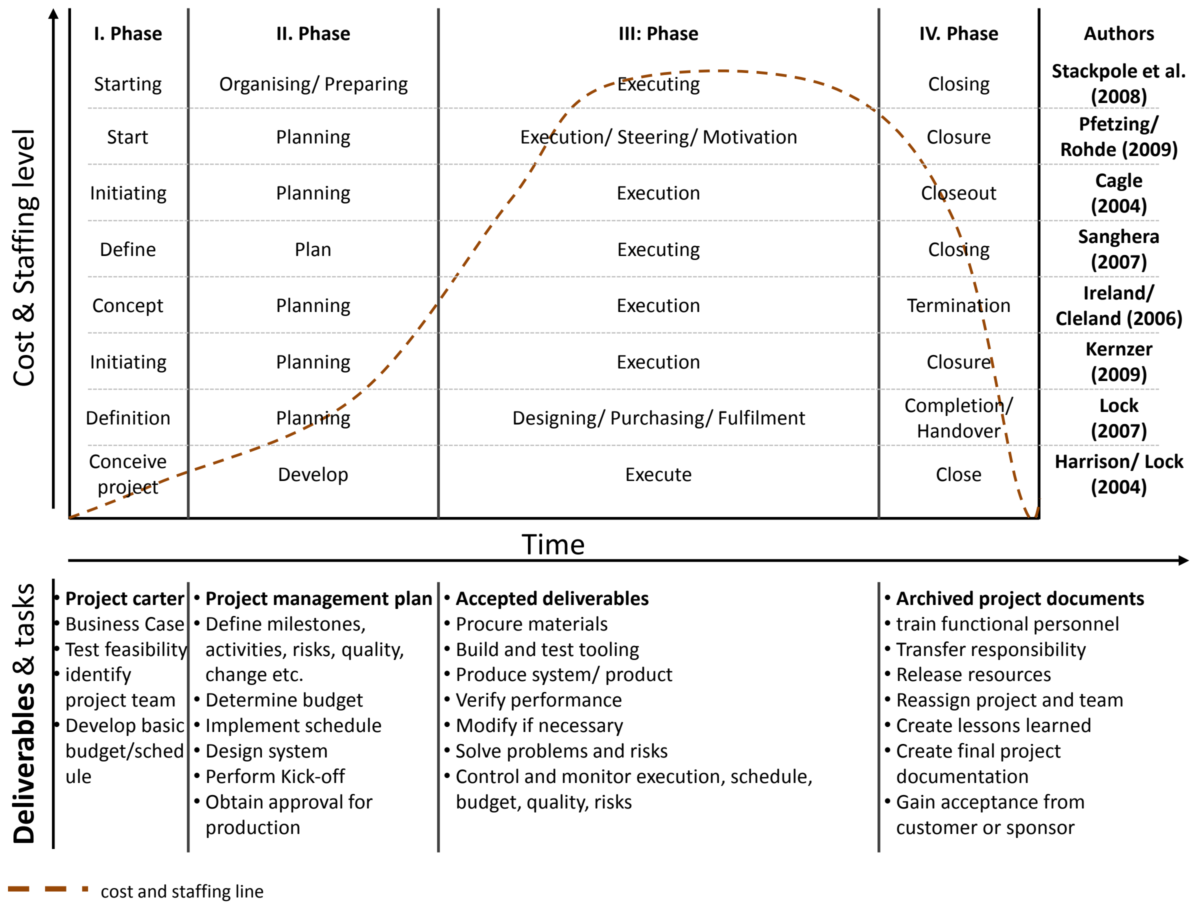


Figure 11: Project life cycle with its phases, deliverables and tasks (developed by author)

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: communication, 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).

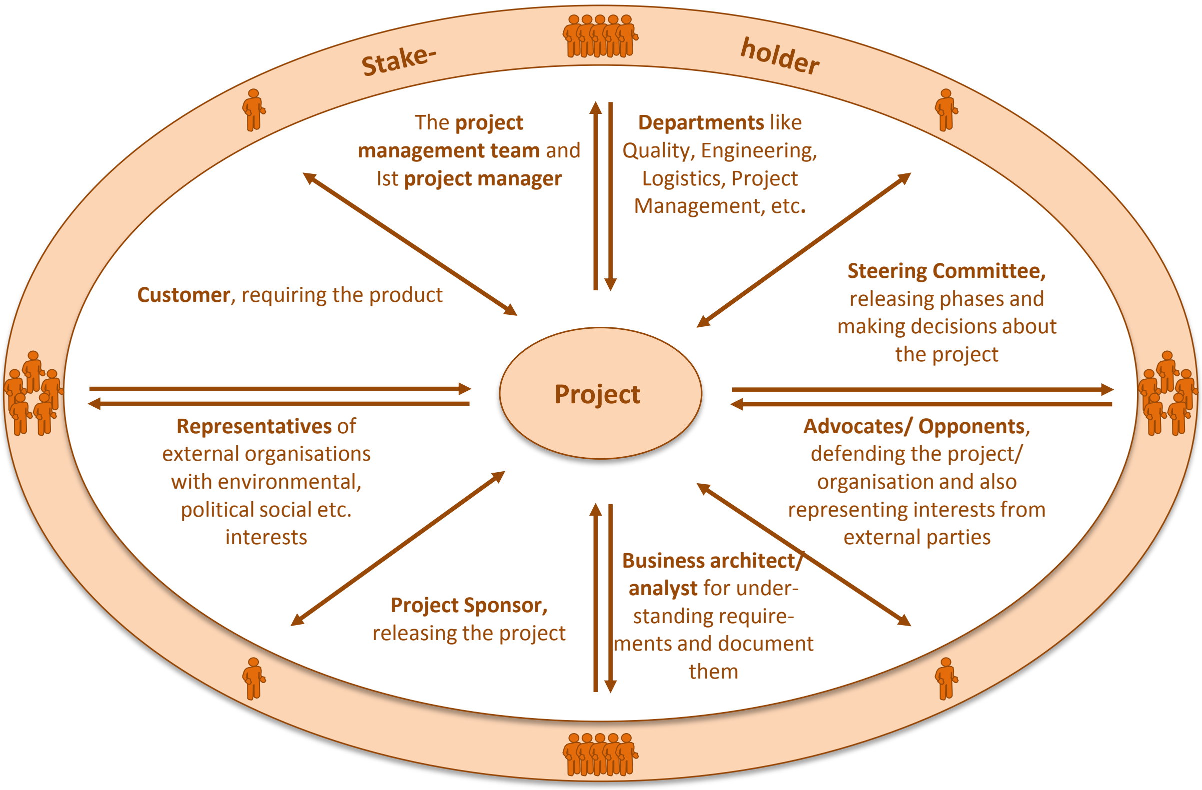


Figure 12: Stakeholder of a project (developed by author)

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.

Leadership	Communi-cation skills	Operational flexibility	Monitor and control	Generalist	Technical skills
High values	Sensitivity for Interpersonal relationships	Ability to get things done	Manage Environment of change	Self confident	Planning skills
Hard worker	Organising	Negotiate	Linked thinking	Self-manifestation	Conflict resolution
Get quality people	Teambuilding	Persuade	Assertiveness	Judicious	Administrative Skills (e.g. staffing)
Keep quality people	Coping (dealing with Stress)	Understand environment of project	Cross-linked thinking	Integrator for people	Assertiveness
Effective Work systems	Anticipate problems	Ability to review	Future orientated	Problem solver	Open minded

Figure 13: Skills and competencies for project managers (summated by author)

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

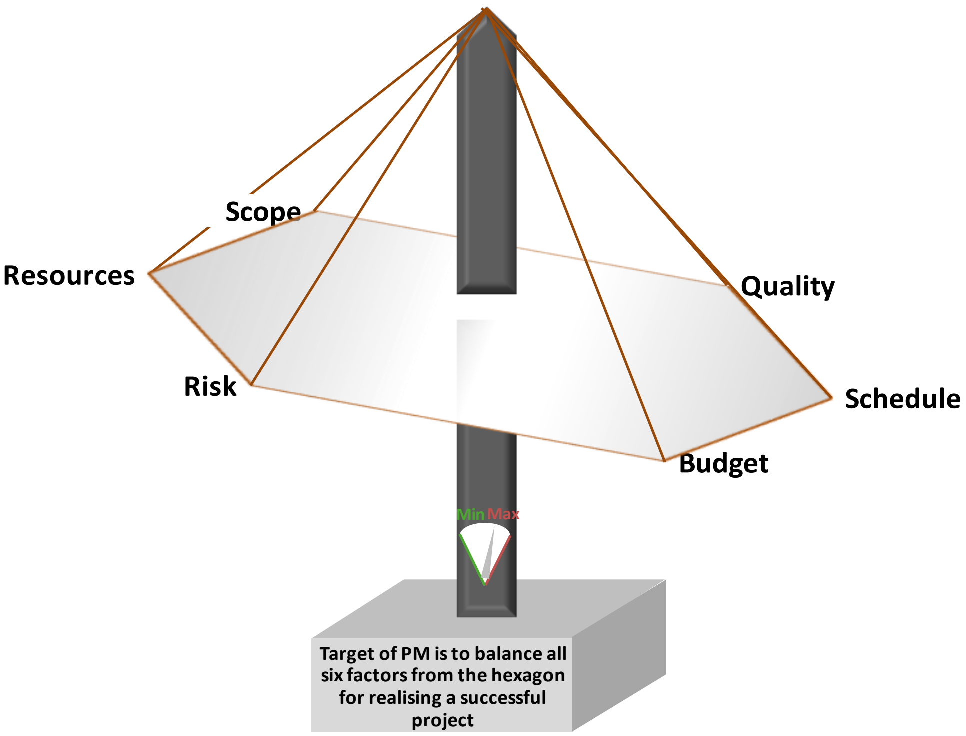
- PMI (Project Management Institute)
- CMMI (Capability Maturity Model Integration)
- PRINCE2 (Project IN Controlled Environments)
- P2M (Project and Programme Management for Enterprise Innovation)
- ICB3.0 (International Competence Baseline)
- AIPM/ NCSPM (Australian Institute of Project Management/ 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 Institut 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).

Target of PM is to balance:



Target of PM is to balance:

Magical hexagon	Scope	Quality	Schedule	Budget	Ressources	Risk	Comment
Stackpole (2008)	✓	✓	✓	✓	✓	✓	
Harrison& Lock (2004)	✓		✓	✓			
Verzuh (2008)		✓	✓	✓			
Cleland& Gareis (2006)	✓	✓	✓	✓			
Dobiéy et al. (2004)		✓	✓	✓			
Kernzer (2009)	✓	✓1)	✓	✓			
Lock (2007)	✓	✓	✓	✓	✓		Derived from Banes (1980)
Lester (2007)	✓	✓1)	✓1)	✓		✓2)	
Aichele (2006)	✓3)	✓	✓	✓			
Litke (2007)	✓	✓	✓	✓			
Mayer et al. (2008)	✓	✓	✓	✓			

1) Described as performance 2) described as safety 3) described as functionality

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

(Bentley, 2010). 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 performance 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).

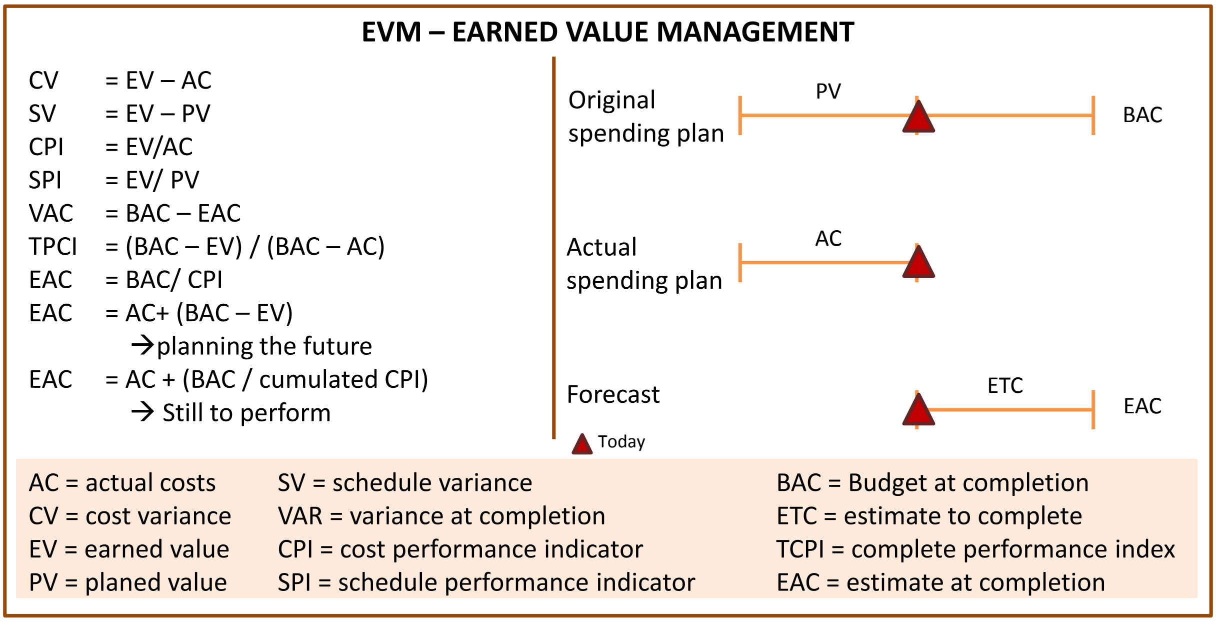


Figure 15: Description of EVM (developed by author)

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 may 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.

Standards / Facts	PMP (PMI)	CMMI (SEI)	Prince2 (OGC)	P2M (JPMF)	ICB3.0 (IPMA)	NCSPM (AIPM)	PMSGB (SAQA)
Country of origin	USA	USA	UK	Japan	Switzerland	Australia	South Africa
Example of associated companies	Bank of America, Booz Allen Hamilton, PWC, U.S. DoD, IBM, Lokheed, ..	Continental AG, ABB, Deloitte, NASA, US AIF, Lockheed, Thales, EADS,...	IBM, SUN, ThyssenKrupp, Deutsche Post, British Telecom, Fraport AG, ...	PME Group Ltd.	Xerox, Disney, Microsoft, IBM, Intel, Ericson, Citigroup, SIEMENS, ...	Boeing, Thales, Arup, Aurecon, JACOBS, BAE Systems, AXA Australia, ...	n.a.
Int. accepted certification	yes	yes	yes	yes	yes	yes	yes
Certification owner/ world	>520.000	>4.000	270.000	2.500	>170.000	3.800	1.200
Practising countries	>200	13	70	n.a.	>60	1	1
Languages	Arabic, Chinese, English, French, German, Italian, Japanese, Korean, Portuguese, Russian, Spanish	English	Chinese, Danish, Dutch, English, French, German, Norwegian, Polish, Spanish	English, Japanese	Chinese, Danish, Dutch, English, French, German, Polish, Spanish	English	English
Year of foundation	1969	1997	1984	2002	1965	1976	1997
Standards	ISO 9001 ISO 10006 ISO 21500 ANSI 99-001 IEEE1490-2003	ISO 9000 ISO 9001	ISO 9000 ISO 9001	ISO 10006	ISO 10006 DIN 69901ISO 21500	ISO 21500	ISO 21500

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, PMIs 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 of 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.

	Experts					
Features of complexity	Valle (2000)	Riedl (2000)	Prucker (2005)	Ehrlenspiel (2009)	Schwarz (2011)	Feess (2013)
continuous motion/ momentum	✓	✓	✓	✓	✓	✓
increase of complexity/ non-transparency	✓	✓	✓	✓	✓	✓
large amount of different elements	✓			✓	✓	✓
adaption	✓	✓		✓	✓	
spontaneity of hierarchy	✓	✓	✓		✓	
irreversible		✓	✓			✓
considering given restrictions	✓	✓				

Table 5: Characteristics of complexity (summarized from Valle, 2004; Riedl, 2000; Prucker, 2005; Ehrlenspiel, 2009; Schwarz, 2011 and Feess, 2013)

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).

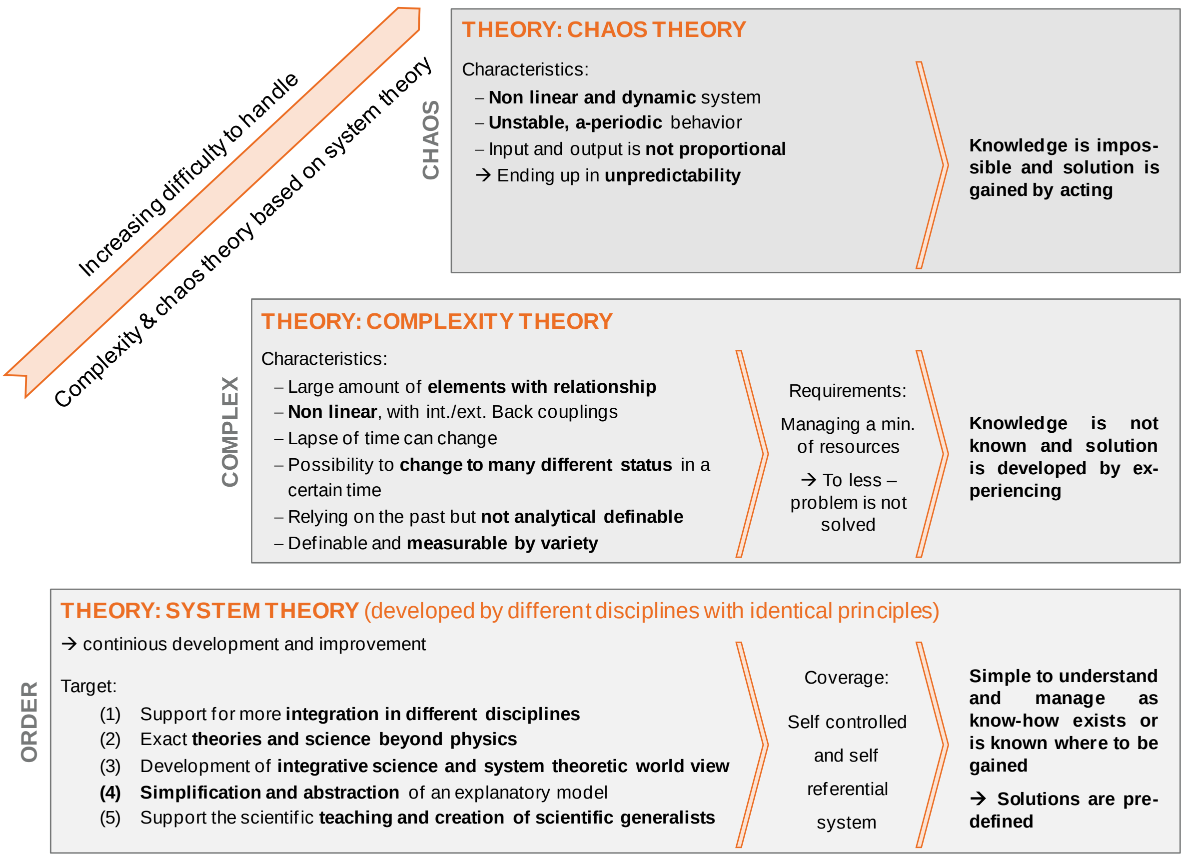


Figure 16: Differences of System-/ Complexity- and Chaos-Theory (summarized by author)

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.

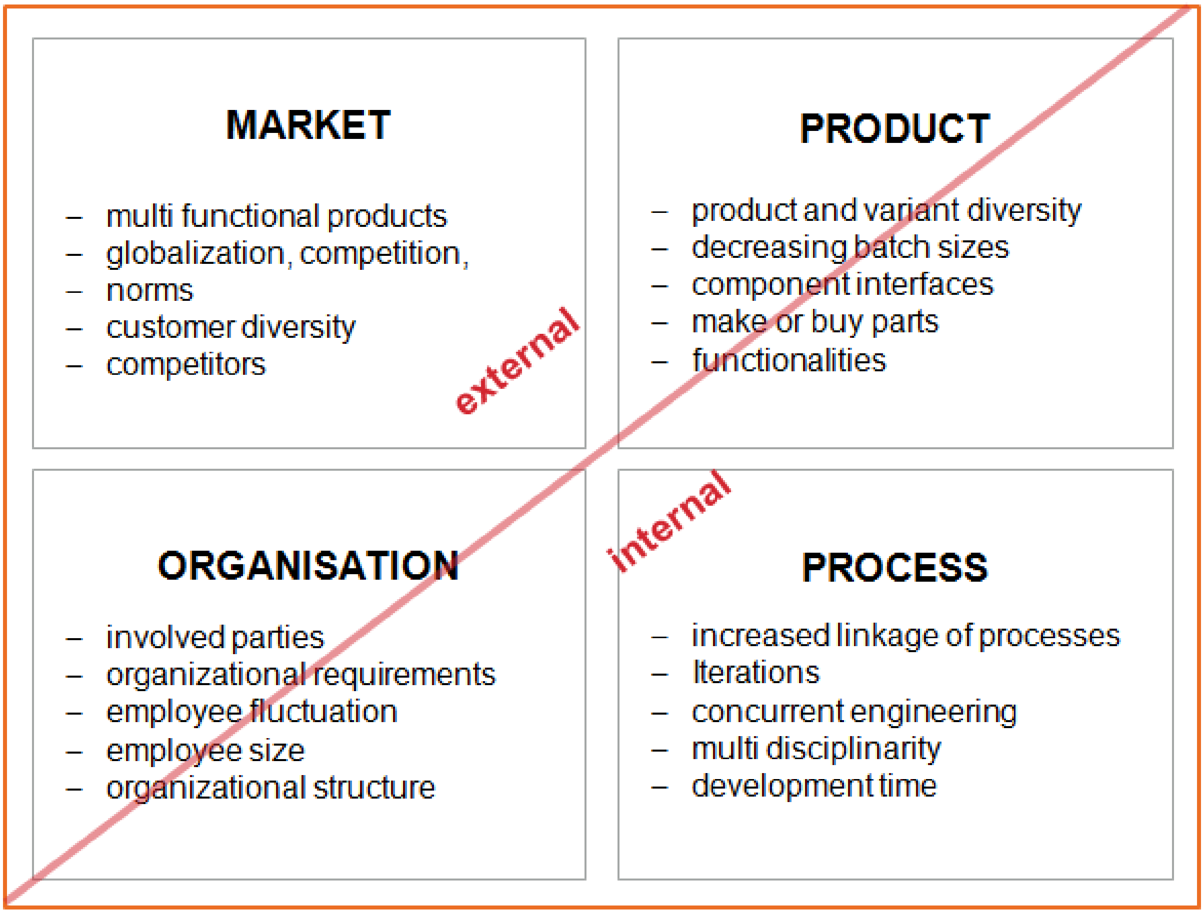


Figure 17: Internal and external root causes for complexity (adapted from Lindemann, Braun & Maurer, 2009)

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 organisation affect the product/ project such as the interfaces or make/ buy-part decision and change the structure of organisation. 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).

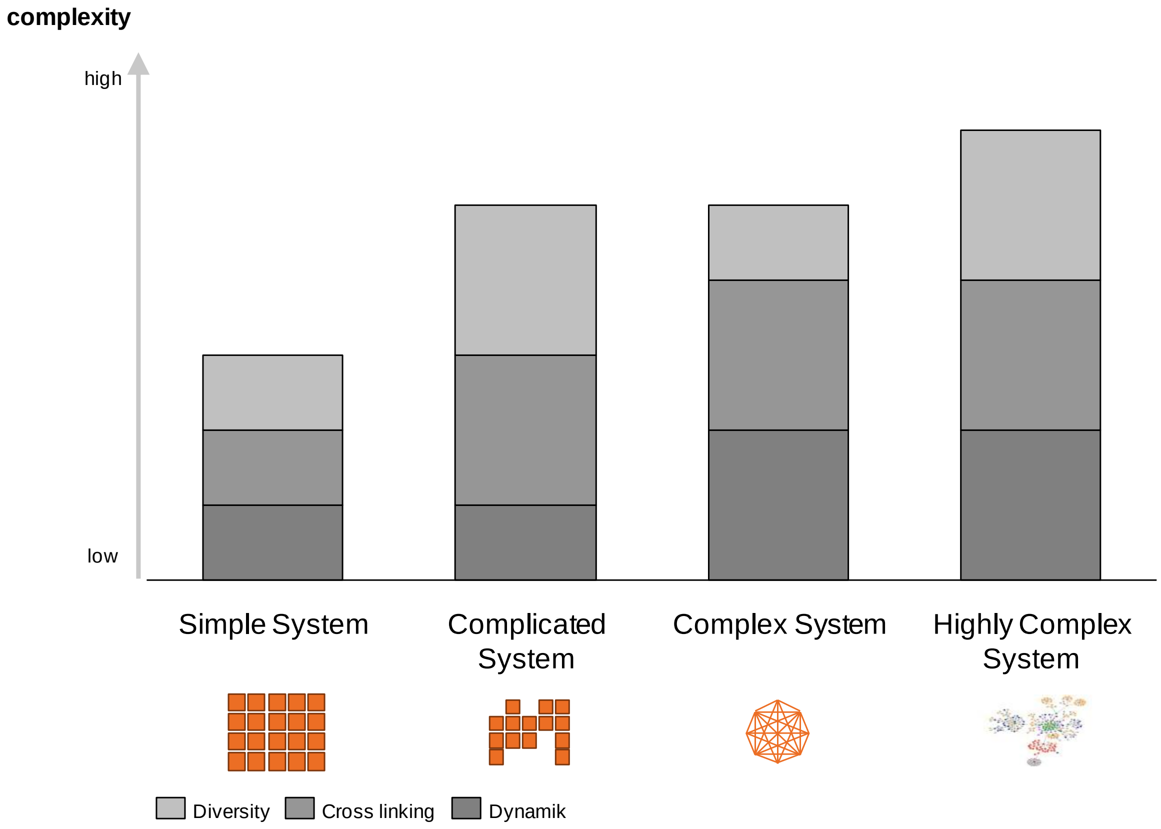


Figure 18: Main dimensions of complexity strengthener (developed by author)

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 strengthners 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, Lammers, & 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).

Complexity strengthener \ Authors/ experts	Koch/ Seliger/ Probst	Krause	Kersten/ Meyer	Lindemann	Maznevski	Schuh	Franke	Haas	Ward	Dobusch	Leybourne	Mayer	Ireland	Chroneer
Size of project/ organisation (people/ assets)	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		
Interface internal/ external for parts, companies, environment and projects	✓		✓	✓	✓	✓	✓	✓				✓	✓	
Customer requirements (country specifics/ functions and individualisation)	✓	✓	✓	✓	✓	✓	✓	✓						
Market dynamics (competitors) => flexibility	✓	✓	✓	✓		✓	✓			✓				
Organisational changes	✓	✓	✓	✓		✓		✓				✓		
Amount of stakeholder/ cooperation with companies	✓	✓	✓	✓					✓			✓		✓
Technical-/ product diversity	✓	✓	✓	✓		✓	✓		✓					
Communication/ decision process/ information use	✓	✓	✓		✓		✓				✓			✓
Laws/ norms/ regulatories	✓	✓	✓	✓	✓		✓		✓					
Changes in time/ schedule (time to market)	✓		✓	✓		✓		✓	✓					
Internationality/ countries/ facilities	✓		✓		✓				✓	✓				
Cultural diversity	✓	✓			✓				✓		✓			
Process/ methods changes		✓	✓	✓		✓								✓
New/ diverse technologies	✓	✓		✓				✓		✓			✓	
Political changes	✓	✓			✓	✓	✓	✓						
Innovation in product/ organisation	✓	✓	✓	✓									✓	
Globalisation/ market opening	✓	✓	✓	✓			✓							
In-house production depth/ production processes	✓		✓							✓				
Economical changes (crises)	✓	✓			✓									
Data storage/ -distribution/ -organisation/ -care		✓	✓								✓			
New materials	✓	✓		✓										
Economical KPIs and diversity	✓								✓					
Demographical change/ change of consumer structure	✓	✓												
Diversity of changes			✓			✓								
Time limited actuality					✓									
Virtuell techniques		✓												
Incompatible systems/ tools		✓												
Partitionment of work/ competency/ responsibility			✓											

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, Warsing, 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.

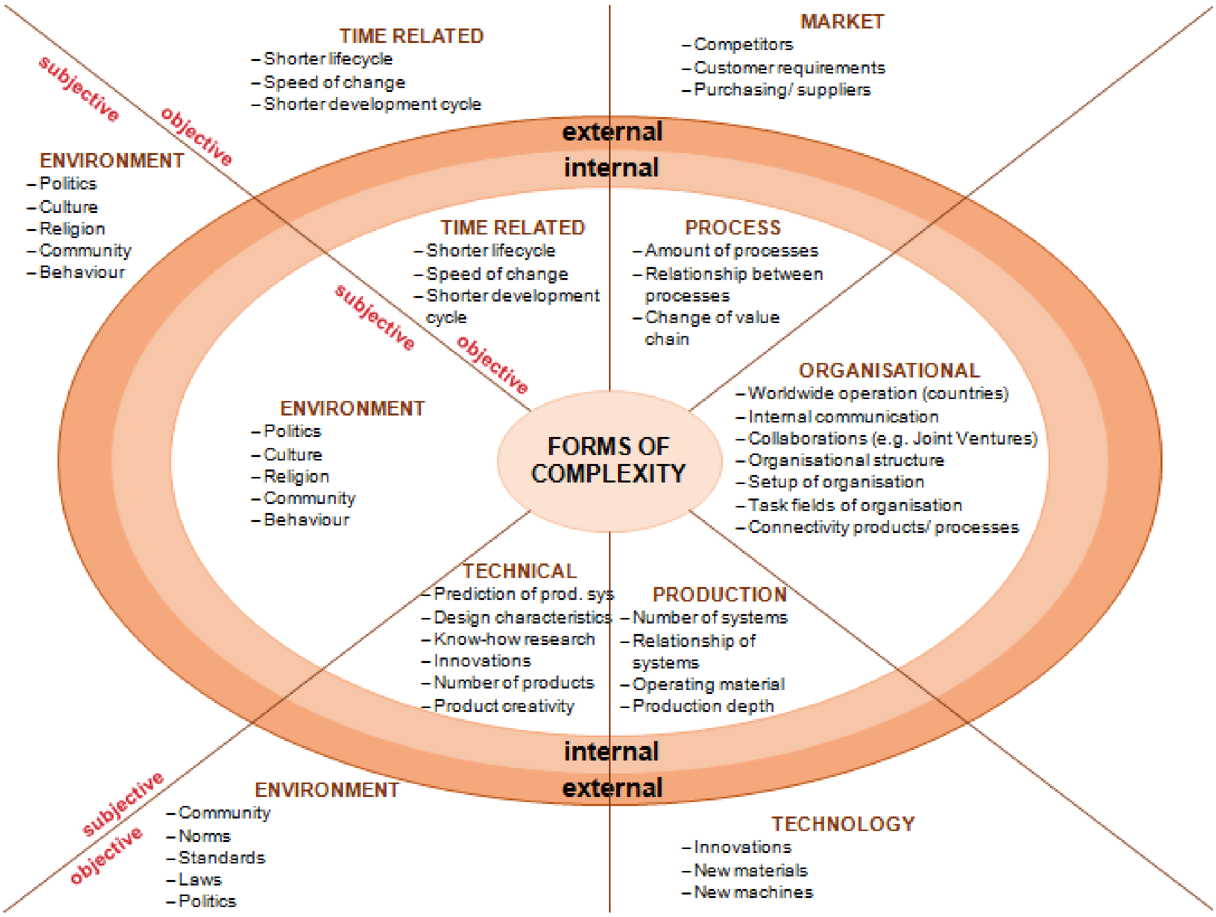


Figure 19: Forms of internal/ external and objective/ subjective complexity (developed by author)

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).

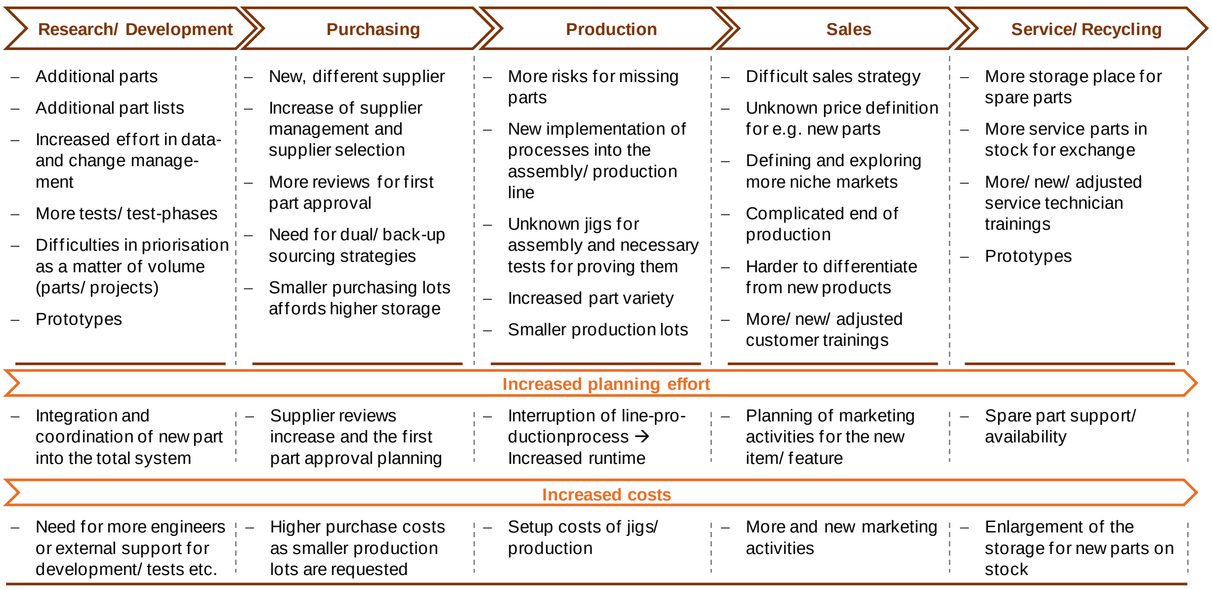


Figure 20: Possible impacts in the value chain (as summarized from Franke et al., 2002)

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.

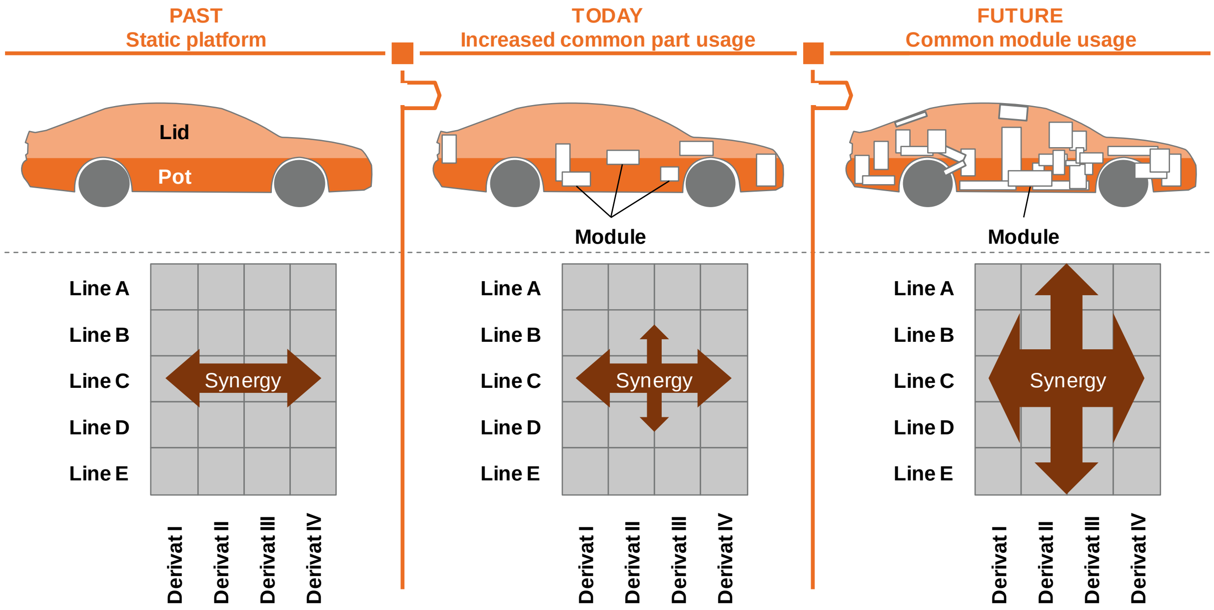


Figure 21: Example for increasing modules in overall systems and its synergy (source: Volkswagen)

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. Continuous 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.

VISUALISATION METHODS FOR COMPLEXITY		
Understand complexity	**Reduce complexity**	**Manage complexity**

– Mapping
  – Mind map
– Rich picture method
– Scenario analysis
– Fuzzy Logic
	– Graph theory
	  – Network (arrow) diagrams like value stream mapping (VSM) and value network mapping (VNM)
	  – GANTT/ PERT/ CPM
	– Portfolio
	– Mapping
	  – Concept map
		– Balanced Score Card (BSC)
		– Data structural matrix (DSM)
		  – Component, people, activity and parameter based DSM
		  – Domain Mapping Matrix (DMM)
		  – Multiple Domain Matrix (MDM)
		– Portfolio
		– Fuzzy Logic

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 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 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.

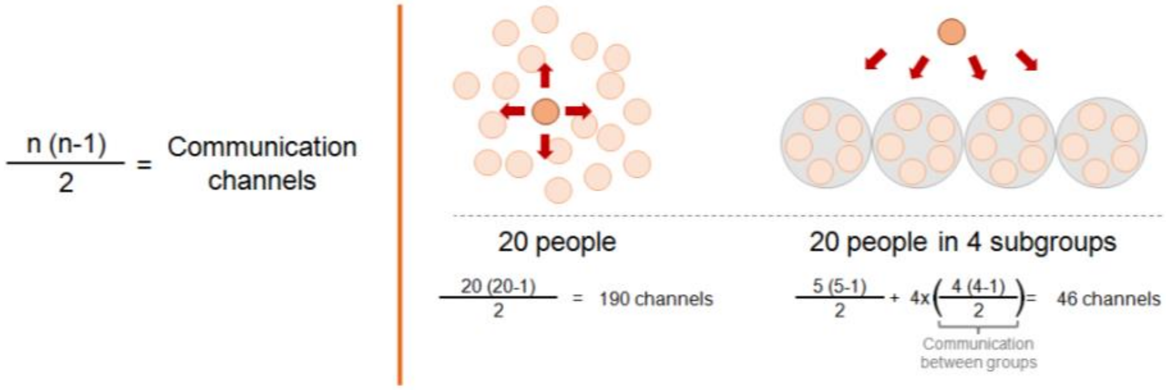


Figure 22: Communication formula (source: derived from Leybourne et al., 2010)

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 categorised 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.

HEURISTIC PROCESS	THEORY OF CREATING ORDER	STEERED ORDER (TAXIS)
PROCESS 1. Perform **simple steps first** 2. Learn to **control simple steps** without problems **3. Implement a new level** above the simple steps **4. Don't change** the simple steps **5. Assure unproblematic work** of the new level **6. Repeat** ad finitum	RESTRICTION – Same approach for **complex and simple situations** – Knowing a small part of **a system gives the possibility to know the total** system – Order can be **created in more or less big systems** and therefore its expectations – **Regularity** is necessary for survival – Order can be **obvious or planned** – **Defined rules** for elements in a system which can move freely inside the system according to the rules – Complexity of **obvious order can never increase complexity of the planning** instance – Spontaneous order has a higher **level on knowledge influencing the order** – Spontaneous order is only **realisable by reconstruction** (e.g. crystals) – Order is created **by know-how of the evolutional** process – Code of conducts are created by **depending on elements and individuals** – Order listening to one element are limited → **complexity increase when rules are more general**	RESTRICTION – **Intentional steered** order – Differentiation into self **coordinated system** (e.g. soccer team in a game) and **coordinated system** (e.g. ships complement) which is mostly build up in a hierarchical way – **System reacts intentional on influences** from an external system

Table 8: Theoretical methods for handling complexity - arrangement (developed by author)

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)

- 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.

Vesters sensitivity model	analytical reductive	constructivist
PROCESS 1. **System description:** 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? 2. **Identification of influencing factors:** Identify intersection, describe the system roughly, documentation of variables 3. **Proofing system relevance:** Physical-, dynamical criteria, Environment (involved people/ resources etc) and system relationships 4. **Questioning interactions:** Impact of variables inside the system (impact matrix) to their under-, over-proportion 5. **Defining roles inside the system:** definition along their activity or passivity 6. **Overall relationship** Outlining the network and back coupling effects inside the system	CONDITION – 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?	CONDITION – Core Idea **based on rational decision** – Strongly **based on mathematical quantitative** approach – Method tries to identify principles, techniques and methods to **make rational decisions** – Constructivist method **can not be realised in reality** -> better decision than evolutionary method – Developing **rational prob. solutions** **1. Define target systems** and priority scales 2. Problem solving process is a **target-necessity-definition process** 3. Intensive **analysis of all alternatives** and its competences 4. Sufficient operationable/ **stable evaluation criteria** → **Mistakes in Method** Respecting know-how limitations, open mindset on all complex problems, inseperably link to facts, incomplete information, overrated evaluation criteria

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

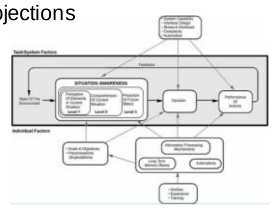
evolutionary	Cognitive mechanism (human)	situation awareness model
CONDITION – Developed by the **evolutional process** – **Too big complexity causes uncertainty** and no decision (too less info for rational decision) – Too less info → **decision is based on cognitive information** closing gaps without knowing it **Characteristics** 1. Consider **limited amount of alternatives** 2. Consider **limited amount of important decisions** 3. Decision making often by **marginal and often incremental differences** of alternatives **4. Interactions** between target and alternatives 5. Permanent **reconstruction of data** **6. Sequential analysis and evaluation** of problem 7. Analysis and evaluation **shall solve the problem** **8. Social fragmentation** of process	CONDITION – **Inferential principle:** The human brain generates conclusions by creating pattern which must not be completed – **Consistence principle:** Conclusions from the inferential principle which are not logical and conflicting are eliminated – **Reality principle:** Close relationship to the environment where the development of the cognitive function is developed in accordance with the environment – **Simplicity principle:** Simplification of complex situations without objective reasons -> selective recording and handling of information – **Stability principle:** Cognitive structures remain stable by themselves – **Abstractive principle:** Each phenomenon in the human mind follows the same rules like all other spontaneous order	PROCESS – **Depending on factors** like workload, available tools, complexity of situation etc. Steps **1. Notice of environment** Notice of dynamic, condition and status of elements in the environment **2. Understanding of actual situation** Synthesis of first step → understanding of overall situation by developing pattern – less important elements are not allowed to be not noticed **3. Projection into the future** Elements and its dynamic (step1) and relevance in total system (step2) are known and will be used for future projections  Source: Endsly (1995)

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 fulfil 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).

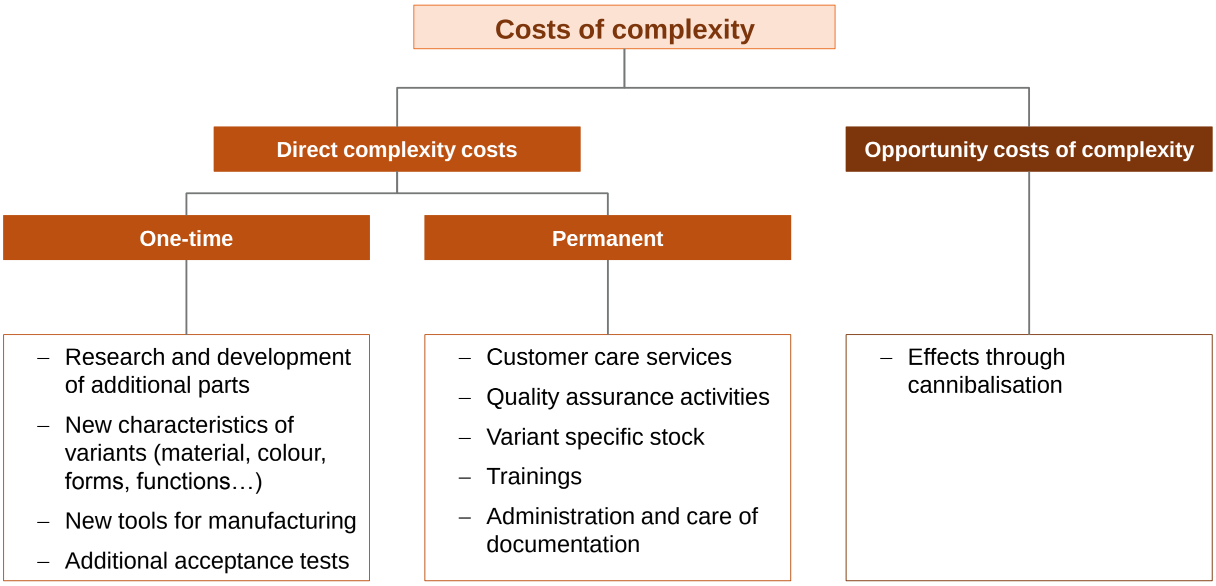


Table 11: Costs of complexity (source: Schuh, 2005a)

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 'strengtheners' 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 handling of complex projects. Each time a team is set up; it will develop differently as humans 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 handling 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). Quantitative 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.

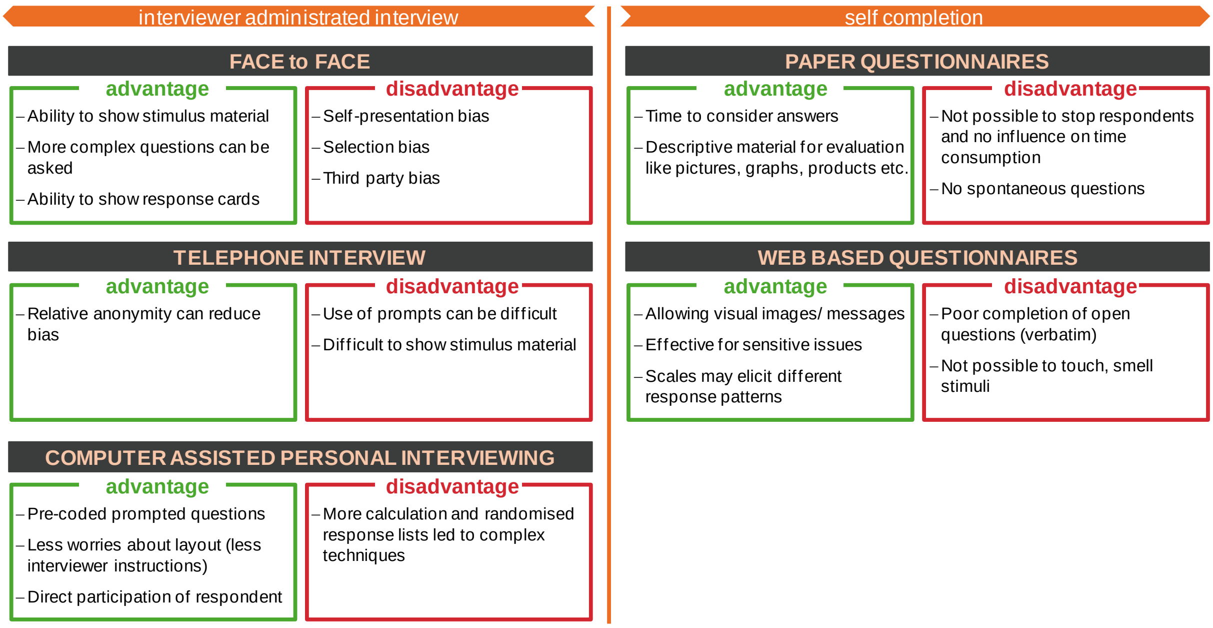


Figure 23: Media for collecting data (summarized by author from Brace (2008))

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 ˈ000 €) 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 on 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): thematizing, 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 round table, 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 "phenomenological 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.

– 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 projects, 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 standard. 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 compared 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

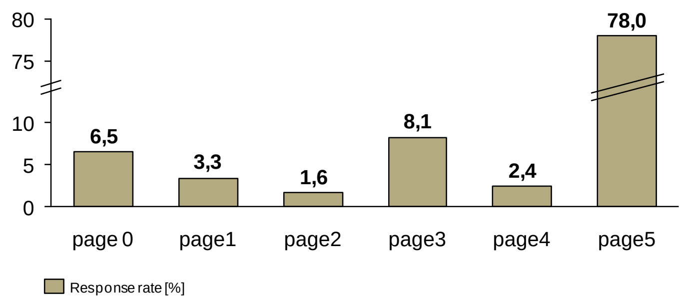
In order to prove experience, a descriptive statistic method was used. This method was characterized by analyzing the frequency, absolute, and percentage figures. Afterward, standard analyzing methods were used such as: arithmetic mean, the standard error of arithmetic mean, median, variance, minimum,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

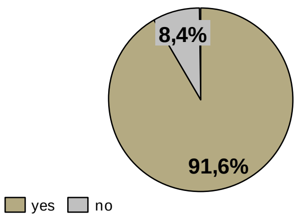
Findings

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.



		frequency	percent	valid percent	cummulated percent
valid	0	8	4,5	6,5	6,5
	1	4	2,3	3,3	9,8
	2	2	1,1	1,6	11,4
	3	10	5,7	8,1	19,5
	4	3	1,7	2,4	22,0
	5	96	54,5	78,0	100,0
	sum	123	69,9	100,0	
missing	system	53	30,1		
total		176	100,0		

Figure 24: Editing of survey by participants

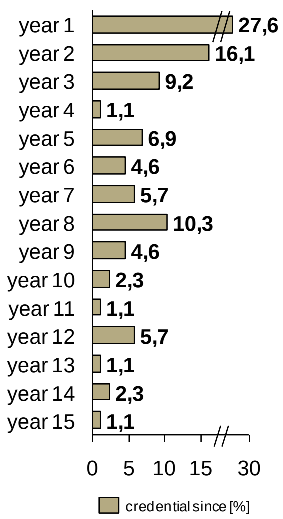


		frequency	percent	valid percent	cummulated percent
valid	no	8	8,3	8,4	8,4
	yes	87	90,6	91,6	100,0
	sum	95	99,0	100,0	
missing	99	1	1,0		
total		96	100,0		

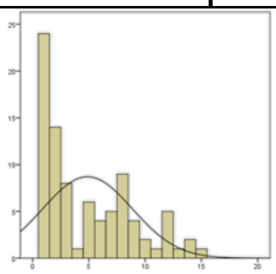
Figure 25: Credential holder of PMP (PMI)

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.



N	valid	87
	missing	9
arithmetic mean		4,87
standard error of arithmetic mean		,428
median		3,00
modus		1
standard deviation		3,988
variance		15,902
span		14
minimum		1
maximum		15
TOTAL		424

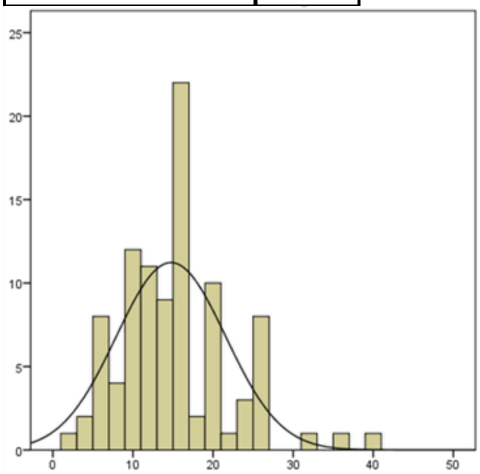


experience		frequency	percent	valid percent	cummulated percent
valid	1	24	25,0	27,6	27,6
	2	14	14,6	16,1	43,7
	3	8	8,3	9,2	52,9
	4	1	1,0	1,1	54,0
	5	6	6,3	6,9	60,9
	6	4	4,2	4,6	65,5
	7	5	5,2	5,7	71,3
	8	9	9,4	10,3	81,6
	9	4	4,2	4,6	86,2
	10	2	2,1	2,3	88,5
	11	1	1,0	1,1	89,7
	12	5	5,2	5,7	95,4
	13	1	1,0	1,1	96,6
	14	2	2,1	2,3	98,9
	15	1	1,0	1,1	100,0
	sum	87	90,6	100,0	
missing	99	9	9,4		
total		96	100,0		

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.

N	valid	96
	missing	0
arithmetic mean		14,75
standard error of arithmetic mean		,696
median		15,00
modus		15
standard deviation		6,821
variance		46,526
span		37
minimum		2
maximum		39



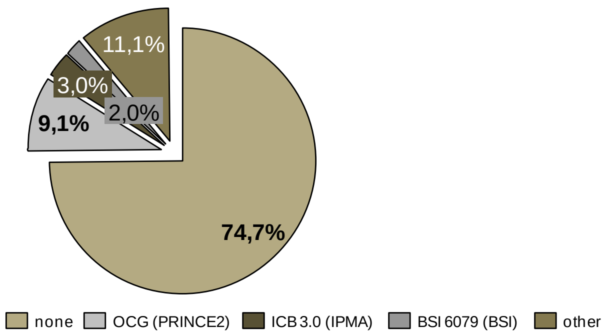
experience		frequency	percent	valid percent	cummulated percent
valid	2	1	1,0	1,0	1,0
	4	2	2,1	2,1	3,1
	5	6	6,3	6,3	9,4
	6	2	2,1	2,1	11,5
	7	1	1,0	1,0	12,5
	8	3	3,1	3,1	15,6
	9	1	1,0	1,0	16,7
	10	11	11,5	11,5	28,1
	11	2	2,1	2,1	30,2
	12	9	9,4	9,4	39,6
	13	7	7,3	7,3	46,9
	14	2	2,1	2,1	49,0
	15	19	19,8	19,8	68,8
	16	3	3,1	3,1	71,9
	17	1	1,0	1,0	72,9
	18	1	1,0	1,0	74,0
	19	1	1,0	1,0	75,0
	20	9	9,4	9,4	84,4
	21	1	1,0	1,0	85,4
	23	2	2,1	2,1	87,5
	24	1	1,0	1,0	88,5
	25	7	7,3	7,3	95,8
	26	1	1,0	1,0	96,9
	32	1	1,0	1,0	97,9
	35	1	1,0	1,0	99,0
	39	1	1,0	1,0	100,0
	total	96	100,0	100,0	

Figure 27: Experience in project management of participants

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.



		responses		percent of cases
		N	percent	
other certifications than PMP	none	74	74,7%	77,9%
	OCG (PRINCE2)	9	9,1%	9,5%
	ICB 3.0 (IPMA)	3	3,0%	3,2%
	BSI 6079 (BSI)	2	2,0%	2,1%
	other	11	11,1%	11,6%
total		99	100,0%	104,2%

Figure 28: Other certifications than PMP (PMI)

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):

(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)

(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.

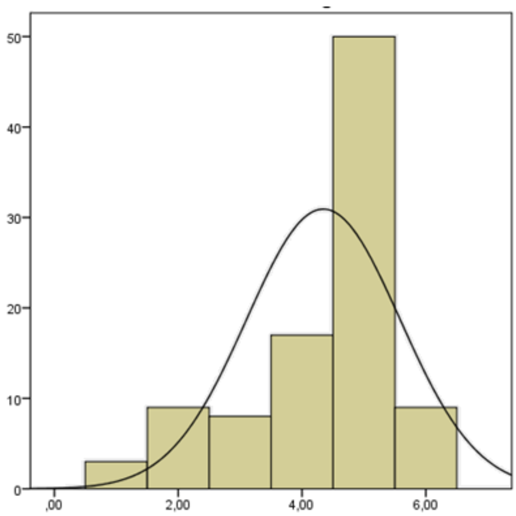
Afterward, the different categorization of projects with appearing strengtheners and preferred handling method were correlated, which was intended to identify significance significant relationship between the answers.

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.



amount of answers		frequency	percent	valid percent	cummulated percent
valid	1	3	3,1	3,1	3,1
	2	9	9,4	9,4	12,5
	3	8	8,3	8,3	20,8
	4	17	17,7	17,7	38,5
	5	50	52,1	52,1	90,6
	6	9	9,4	9,4	100,0
	Gesamt	96	100,0	100,0	

N	valid	96
	missing	0
arithmetic mean		4,3438
standard error of arithmetic mean		,12638
median		5,0000
modus		5,00
standard deviation		1,23823
variance		1,533
span		5,00
minimum		1,00
maximum		6,00

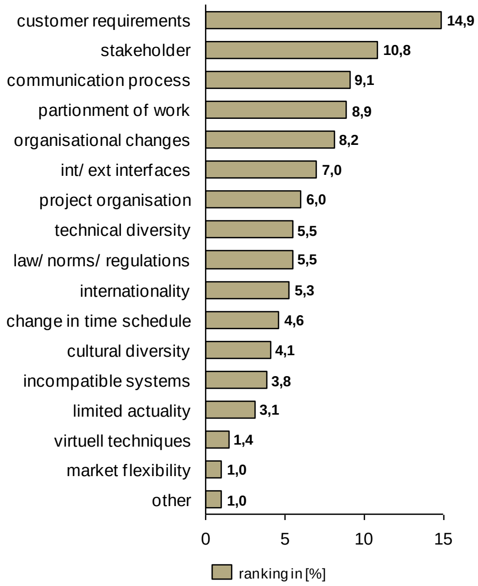
Figure 29: Transformed answers according to respondents for complexity strengtheners

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.

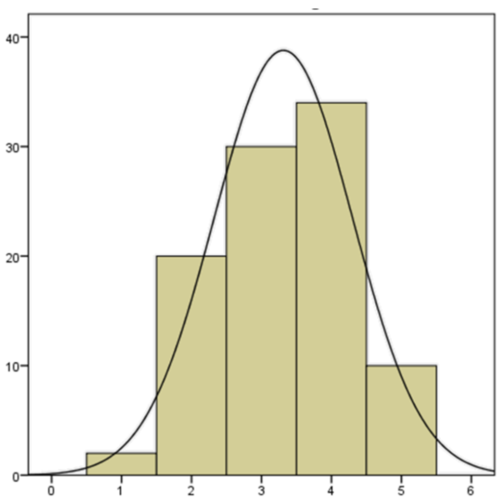
	cases					
	valid		missing		total	
	N	percent	N	percent	N	percent
complexity strenghtener in	96	100,0%	0	0,0%	96	100,0%



		responses		percent of cases
		N	percent	
complexity strengtheners in projects	customer requirements	62	14,9%	64,6%
	stakeholder	45	10,8%	46,9%
	communication process	38	9,1%	39,6%
	partionment of work	37	8,9%	38,5%
	organisational changes	34	8,2%	35,4%
	int/ ext interfaces	29	7,0%	30,2%
	project organisation	25	6,0%	26,0%
	technical diversity	23	5,5%	24,0%
	law/ norms/ regulations	23	5,5%	24,0%
	internationality	22	5,3%	22,9%
	change in time schedule	19	4,6%	19,8%
	cultural diversity	17	4,1%	17,7%
	incompatible systems	16	3,8%	16,7%
	limited actuality	13	3,1%	13,5%
	virtuell techniques	6	1,4%	6,3%
	market flexibility	4	1,0%	4,2%
	other	4	1,0%	4,2%
total		417	100,0%	434,4%

Figure 30: ranking of complexity strengtheners appeared in real 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.

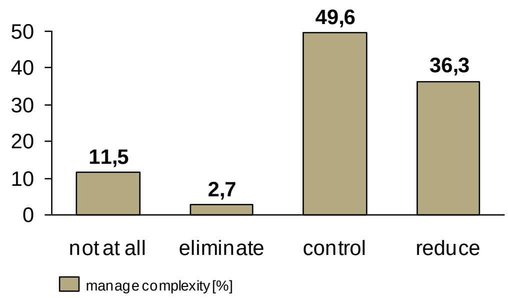


N	valid	96
	missing	0
arithmetic mean		3,31
standard error of arithmetic mean		,101
median		3,00
modus		4
standard deviation		,987
variance		,975
span		4
minimum		1
maximum		5

		frequency	percent	valid percent	cummulated percent
valid	1 (low)	2	2,1	2,1	2,1
	2	20	20,8	20,8	22,9
	3	30	31,3	31,3	54,2
	4	34	35,4	35,4	89,6
	5 (high)	10	10,4	10,4	100,0
	total	96	100,0	100,0	

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%.



	cases					
	valid		missing		total	
	N	percent	N	percent	N	percent
managaing complexity	96	100,0%	0	0,0%	96	100,0%

		responses		percent of cases
		N	percent	
managing complexity	not at all	13	11,5%	13,5%
	eliminate	3	2,7%	3,1%
	control	56	49,6%	58,3%
	reduce	41	36,3%	42,7%
total		113	100,0%	117,7%

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):

			Q12_ranking_of_project_concerning_complexity
Spearman-Rho	Q13_managing_complexity___not_at_all	correlation coefficient	,053
		Sig. (double sided)	,609
		N	96
	Q13_managing_complexity___eliminate	correlation coefficient	-,009
		Sig. (double sided)	,930
		N	96
	Q13_managing_complexity___control	correlation coefficient	,013
		Sig. (double sided)	,902
		N	96
	Q13_managing_complexity___reduce	correlation coefficient	,010
		Sig. (double sided)	,920
		N	96

**. Correlation is on the level 0,01 significant (double sided).

Figure 33: Correlation of question 12 and 13

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 $p \leq 0.01$): 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.

			Q12 (1=low; 5=high)
Spearman-Rho	project organisation	correlation coefficient	,096
		Sig. (double sided)	,353
		N	96
	int/ ext interfaces	correlation coefficient	,030
		Sig. (double sided)	,772
		N	96
	customer requirements	correlation coefficient	,053
		Sig. (double sided)	,605
		N	96
	market flexibility	correlation coefficient	-,010
		Sig. (double sided)	,924
		N	96
	organisational changes	correlation coefficient	-,049
		Sig. (double sided)	,633
		N	96
	stakeholder	correlation coefficient	-,002
		Sig. (double sided)	,982
		N	96
	limited actuality	correlation coefficient	,152
		Sig. (double sided)	,140
		N	96
	virtuell techniques	correlation coefficient	,044
		Sig. (double sided)	,672
		N	96
	incompatible systems	correlation coefficient	,056
		Sig. (double sided)	,589
		N	96
	technical diversity	correlation coefficient	,185
		Sig. (double sided)	,071
		N	96
	communication process	correlation coefficient	-,041
		Sig. (double sided)	,692
		N	96
	law/ norms/ regulations	correlation coefficient	,171
		Sig. (double sided)	,095
		N	96
	law/ norms/ regulations	correlation coefficient	-,087
		Sig. (double sided)	,400
		N	96
	internationality	correlation coefficient	,114
		Sig. (double sided)	,268
		N	96
	cultural diversity	correlation coefficient	-,252*
		Sig. (double sided)	,013
		N	96
	partionment of work	correlation coefficient	0,000
		Sig. (double sided)	1,000
		N	96
	other	correlation coefficient	-,073
		Sig. (double sided)	,481
		N	96

**. 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

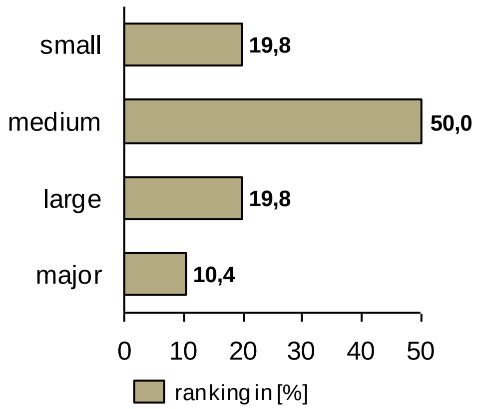
All questions were analyzed with a descriptive statistic method according to frequency. Than the analytic κ^2-test was applied for the question 9 and question 10. This was necessary because an ordinal scale was used for question 10 and a nominal scale was used for question 9.

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).



N	valid	96
	missing	0
arithmetic mean		2,21
standard error of arithmetic mean		,090
median		2,00
modus		,882
standard deviation		,777
variance		3
span		1
minimum		4
maximum		212

		frequency	percent	valid percent	cummulated percent
valid	small	19	19,8	19,8	19,8
	medium	48	50,0	50,0	69,8
	large	19	19,8	19,8	89,6
	major	10	10,4	10,4	100,0
	sum	96	100,0	100,0	

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.

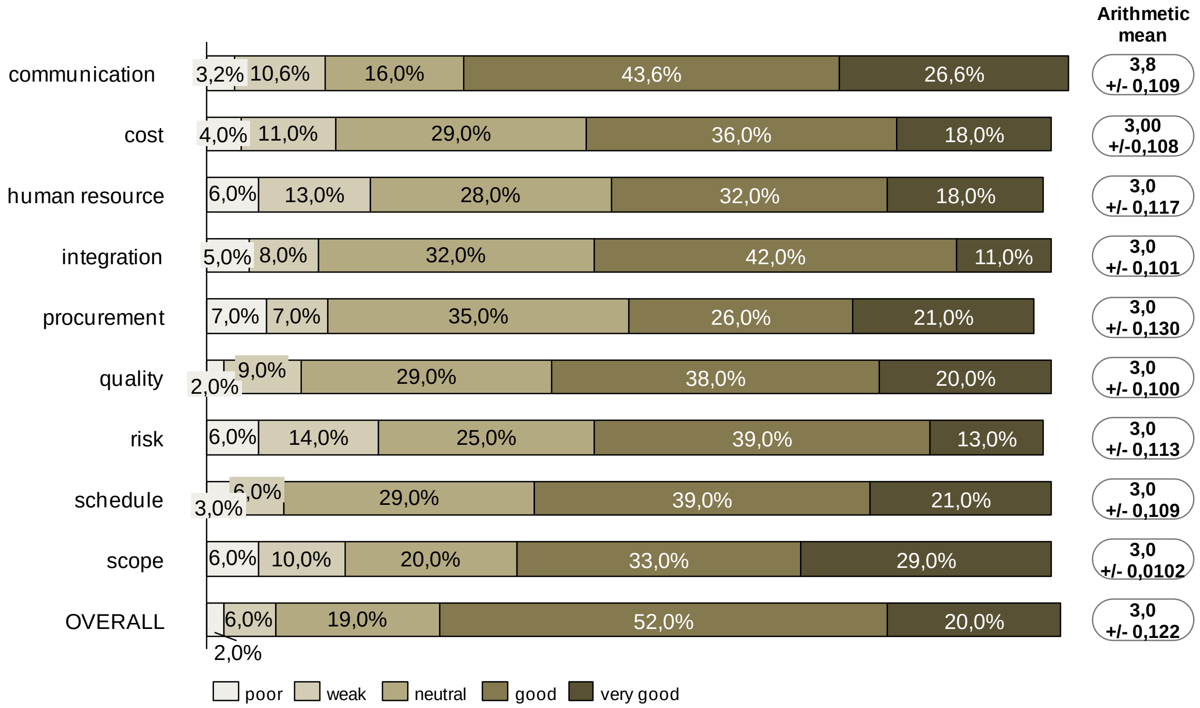


Figure 36: Success of projects according to PMI knowledge areas and in total (developed by author)

communication mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	3	3,1	3,2	3,2
	weak	10	10,4	10,6	13,8
	neutral	15	15,6	16,0	29,8
	good	41	42,7	43,6	73,4
	very good	25	26,0	26,6	100,0
	sum	94	97,9	100,0	
missing	99	2	2,1		
total		96	100,0		

quality mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	2	2,0	2,0	2,0
	weak	9	9,4	9,0	11,0
	neutral	28	29,0	29,0	41,0
	good	37	38,0	38,0	80,0
	very good	19	19,0	20,0	100,0
	sum	95	98,0	100,0	
missing	99	1	1,0		
total		96	100,0		

cost mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	4	4,0	4,0	4,0
	weak	11	11,0	11,0	15,0
	neutral	28	29,0	29,0	45,0
	good	34	35,0	36,0	81,0
	very good	17	17,0	18,0	100,0
	sum	94	97,0	100,0	
missing	99	2	2,0		
total		96	100,0		

risk mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	6	6,3	6,0	6,0
	weak	14	14,0	14,0	21,0
	neutral	24	25,0	25,0	46,0
	good	37	38,0	39,0	86,0
	very good	13	13,0	13,0	100,0
	sum	94	97,0	100,0	
missing	99	2	2,0		
total		96	100,0		

human resource mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	6	6,3	6,0	6,0
	weak	13	13,0	13,0	20,0
	neutral	27	28,1	28,0	48,0
	good	31	32,0	32,0	81,0
	very good	17	17,0	18,0	100,0
	sum	94	97,0	100,0	
missing	99	2	2,0		
total		96	100,0		

schedule mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	3	3,1	3,0	3,0
	weak	6	6,3	6,0	9,0
	neutral	27	28,1	29,0	38,0
	good	37	38,0	39,0	78,0
	very good	20	20,0	21,0	100,0
	sum	93	96,9	100,0	
missing	99	3	3,1		
total		96	100,0		

integration mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	5	5,0	5,0	5,0
	weak	8	8,0	8,0	13,0
	neutral	31	32,0	32,0	46,0
	good	40	41,0	42,0	88,0
	very good	11	11,0	11,0	100,0
	sum	95	98,0	100,0	
missing	99	1	1,0		
total		96	100,0		

scope mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	6	6,3	6,0	6,0
	weak	10	10,0	10,0	16,0
	neutral	19	19,0	20,0	36,0
	good	32	33,0	33,0	70,0
	very good	28	29,0	29,0	100,0
	sum	95	98,0	100,0	
missing	99	1	1,0		
total		96	100,0		

procurement mngt.		frequency	percent	valid percent	cummulated percent
valid	poor	6	6,3	7,0	7,0
	weak	6	6,3	7,0	15,0
	neutral	28	29,0	35,0	51,0
	good	21	21,9	26,0	78,0
	very good	17	17,0	21,0	100,0
	sum	78	81,3	100,0	
missing	99	18	18,8		
total		96	100,0		

OVERALL MNGT.		frequency	percent	valid percent	cummulated percent
valid	poor	2	2,0	2,0	2,0
	weak	6	6,3	6,0	8,0
	neutral	18	18,8	19,0	27,0
	good	49	51,0	52,0	79,0
	very good	19	19,0	20,0	100,0
	sum	94	97,0	100,0	
missing	99	2	2,0		
total		96	100,0		

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.

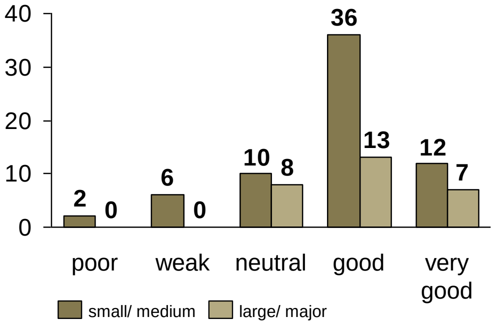
This could be a result of a specific knowledge area that is outside of a project manager's responsibility. For example, procurement is often performed by a separate department without the influence of the project manager.

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 κ^2-test, the categorization of the projects was transformed to show that only two groups exist (1 – small & medium; 2 – large & major). With the κ^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."

	cases					
	valid		missing		total	
	N	%	N	%	N	%
Q10_quality_of_project_overall_success * Q9_UMKODIERUNG_Gruppensplit	94	97,9%	2	2,1%	96	100,0%



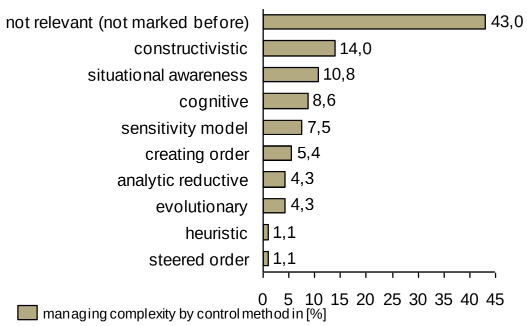
Chi²- test (Pearson)	value	df	asymptotic significance (double sided)
Chi²- test (Pearson)	5,944[a]	4	,203
likelihood-Quotient	8,066	4	,089
relationship linear to linear	1,029	1	,310
amount of valid cases	94		

a. 4 cells (40,0%) have an expected frequency smaller than 5. Minimum expected frequency is ,60.

Figure 38: Non statistical significance between success and categorisation of project by κ^2-test

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 constructivistic 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.

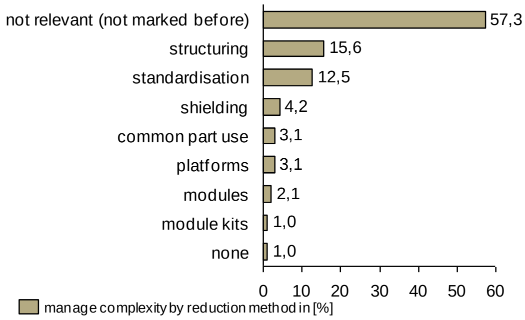
These top three approaches can be interpreted direct methods, seldom listed methods (sensitivity model (7.5%/ n = 7), creating order (5.4%/ n = 5), analytic reductive (4.3%/ n = 4), evolutionary (4.3%/ n = 4), heuristic (1.1%/ n = 1) and steered order (1.1%/ n = 1)) were not considered. Projects often 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.



managing complexity by control		frequency	percent	valid percent	cummulated percent
valid	not relevant (not marked before)	40	41,7	43,0	100,0
	constructivistic	13	13,5	14,0	26,9
	situational awareness	10	10,4	10,8	55,9
	cognitive	8	8,3	8,6	12,9
	sensitivity model	7	7,3	7,5	45,2
	creating order	5	5,2	5,4	32,3
	analytic reductive	4	4,2	4,3	4,3
	evolutionary	4	4,2	4,3	36,6
	heuristic	1	1,0	1,1	37,6
	steered order	1	1,0	1,1	57,0
	sum	93	96,9	100,0	
missing	99	3	3,1		
total		96	100,0		

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).



managing complexity by reduction		frequency	percent	valid percent	cummulated percent
valid	common part use	3	3,1	3,1	3,1
	module kits	1	1,0	1,0	4,2
	modules	2	2,1	2,1	6,3
	none	1	1,0	1,0	7,3
	platforms	3	3,1	3,1	10,4
	shielding	4	4,2	4,2	14,6
	standardisation	12	12,5	12,5	27,1
	structuring	15	15,6	15,6	42,7
	not relevant (not marked before)	55	57,3	57,3	100,0
	total	96	100,0	100,0	

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.

frequency most vulnerable processes		response N	response %	% of cases
$Q16_most_vulnerable[a]	define scope	49	6,7%	52,7%
	manage stakeholder	47	6,5%	50,5%
	collect requirements	40	5,5%	43,0%
	identify risks	33	4,5%	35,5%
	control scope	28	3,9%	30,1%
	perform integrated change control	27	3,7%	29,0%
	estimate duration	26	3,6%	28,0%
	estimate costs	26	3,6%	28,0%
	identify stakeholder	25	3,4%	26,9%
	manage team	24	3,3%	25,8%
	direct/ manage execution	22	3,0%	23,7%
	monitor/ control project work	20	2,8%	21,5%
	create WBS	19	2,6%	20,4%
	control schedule	19	2,6%	20,4%
	control quality	19	2,6%	20,4%
	define schedule	18	2,5%	19,4%
	distribute info	18	2,5%	19,4%
	plan communication	17	2,3%	18,3%
	verify scope	17	2,3%	18,3%
	develop PM plan	16	2,2%	17,2%
	perform QM assurance	16	2,2%	17,2%
	acquire PM team	15	2,1%	16,1%
	report performance	15	2,1%	16,1%
	control/ monitor risks	15	2,1%	16,1%
	project charter	14	1,9%	15,1%
	define activities	13	1,8%	14,0%
	estimate resources	13	1,8%	14,0%
	determine budget	13	1,8%	14,0%
	pla/ develop QM plan	13	1,8%	14,0%
	plan risk responisbilities	13	1,8%	14,0%
	control costs	12	1,7%	12,9%
	perform qualitative risk mngt	10	1,4%	10,8%
	develop PM team	10	1,4%	10,8%
	sequence activities	8	1,1%	8,6%
	develop HR plan	8	1,1%	8,6%
	plan risk mngt	8	1,1%	8,6%
	perform quantitaive risk mngt	8	1,1%	8,6%
	close project phase	6	,8%	6,5%
	conduct procurement	5	,7%	5,4%
	plan procurement	2	,3%	2,2%
total		727	100,0%	781,7%

a. dichotomy group is outlined in a table from with a value of 1.

	cases					
	valid		missing		total	
	N	%	N	%	N	%
$Q16_most_vulnerable[a]	93	96,9%	3	3,1%	96	100,0%

a. dichotomy group is outlined in a table from with a value of 1.

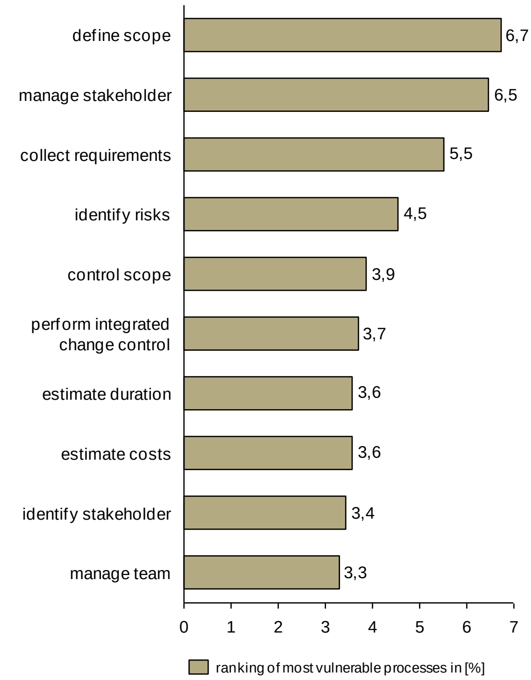


Figure 41: PM processes most vulnerable for complexity

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.

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 managers 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.

frequency leat vulnerable processes		response N	response %	% of cases
$Q17_least_vulnerable[a]	create project charter	28	4,9%	35,0%
	identify stakeholder	26	4,5%	32,5%
	close procurements	24	4,2%	30,0%
	plan communication	23	4,0%	28,8%
	plan procurement	22	3,8%	27,5%
	close project phase	22	3,8%	27,5%
	administer procurement	21	3,7%	26,3%
	control costs	20	3,5%	25,0%
	acquire PM team	19	3,3%	23,8%
	report performance	18	3,1%	22,5%
	define activities	17	3,0%	21,3%
	sequence activities	16	2,8%	20,0%
	distribute info	16	2,8%	20,0%
	define scope	15	2,6%	18,8%
	determine budget	15	2,6%	18,8%
	identify risks	15	2,6%	18,8%
	manage team	15	2,6%	18,8%
	conduct procurement	15	2,6%	18,8%
	control schedule	15	2,6%	18,8%
	create WBS	14	2,4%	17,5%
	develop PM plan	13	2,3%	16,3%
	define schedule	13	2,3%	16,3%
	estimate costs	13	2,3%	16,3%
	develop HR plan	12	2,1%	15,0%
	develop PM team	12	2,1%	15,0%
	manage stakeholder	12	2,1%	15,0%
	plan risk mngt	11	1,9%	13,8%
	monitor/ control PM work	11	1,9%	13,8%
	plan/ develop QM plan	10	1,7%	12,5%
	plan risk responsibilities	10	1,7%	12,5%
	verify scope	10	1,7%	12,5%
	control scope	10	1,7%	12,5%
	collect requirements	8	1,4%	10,0%
	estimate resources	7	1,2%	8,8%
	direct/ manage execution	7	1,2%	8,8%
	control quality	7	1,2%	8,8%
	estimate duration	6	1,0%	7,5%
	perform qualitative risk	6	1,0%	7,5%
	control/ monitor risks	6	1,0%	7,5%
	perform QM assurance	5	,9%	6,3%
	perform integrated	5	,9%	6,3%
	perform quantitative risk	3	,5%	3,8%
total		573	100,0%	716,3%

a. dichotomy group is outlined in a table from with a value of 1.

	cases					
	valid		missing		total	
	N	%	N	%	N	%
$Q17_least_vulnerable[a]	80	83,3%	16	16,7%	96	100,0%

a. dichotomy group is outlined in a table from with a value of 1.

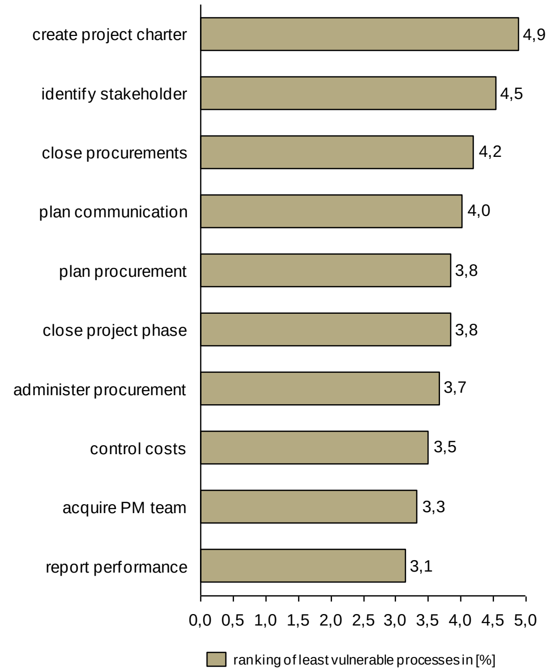


Figure 42: PM processes least vulnerable for complexity

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):

(5) How many people work in your project team?

(6) How many sub-projects has your project?

(7) Your project is placed in… (Selecting a specific field of industry)?

(8) What is the total value of your project in ˈ000 €.

(9) How would you categorize the size of your project? (small, medium, large, major)

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

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

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

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

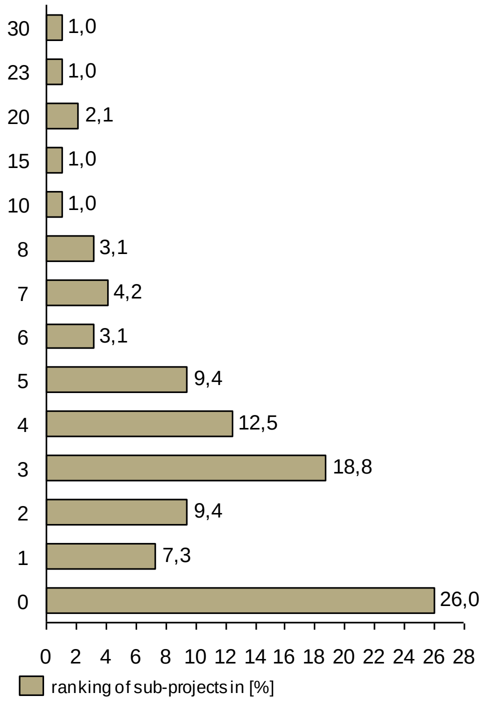
The arithmetic mean of involved people in a project is 27.97. However, the majority of projects (11.5%) consist of 10 team members. The 25^{th} percentile is 6 team members and 75^{th} percentile is almost 25 team members. As the arithmetic mean for team members is higher than 75^{th} percentile, it can be clearly identified that some of the participants' projects have a large amount of team members, shifting the arithmetic mean above the 75^{th} 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.

N	valid	96
	missing	0
arithmetic mean		3,75
standard error of arithmetic		,505
median		3,00
standard deviation		4,944
variance		24,442
span		30
minimum		0
maximum		30
sum		360

N	valid	96
	missing	0
arithmetic mean		27,97
standard error of arithmetic mean		4,921
median		12,00
standard deviation		48,215
variance		2324,704
span		300
minimum		0
maximum		300
sum		2685
percentile	25	6,00
	50	12,00
	75	24,75



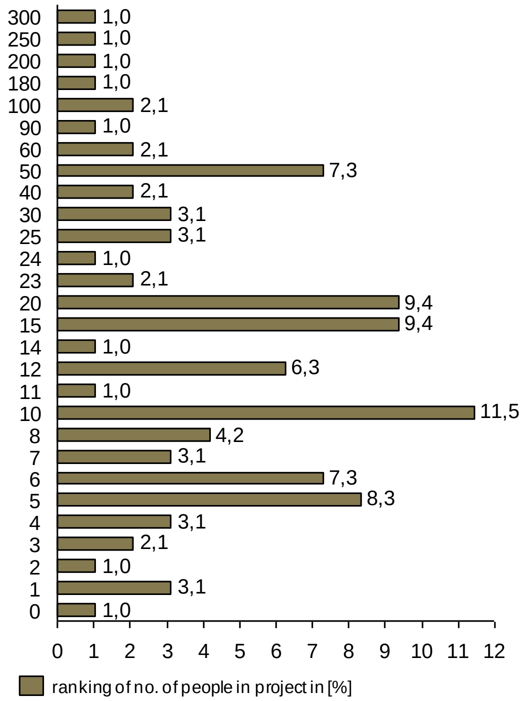


Figure 43: Distribution of people and sub-projects in participant's projects

The significance was calculated according to Pearson. The correlation showed a strong statistical significance (N = 96, r = -.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 * “number of team members.” Referring to the result from the arithmetic mean, the estimated assumption is confirmed.

			Q5_How_many_people_work_in_your_project team	Q6_How_many_sub-projects_has_your_project
Spearman-Rho	Q5_How_many_people_work_in_your_project team	correlation coefficient		
		Sig. (double sided)		
		N	96	96
	Q6_How_many_sub-projects_has_your_project	correlation coefficient	,706**	1,000
		Sig. (double sided)	,000	
		N	96	96

**. correlation is on the level 0,01 significant (double sided).

Figure 44: Correlation between team members and sub-projects

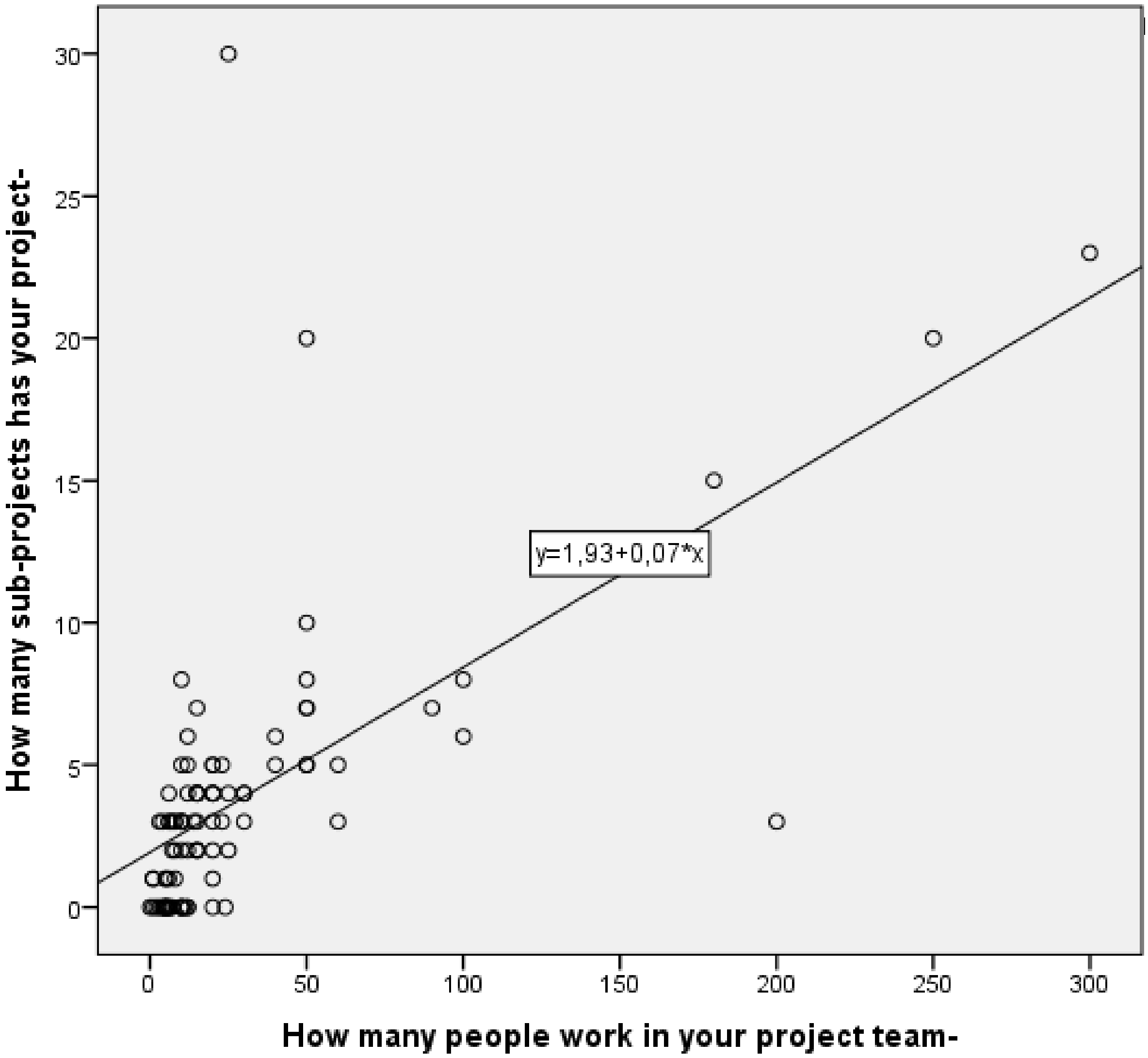
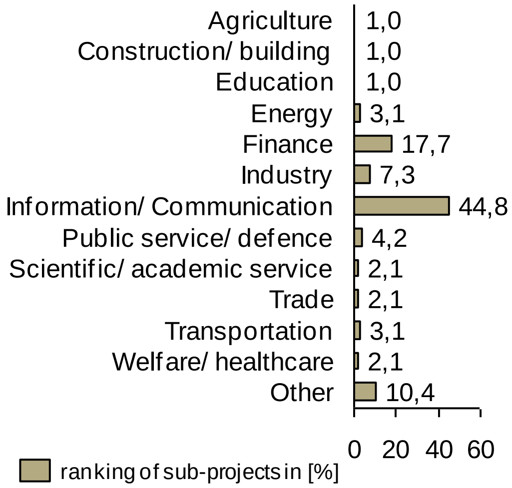


Figure 45: Graphical illustration of correlation between team members and sub-projects

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 ˈ000 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.

N	valid	96
	missing	0
arithmetic mean		7,32
standard error of arithmetic		,268
median		7,00
standard deviation		2,630
variance		6,916
span		12
minimum		1
maximum		13
sum		703



project is place in …		frequency	percent	valid percent	cummulated percent
valid	Agriculture	1	1,0	1,0	1,0
	Construction/ building	1	1,0	1,0	2,1
	Education	1	1,0	1,0	3,1
	Energy	3	3,1	3,1	6,3
	Finance	17	17,7	17,7	24,0
	Industry	7	7,3	7,3	31,3
	Information/ Communication	43	44,8	44,8	76,0
	Public service/ defence	4	4,2	4,2	80,2
	Scientific/ academic service	2	2,1	2,1	82,3
	Trade	2	2,1	2,1	84,4
	Transportation	3	3,1	3,1	87,5
	Welfare/ healthcare	2	2,1	2,1	89,6
	Other	10	10,4	10,4	100,0
	total	96	100,0	100,0	

Figure 46: Distribution of projects across different fields of industry

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 it into account. Ranges for project values are shown in Figure 47.

N	valid	66
	missing	30
arithmetic mean		3262290,94
standard error of arithmetic mean		3030866,853
median		1550,00
standard deviation		24622878,713
variance		606286156090598,000
span		199999999
minimum		1
maximum		200000000
sum		215311202
percentile	25	400,00
	50	1550,00
	75	8000,00

total project value in ´000 EURO		frequency	percent	valid percent	cummulated percent
valid	200000000	1	1,0	1,5	100,0
	10000000	1	1,0	1,5	98,5
	3000000	1	1,0	1,5	97,0
	1000000	2	2,1	3,0	95,5
	50000	2	2,1	3,0	92,4
	35000	1	1,0	1,5	89,4
	20000	2	2,1	3,0	87,9
	12000	1	1,0	1,5	84,8
	11115	1	1,0	1,5	83,3
	11000	1	1,0	1,5	81,8
	10000	2	2,1	3,0	80,3
	8000	2	2,1	3,0	77,3
	5000	4	4,2	6,1	74,2
	4000	1	1,0	1,5	68,2
	3000	2	2,1	3,0	66,7
	2500	1	1,0	1,5	63,6
	2000	7	7,3	10,6	62,1
	1600	1	1,0	1,5	51,5
	1500	1	1,0	1,5	50,0
	1400	1	1,0	1,5	48,5
	1300	1	1,0	1,5	47,0
	1200	2	2,1	3,0	45,5
	1000	6	6,3	9,1	42,4
	600	2	2,1	3,0	33,3
	500	2	2,1	3,0	30,3
	450	1	1,0	1,5	27,3
	400	2	2,1	3,0	25,8
	350	1	1,0	1,5	22,7
	300	2	2,1	3,0	21,2
	250	1	1,0	1,5	18,2
	200	1	1,0	1,5	16,7
	100	2	2,1	3,0	15,2
	95	1	1,0	1,5	12,1
	85	1	1,0	1,5	10,6
	50	2	2,1	3,0	9,1
	30	1	1,0	1,5	6,1
	25	1	1,0	1,5	4,5
	1	2	2,1	3,0	3,0
	total	66	68,8	100,0	
missing	99	30	31,3		
total project value in ´000 EURO		96	100,0		

Figure 47: Range of project's value

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).

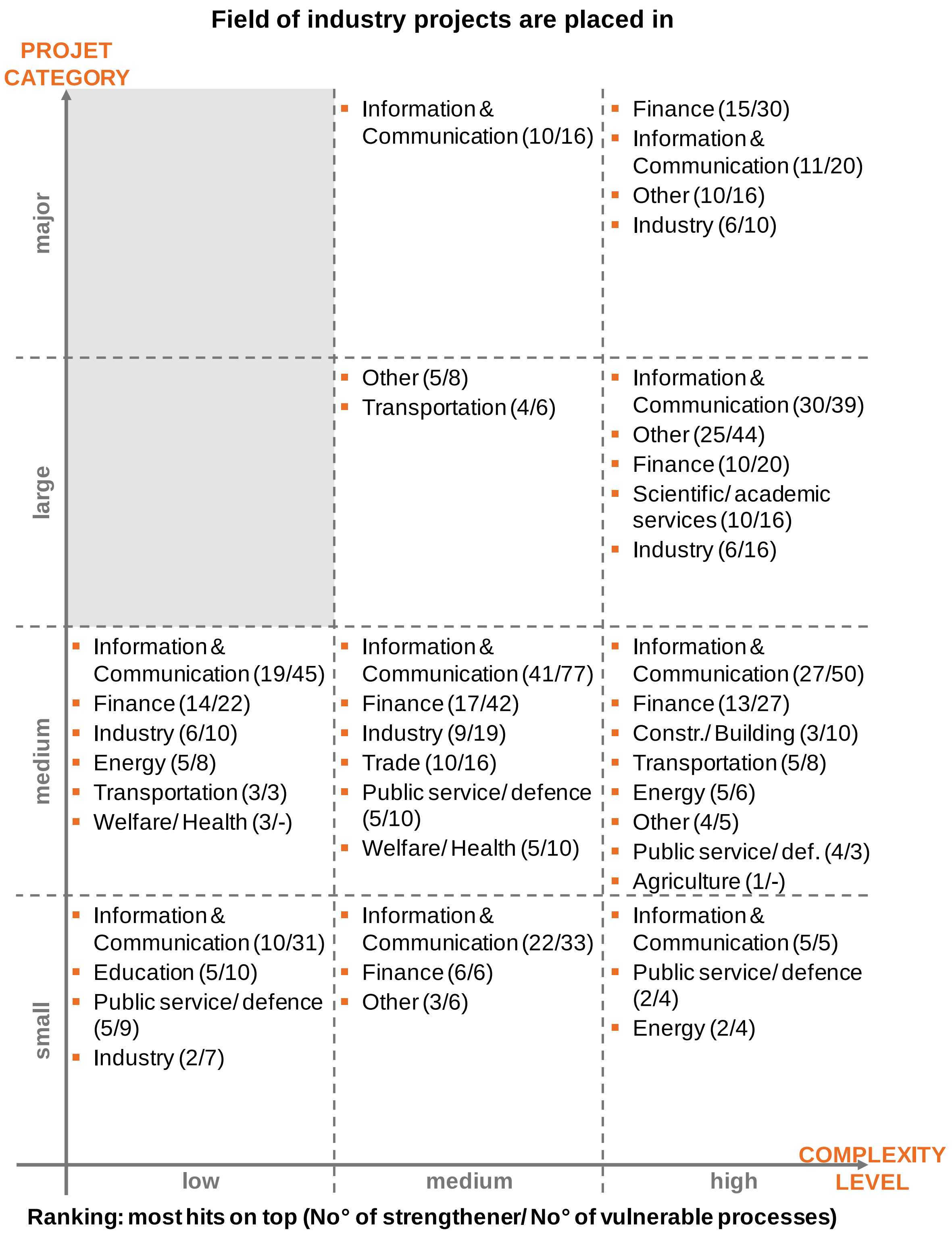


Figure 48: First matrix layer for selecting the field of industry the PM's project shows accordance

The strengtheners for complexity in projects which participants selected are ranked by the top ten hits, minimum marked twice (Figure 49).

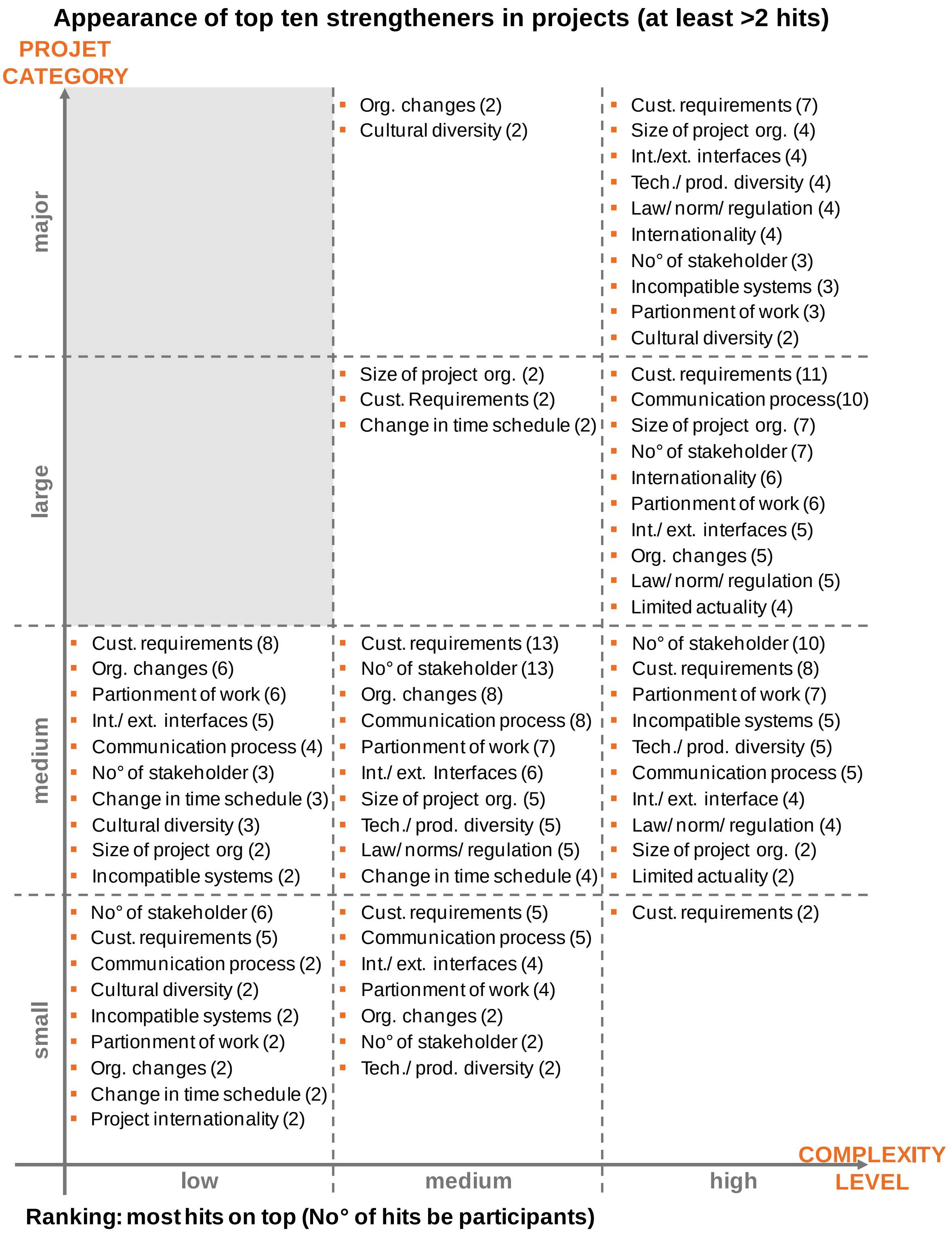


Figure 49: Second matrix layer identifying the top ten strengtheners for complexity in your project

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)

PROJET CATEGORY	low	medium	high
major		▪ 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)
large		▪ 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)
medium	▪ 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)	▪ Manage 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)
small	▪ 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) ▪ Define scope (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)	▪ Estimate costs (2) ▪ Manage team (2) ▪ Perform integrated CCB (2)

COMPLEXITY LEVEL

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 κ^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.

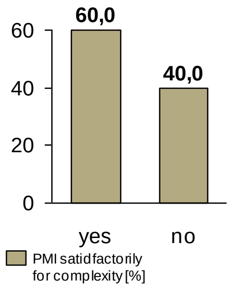
Justification

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 partic-

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.



		frequency	percent	valid percent	cummulated percent
valid	no	20	20,8	40,0	40,0
	yes	30	31,3	60,0	100,0
	sum	50	52,1	100,0	
missing	99	46	47,9		
total		96	100,0		

N	valid	50
	missing	46
arithmetic mean		,60
standard error of arithmetic		,070
median		1,00
modus		1
standard deviation		,495
variance		,245
span		1
minimum		0
maximum		1

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.

	cases					
	valid		missing		total	
	N	percent	N	percent	N	percent
manage complexity with PMI tool/ method	30	31,3%	66	68,8%	96	100,0%

		responses N	responses percent	percent of cases		responses N	responses percent	percent of cases
manage complexity with PMI tool/ method	trend analysis	1	,3%	3,3%	network diagram	6	2,1%	20,0%
	adjusting leads and lags	1	,3%	3,3%	RBS - rescource breakdown structure	6	2,1%	20,0%
	schedule compression	1	,3%	3,3%	RASI chart	6	2,1%	20,0%
	scatter diagram	1	,3%	3,3%	requirement traceability matrix	7	2,4%	23,3%
	procuement audit	2	,7%	6,7%	SWOT analysis	8	2,8%	26,7%
	make/ buy analysis	2	,7%	6,7%	communication channel analysis	8	2,8%	26,7%
	mote carlo analysis	2	,7%	6,7%	process analysis	8	2,8%	26,7%
	PM information systems	2	,7%	6,7%	chritical chain methods	8	2,8%	26,7%
	reserve analysisi	2	,7%	6,7%	critical path methods	8	2,8%	26,7%
	PERT analysis	2	,7%	6,7%	cause effect diagram	8	2,8%	26,7%
	control flow run chart	2	,7%	6,7%	risk audit	9	3,1%	30,0%
	precedence diagramming method	2	,7%	6,7%	rolling wave planning	9	3,1%	30,0%
	resource leveling	3	1,0%	10,0%	conflict managemend	9	3,1%	30,0%
	benchmark	3	1,0%	10,0%	earned value managemend	9	3,1%	30,0%
	record management system (HR/ cost/ quality…)	3	1,0%	10,0%	project management plan	9	3,1%	30,0%
	performance reports	3	1,0%	10,0%	issue log	9	3,1%	30,0%
	quality audit	4	1,4%	13,3%	project scope statement	10	3,5%	33,3%
	product system analysisi	4	1,4%	13,3%	project charter	11	3,8%	36,7%
	pareto diagram	4	1,4%	13,3%	risk register	12	4,2%	40,0%
	performance review	5	1,7%	16,7%	mindmap	13	4,5%	43,3%
	change control board meetings	5	1,7%	16,7%	stakeholder analysis	15	5,2%	50,0%
	variance analysis	5	1,7%	16,7%	checklist	15	5,2%	50,0%
	scenario analysis	5	1,7%	16,7%	WBS - work break down structure	18	6,3%	60,0%
					no answer	1	,3%	3,3%
						286	100,0%	953,3%

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

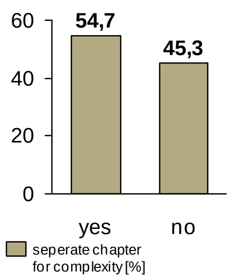
49 methods/ tools were taken directly from the PMI standard and were presented as choices to the group of participants that had expressed satisfaction with the standard. The total sum of all methods chosen was 286. Participants were given the option of choosing multiple methods/tools. The top three choices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



		frequency	percent	valid percent	cummulated percent
valid	no	39	40,6	45,3	45,3
	yes	47	49,0	54,7	100,0
	sum	86	89,6	100,0	
missing	99	10	10,4		
total		96	100,0		

N	valid	86
	missing	10
arithmetic mean		,55
standard error of arithmetic mean		,054
median		1,00
modus		1
standard deviation		,501
variance		,251
span		1
minimum		0
maximum		1

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, κ^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 κ^2-test is outlined in Figure 54.

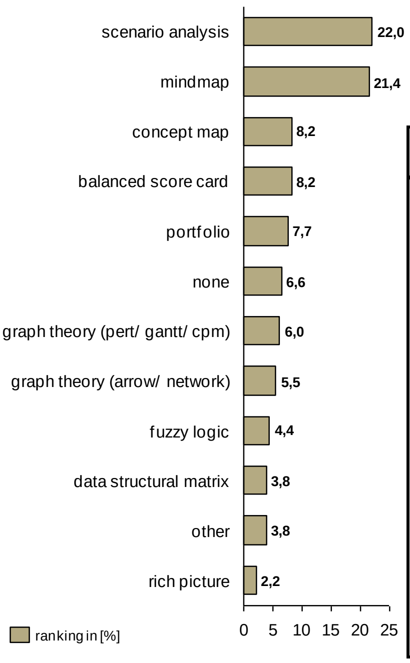
	value	df	asymptotic significance (double sided)
Chi²-test (Pearson)	5,363[a]	4	,252
Likelihood-Quotient	5,520	4	,238
amount of valid cases	96		

a. 3 cells (33,3%) have an expected frequency of smaller than 5. Minimum expected frequency is 2,08.

Figure 54: κ²-test for satisfactorily handling of complexity in PMI vs separate chapter for complexity

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.



	cases valid N	valid percent	missing N	missing percent	total N	total percent
method for manageing complexity to be implemented in PMI	96	100,0%	0	0,0%	96	100,0%

		responses N	responses percent	percent of cases
method for manageing complexit to be implemented in PMI	scenario analysis	40	22,0%	41,7%
	mindmap	39	21,4%	40,6%
	concept map	15	8,2%	15,6%
	balanced score card	15	8,2%	15,6%
	portfolio	14	7,7%	14,6%
	none	12	6,6%	12,5%
	graph theory (pert/ gantt/ cpm)	11	6,0%	11,5%
	graph theory (arrow/ network)	10	5,5%	10,4%
	fuzzy logic	8	4,4%	8,3%
	data structural matrix	7	3,8%	7,3%
	other	7	3,8%	7,3%
	rich picture	4	2,2%	4,2%
total		182	100,0%	189,6%

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

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) – ($N = 50$, $r = -.050$, no s.s. at $p < 0.731$). In addition, no statistical significance exists in the correlation with question 21 (necessity of separate chapter) – ($N = 86$, $r = .211$, 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.

			Q22_TRANSFORMIEREN_SUM_NACH_PERSONEN	Q18_PMI_satisfactorily_for_complexity
Spearman-Rho	Q22_TRANSFORMIEREN_SUM_NACH_PERSONEN	Korrelationskoeffizient	1,000	-,050
		Sig. (double sided)		,731
		N	96	50
	Q18_PMI_satisfactorily_for_complexity	correlation coefficient	-,050	1,000
		Sig. (double sided)	,731	
		N	50	50

**. Correlation is on the level 0,01 significant (double sided).

*. Correlation is on the level 0,05 significant (double sided).

Figure 56: Correlation of question 22 and 18

			Q21_separate_chapter_complexity_in_PMI	Q22_TRANSFORMIEREN_SUM_NACH_PERSONEN
Spearman-Rho	Q21_separate_chapter_complexity_in_PMI	correlation coefficient	1,000	,211
		Sig. (double sided)		,052
		N	86	86
	Q22_TRANSFORMIEREN_SUM_NACH_PERSONEN	correlation coefficient	,211	1,000
		Sig. (double sided)	,052	
		N	86	96

**. Correlation is on the level 0,01 significant (double sided).

*. Correlation is on the level 0,05 significant (double sided).

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 "partionment 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 "partionment" 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 certification 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.

Top strengtheners for complexity		
Survey	**Focus interview**	**Literature**
– Customer – Requirements – Communication – Partionment of work – Organisational changes	– Change in customer requirements – Change in stakeholder – Change in communication – Change of partionment on work and its communication – Change in organisational changes – Change in cultural diversity	– Risks – Scope/ requirements – Communication – Stakeholder – Organisation – Change – Flexibility – Urgency

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, partionment 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 manager 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 FGIs 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.

Management of complex projects			
Survey	**Focus interview**	**Literature**	**Resulting in …**
– Ignore ✗	– Ignore ✗	– Ignore ✗	➢ Unsuccessful project with no manageable complexity
– Eliminate ✗	– Eliminate ✗	– Eliminate ✗	➢ Disadvantages for project
– Reduce ✓	– Reduce ✗	– Reduce ✓	➢ Meet market demands ➢ Protection against plagiarism
– Control ✓ ➢ Rational (define target & describe process/ alternatives) ➢ Reality (consider reality & perform subsequent simplification	– Control ✓ Premises: stay flexible ➢ Depending on situation	– Control ✓ Premises: stay flexible	➢ Meet market demands ➢ Protection against plagiarism ➢ Sub packages identify potential risks

✗ rejected ✓ agreed

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 stakeholder, 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 manger, 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.

Handling PMI methodology in projects a guarantor for success			
Survey	**Focus interview**	**Literature**	**Resulting in ...**
Rate of unsuccessful projects: 8% Not confirmed	**Rate of unsuccessful projects: n.a.** Not confirmed	**Rate of unsuccessful projects: >60%**	
– PMI methodology	– PMI methodology	– PM techniques in general	➢ Methodology to follow is essential
–	– Any methodology to follow	– Any methodology to follow	➢ Methodology not depending on any released official accepted standard
– N.a., but 91% with an experience of min 7 years	– Experience	– Experience	➢ Experience in PM supports the practice of handling complex projects
– N.a.	– Experience & seniority	– Soft skills & leadership	➢ Interpersonal relations are important
– N.a.	– Proactive action		➢ No tossing & turning of tasks
– N.a.	– Sufficient staffed resources		

PMI methodology is supportive, but not a guarantor for success

Table 14: Analysis on handling complex projects by survey/ interview/ literature (developed by author)

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.

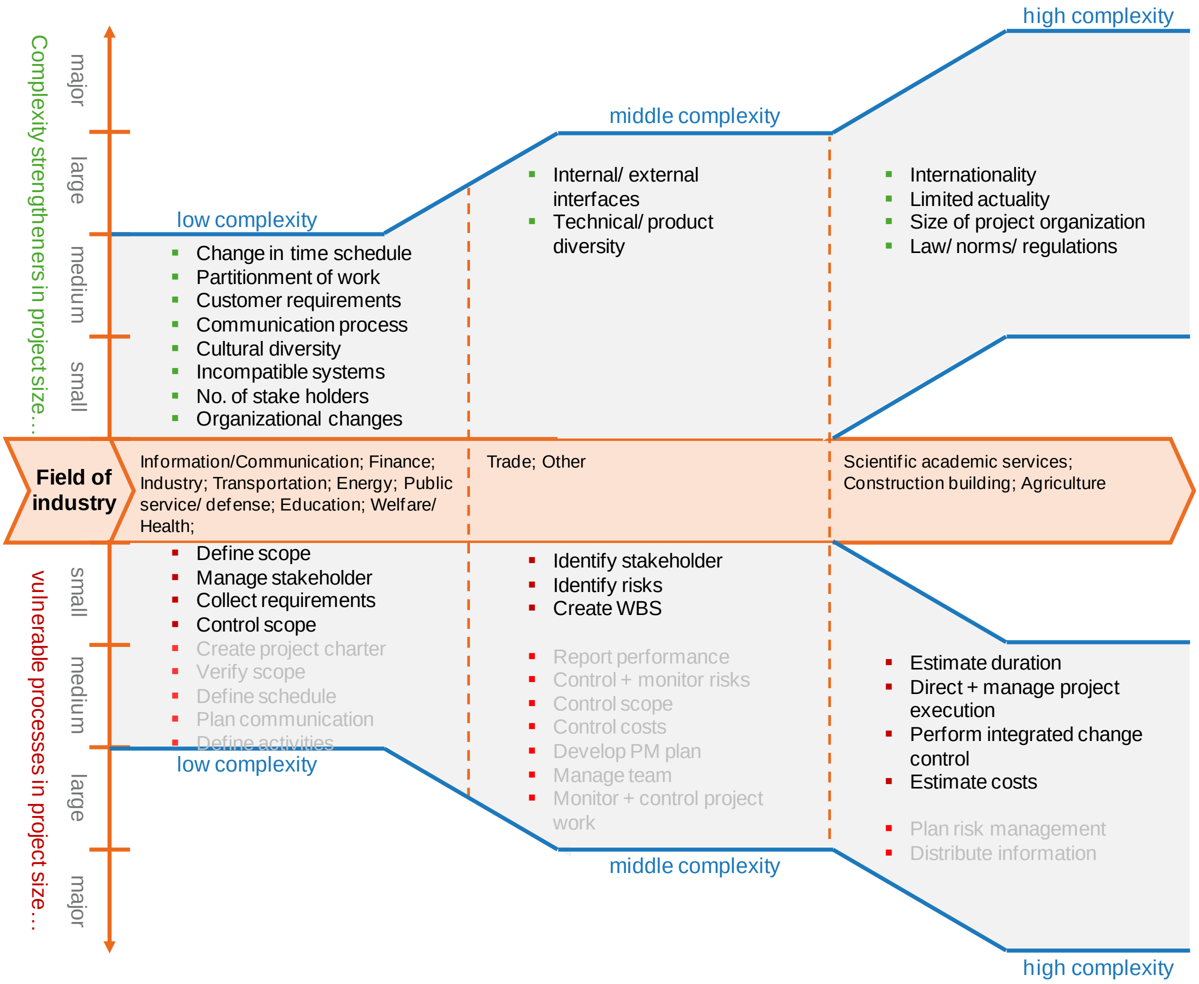


Figure 58: Funnel model for identification of complexity (developed by author)

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 focuse 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 amplification of PM standard with possible instructions is not recommended. A new wide-spread 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.

Shall PMI standard be adopted for managing complexity in projects			
Survey	**Focus interview**	**Literature**	**Resulting in …**
– PMI is sufficient for managing complex projects (60% of participants) ✓	– PMI is sufficient for managing complex projects ✓	– Actual PM standards are sufficient for managing complex projects ✓	➢ PMI and the actual traditional PM standards are still valid
– Separate chapter for managing complexity ✓	– Separate chapter for managing complexity ✗	– Separate chapter for managing complexity Not mentioned	➢ A separate chapter should not be integrated as complexity can not be standardised
– Give advisory in the PMI standard where complexity can appear Not mentioned	– Give advisory in the PMI standard where complexity can appear ✓	– Give advisory in the PMI standard where complexity can appear Not mentioned	➢ Standards would be over-crowded with hints and would cause babel
– Separate guide for managing complex projects including methods, tools, cases etc. Not mentioned	– Separate guide for managing complex projects including methods, tools, cases etc. ✓	– Separate guide for managing complex projects including methods, tools, cases etc. ✓	➢ Separate guides exist, further investigation for practical application needs to be scrutinised

✗ rejected ✓ agreed

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 und 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 strengthener 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.

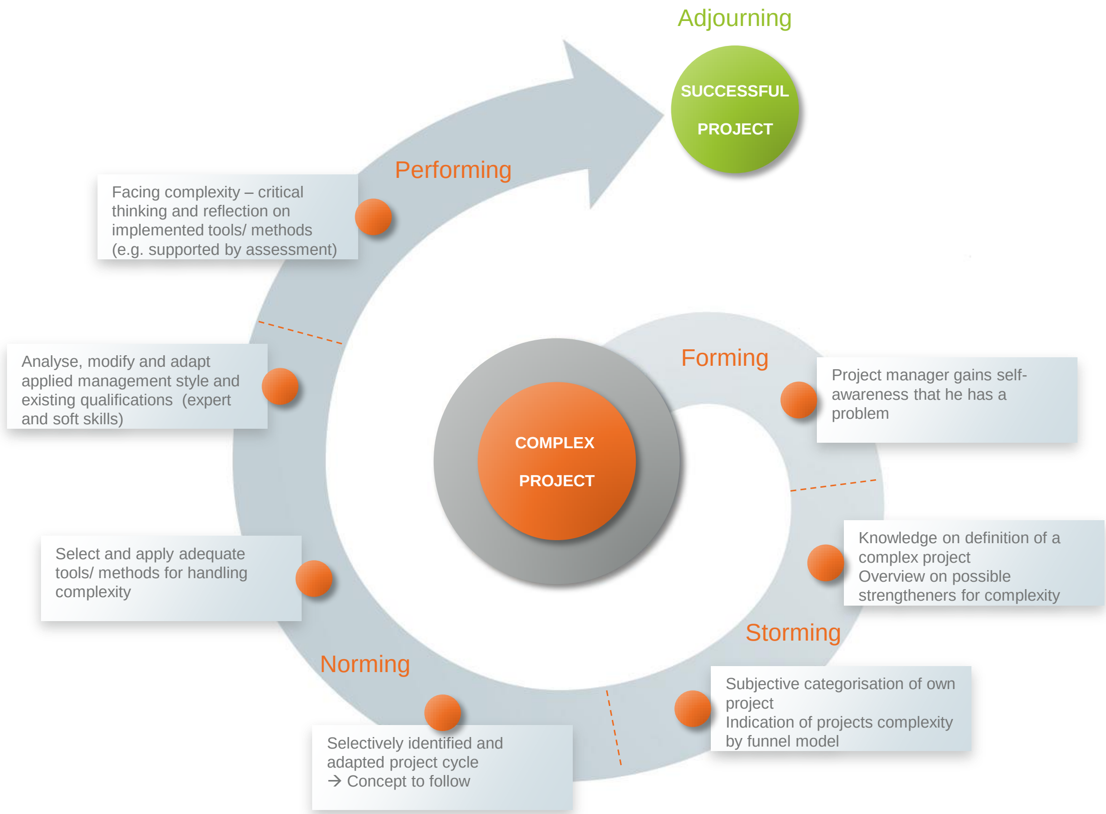


Figure 59: Five phases to successful complex projects (developed by author)

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 a 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

Large, long-duration projects

Reason:

- Constant change
- Size of the project
- Team fatigue and staff turnover

Planning and structuring the project:

- Select appropriate mngt. approach
- Progressively elaborate the plan
- Use a systematic, reliable approach to estimating
- Perform rigorous time and cost mngt.
- Use stage-gate mngt.
- Conduct rigorous risk mngt.

Developing and delivering the solution:

- Structure your project to develop and deliver the solution incrementally
- Minimize scope
- Delay design decisions until the last responsible moment
- Use rapid application development
- Use lean development techniques

Sustaining a high performing team/ selecting team members:

- Select team members for the long haul
- Pay close attention to team health
- Share resources

Large, dispersed, culturally diverse project teams

Reason:

- Team as complex adaptive systems
- The art of team leadership

Team potential:

- Leverage the power of teams
- Harness the wisdom of teams

Team leadership:

- Accept no substitute for experience at the helm
- Build a great team
- Get the "right stuff" on your team
- Establish a great team structure
- Empower your team members
- Build a culture of discipline
- Lead, don't manage, contractor teams
- Use virtual tea,s as a strategic advantage
- Encourage innovation through edge-of-chaos leadership
- Manage agile teams with a light touch

Team collaboration, communication + coordination:

- Use a standard formal methodology
- Insist on collaborative planning
- Acquire state-of-the-art collaboration tools

Highly innovative, urgent projects

Reason:

- Nontraditional project start-up methods
- High stakes
  - Little time to experiment
  - Team strives to produce a project free from demands/ dependencies
  - Project teams operate concurrently

Planned urgent projects:

- Establish permanent, flexible innovation teams
- Assign the best resources
- Time-box the effort

Unexpected urgent projects:

- Establish and maintain a sense of urgency by adopting to the situation
  - Staffing with flexible, high-performing team members, welcoming unorthodox practices
  - Clear mindset that time drives all decisions
  - Be involved on mngt. level only in dire situations
- Implement proven critical practices
  - Assign full-time, temporary teams
  - Use twinned leadership
  - Insist on face-to-face decision making
  - Deploy all available resources
  - Employ a proactive communication strategy
  - Support teambuilding
  - Monitor changing perceptions of urgency

Ambiguous business problems, opportunities and solutions

Reason:

- Ambiguous business problem and opportunity
- Ambiguous business solution

Ambiguous business problem or opportunity:

- Focus initial efforts on determining a clear business objective
- Embrace professional business analysis

Ambiguous business solution:

- Form a special "innovation team"
- Use edge-of-chaos management to bring the solution into view
- Become an expert at facilitating teams to make innovative decisions
- Conduct a feasibility study to identify and analyse solution options
- Conduct value-chain analysis for cross-functional enterprise solutions
- Conduct root-cause analysis to ensure the solution will solve the business problem
- Become adept at using tools and techniques that foster creativity and innovation
- Lead your team into "the zone"

Poorly understood, volatile requirements

Reason:	Rigorous enterprise analysis:	A framework for managing requirements complexity:	Agile methods:
▪ Deficient requirements practices ▪ Insufficient stakeholder involvement ▪ Requirements interdependencies	▪ Complete rigorous analysis prior to project funding ▪ Secure executive approval for the project scope and approach	▪ 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, iterative requirements definition and analysis techniques ▪ Sophisticated requirements visualisation techniques ▪ Incremental solution development techniques

High-visibility strategic projects

Reason:	Executive support:	Political management strategy:	Stakeholder management:
▪ Political maneuvers and power struggles ▪ Changing strategies and expectations	▪ Enlist the support of a strong executive sponsor ▪ Establish a steering committee ▪ Focus on business benefits	▪ Create a political management plan ▪ Promote yourself and your project ▪ Leverage the formal authority of functional managers	▪ 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:	Change management framework:	Internal motivation for change:	Groundbreaking commercial practices:

▪ 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
	(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
			▪ 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

Significant, dependencies and external constraints			

Reason:
▪ Complex behaviours and reactions to changes
▪ Unintended consequences of interventions
▪ Outsourced products, services or solutions
▪ Cross-functional and cross-project dependencies
▪ Regulatory and environmental constraints
▪ Integration issues
	Risks and uncertainties:
	▪ Managing risks
	  ▪ Supportive organisation
	  ▪ Competent people
	  ▪ Appropriate methods, tools, techniques
	  ▪ Simple, scalable process
	▪ Managing uncertainties
	(1) Identify uncertainties
	(2) Consider the impact of your uncertainties
	(3) Consider monitoring and research
	(4) Consider mitigation and exploitation
	(5) Clarify alternative future outcomes
	(6) Make risk-aware plans
	(7) Design internal control systems
		Dependencies and external constraints:
		▪ Identify inter-group and cross-project dependencies
		▪ Assign ownership to dependencies
		▪ Manage your project in the midst of changes in your IT environment
		▪ Use edge-of-chaos management to adapt to changes onm the external environment
			Complex outsourced projects:
			▪ Establish positive supplier partnerships
			(1) Clear defined scope
			(2) Evaluate like an employee
			(3) Specific experience fit
			(4) Don't choose vendor on price
			(5) Review portfolios
			(6) Start small
			(7) Payment to defined gates
			(8) Clear ownership of work
			(9) Support after the project
			(10)Get it in writing
			▪ Create an integrated project management team
			▪ Establish a framework for managing outsourced projects
			  ▪ Governance layer
			  ▪ Management layer
			  ▪ Technical layer
			  ▪ Communication layer

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 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.

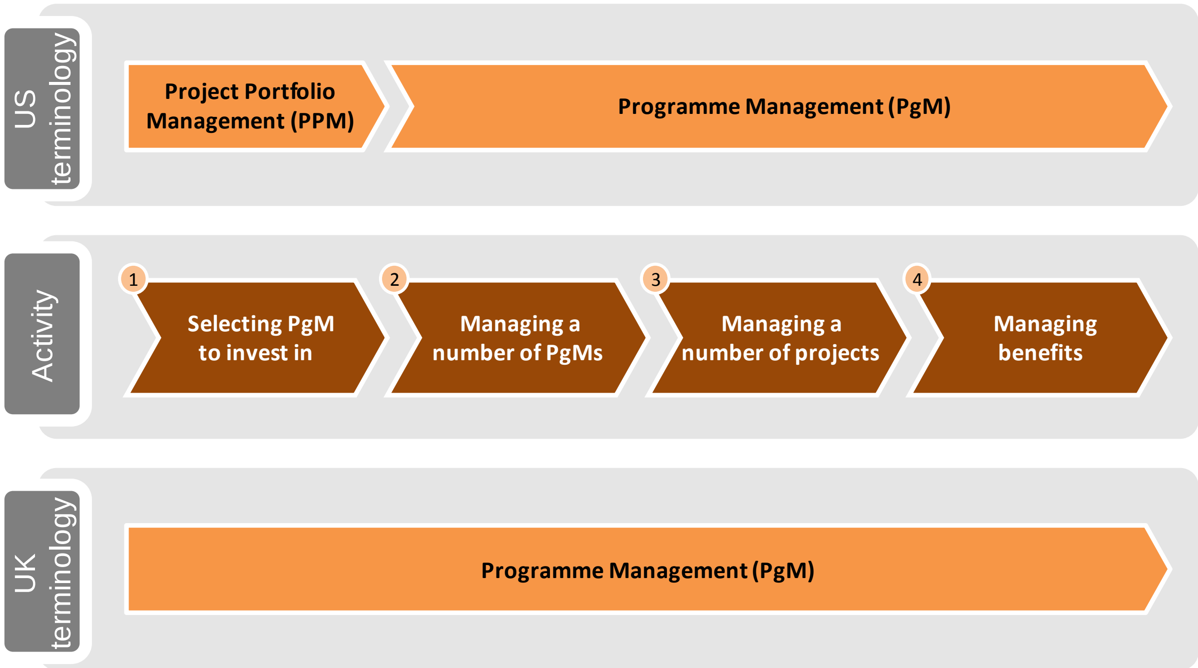


Figure 60: Differences between US and UK terminology for PPM and PgM (developed by author)

Jenny (2009) stated that PPM leads all projects within one division. PPM prioritize, coordinate, control, 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 organisations 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):

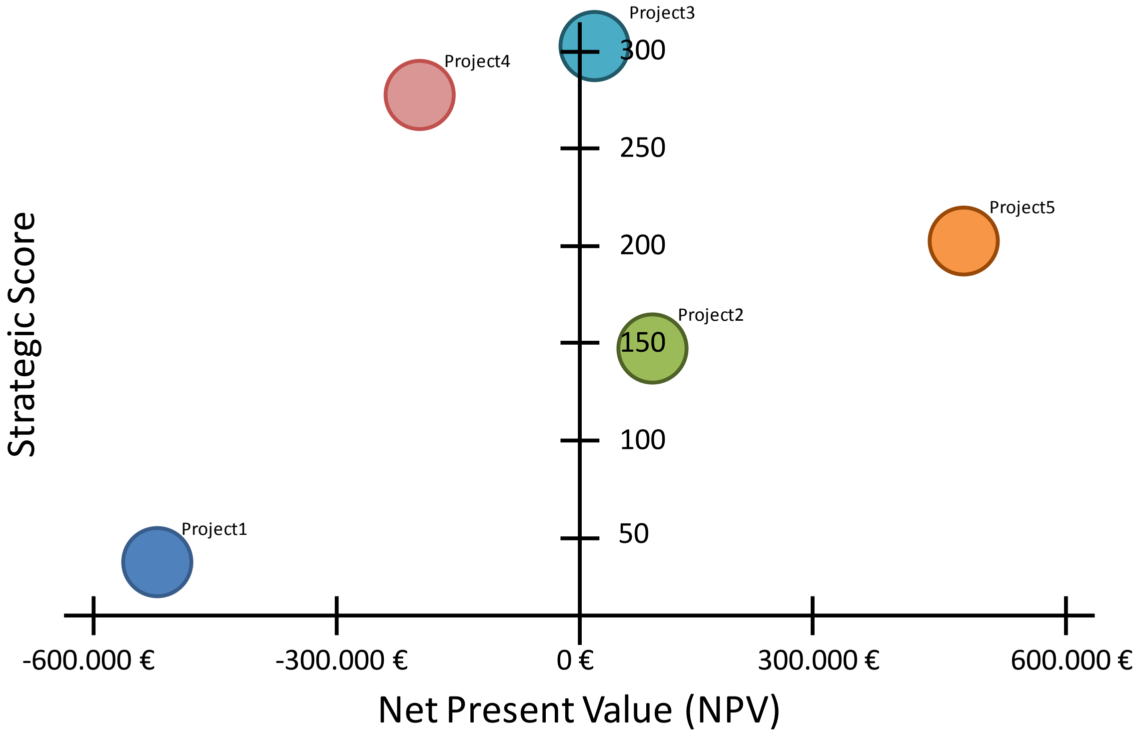
– Financial: maximizing return on research, development and technology spending
– Resources: Allocation of lack resources
– Linking: Linkage between programme/ project and the business strategy
– Communication: Communication of project priority horizontally and vertically
– Objectivity: achieving a greater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

- 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 61demonstrates an example of measuring benefit over two dimensions (NPV and strategic evaluation).



	Project1	Project2	Project3	Project4	Project5
NPV	-500.00 €	100.000 €	50.000 €	-200.000 €	400000 €
Strategic score	30	150	300	270	200

Figure 61: Benefit over two dimensions (developed by author)

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 longer 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, selected and prioritized (Pennypacker & Dye, 2002). T. Mayer et al. (2008) described this situation, but also showed the potenial problems and risks, especially those for the future. In general, T. Mayer et al. (2008) positioned the portfolio review team on the second 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 objectives are clear to everybody. Another target of PPM is to communicate the organisation's strategy and the meaning to all programmes and projects. Projects and programmes 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. Prioritiatzion 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).

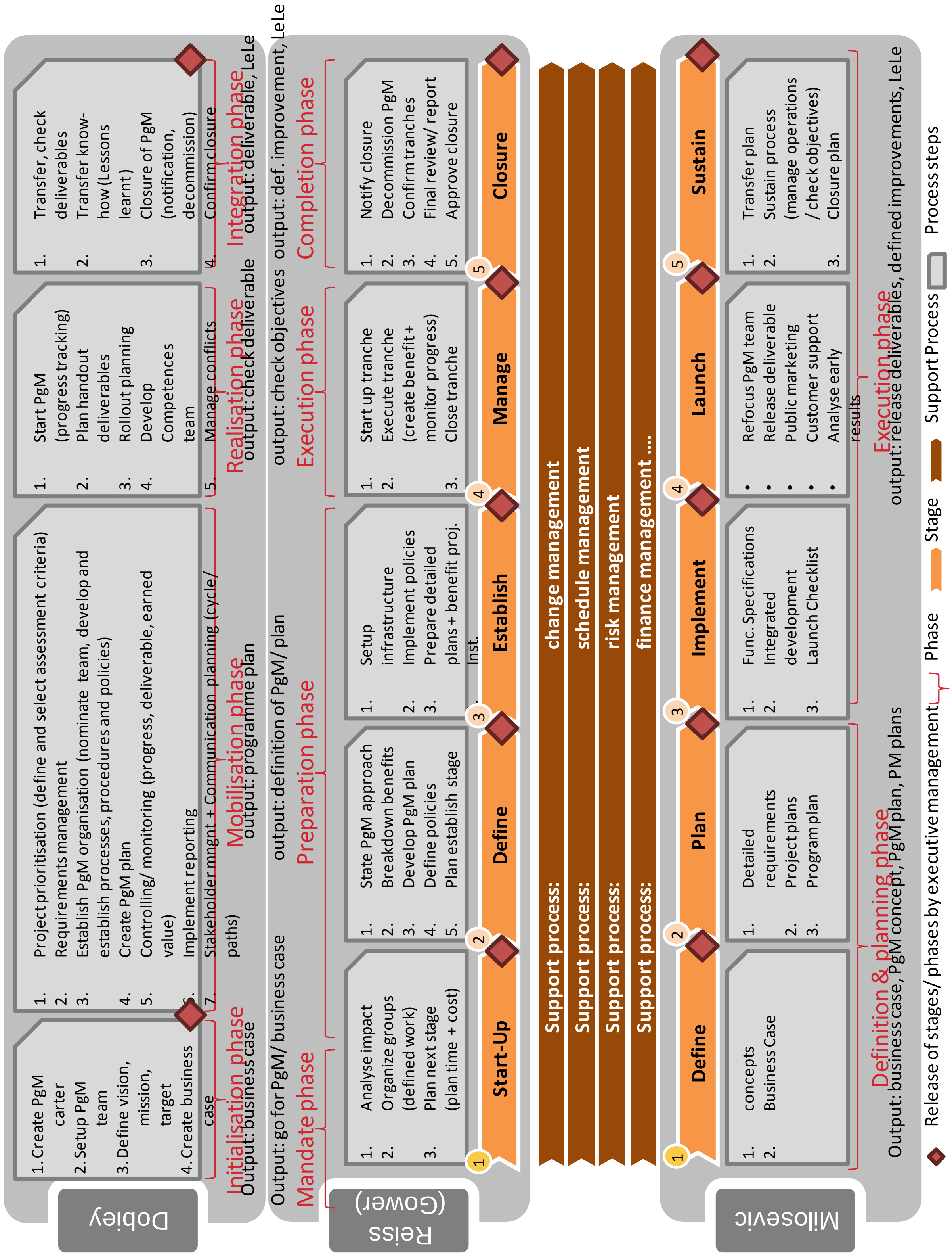


Figure 62: Comparison of PgM Lifecycles (developed by author)

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 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).

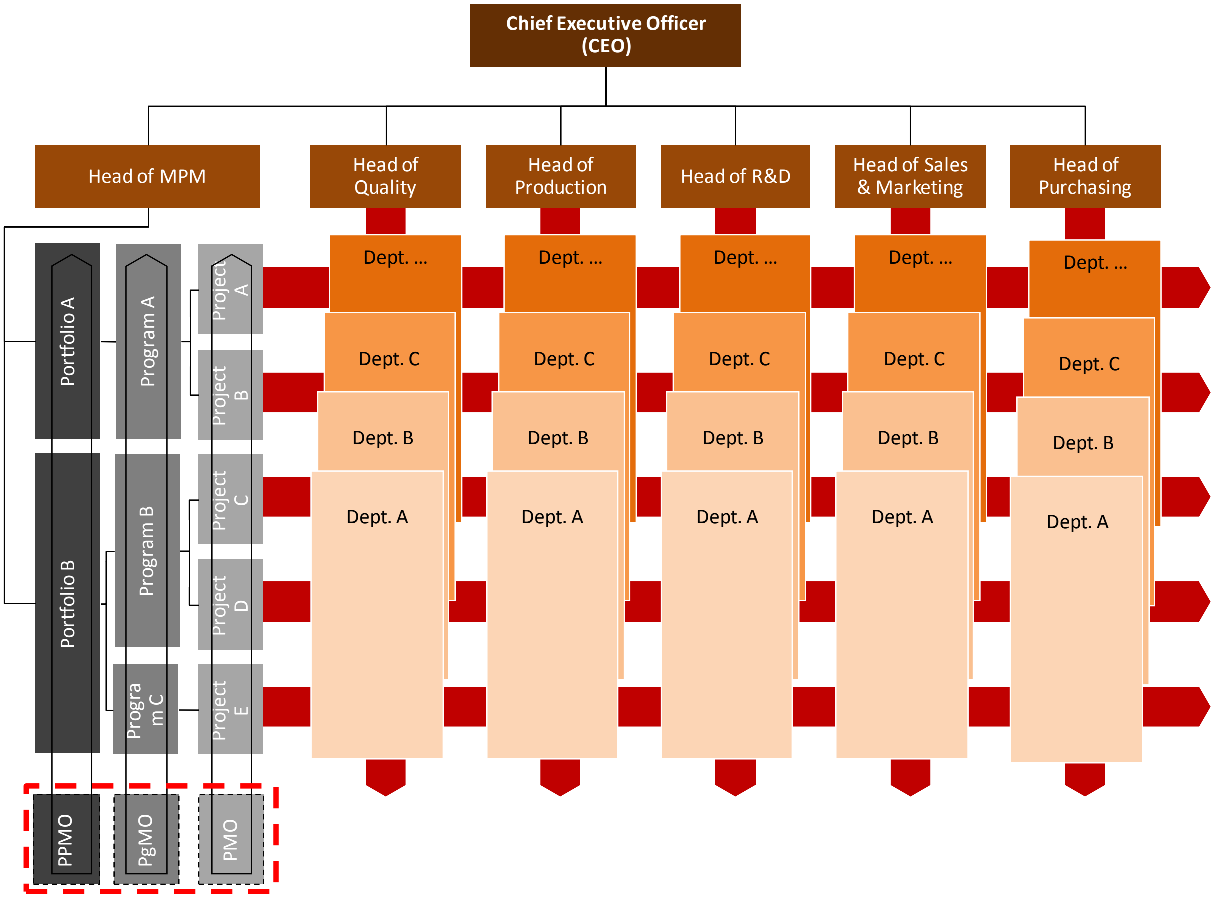


Figure 63: Matrix organisation of a MPM/PPM/PgM/PM (developed by author)

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 realistic 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).

	PgM1	PgM2	PgM3	PgM4	PgM5
organisation objective 1	y	y	n	n	y
organisation objective 2	y	n	n	y	y
organisation objective 3	n	y	n	y	y
organisation objective 4	y	y	n	y	y
organisation objective 5	n	y	y	y	y
organisation objective 6	y	y	y	n	y

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).

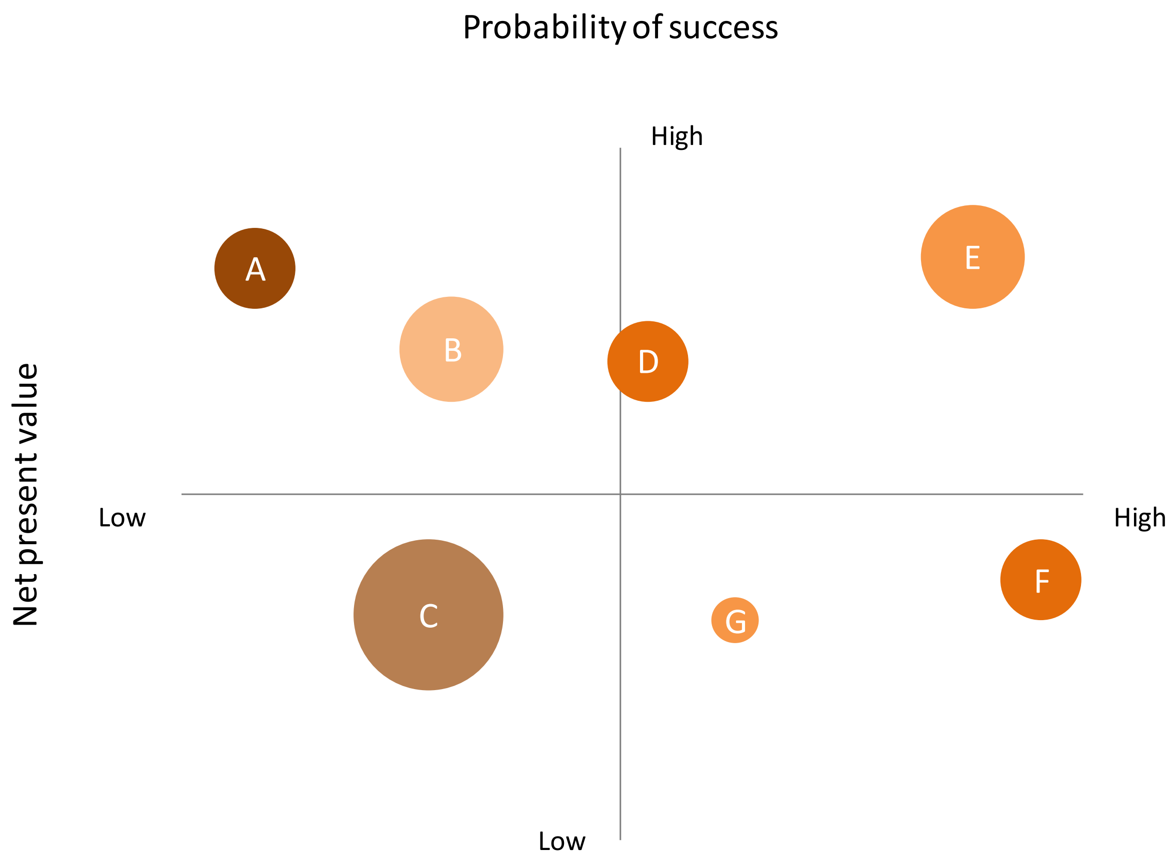


Figure 64: Portfolio map with a programme (developed by author)

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 tatus 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).

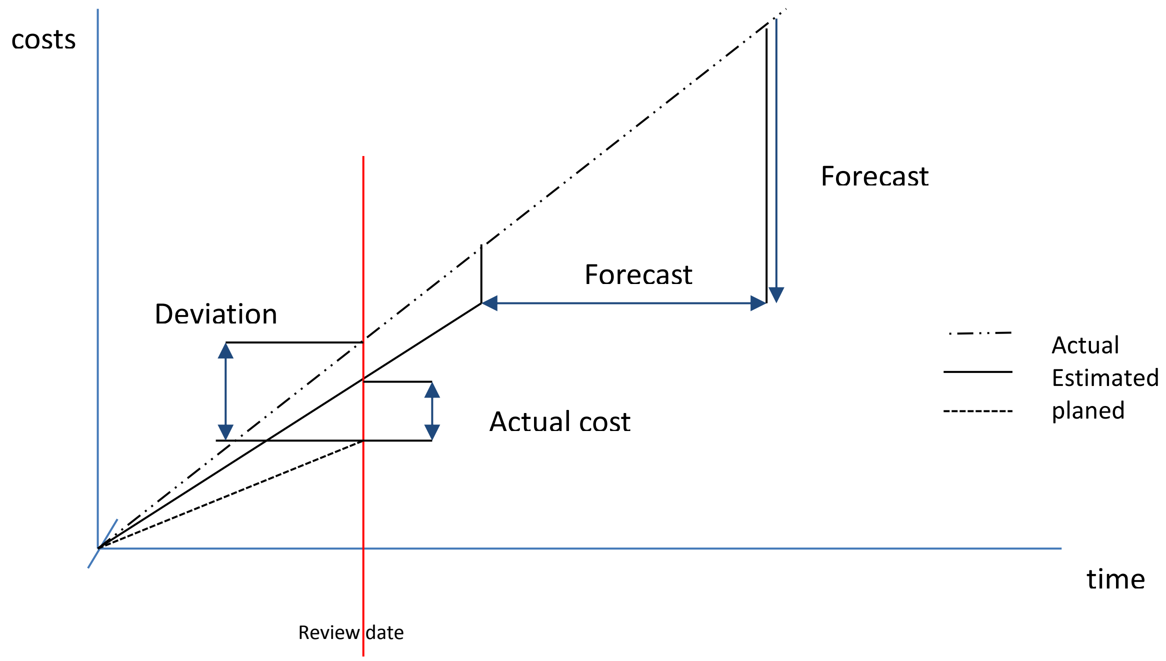


Figure 65: Earned Value Method graph (source: (Dobiéy et al., 2004))

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 planed 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

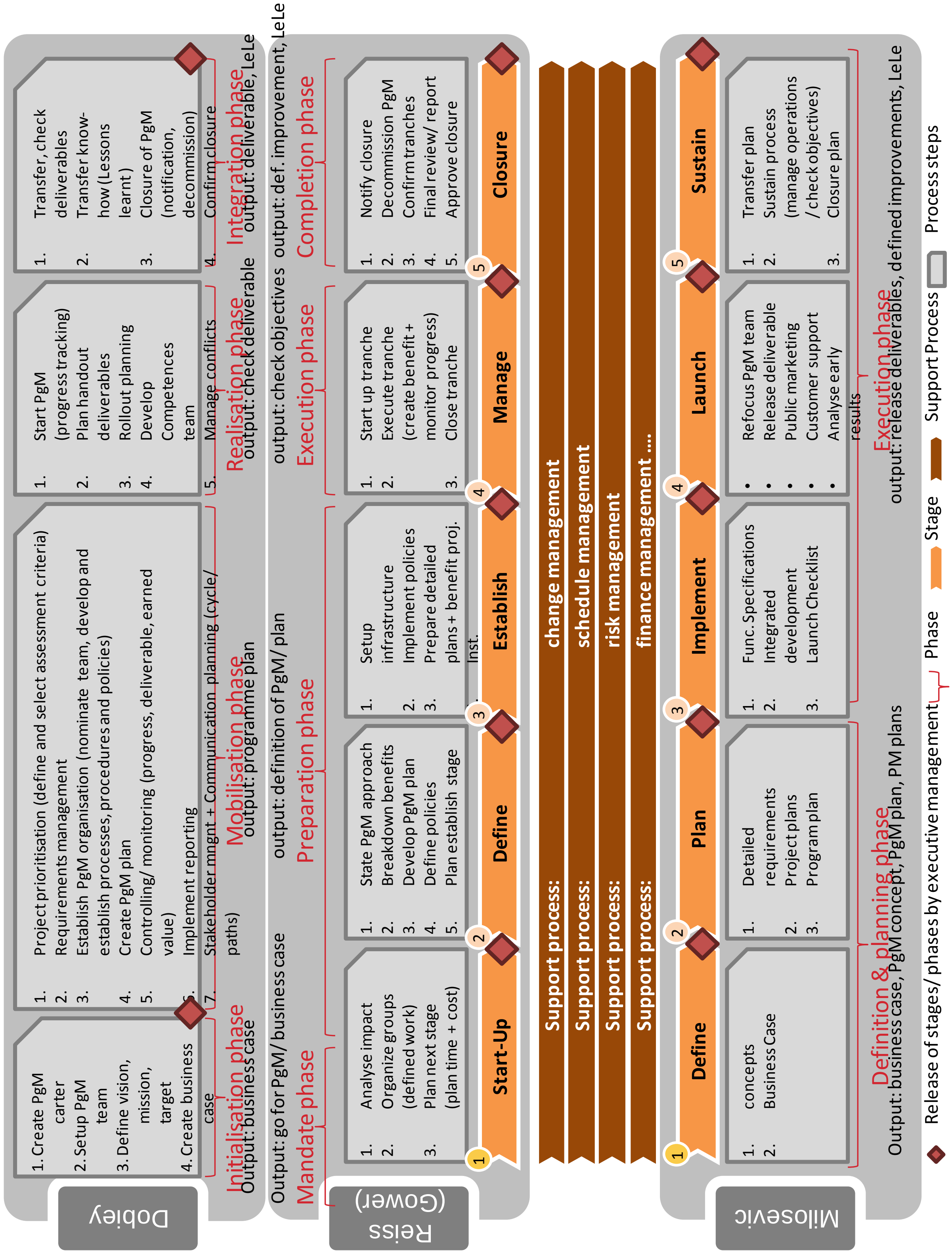


Figure 66: Comparison of PgM Lifecycles (developed by author)

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.

Appendix V – Matrix organisation of a MPM/PPM/PgM/PM environment

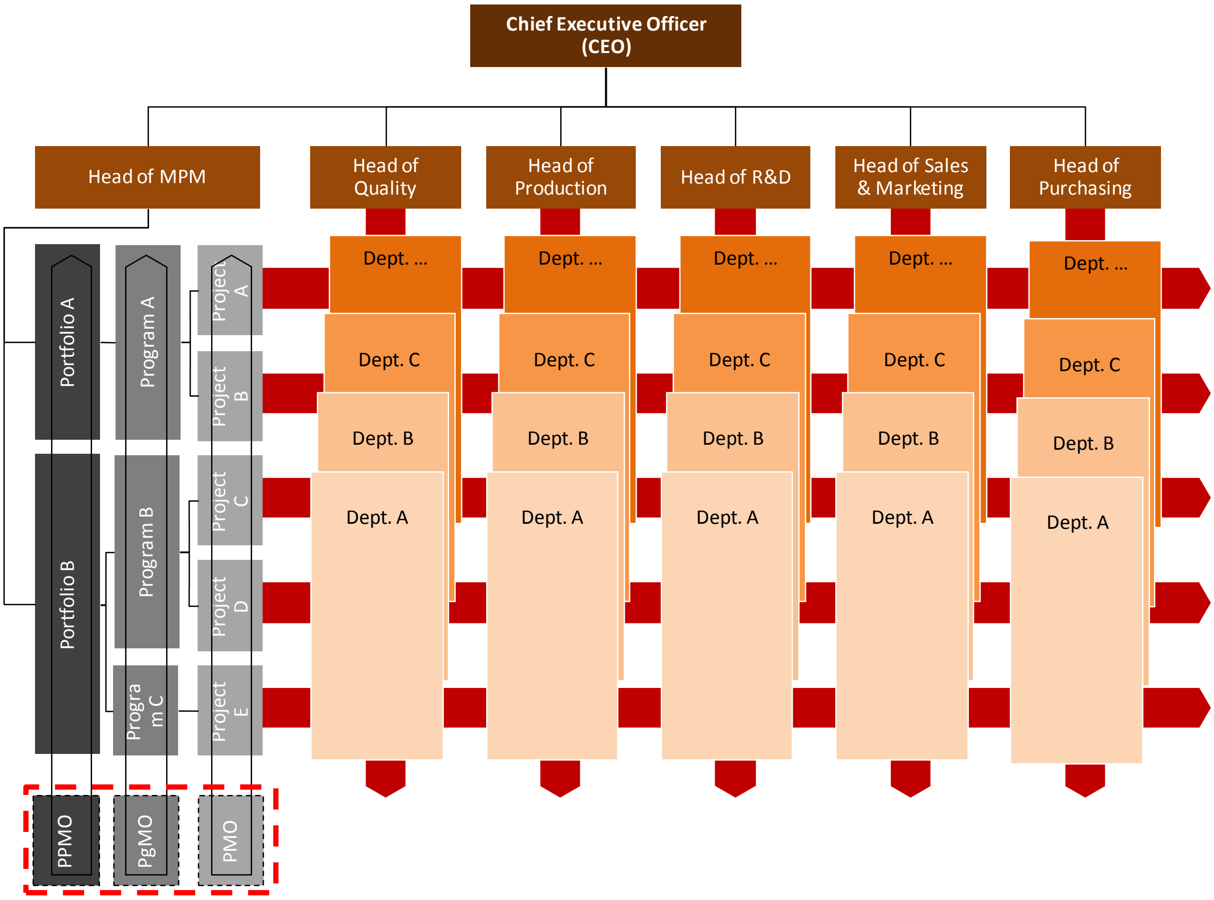


Figure 67: Matrix organisation of a MPM/PPM/ PgM/PM environment (developed by author)

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

YEAR OF DEVELOPMENT	*2013*
LANGUAGE	*ENGLISH, FRENCH, GERMAN, SPANISH*
LEGAL RIGHTS BY	*INTERNATIONAL ORGANISATION FOR STANDARDIZATION*
CERTIFICATION	*NONE*
STANDARDS	*ISO 21500*
MEMBERS WORLDWIDE	*162 COUNTIES WORLD WIDE AS A MEMBER OF THE ISO COMMITTEE*
ASSOCIATED COMPANIES WITH CMMI	*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*

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.

Process group Subject group	Initiating	Planning	Implementing	Controlling	Closing
Integration	develop project charter	develop project plans	direct project work	control project work control changes	close project phase or project collect lessons learned
Stakeholder	identify stakeholder		manage stakeholder		
Scope		Define scope create work breakdown structure define activities		control scope	
Resource	establish project team	estimate resources define project organisation	develop project team	control resources manage project team	
Time		sequence activities estimate activity duration develop schedule		control schedule	
Cost		estimate costs develop budget		control costs	
Risk Management		identify risks develop budget	treat risks	control risks	
Quality		plan quality	perform quality assurance	perform quality control	
Procurement		plan procurements	select suppliers	administer procurements	
Communication		plan communications	distribute information	manage communications	

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.

Standards / Process	PMI PMBoK 4th ed	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
INITIATING							
Create project carter	4.1	PI-SP1.1; PI-SP1.2; PI-SP1.3; QOM-SP1.1; OPM-SP1.1	SU1; SU4; SU6; DP1; DP2; DP3; IP8; Theme: Business case	1.2; 1.3; 3.1; 6.1;6.2;6.3;6.4	1.01; 1.19	2 – 2.2; 2.4; 3 – 3.2	Prerequisite (level 4)
Identify stakeholder	10.1	PP-SP2.6	Principle: defined roles and responsibilities	1.1	1.02	2 – 2.2; 18 – 18.3	CC5.12
PLANNING							
Develop project management plan	4.2	PP-SP2.7; OPD-SP1.6; OPD-SP1.7; OPM-SP1.2	SU5; SB1; SB2; Theme: plans	3.3; 3.6; 7.2; 10.1; 10.2	1.06; 1.11	2 – 2.3;2.4; 3 – 3.1; 4 – 4.1; 4.2; 15 – 15.4	CC5.7; CC5.9
Determine process improvement	1)	OPF-SP1.1; OPF-SP1.2; OPF-SP1.3	-	-	1)	4 – 4.4	-
Collect requirements	5.1	REQM-SP1.1; RD-SP1.1; RD-SP1.2; RD-SP3.5	Principle: focus on products	3.2	1.02; 1.03	6; 7 – 7.1; 8 – 8.1; 30 – 30.1;	CC5.6
Define scope	5.2	CM-SP1.1; PP-SP1.1; PP-SP1.4; RD-SP2.1; OPP-SP1.1; OPP-SP1.2; OPP-SP1.3; OPP-SP1.5	Principle: manage by exceptions	3.2	1.03	6; 7 – 7.1; 7.3; 8 – 8.1	CC5.5; CC5.6
Work breakdown structure (WBS)	5.3	CM-SP1.1; PP-SP1.1; RD-SP2.2; RD-SP2.3; RD-SP3.2; QPM-SP1.2; QPM-SP1.3; OPP-SP1.1; OPP-SP1.2; OPP-SP1.3; OPP-SP1.4; OPP-SP1.5	Theme: progress (product based); Principle: defined roles and responsibilities	3.2	1.09; 1.10	6; 7 – 7.1; 18 – 18.1;	CC5.5; CC5.6
Define activities	6.1	PP-SP1.2	IP6; Principle: manage by stages	3.4	1.09; 1.10	9 – 9.2	-
Sequence activities	6.2	-	IP6; Principle: manage by stages	3.4	1.09; 1.10; 1.11	9 – 9.1	-
Estimate resources	6.3	-	IP6; Principle: manage by stages	8.1; 8.2	1.12	9 – 9.1	-

Standards / Process	PMI	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
Estimate duration	6.4	-	IP6; Principle: manage by stages	3.4; 3.6	1.09; 1.10; 1.11	9 – 9.1	-
Define schedule	6.5	PP-SP2.1; OPP-SP1.1; OPP-SP1.2; OPP-SP1.3; PP-SP1.4; OPP-SP1.5	SU5, IP6; Principle: manage by stages	3.4; 3.6	1.11	2 – 2.4; 9 – 9.3; 10 – 10.1	CC5.8
Estimate costs	7.1	PP-SP1.4	Theme: business case	3.3	1.13; 1.19	12 – 12.1	Prerequisite (level 4)
Determine budget	7.2	PP-SP2.1; OPP-SP1.1; OPP-SP1.2; OPP-SP1.3; PP-SP1.4; OPP-SP1.5	SU5; Theme: business case	3.3; 3.6; 3.7	1.13; 1.19	2 – 2.3; 12 – 12.2; 13 – 13.1;13.2; 13.3	CC5.7
Plan quality/ develop quality plan	8.1	MA-SP1.1; MA-SP1.2; QPM-SP1.2; QPM-SP1.4	SU5; IP2; Theme: plans	3.5	1.05	1; 2 – 2.3; 15 – 15.1;15.2; 15.3; 15.4; 16 – 16.3	CC5.7
Develop human resource plan	9.1	PP-SP2.4	SU3, SU5; Theme: plans/ organisations; Principles: defined roles and responsibilities	7.1; 7.3; 8.1	1.12	2 – 2.3; 18 – 18.2; 18.5; 20 – 20.6	CC5.8; EC5.5
Plan communi-cation	10.2	PP-SP2.6; RD-SP3.3	SU5; IP4	5.1; 7.2; 11.1; 11.2	1.07; 1.17; 1.18	2 – 2.3; 20 – 20.3 22 – 22.1; 22.2; 24 – 24.2	FC5.3; EC5.5
Plan risk management	11.1	RSKM-SP1.3	SU5; IP1; Theme: risk	2.1; 4.1; 4.2	1.04	2 – 2.3; 26 – 26.3; 26.4	CC5.7
Identify risks	11.2	PP-SP2.2; RSKM-SP2.1	IP1; Theme: risk	4.3	1.04	26 – 26.1	-
Perform qualitative risk mngnt.	11.3	DAR-SP1.2; DAR-SP1.3; DAR-SP1.4; DAR-SP1.5; DAR-SP1.6; RSKM-SP1.1; RSKM-SP1.2; RSKM_SP2.2	IP1; IP5; Theme: risk	4.3	1.04; 1.08	26 – 26.2	-
Perform quantitative risk mngnt.	11.4	DAR-SP1.2; DAR-SP1.3; DAR-SP1.4; DAR-SP1.5; DAR-SP1.6; RSKM-SP1.1; QPM-SP1.4	IP1; IP5; Theme: risk	4.3	1.04; 1.08	26 – 26.2	-
Plan risk responses	11.5	-	IP1; Theme: risk	4.3	1.04; 1.08	28 – 28.3	-

Standards / Process	PMI	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
Plan procument	12.1	SAM-SP1.1; TS-SP2.4	-	-	1.14	30 – 30.2	-
Plan data collection	-	MA-SP1.3; MA-SP1.4; PP-SP2.3	-	-	1.17	-	-
EXECUTING							
Direct an manage project execution	4.3	IPM-SP1.1; IPM-SP1.2; PI-SP3.1; PI-SP3.2; PI-SP3.4; QPM-SP2.2	CS1; CS2; CS3; CS4; MP1; MP2; MP3; SB2; Theme: change; Principle: tailor to suit the project environment	3.8; 10.3	1.16	3 – 3.1; 4 – 4.2; 4.3; 5	CC5.14
Implement process action	2)	OPF-SP2.1; 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	EC5.7
Perform quality assurance	8.2	PMC-SP2.2; PMC-SP2.3; MA-SP2.1; MA-SP2.2; PPQA-SP1.1; PPQA-SP1.2; OPD-SP1.1; PI-SP3.3; OPF-SP3.4; QPM-SP2.3	SB2; Theme: quality/ change	3.10	1.05	16 – 16.1; 16.2	-
Deploy process improvement	-	OPM-SP1.2; OPM-SP3.1; OPM-SP3.2; OPM-SP3.3	Theme: quality	3.10	1.12; 1.19	4 – 4.4; 5 ; 16 – 16.3; 17 – 17.1;	-
Acquire project team	9.2	IPM-SP1.6	SU3, SB2; Theme: organisation	8.2	1.12; 1.19	18 – 18.4	FC5.2; EC5.21; EC5.23
Develop team	9.3	PP-SP2.5; 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	CC5.10; EC5.4; EC5.15; EC5.19
Manage team	9.4	PMC-SP2.2; PMC-SP2.3; PPQA-SP1.1; OPF-SP3.4	SB2; Theme: organisation/ Change; Principle: tailor to suit the project environment	7.4; 8.3; 8.4	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	3 – 3.1; 20 – 20.2; 20.5	CC5.10; EC5.5; EC5.18
Distribute information	10.3	MA-SP2.4; PPQA-SP1.1; PPQA-SP2.1; PP-SP3.2; PP-SP3.3; REQM-SP1.2; IPM-SP2.1; OPF-SP3.4	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	CC5.12

Standards / Process	PMI	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
Manage stakeholder expectation	10.4	PMC-SP1.5; PMC-SP2.2; PMC-SP2.3; PPQA-SP1.1; IPM-SP2.2; IPM-SP2.3; OPF-SP3.4;	-	5.2; 5.3	1.02; 1.17; 1.18	2 – 2.1; 3 – 3.1; 9 – 9.2; 20 – 20.4; 23 – 23.3	CC5.12
Conduct procurement	12.2	PMC-SP2.2; PMC-SP2.3; SAM-PP1.2; SAM-SP2.1; SAM-PP2.2; SAM-PP2.3	-	-	1.14	31 – 31.1; 31.2; 32 – 32.1; 32.2; 32.3	CC5.13
Execute data mngnt. By storing data	-	MA-SP2.3; PPQA-SP2.2; REQM-SP1.4	-	-	1.17	-	-
Tailoring criteria and guidelines	3)	OPD-SP1.3	Theme: organisation; Principle: tailor to suit the project environment	-	1.06; 1.09	-	-
Implement and establish process assets	4)	OPD-SP1.5	-	-	-	-	-
Select product component solution	5)	TS-SP1.1; TS-SP1.2	5)	5)	5)	5)	5)
Develop/ establish design of product	5)	TS-SP2.1; TS-SP2.2; TS-SP2.3; TS-SP2.4	-5)	5)	5)	5)	5)
Implement product design	5)	TS-SP3.1; TS-SP3.2	5)	5)	5)	5)	5)
MONITORING AND CONTROL							
Monitor and control project work	4.4	PMC-SP1.1; PMC-SP1.4; PMC-SP2.2; PMC-SP2.3; IPM-SP1.4; IPM-SP1.5; OPF-SP3.3; QPM-SP2.1	Principle: manage by stages	10.4; 11.3	1.16	3 – 3.1; 3.2; 10 – 10.2; 10.3	CC5.14; CC5.15; EC5.2
Perform change control	4.5	PMC-SP1.1; PMC-SP2.2; PMC-SP2.3; CM-SP1.2; CM-SP1.3	Theme: change; Principle: manage by stages	3.11	1.15	8 – 8.2; 8.3; 10 – 10.3; 17 – 17.3	-
Verify scope	5.4	PMC-SP1.4; PMC-SP2.2; PMC-SP2.3; CM-SP2.2; REQM-SP1.3; RD-SP3.3; RD-SP3.4	Principle: manage by exceptions	10.4	1.02; 1.03; 1.10	7 – 7.2	CC5.5

Standards / Process	PMI	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
Control scope	5.5	PMC-SP1.2; PMC-SP1.4; PMC-SP2.2; PMC-SP2.3; CM-SP2.1; CM-SP2.2; CM-SP3.2; REQM-SP1.3; REQM-SP1.5; OPF-SP3.4	Principle: manage by stages	10.4	1.16	8 – 8.2; 8.3	CC5.5
Control schedule	6.6	PMC-SP2.2; PMC-SP2.3; OPF-SP3.4	SB2	3.9; 3.13; 3.15	1.11; 1.16	10 – 10.2; 10.3	EC5.6
Control costs	7.3	PMC-SP2.2; PMC-SP2.3; OPF-SP3.4	Theme: business case; Principle: continued business justification	3.7; 3.15	1.11; 1.16	13 – 13.4	EC5.6
Control quality	8.3	PMC-SP2.2; PMC-SP2.3; CM-SP3.2; REQM-SP1.5; OPF-SP3.4; OPM-SP1.3; OPM-SP2.1; OPM-SP2.2; OPM-SP2.3; OPM-SP2.4	SB2; Theme: quality	3.14	1.05; 1.06	16 – 16.2	-
Validation of product	5)	VAL-SP1.1; VAL-SP1.2; VAL-SP1.3; VAL-SP2.1; VAL-SP2.2	MP3; Theme: quality	3.12	5)	5)	5)
Verification of product	5)	VER-SP1.1; VER-SP1.2; VER-SP1.3; VER-SP2.1; VER-SP2.2; VER-SP2.3; VER-SP3.1; VER-SP3.2	MP3; Theme: quality	3.12	5)	5)	5)
Report performance	10.5	PMC-SP1.6; PMC-SP1.7; PMC-SP2.2; PMC-SP2.3; OPF-SP3.4	CS5; Theme: progress; Principle: mange by stages	3.11; 11.3; 11.4	1.16; 1.17	7 – 7.2; 8 – 8.4; 9 – 9.4; 11 – 11.2; 14 – 14.4; 16 – 16.2; 17 – 17.2; 19 – 19.3; 23 – 23.1; 24 – 24.1; 28 – 28.2; 29-29.1; 29.2; 34-34.2	FC5.2; FC5.3; CC5.10; CC5.12
Control and monitor risks	11.6	PMC-SP1.3; PMC-SP2.2; PMC-SP2.3; RSKM-SP3.1; RSKM-SP3.2; OPF-SP3.4	CS6; CS7; CS8; SB2; Theme: risk	2.1; 4.3; 4.4	1.04; 1.16	28 – 28.1; 28.1	-

Standards / Process	PMI	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
Administer procurement	12.3	PMC-SP2.2; PMC-SP2.3; SAM-SP2.2; SAM-SP2.3; OPF-SP3.4	-	-	1.14; 1.16	31 – 31.1; 33 – 33.1; 33.2; 33.3	Prerequisite (level 4)
CLOSING							
Close project/ phase	12.3	PMC-SP2.2; PMC-SP2.3; SAM-SP2.2; SAM-SP2.3; OPF-SP3.4	DP5; MP3; SB4; CP1; CP2; CP3; CP4; CP5; SU2; Principle: learn from experience	3.12; 3.16; 3.17	1.20	11 – 11.1; 14 – 14.1; 14.2; 14.3; 17 – 17.3; 25 – 25.1; 25.2; 25.3; 29 – 29.2; 34 – 34.2	CC5.2
Close procurement	4.6	-	-	-	1.20	34 – 34.1	CC5.2

1) Performed by adopting and modifying the existing processes during the planning stage
2) Processes and organisation process assets are updated regularly
3) not explicit named here, only that it has to be performed at least once at the beginning
4) Only updates
5) Product specific wording is not mentioned in this standard

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.

Processes of a PM-standard, not mentioned in the comparison							
Standards / Process	PMI	CMMI	Prince2	P2M	ICB3.0	AIPM/ NCSPM	PMSGB/ SAQA
Processes	-	PMC-SP2.1; PP-SP1.3; PP-SP3.1; CM-SP3.1; SAM-SP3.1; IPM-SP1.3; IPM-SP1.7; OPD-SP1.1; OPD-SP1.2; RD-SP3.1; PI-SP2.1; PI-SP2.2; DAR-SP1.1; CAR-SP1.1; CAR-SP1.2; CAR-SP2.1; CAR-SP2.2; CAR-SP2.3	DP4; IP3; IP7; SB3; SB5	5.4; 9.1	3.1; 3.2; 3.3; 3.4; 3.5; 3.6; 3.7; 3.8; 3.9; 3.10; 3.11	3-3.2; 21; 27; 23-23.2; 32-32.3	FC5.1; CC5.1; CC5.3; CC5.4; CC5.11; CC5.16; EC5.1; EC5.3; EC5.8; EC5.9; EC5.10; EC5.11; EC5.12; EC5.13; EC5.14; EC5.16; EC5.17; EC5.20; EC5.22

Table 20: PM standard specific processes (developed by author)

Appendix VIII – Project management method "capability maturity model integration" (CMMI)

CMMI – Facts

Year of development/ Foundation	*1987*
Language	*English*
Origin in	*Software Development*
Legal rights by	*Software Engineering Institute (SEI), Carnegie Mellon University*
Certification	*A company is certified not a single person.* *SCAMPI Assessment (**S**tandard **CMMI** **A**ppraisal **M**ethod for **P**rocess **I**mprovement) by authorised SEI consultants or a BOX Business which is afterwards audited*
Standards	*ISO9000, ISO15504*
Country	*USA*
Members worldwide	*More than 4.000(certification of companies)*
Associated companies with CMMI	*Method Park, Continental AG, ABB Switzerland, Accenture, BNP Paribas, Deloitte, EADS CASA, General Dynamics, Lockheed Martin, NASA Langley Research Center, Thales, US Navy, US Air Force,*

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 document, 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.

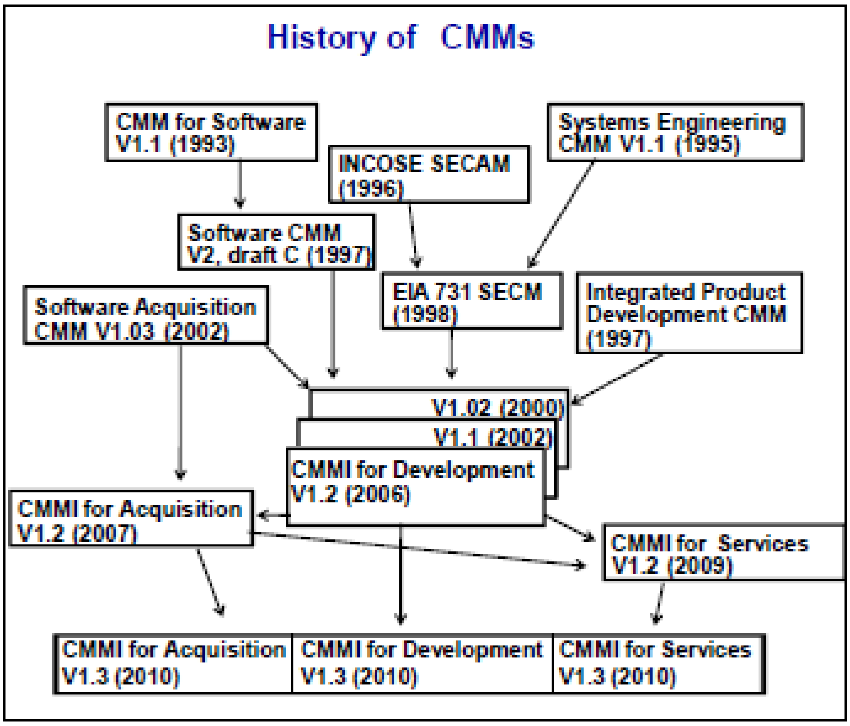


Figure 68: The History of CMM's (Source: CMMI-DEV (V1.3))

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 & Jujjuru, 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.

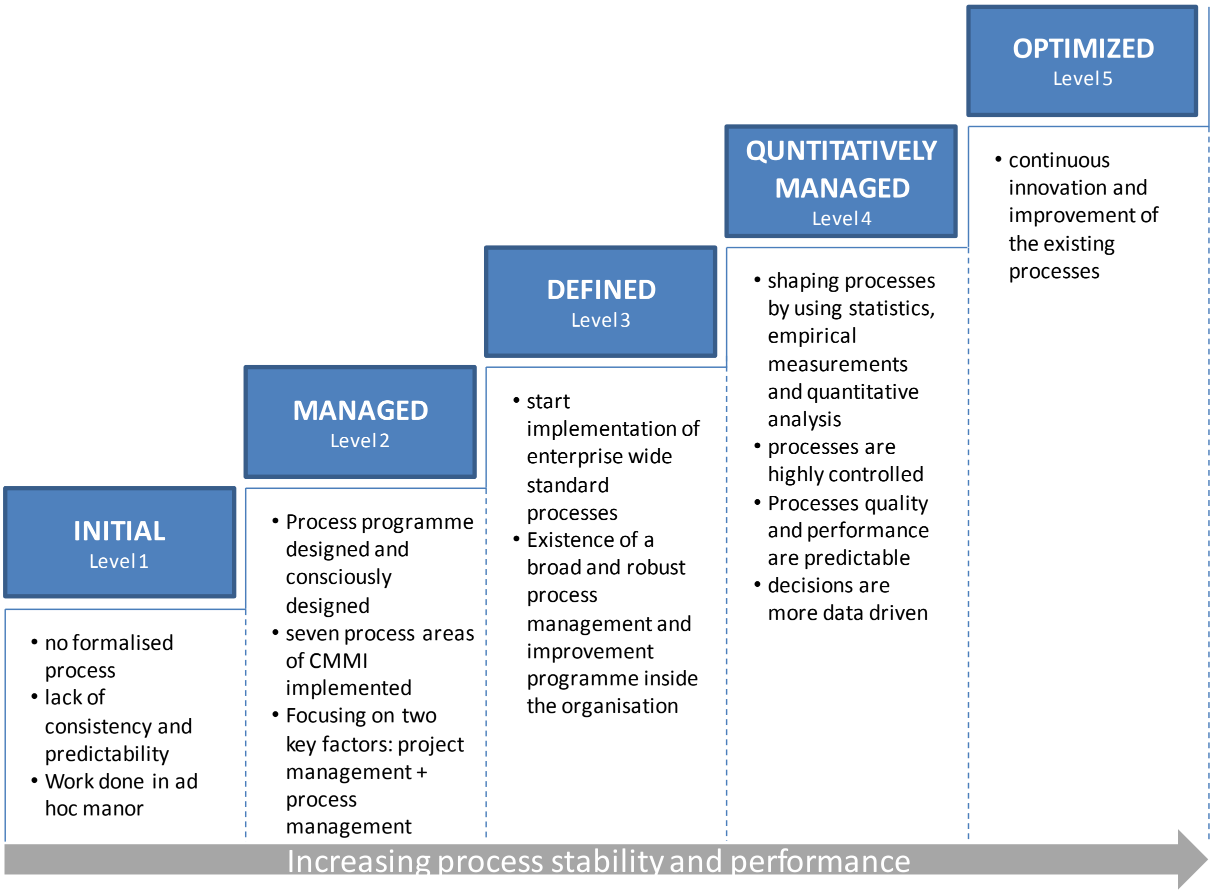


Figure 69: CMMI Maturity Levels (Developed by author)

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.

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

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 specific 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.

category maturity	Project Management	Process Management	Engineering	Support
Definition	related to defining, planning, monitoring, controlling	related to defining, planning, deploying, implementing, monitoring, controlling, appraising, measuring and improving process	related to development process improvement	provide objective evaluation of processes and work products described in the project
Maturity Level1				
Maturity Level2	**Project Monitoring and Control (PMC)** *SG1-Monitor the Project against the Plan* SP1.1-Monitor Project Planing Parameters SP1.2-Monitor Commitments SP1.3-Monitor Project Risks SP1.4-Monitor Data Management SP1.5-Monitor Stakeholder Involvement SP1.6-Conduct Progress Reviews SP1.7-Conduct Milestone Reviews *SG2-Manage Corrective Action to Closure* SP2.1-Analyse Issues SP2.2-Take Corrective Action SP2.3-Manage Corrective Action			**Configuration Management (CM)** *SG1-Establish Baselines* SP1.1-Identify Configuration Items SP1.2-Establish a Configuration Management System SP1.3-Create or Release Baselines *SG2-Track and Control Changes* SP2.1-Track Change Requests SP2.2-Control Configuration Items *SG3-Establish Integrity* SP3.1-Establish Configuration Management Records SP3.2-Perform Configuration Audits

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

Table 22: CMMI-DEV processes, Maturity Level 1-2 (developed by author derived from CMMI)

category maturity	Project Management	Process Management	Engineering	Support
Definition	related to defining, planning, monitoring, controlling	related to defining, planning, deploying, implementing, monitoring, controlling, appraising, measuring and improving process	related to development process improvement	provide objective evaluation of processes and work products described in the project
Maturity Level3	**Integrated Project Management (IPM)**	**Organisational Process Definition (OPD)**	**Product Integration (PI)**	**Decision Analysis and Resolution (DAR)**
	SG1-Use the Project's Defined Processes	*SG1-Establish Organisational Process Assets*	*SG1-Prepare for Productintegration*	*SG1-Evaluate Alternatives*
	SP1.1-Establish the Project's Defined Processes	SP1.1-Establish Standard Processes	SP1.1-Establish an Integration Strategy	SP1.1-Establish Guidelines for Decision Analysis
	SP1.2-Use Organistional Process Assets for Planning Project Activities	SP1.2-Establish Lifecycle Model Discriptions	SP1.2-Establish a Product Integration Environment	SP1.2-Establish Evaluation Criteria
	SP1.3-Establish Projects Work Environment	SP1.3-Establish Tailoring Criteria and Guidelines	SP1.3-Establish Product Integration Procedures and Criteria	SP1.3-Identify Alternative Solutions
	SP1.4-Integrate Plans	SP1.4- Establish the Organisation's Measurement Repository	*SG2-Ensure Interface Compability*	SP1.4-Select Evaluation Methods
	SP1.5-Manage the Project Using Integrated Plans	SP1.5-Establish the Organisation's Process Assets Library	SP2.1-Review Interface Discriptions for Completeness	SP1.5-Evaluate Alternative Solutions
	SP1.6-Establish Teams	SP1.6-Establish Work Environment Standards	SP2.2-Manage Interfaces	SP1.6-Select Solution
	SP1.7-Contribute to Organisational Process Assets	SP1.7-Establish Rules and Guidelines for Teams	*SG3-Assemble Product Components and Deliver the Product*	
	SG2-Coordinate and Colaborate with relevant Stakeholders		SP3.1-Confirm Readiness of Product Components for Integration	
	SP2.1-Manage Stakeholder Involvement		SP3.2-Assemble Product Components	
	SP2.2-Manage Dependencies		SP3.3-Evaluate Assembled Product Components	
	SP2.3-Resolve Coordination Issues		SP3.4-Package and Deliver the Product or Product Components	
	Risk Management (RSKM)	**Organisational Process Focus (OPF)**	**Requirements Development (RD)**	
	SG1-Prepare for Riskmanagement	*SG1-Determine Process Improvement Opportunities*	*SG1-Develop Customer Requirements*	
	SP1.1-Determine Risk Sources and Categories	SP1.1-Establish Organisational Process Needs	SP1.1-Elicit Needs	
	SP1.2-Determine Risk Parameters	SP1.2-Appraise the Organisation's Processes	SP1.2-Transform Stakeholder Needs into Customer Requirements	
	SP1.3-Establish a Riskmanagement Strategy	SP1.3-Identify the Organisation's Process Improvements	*SG2-Develop Product Requirements*	
	SG2-Identify and Analyse Risks	*SG2-Plan and Implement Process Actions*	SP2.1-Establish Product and Product Component Requirements	
	SP2.1-Identify Risks	SP2.1-Establish Process Action Plans	SP2.2- Allocate Product Component Requirements	
	SP2.2-Evaluate, Categorise and Prioritise Risks	SP2.2-Implement Process Action Plans	SP2.3-Identify Interface Requirements	
	SG3Mitigate Risks	*SG3-Deploy Organisational Process Assets and Incorporate Experiences*	*SG3-Analyse and Validate Requirements*	
	SP3.1-Develop Risk Mitigation Plan	SP3.1-Deploy Organisational Process Assets	SP3.1-Establish Operational Concepts and Scenarios	
	SP3.2-Implement Risk Mitigation Plan	SP3.2-Deploy Standard Processes	SP3.2-Establish a Definition of Functionality and Quality Attributes	
		SP3.3-Monitor the Implementation	SP3.3-Analyse Requirements	
		SP3.4-Incorporate the Experience into the Organisational Process Assets	SP3.4-Analyse Requirements to Archive Balance	
			SP3.5-Validate Requirements	

		Organisational Training (OT) *SG1-Establish and Organisational Training Capability* SP1.1-Establish Strategic Training Needs SP1.2-Determine Which Training Needs Are the Responsibility of the Organisation SP1.3-Establish an Oragnisational Training Tactical Plan SP1.4-Establish a Training Capability *SG2-Provide Training* SP2.1-Deliver Training SP2.2-Establish Training Records SP2.3-Assess Training Effectiveness	**Technical Solutions (TS)** *SG1-Select Product Component Solutions* SP1.1-Develop Alternative Solution and Selection Criteria SP1.2-Select Product Component Solutions *SG2-Develop the Design* SP2.1-Design the Product or Product Component SP2.2-Establish a Technical Data Package SP2.3-Design Interface Using Criteria SP2.4-Perform Make, Buy or Reuse Analysis *SG3-Implement the Product Design* SP3.1-Implement the Design SP3.2-Develop Product Support Documentation **Validation (VAL)** *SG1-Prepare for Validation* SP1.1-Select Products for Validation SP1.2-Establish the Validation Environment SP1.3-Establish Validation Procedure and Criteria *SG2-Validate Product or Product Components* SP2.1-Perform Validation SP2.2-Anayse Validation Results **Verification (VER)** *SG1-Prepare for Verification* SP1.1-Select Workproducts for Verification SP1.2-Establish the Verification Environment SP1.3-Establish Verification Procedures and Criteria *SG2-Performk Peer Reviews* SP2.1-Prepare Peer Reviews SP2.2-Conduct Peer Reviews SP2.3-Analyse Peer Review Data *SG3-Verify Selected Work Products* SP3.1-Perform Verification SP3.2-Analyse Verification Results	

Table 23: CMMI-DEV processes, Maturity Level 3 (developed by author derived from CMMI)

maturity / category	Project Management	Process Management	Engineering	Support
Definition	related to defining, planning, monitoring, controlling	related to defining, planning, deploying, implementing, monitoring, controlling, appraising, measuring and improving process	related to development process improvement	provide objective evaluation of processes and work products described in the project
Maturity Level4	**Quantitative Project Management (QPM)** *SG1-Prepare for Quantitative Management* SP1.1-Establish the Project's Objectives SP1.2-Compose the Defined Processes SP1.3-Select Subprocesses and Attributes SP1.4-Select Measures and Analytic Techniques *SG2-Quantitatively Manage the Project* SP2.1-Monitor the Performance of Selected Subprocesses SP2.2-Manage Project Performance SP2.3-Perform Root Cause Analyis	**Organisational Process Performance (OPP)** *SG1-Establish Performance Baselines and Models* SP1.1-Establish Quality and Process Performance Objectives SP1.2-Select Processes SP1.3-Establish Process Performance Measures SP1.4-Analyse Process Performance and Establish Process Performance Baselines SP1.5-Establish Process Performance Models		
Maturity Level5		**Organisational Performance Management (OPM)** *SG1-Manage Business Performance* SP1.1-Maintain Business Objectives SP1.2-Analyse Process Performance Data SP1.3-Identify Potential Areas for Improvement *SG2-Select Improvements* SP2.1-Edit Suggested Improvement SP2.2-Analyse Suggested Improvements SP2.3-Validate Improvements SP2.4-Select and Implement Improvements for Deployment *SG3-Deploy Improvements* SP3.1-Plan the Deployment SP3.2-Manage the Deployment SP3.3-Evaluate Improvement Effects		**Causal Analysis and Resolution (CAR)** *SG1-Determine Causes of Selected Customers* SP1.1-Select Outcomes for Analysis SP1.2-Anayse Causes *SG2-Address Causes of Selected Customers* SP2.1-Implement Action Proposals SP2.2-Evaluate the Effect of Implemented Actions SP2.3-Record Casual Analysis Data

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

YEAR OF DEVELOPMENT/ FOUNDATION	*1969*
LANGUAGE	*ENGLISH, GERMAN, ITALIAN, SPANISH, ARABIC, FRENCH, RUSSIAN, PORTUGUESE, KOREAN, CHINESE ,JAPANESE*
ORIGIN IN	*SOFTWARE DEVELOPMENT*
LEGAL RIGHTS BY	*PROJECT MANAGEMENT INSTITUTE (PMI)*
CERTIFICATION	*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)*
STANDARDS	*ISO9001, ISO10006, ISO21500* *ANSI/PMI 99-001-2008,* IEEE Standard 1490-2003
COUNTRY	*USA, NEWTOWN SQUARE (PA)*
MEMBERS WORLDWIDE	*>430.000 ACTIVE MEMBERS/ >600.000 CERTIFIED PMP HOLDERS IN OVER 200 COUNTRIES WORLDWIDE*
ASSOCIATED COMPANIES WITH CMMI	*BANK OF AMERICA, BOOZ ALLEN HAMILTON, BOSTON UNIVERSITY, IBM, LOCKHEED MARTIN, PRICE WATERHOUSE COOPERS, U.S. DEPARTMENT OF DEFENCE*

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.

Process group / Knowledge area	Initiating	Planning	Executing	Monitoring & Controlling	Closing
Integration Management	develop project charter	develop project management plan	direct and manage project execution	monitor and control project work perform integrated change control	close project or phase
Scope Management		collect requirements define scope create work breakdown structure		verify scope control scope	
Time Management		define activities sequence activities estimate ressources estimate duration define schedule		control schedule	
Cost Management		estimate costs determine budget		control costs	
Quality Management		plan quality	perform quality assurance	control quality	
Human Ressource Management		develop human ressource plan	acquire project team develop project team manage project team		
Communication Management	identify stakeholder	plan communication	distribute information manage stakeholder expectation	report performance	
Risk Management		plan risk management identify risks perform qualitative risk management perfom quanitative risk management plan risk responsibilities		control and monitor risks	
Procurement Management		plan procurements	conduct procurements	administer procurements	close procurements

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)*.

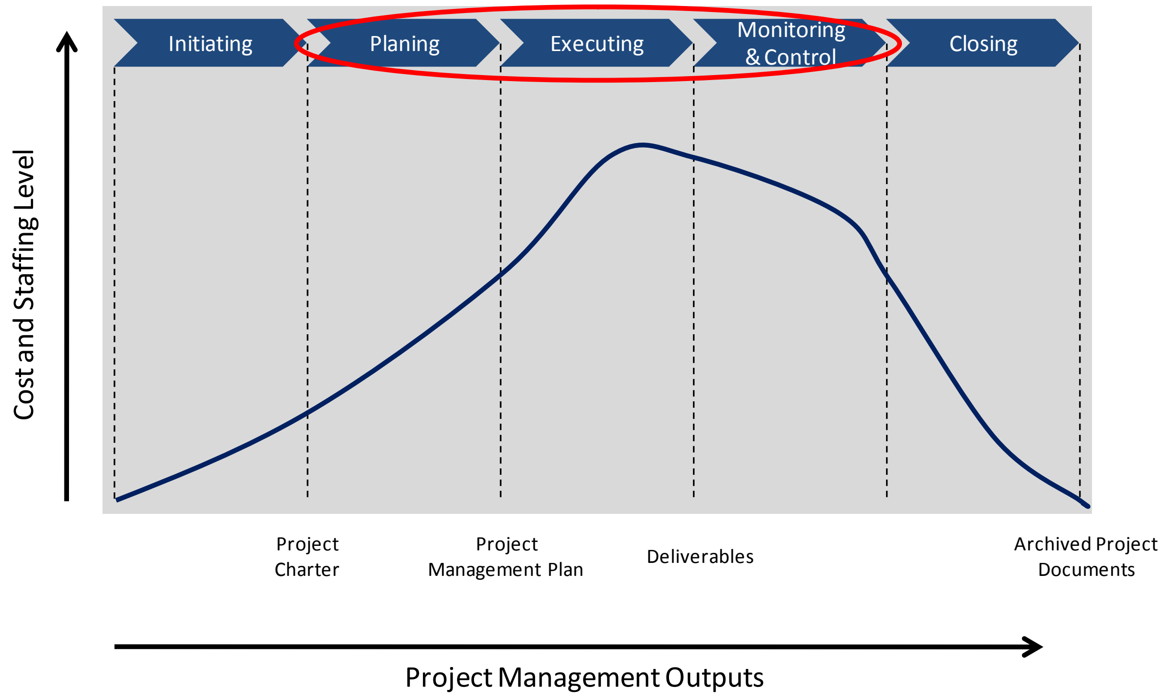


Figure 70: PMI PLC - Cost-/staffing Level and Deliverables (source: PMI)

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)*.

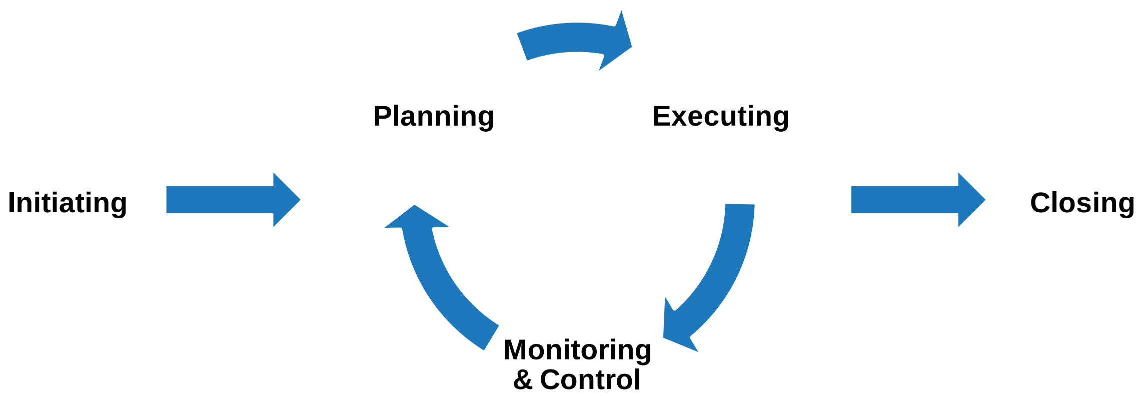


Figure 71: Interaction of process groups (source: derived from PMI)

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 be realized at a late stage. Therefore, stakeholders should be involved at an early stage (Stackpole et al., 2008).

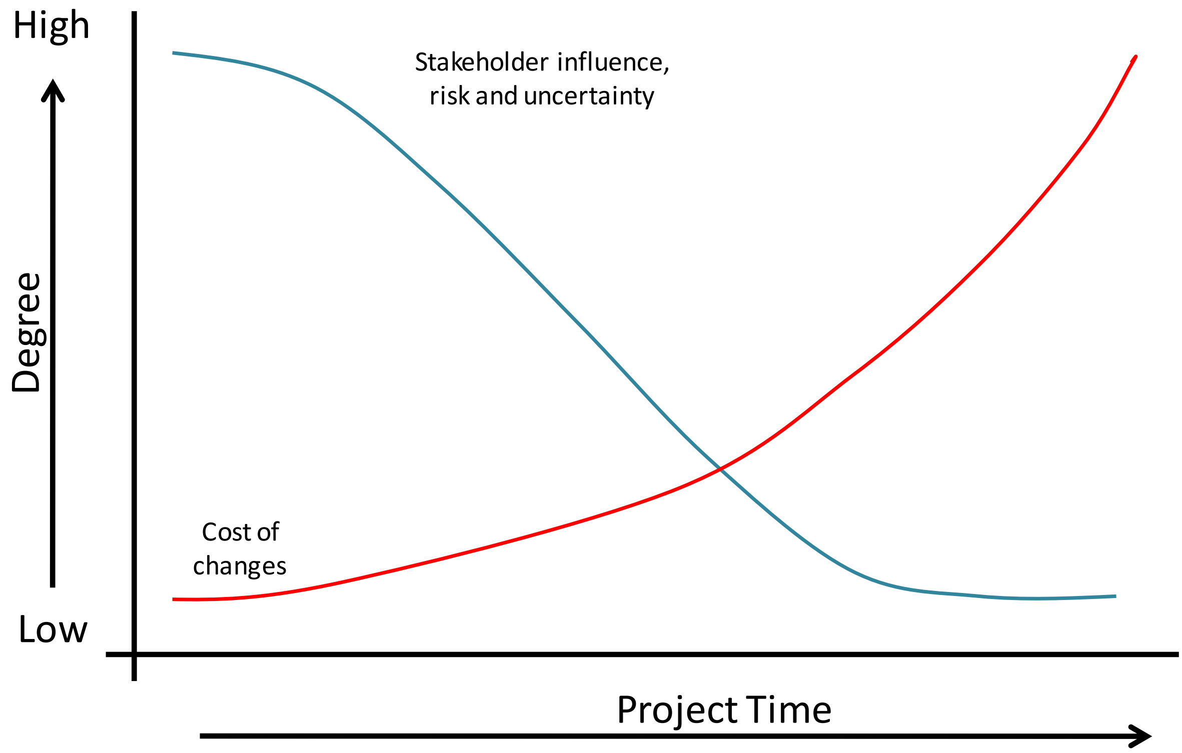


Figure 72: Impact of variable based on project time (source: PMI)

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).

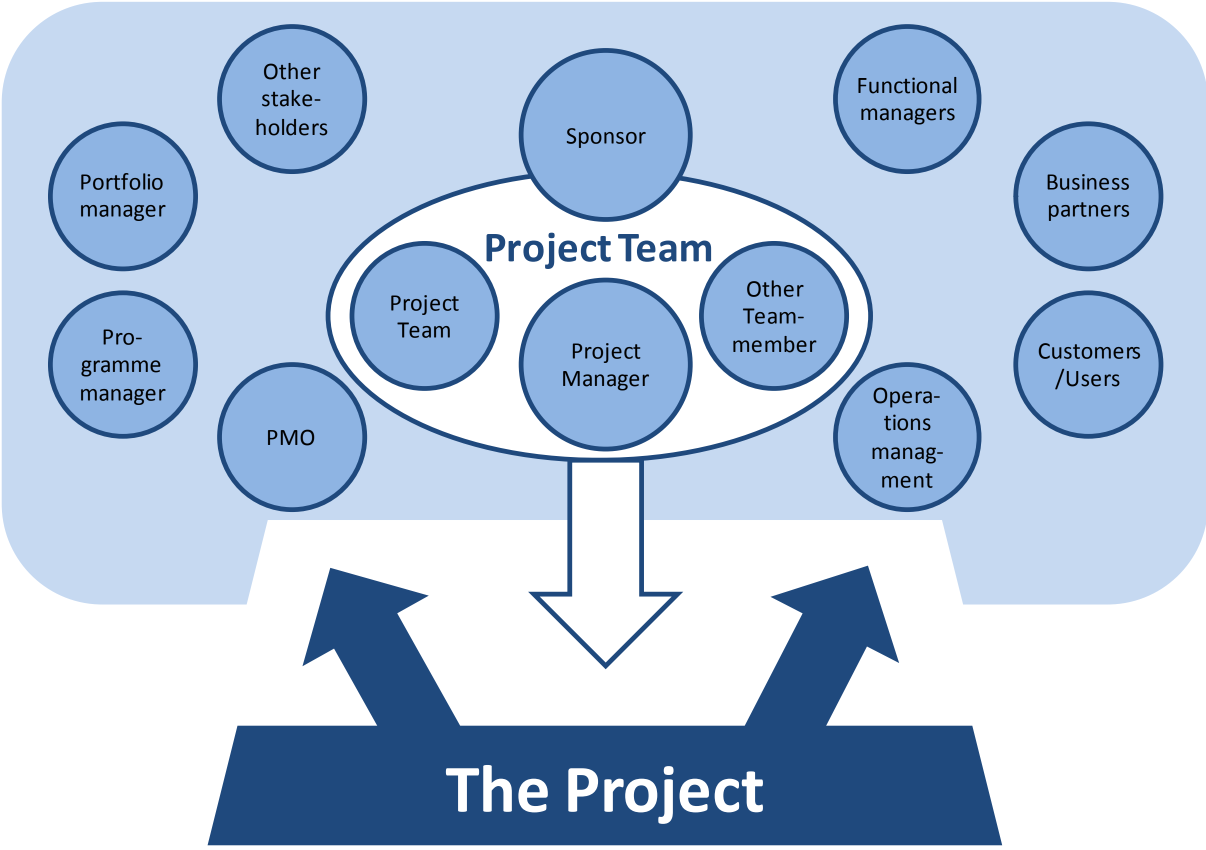


Figure 73: Relationship between stakeholders and the project (source: PMI)

- **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) .

	PMBoK 4th edition	PMBoK 5th edition	ISO 21500
Stages	**5 stages** 1. Initiating 2. Planning 3. Execution 4. Monitoring & Control 5. Closing	**5 stages** 1. Initiating 2. Planning 3. Execution 4. Monitoring & Control 5. Closing	**5 stages** 1. Initiating 2. Planning 3.Implementing 4. Controlling 5. Closing
Areas	**9 areas** 1. Integration (6 processes) 2. Scope (5 processes) 3. Time (6 processes) 4. Cost (3 processes) 5. Quality (3 processes) 6. Human Resource (4 processes) 7. Communication (5 processes) 8. Risk (6 processes) 9. Procurement (4 processes)	**10 areas** 1. Integration (6 processes) 2. Scope (6 processes) 3. Time (7 processes) 4. Cost (4 processes) 5. Quality (3 processes) 6. Human Resource (4 processes) 7. Communication (3 processes) 8. Risk (6 processes) 9. Procurement (4 processes) 10. Stakeholder (4 processes)	**10 areas** 1. Integration (7 processes) 2. Stakeholder (2 processes) 3. Scope (4 processes) 4. Resource (6 processes) 5. Time (4 processes) 6. Cost (3 processes) 7. Risk (4 processes) 8. Quality (3 processes) 9. Procurement (3 processes) 10. Communication (3 processes)
Total of processes	**42 processes**	**47 processes**	**39 processes**

Table 26: Changes in PMBoK 4th edition to PMBoK 5th edition (developed by author)

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 ws 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.

Process group / Knowledge area	Initiating	Planning	Executing	Monitoring & Controlling	Closing
Integration Management	develop project charter	develop project management plan	direct and manage project work	monitor and control project work perform integrated change control	close project or phase
Scope Management		plan scope management collect requirements define scope create work breakdown structure		verify scope control scope	
Time Management		plan schedule management define activities sequence activities estimate ressources estimate duration develop schedule		control schedule	
Cost Management		plan cost management estimate costs determine budget		control costs	
Quality Management		plan quality management	perform quality assurance	control quality	
Human Ressource Management		plan human ressource management	acquire project team develop project team manage project team		
Communication Management		plan communication management	manage communications	control communications	
Risk Management		plan risk management identify risks perform qualitative risk management perfom quanitative risk management plan risk responsibilities		control risks	
Procurement Management		plan procurements	conduct procurements	control procurements	close procurements
Project Stakeholder Management	identify stakeholder	plan stakeholder management	manage stakeholder management	control stakeholder engagement	

Table 27: PMI process groups and knowledge areas mapping – PMBoK 5th edition (source: PMI)

PMI – Target

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):

- 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

Year of development/ Foundation	*1989 by the CCTA (Central Computer and Telecommunications Agency) for IT. Since 1996 published as an overall applicable PM standard*
Language	*Chinese, Danish, Dutch, English, French, German, Norwegian, Polish, Spanish*
Origin in	*Software Development*
Legal rights by	*Royal Crown – administered by CCTA replaced by OGC (Office of Government Commerce)*
Certification	*Foundation level for project team* *Practitioner level for project manager* *(accrediting body is the APM group)*
Standards	*ISO9001, ISO21500*
Country	*UK, Norwich, Norfolk*
Members worldwide	*500.000 certified people on foundation level and 270.000 people on practitioner level since 1996*
Associated companies with PRINCE2	*UK Gouvernement, Fraport AG, IBM, Sun Microsystes GmbH, ThyssenKrupp AG, British Telecom, Deutsche Post AG,*

PRINCE2 – History

PRINCE2 is derived from PRoject IN Controlled Environments (PRINCE) andProject 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.

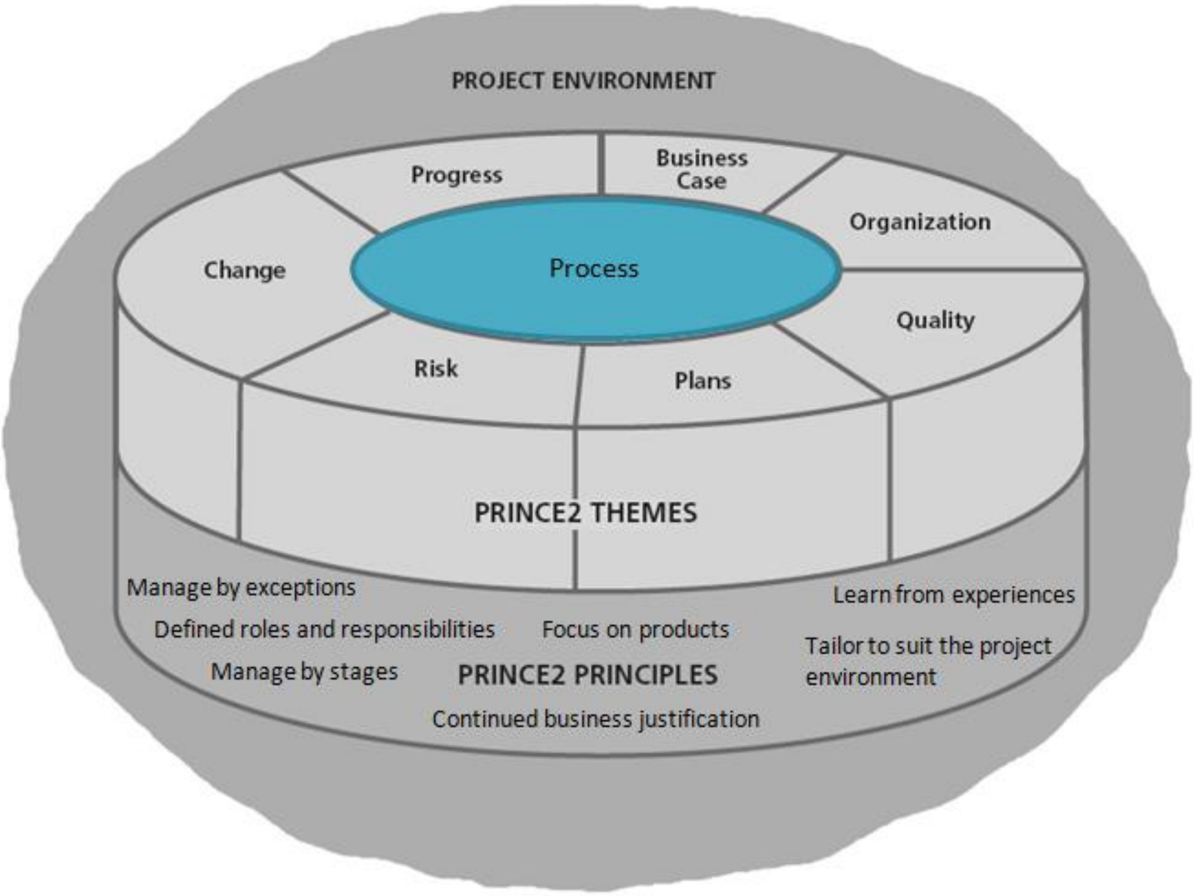


Figure 74: The structure of PRINCE2 (source: PRINCE2 Pocketbook, OGC)

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.

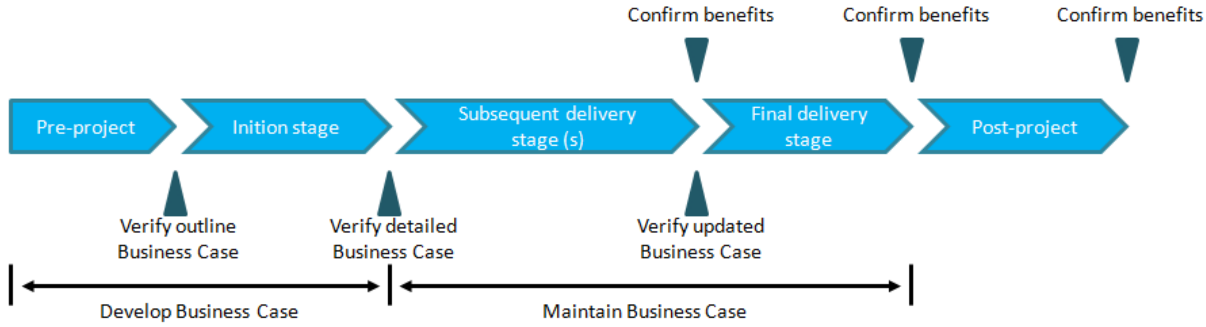


Figure 75: The development path of the Business Case (source: PRINCE2 pocketbook, OGC)

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.

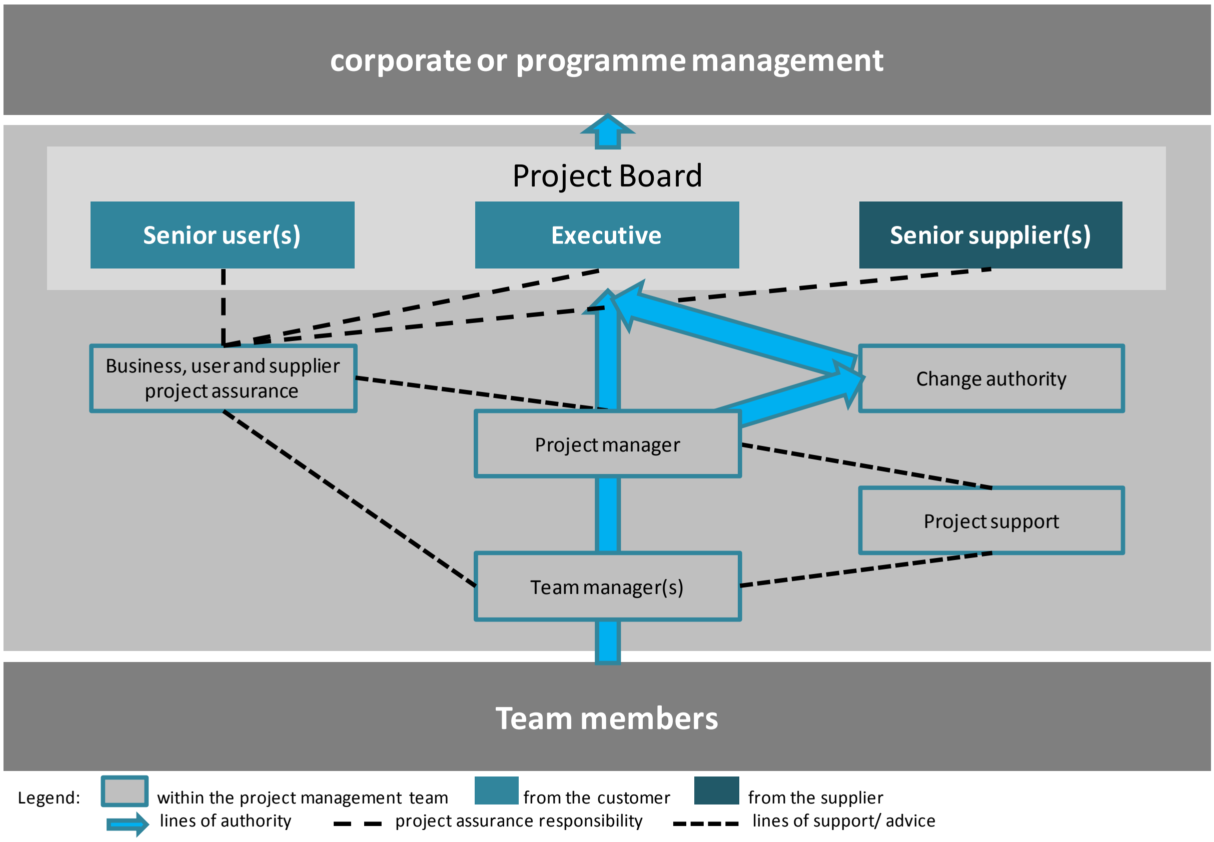


Figure 76: Project management team structure (source: PRINCE2 pocketbook, OGC)

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.

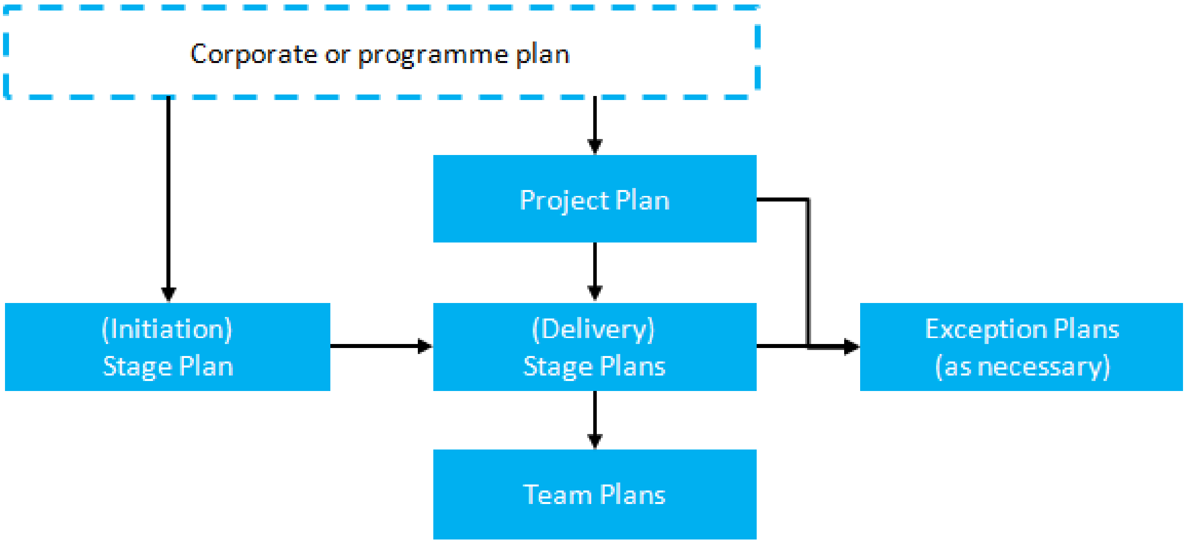


Figure 77: PRINCE2's planning levels (source: PRINCE2 pocketbook, OGC)

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.

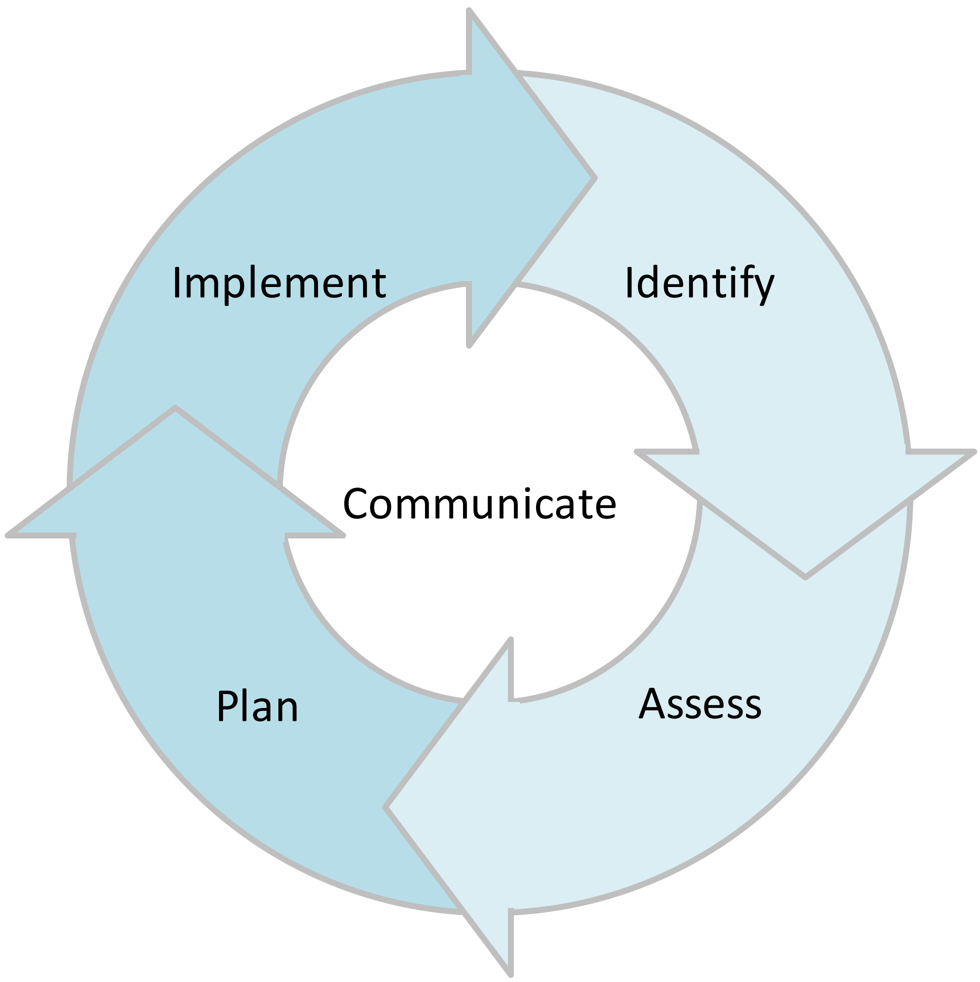


Figure 78: The risk management procedure (source: PRINCE2 pocketbook, OGC)

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. Afterward, the planning of cost and timescale can be started. The quality audit trail with planning and control is shown in Figure 79.

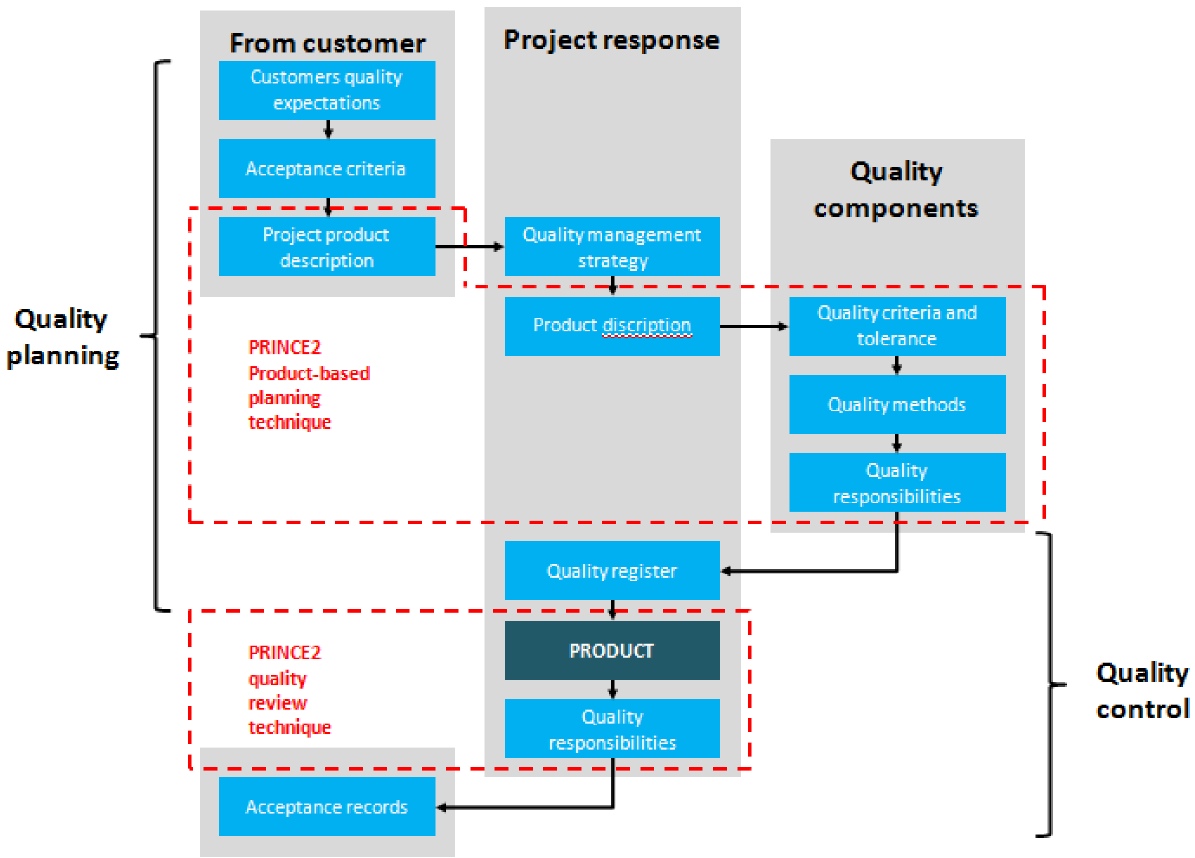


Figure 79: The quality audit trail (source: PRINCE2 pocketbook, OGC)

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.

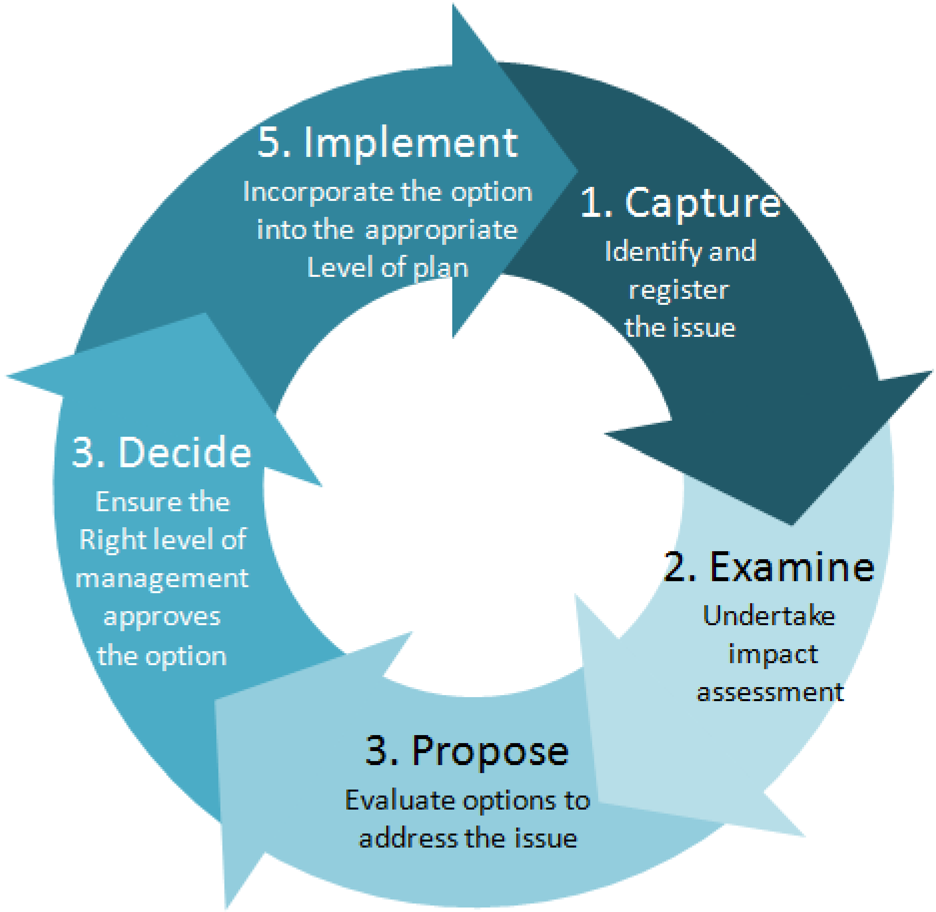


Figure 80: Procedure for managing changes (developed by author)

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.

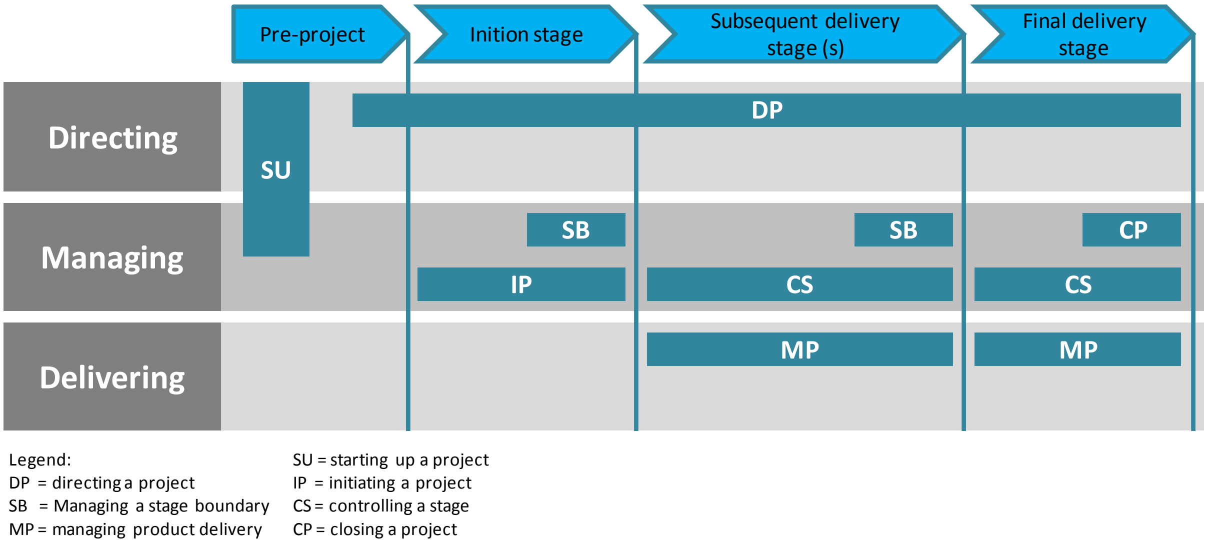


Figure 81: The PRINCE2 processes (source: PRINCE2 pocketbook, OGC)

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 l 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 sub-processes 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 sub-processes 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.

Phase	Shortcut	Pre-Project	Inition stage	subsequent delivery stage	final delivery stage
Starting up a project	SU1	nominate sponsor and project manager			
	SU2	note down the existing knowledge			
	SU3	create and nominate project management team			
	SU4	create business case			
	SU5	merge project description			
	SU6	plan project initiation			
Directing a project	DP1	release initiation			
	DP2	release project			
	DP3	release phase- and exception plan	release phase- and exception plan	release phase- and exception plan	release phase- and exception plan
	DP4	define ad-hoc instructions	define ad-hoc instructions	define ad-hoc instructions	define ad-hoc instructions
	DP5				Release project closure
Initiating a project	IP1		create risk management strategy		
	IP2		create quality management strategy		
	IP3		create configuration management strategy		
	IP4		create communication management strategy		
	IP5		implement project steering tools		
	IP6		create project plan		
	IP7		rework and detail business case		
	IP8		merge project initiation documentation		
Controlling a stage	CS1			release work packages	release work packages
	CS2			approve status of a work package	approve status of a work package
	CS3			approve closed work packages	approve closed work packages
	CS4			check phase status	check phase status
	CS5			report on actual project status	report on actual project status
	CS6			engage and investigate open tasks and risks	engage and investigate open tasks and risks
	CS7			escalate open tasks and risks if necessary	escalate open tasks and risks if necessary
	CS8			implement countermeasures	implement countermeasures
Managing product delivery	MP1			accept work package	accept work package
	MP2			execute work package	execute work package
	MP3			finish and deliver work package	finish and deliver work package
Managing a stage boundary	SB1		plan the next phase	plan the next phase	
	SB2		update project plan	update project plan	
	SB3		update business case	update business case	
	SB4		report about phase closure	report about phase closure	
	SB5		create exception plan if necessary	create exception plan if necessary	
Closing a project	CP1				plan scheduled project closure
	CP2				plan premature project closure
	CP3				handover of final product
	CP4				evaluation of project
	CP5				recommendation of project closure

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

Year of development/ Foundation	*Nov. 2002 by consolidation of JPMF (Japan Project Management Forum) est. as 1998 and PMCC (Project Management Certification Center) est. Apr. 2002*
Language	*English, Japanese*
Origin in	*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)*
Legal rights by	*PMAJ (Project Management Association of Japan)*
Certification	*Project Management Architect (PMA)* *Project Manager Registrated (PMR)* *Project Management Specialist (PMS)* *Project Management Coordinator (PMC)*
Standards	*ISO10006, ISO21500*
Country	*Japan*
Members worldwide	*4000 qualified people there from 2500 people certified*
Associated companies with P2M	*PME Group LTD.*

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

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.

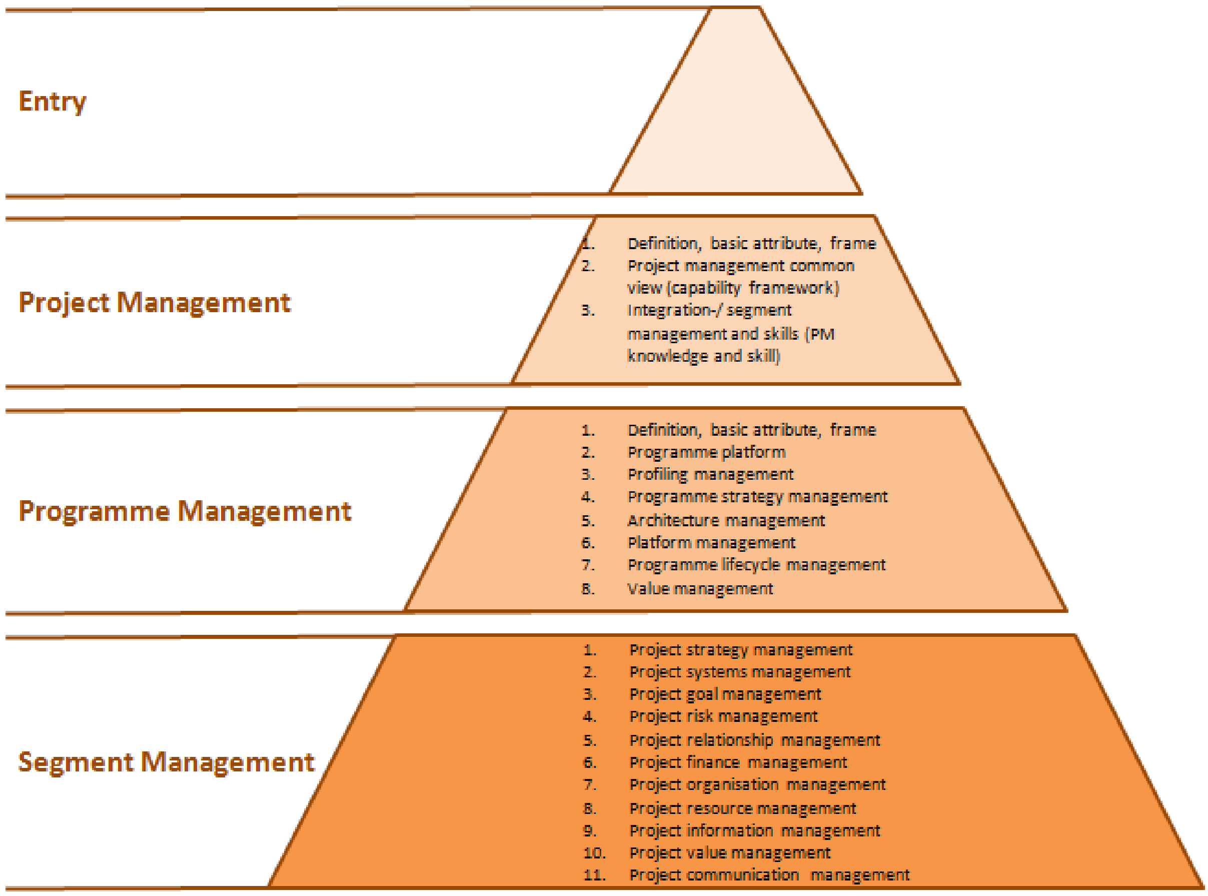


Figure 82: Project Management "Tower" P2M (source: P2M Guidebook Volume1)

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).

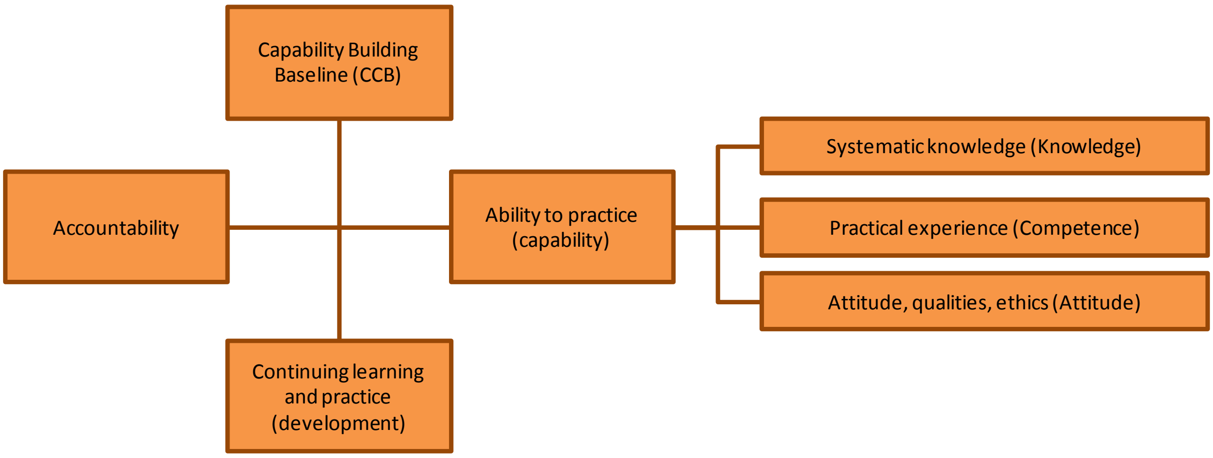


Figure 83: P2M Mission-Achievements Professionals (source: P2M Guidebook Volume1)

- *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 is 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.

	Project management	Programme management
Definition	Value creative undertaking based on a specific mission	Value creating undertaking based on a holistic mission
Basic attitude	Uniqueness, temporary nature, uncertainty	Multiplicity, scalability, complexity, uncertainty
Common view	• Systems approach • Project life cycle • Mental space of projects • Project stakeholder • Use of management skills	• Programme mission • Programme value • Programme community • Programme architecture • Programme integration management skill

Table 29: Project and programme management according to P2M (source: P2M Guidebook Volume1)

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.

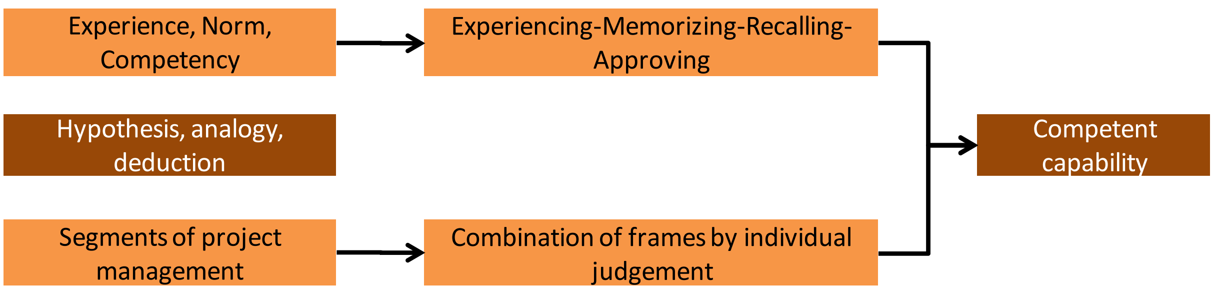


Figure 84: Structure of judgment capability P2M (source: P2M Guidebook Volume1)

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.

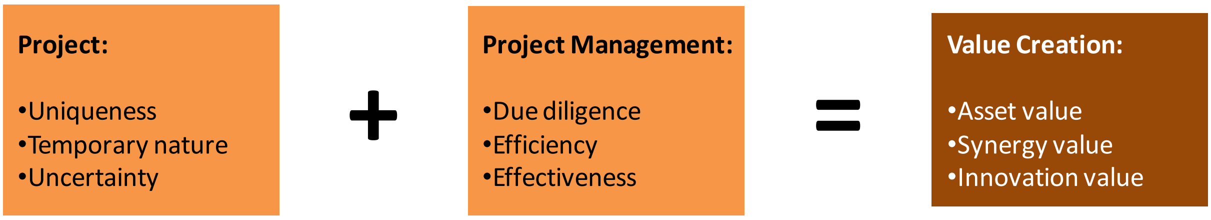


Figure 85: Project, Project Management and Value Creation according to P2M (developed by author)

– *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.

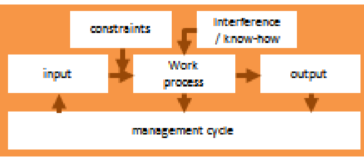
	description
system approach	Complex issues addressed and solved according following pattern by analysing, defining and proposing them, involving external influencing factors 
Project Life Cycle (PLC)	Separated into at least three phases (initial, intermediate, final), which are characterised by distinctive attributes like mission implementation and deliverable. The work effort level starts moderate and strongly increases during in the meanwhile where it stagnates at the end. Each phase is a tailored approach as the intermediate phase can be divided into two or more phases
mental space	Interweaves stakeholder, that they all recognise the value of the project mission and commit themselves to it. Well distinctive communication channels and team building activities inside the project are forced
project stakeholder	Managing all affected or involved people of the project by executing project work under a set of constraints
management skills	Skills to form an organisation to get assignments done with expected results in an efficient and effective way by motivating intrinsic. These skills are theorised as discipline, norm, wisdom, practice and expertise, acquired through experience

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).

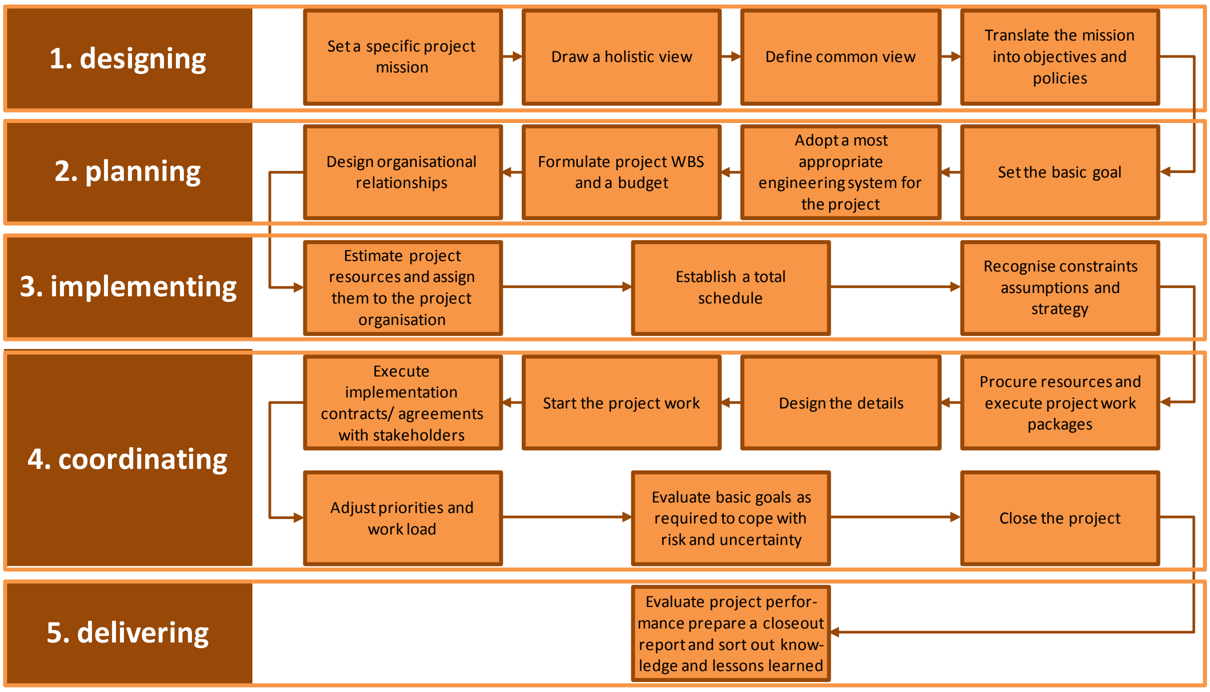


Figure 86: P2M standard project work process (source: P2M Guidebook Volume1)

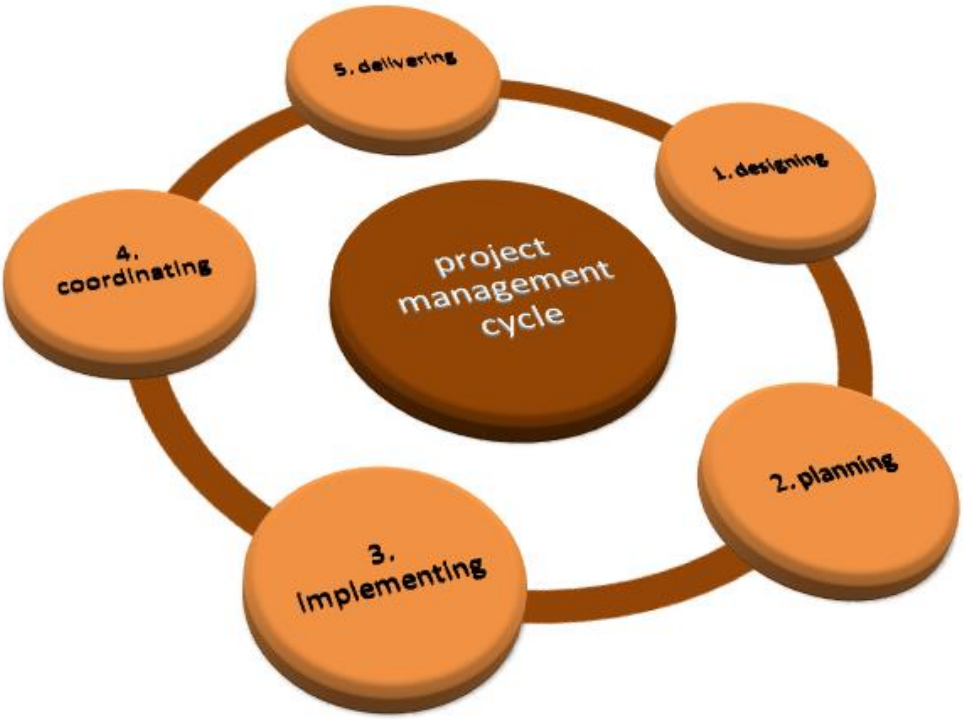


Figure 87: project management cycle according to P2M (source: P2M Guidebook Volume1)

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.

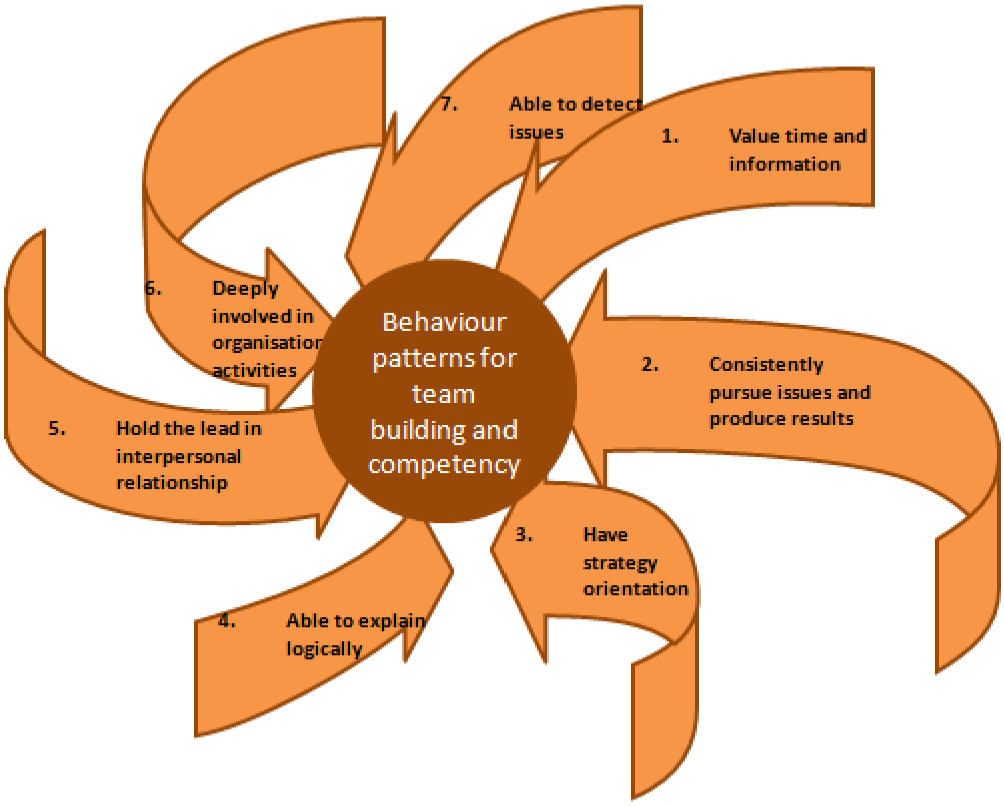


Figure 88: P2M team building and competency (source: P2M Guidebook Volume1)

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 operationaland 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).

Classification	Sub-classification	Technique
Diversion technique	Free association method	Brainstorming method
		Card BS method
		Brain-writing method
		Short coming/ wishes enumeration method
		Input/ Output method
	Forced association method	Attribute listening method
		Checklist method
		Matrix method
		Morphological analysis method
	Analogy method	Synectics
		Gordon method
		NM method
Convergence technique		Affinity graph method
		Cross method
		Characteristics factor diagram
		Card part method
Integration technique		Work design
		High bridge method

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, accountability, 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.

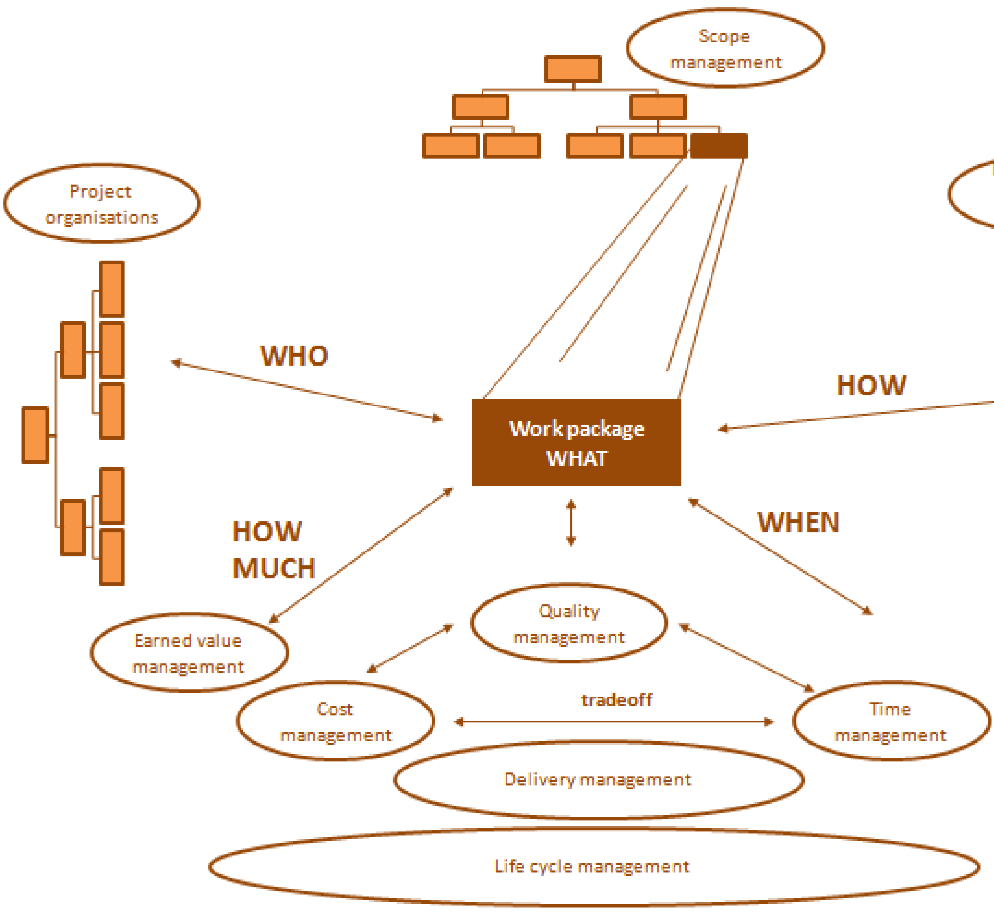


Figure 89: Interrelations among goal management processes in P2M (source: P2M Guidebook Volume1)

– *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).

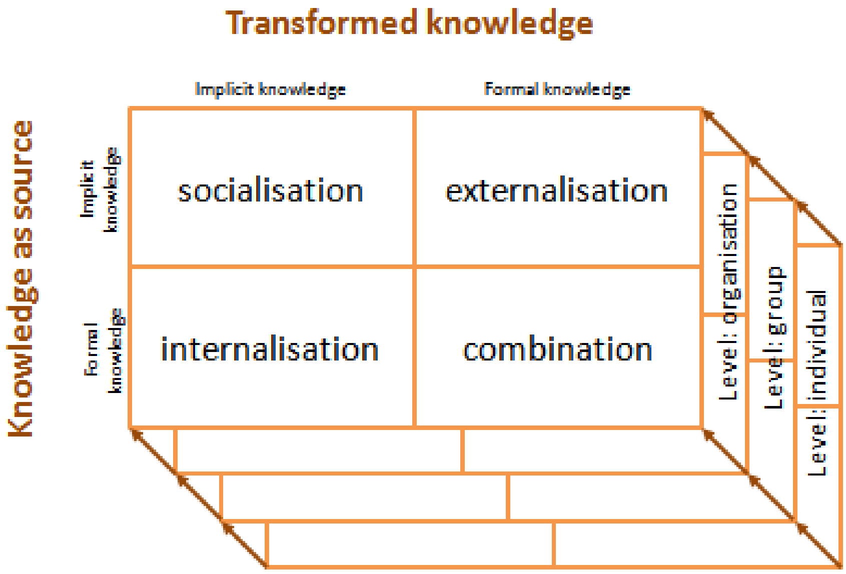


Figure 90: Modes of knowledge transformation (source: P2M Guidebook Volume2)

method	abbreviation	description
Statistical Quality Control	SQC	
Quality Function Development List	QFD	Quality development and quality list
Failure Mode and Effect Analysis	FMEA	Failure mode and influence list
Fault Tree Analysis	FTA	Influence analysis
Design Review	DR	Examination of designing contents and review of design process
Operation Research	OR	Optimisation method
Industrial Engineering	IE	Work analysis, work design, etc.
Value Engineering	VE	Value analysis

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.

Process group Knowledge area	designing	planning	implementing	coordinating	delivering
1. project strategy management	1.1 - relationship between projects 1.2 - strategy of project according to corporate visions 1.3 - select project				
2. project systems management	2.1 - problem solving	2.1 - problem solving	2.1 - problem solving	2.1 - problem solving	2.1 - problem solving
3. project goal management	3.1 - PLC: manage concept	3.2 - scope management (defining, preparing WBS, grasping contractual conditions) 3.3 - cost management (calculation, setting budget, define measures) 3.3 - PLC: manage planning phase 3.4 - time management (initiate schedule) 3.5 - quality management (planning) 3.6 - earned value (EV) management (setting baselines)	3.7 - cost management (install measures for improving income and expenditure) 3.8 - PLC: manage execution 3.9 - time management: manage progress of project 3.10 - quality management (manage) 3.11 - report/ change management (report performance and communication, perform change management with influences and preventions) 3.12 - delivery manmagement (test run, guarantee of performance)	3.13 - time management (analyse trends and forecasts of progress, correction of schedule) 3.14 - quality management (assure, and improve quality) 3.15 - earned value (EV) management (varicance and trend analysis (SPI/ CPI); measuring earned value) 3.11 - report/ change management (report performance and communication, perform change management with influences and preventions)	3.16 - PLC: manage termination 3.17 - delivery manmagement (tunover and acceptance of project)

4. project risk management		4.1 - plan risk management 4.2 - create a risk plan	4.3 - develop and install measures against risk	4.4 - identify risks	
5. project relationship management		5.1 - plan relationship between stakeholders	5.2 - maintain relationship (claim handling, consisting contract/ proposal etc)	5.3 - maintain relationship (coordination between contract parties, quick responses, etc)	5.4 - restructuring relationship (strategic alliances, etc.)
6. project finance management	6.1 - risk process for implementation (analyse, select, share, evaluate, coordinate, contract) 6.2 - business eligibility 6.3 - economic efficiency 6.4 - defining requirements				
7. project organisation management		7.1 - formation of project team 7.2 - define project organisation 7.3 - human resource ensuring	7.4 - manage project organisation		
8. project ressource management		8.1 - identify resources 8.2 - choose right resources	8.2 - choose right resources	8.3 - monitor resources 8.4 - analyse, evaluate and predict resources	
9. project information management		9.1 - determining IT support systems for communication and sharing information			
10. project value management		10.1 - definition of value 10.2 - definition of value indicators	10.3 - evaluation of value	10.4 - provision of value	10.4 - provision of value
11. project communication management		11.1 - understanding of cultures and cross cultural communities 11.2 - structuring communictaion	11.1 - understanding of cultures and cross cultural communities 11.2 - structuring communictaion 11.3 - coordination of tasks	11.4 - control distribution of information 11.3 - coordination of tasks	

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).

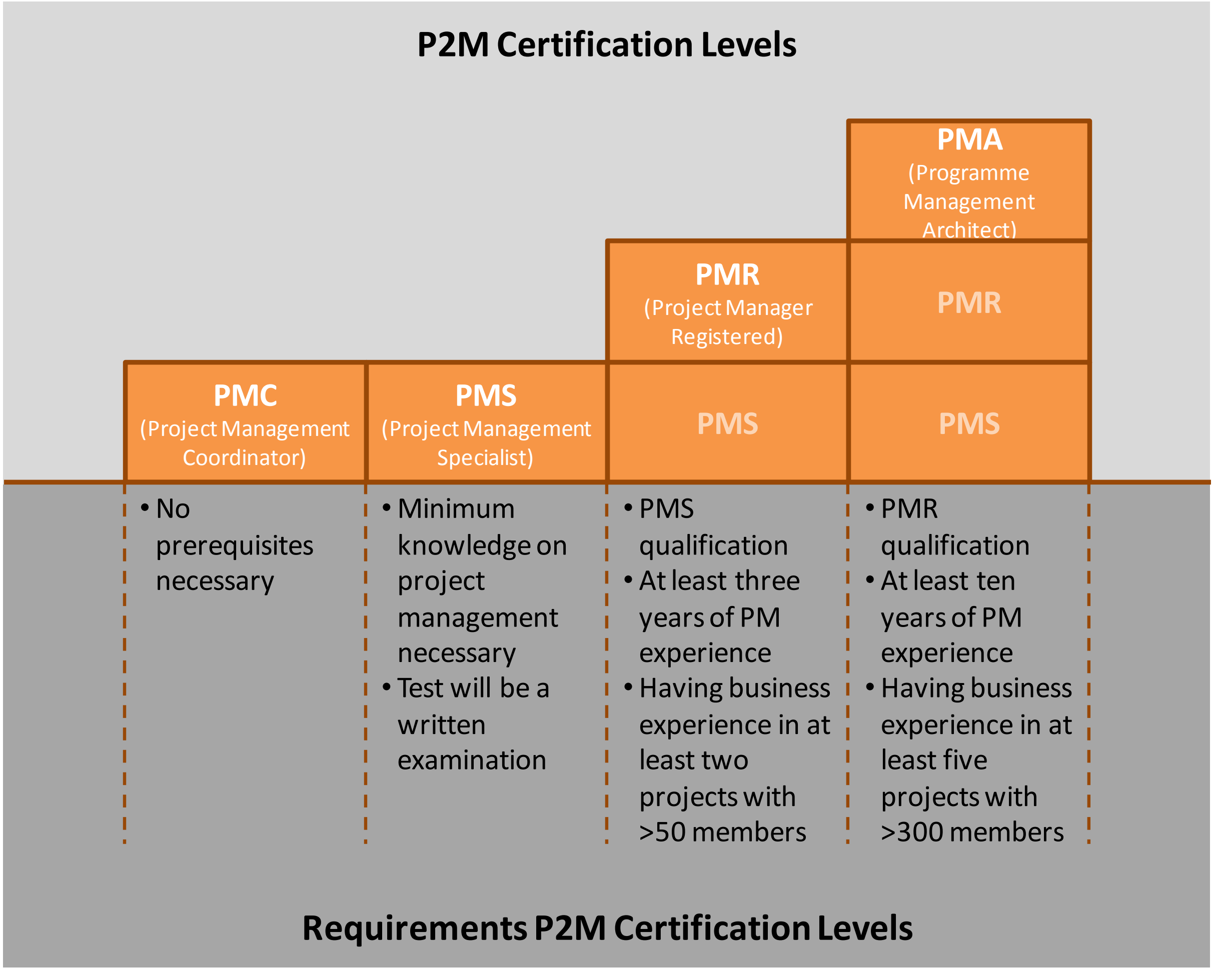


Figure 92: Certification levels P2M and its requirements (source: derived from P2M Guidebook Volume2)

P2M – Target

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

Year of development/ Foundation	*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*
Language	*Chinese, Danish, Dutch, English, French, German, Polish, Spanish*
Origin in	*Management/ Project Management*
Legal rights by	*IPMA (International Project Management Association) with its headquarter in Nijkerk, Netehrlands*
Certification	*A-Level for project directors* *B-Level for senior project manager* *C-Level for project manager* *D-Level for project management associate*
Standards	*ISO10006, DIN 69901, ISO 21500*
Country	*In 2010, the IPMA standard was represented in >60 countries worldwide*
Members worldwide(2010)	*A-Level → 350 people* *B-Level → 7.100 people* *C-Level → 32.300 people* *D-Level → 90.750 people*
Associated companies with PM3	*Xerox, Disney, IBM, Microsoft, Intel, Ericson, Citigroup, SIEMENS, Nextel, …*

ICB 3.0 – International Competence Baseline – History

In 1965, a group of managers in Vienna founded in 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 managers 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).

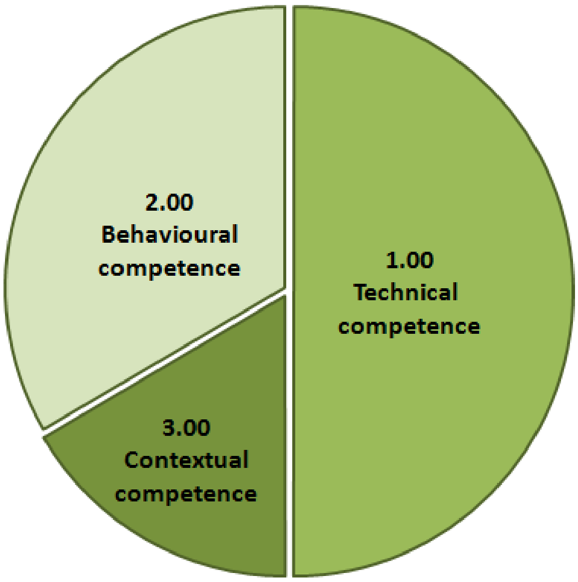


Figure 93: ICB 3.0 - eye of competence (derived from ICB3.0, IPMA)

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)*

<u>Target</u>: Measure the success of a project; define milestones for measuring the success; description of success controlling by central instruments.

<u>Method</u>: 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.

<u>Tools</u>: earned value analysis; customer-/team surveys; project benchmark; stakeholder management; feasibility studies

<u>Competence level</u>: know (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 94.

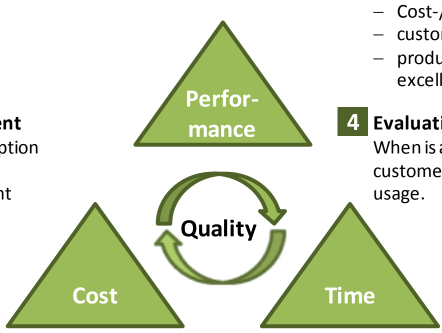
Project success criteria (1.01) analyses the efficiency and effectiveness of topics and influence therefore the PM-processes

Project success is the performance of contractual agreed benefit in required quality and quantity of time and finances by car ing 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. Check lists
3. Consistent report management
4. Prompt overviews on projects and familiarisation in project

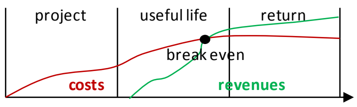


5 Tools

– feasibility study: scenario technique
– Cost-/ benefit analysis: sensitivity analysis
– customer-/ employee questioning (stakeholder)
– product (management) benchmarking: project excellence (GPM)

4 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.



Processing and practice success (Motzel, 2006, p.152)

3 Success factors

Top Management	Project Manager	Project Team	Stakeholder/ Customer	Project Rival
• Human resource development • Official PM/ project handbook • Knowledge management • Development of PM • Forcing WIN/WIN situations • Clear interfaces	• Define, communicate and document targets • Enforce acceptance and identification • Integration of project team • Strict claim-/ risk management • Courage to accept/ decline projects	• Take over of responsibility • Motivation • Engagement	• Clear and realistic visions • Financial strength • reliability	• Open information policy • Direct involvement

(Möller & Dörrenberg, 2003, pp.28-30)

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.

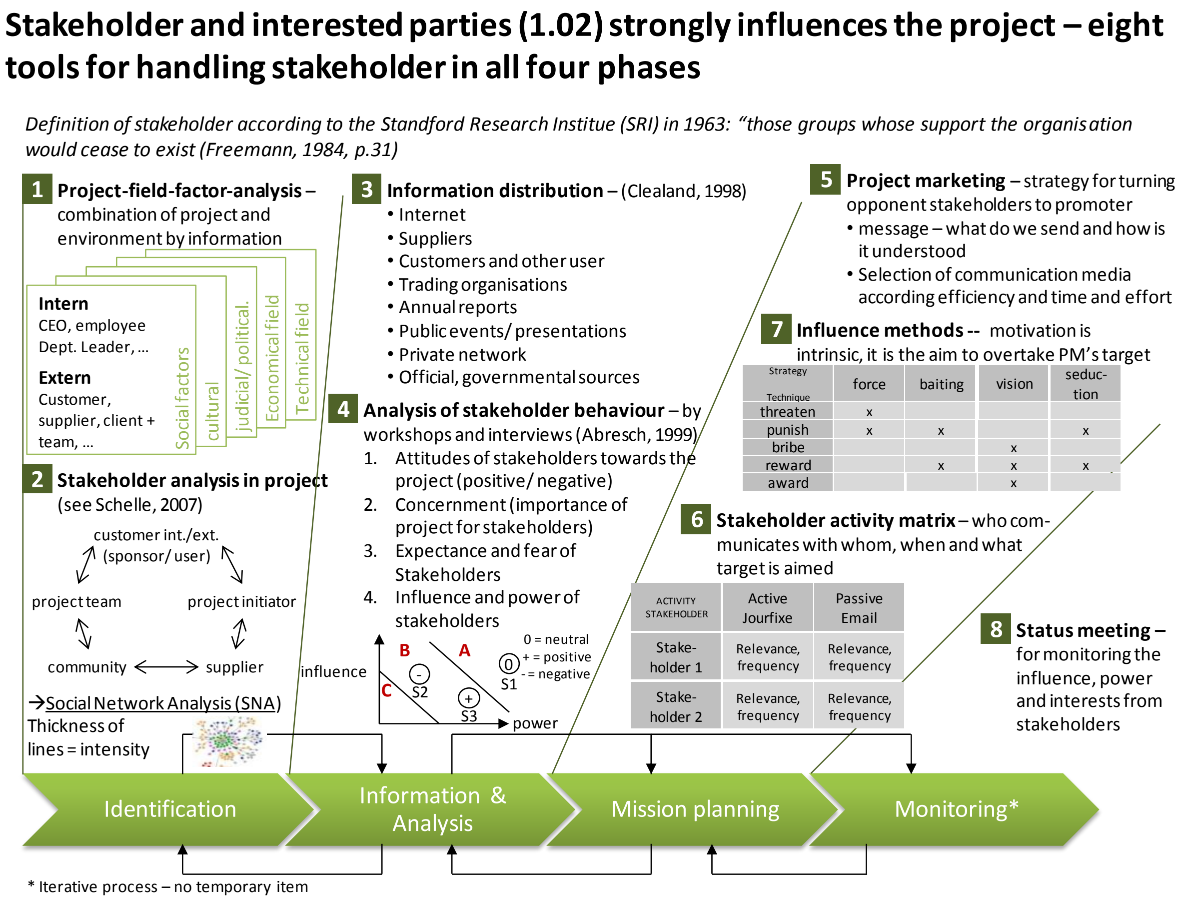


Figure 95: ICB 3.0 - Stakeholder and interested parties (developed by author)

1.03 – Objectives and strategies *(Grau & Eberhard, 2009)*

<u>Target</u>: define roughly the project's target for team members; create dynamics in the team so that a relationship can be built up; requirements are clearly defined and are a clear basis for changes.

<u>Method</u>: Perform a decision out of various possibilities in terms of project's target; coordination of work packages for each team member in different departments; controlling and evaluation of smaller targets according their fulfilment and success; alignment of the team into one direction.

<u>Tools</u>: SMART method for defining targets; evaluation of targets with the earned value analysis; prioritization of requirements according must, shall, could scheme.

<u>Competence level</u>: skill (D-level), skill (C-level), skill (B-level), skill (A-level).

More details of this technical competence field are shown in Figure 96.

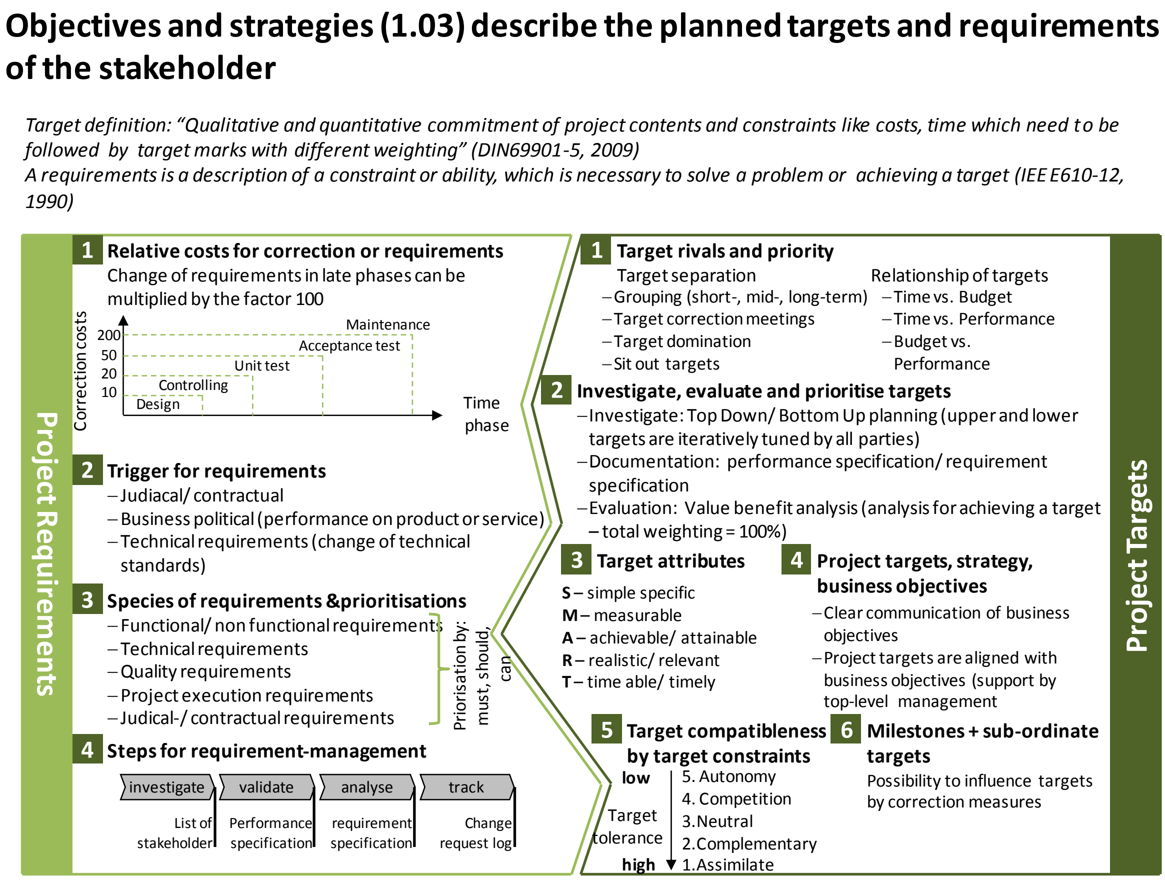


Figure 96: ICB 3.0 - Objectives and strategies (developed by author)

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.

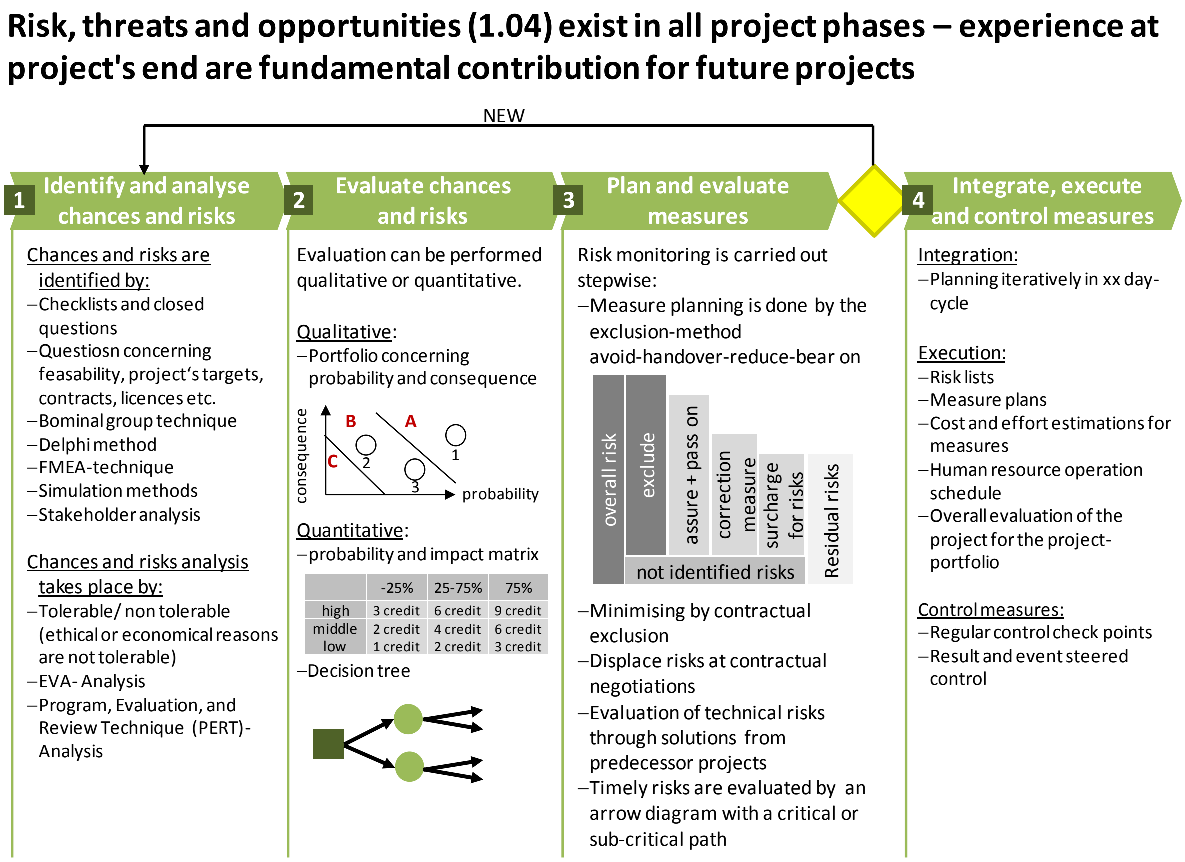


Figure 97: ICB 3.0 - Risks, threats and opportunities (developed by author)

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.

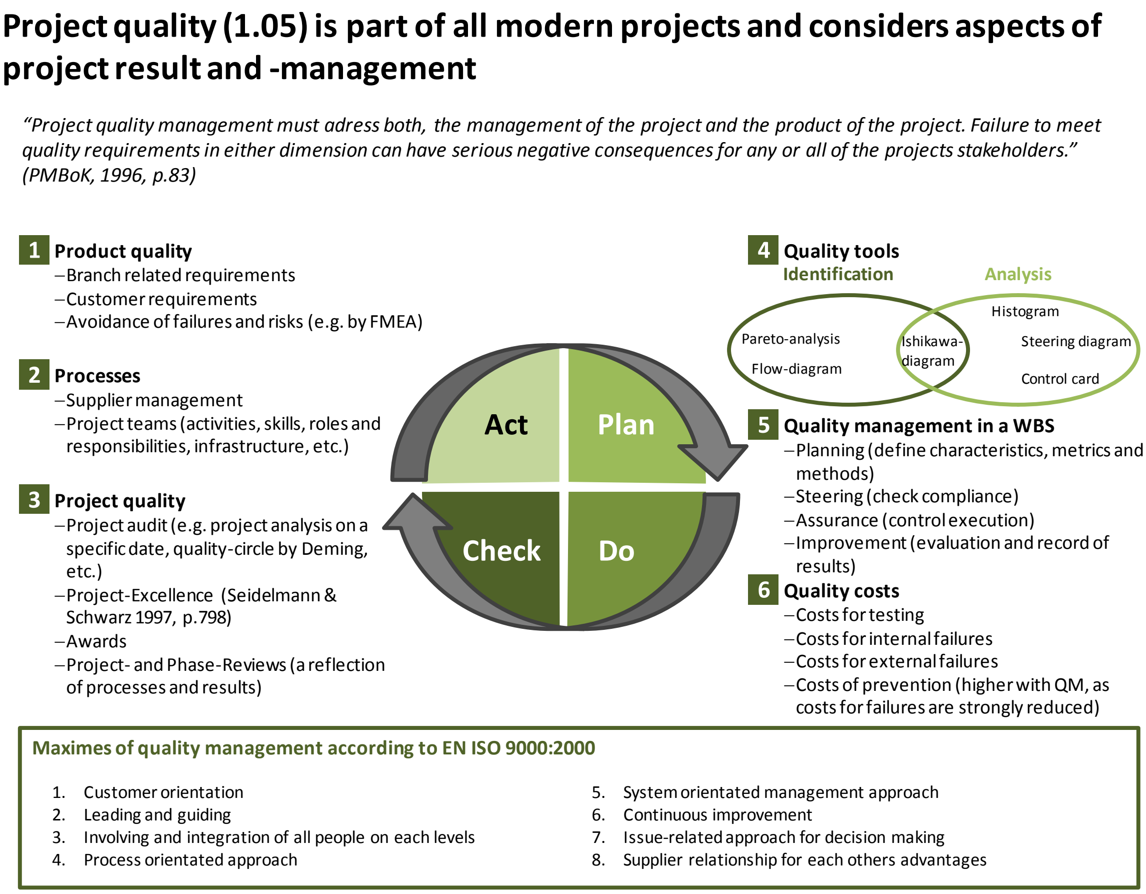


Figure 98: ICB 3.0 - Project quality (developed by author)

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 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.

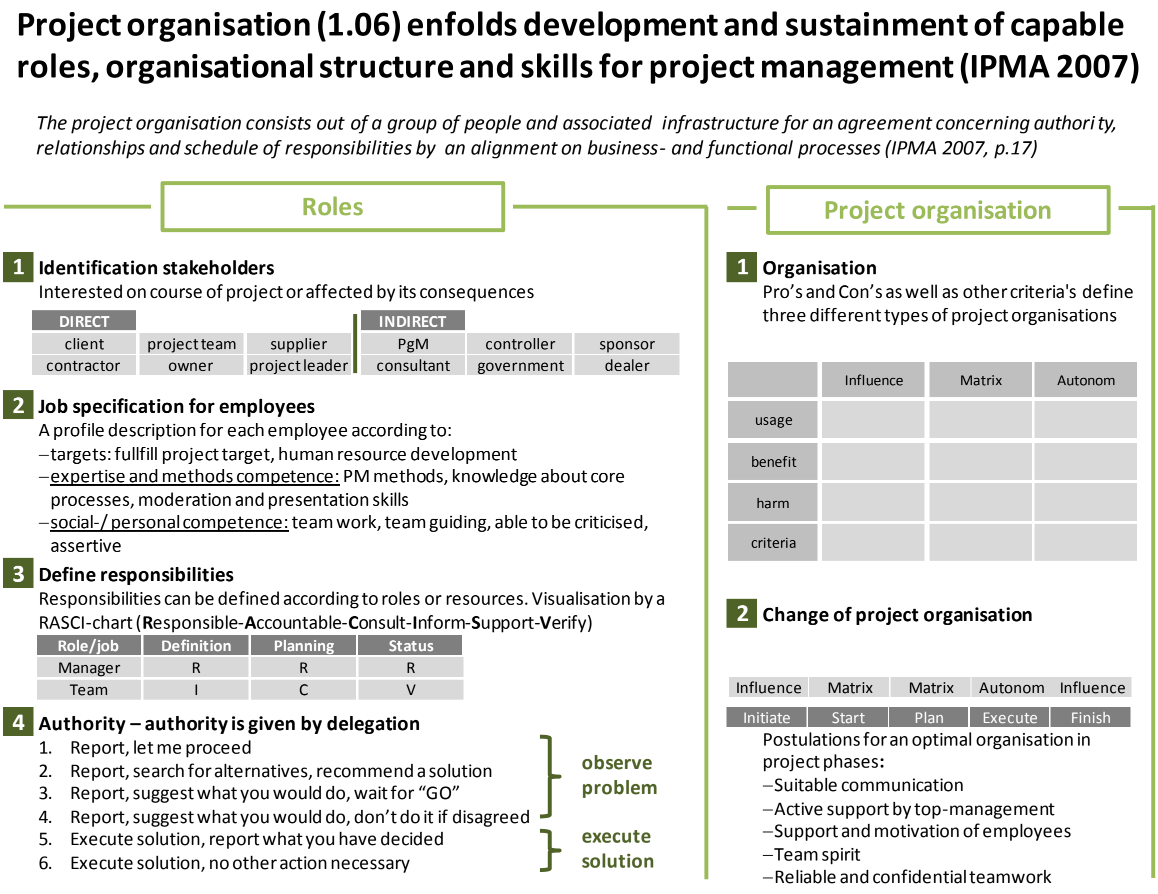


Figure 99: ICB 3.0 - Project organisation (developed by author)

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.

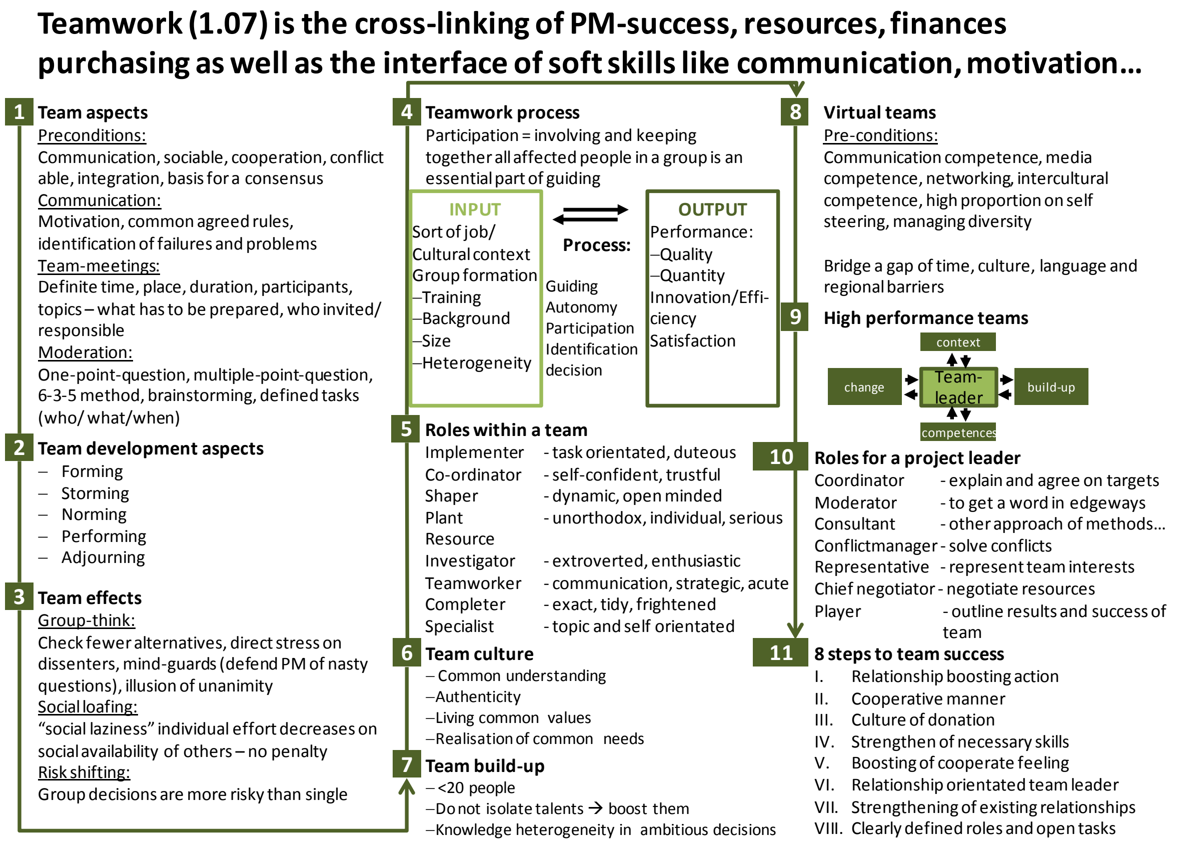


Figure 100: ICB 3.0 - Teamwork (developed by author)

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.

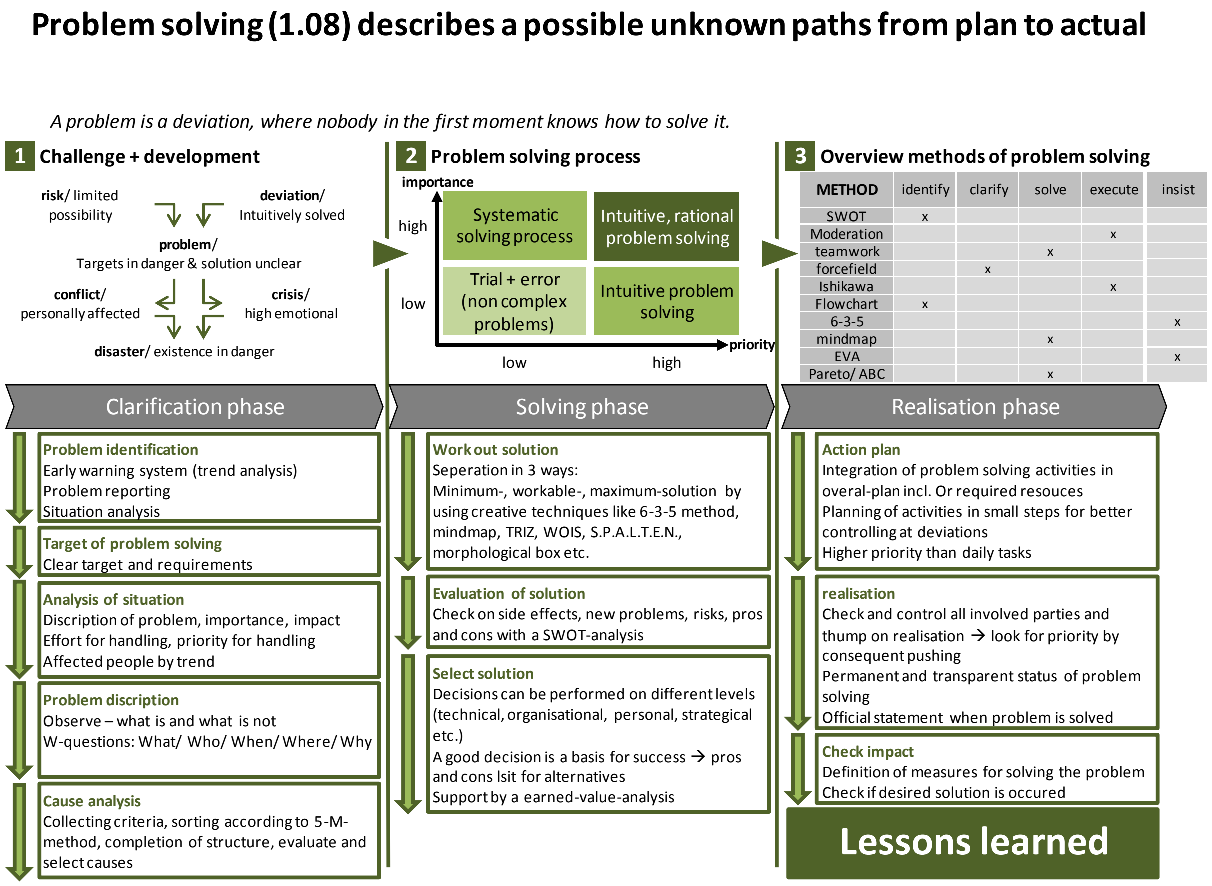


Figure 101: ICB 3.0 - Problem solving (developed by author)

1.09 – Project scope *(Wolff, Rosenthaler, & Knoepfel, 2009)*

<u>Target</u>: Creation of a structure inside the project; coordinated diagram and logical visualization of all components of a project.

<u>Method</u>: Itemization of the project according the top-down approach; generating work packages, which are the smallest unit of a project with only one responsibility.

<u>Tools</u>: Work package (WP) for a distinctive description; work breakdown structure (WBS) as an overview on WPs.

<u>Competence level</u>: skill (D-level), skill (C-level), skill (B-level), manage (A-level).

More details of this technical competence field are shown in Figure 102.

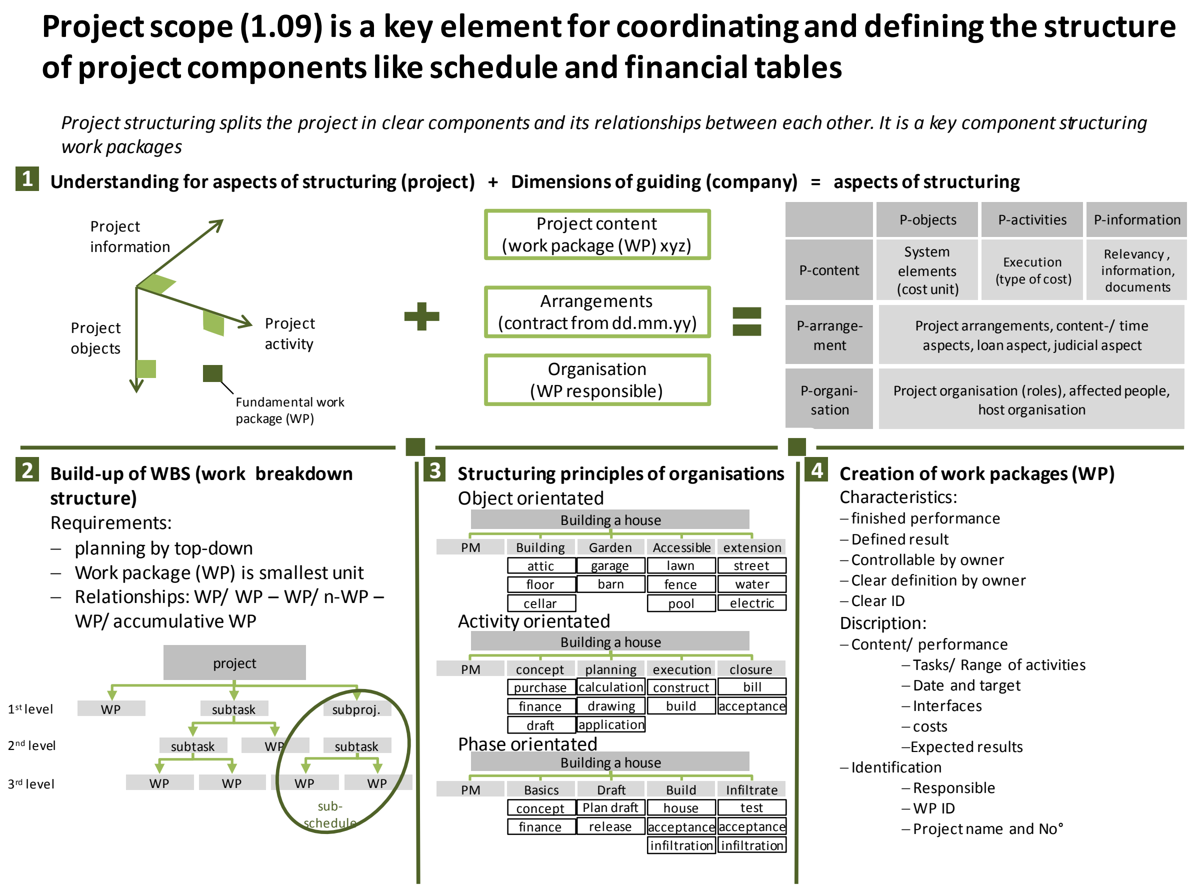


Figure 102: ICB 3.0 - Project scope (developed by author)

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.

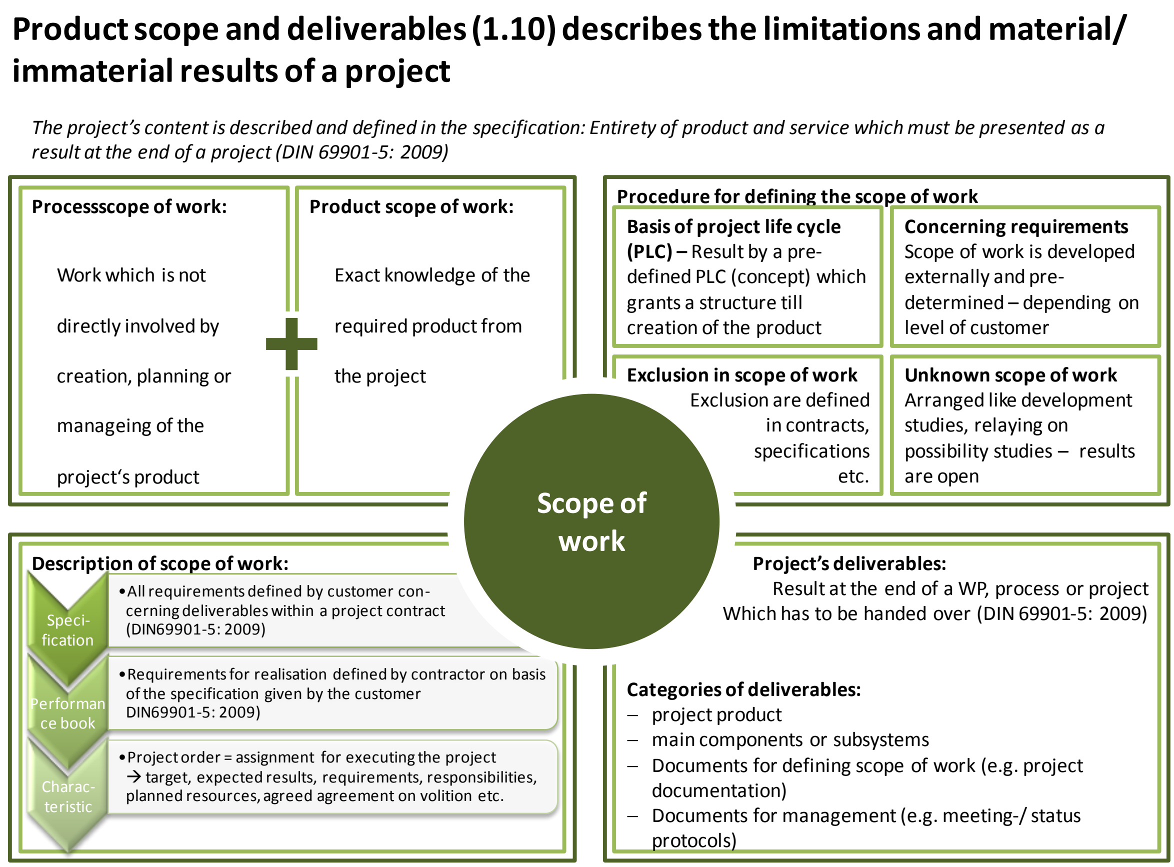


Figure 103: ICB 3.0 - Product scope (developed by author)

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.

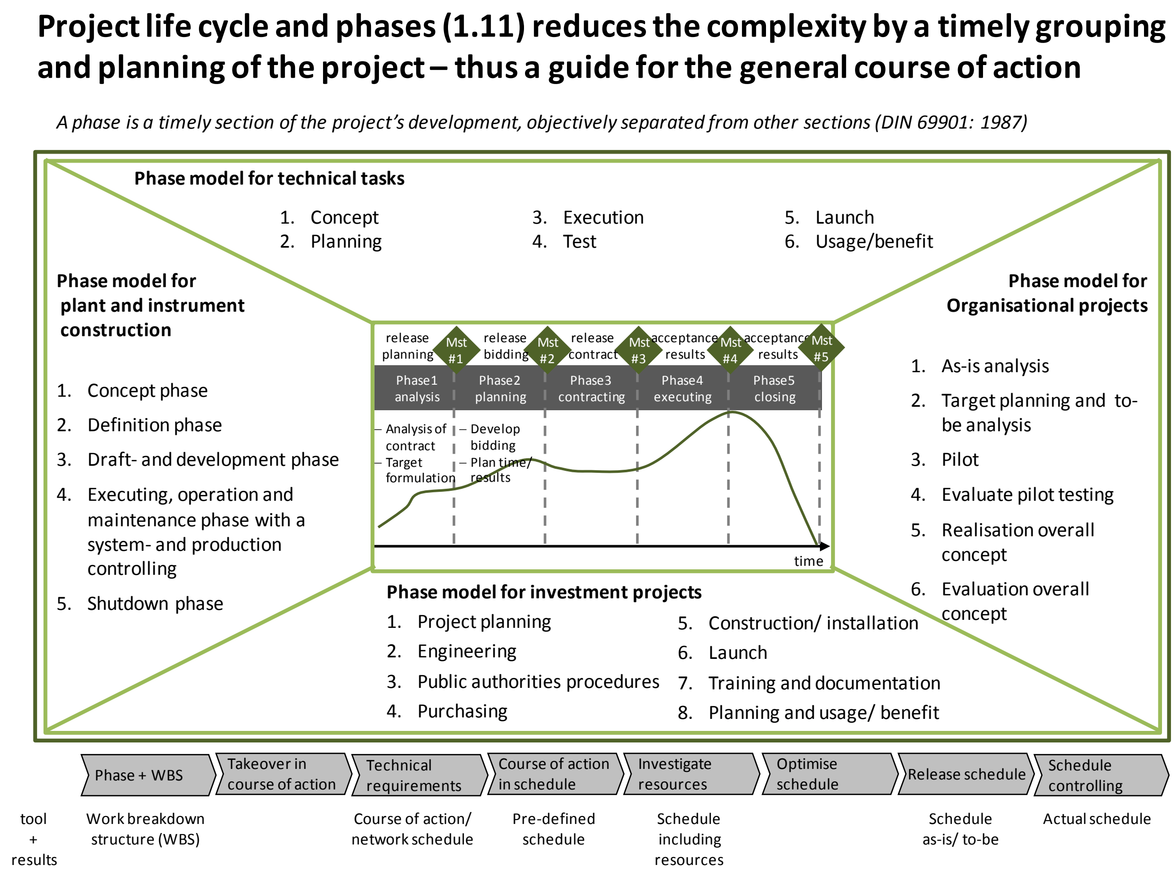


Figure 104: ICB 3.0 - Project lifecycle and phases (developed by author)

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 predicitive 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/ -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.

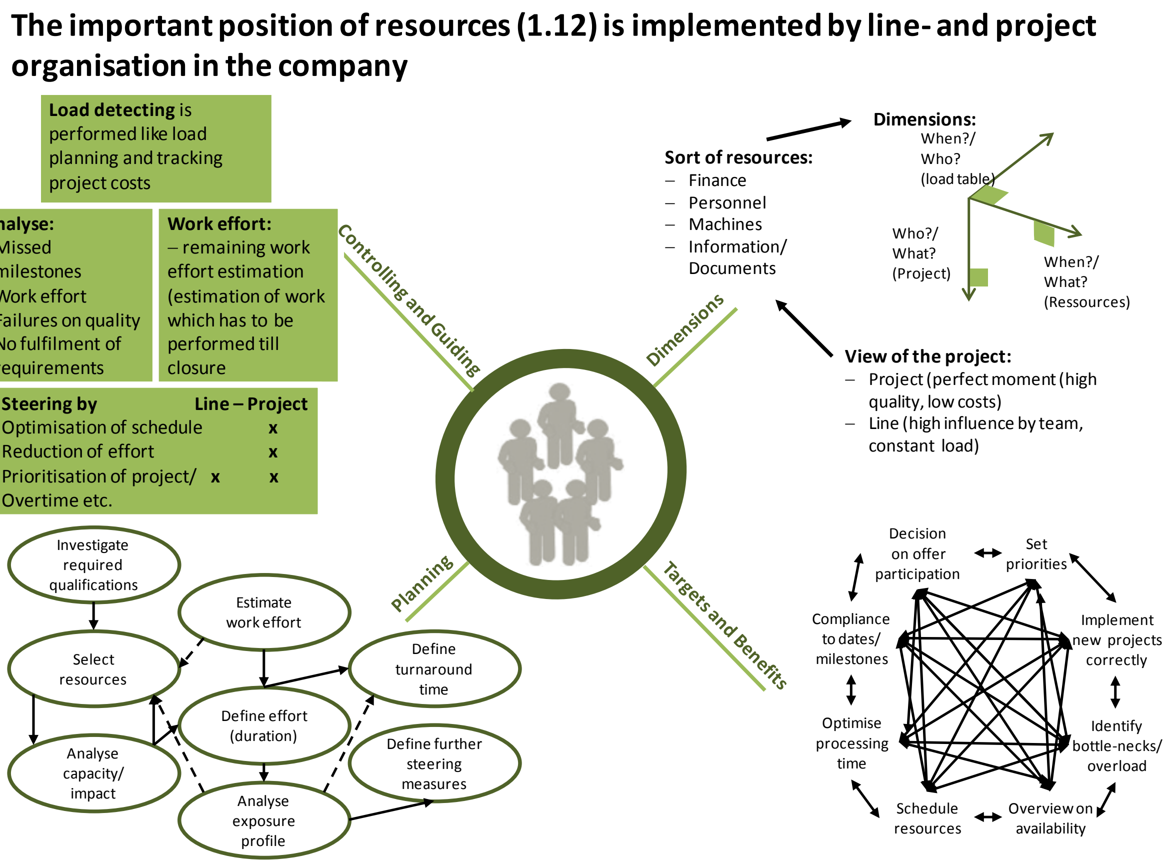


Figure 105: ICB 3.0 - Resources (developed by author)

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 projects 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 profitability and finance accounting in projects

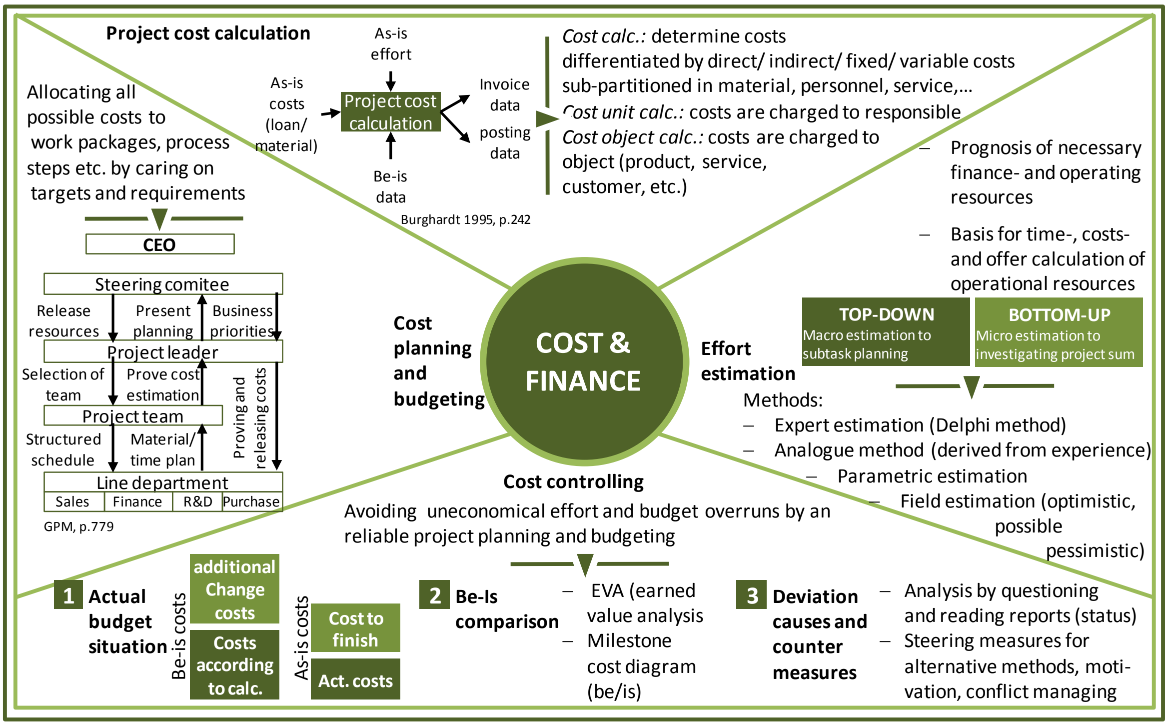


Figure 106: ICB 3.0 - Cost and finance (developed by author)

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
9. Rating of supplier's performance.

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.

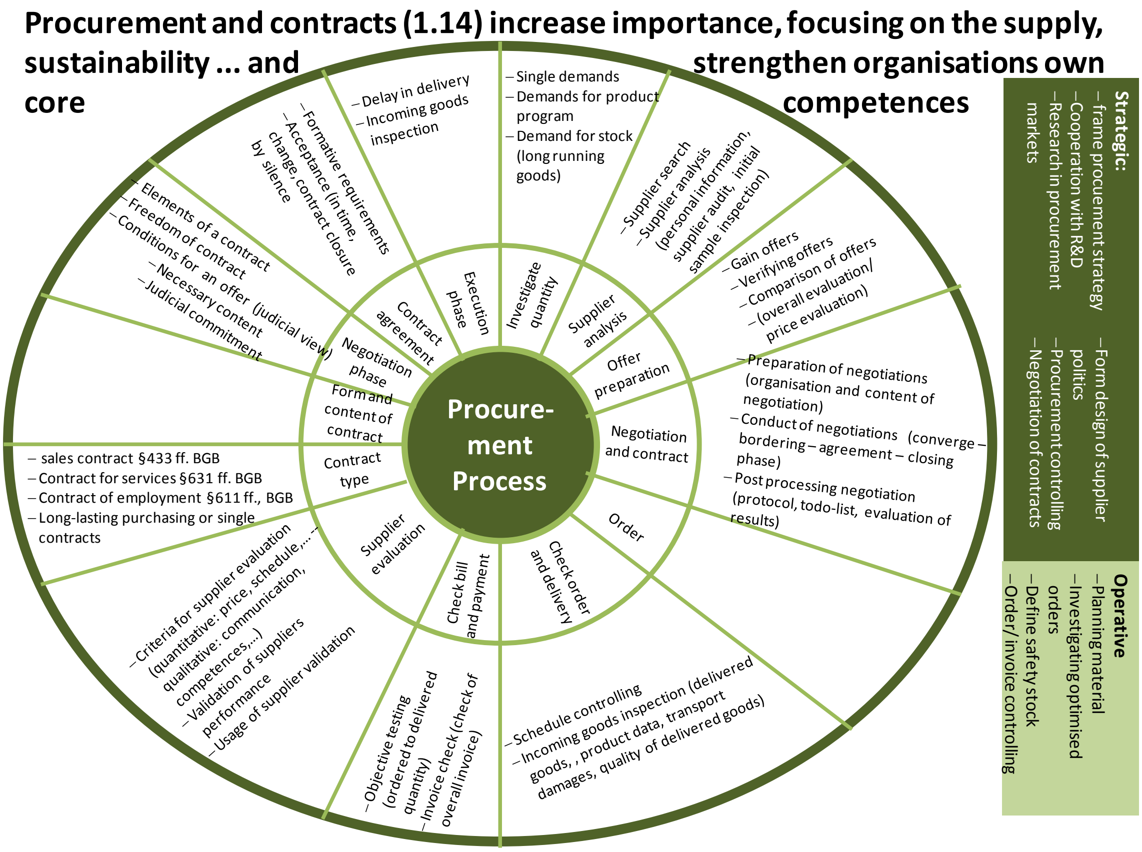


Figure 107: ICB 3.0 - Procurement and contracts (developed by author)

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.

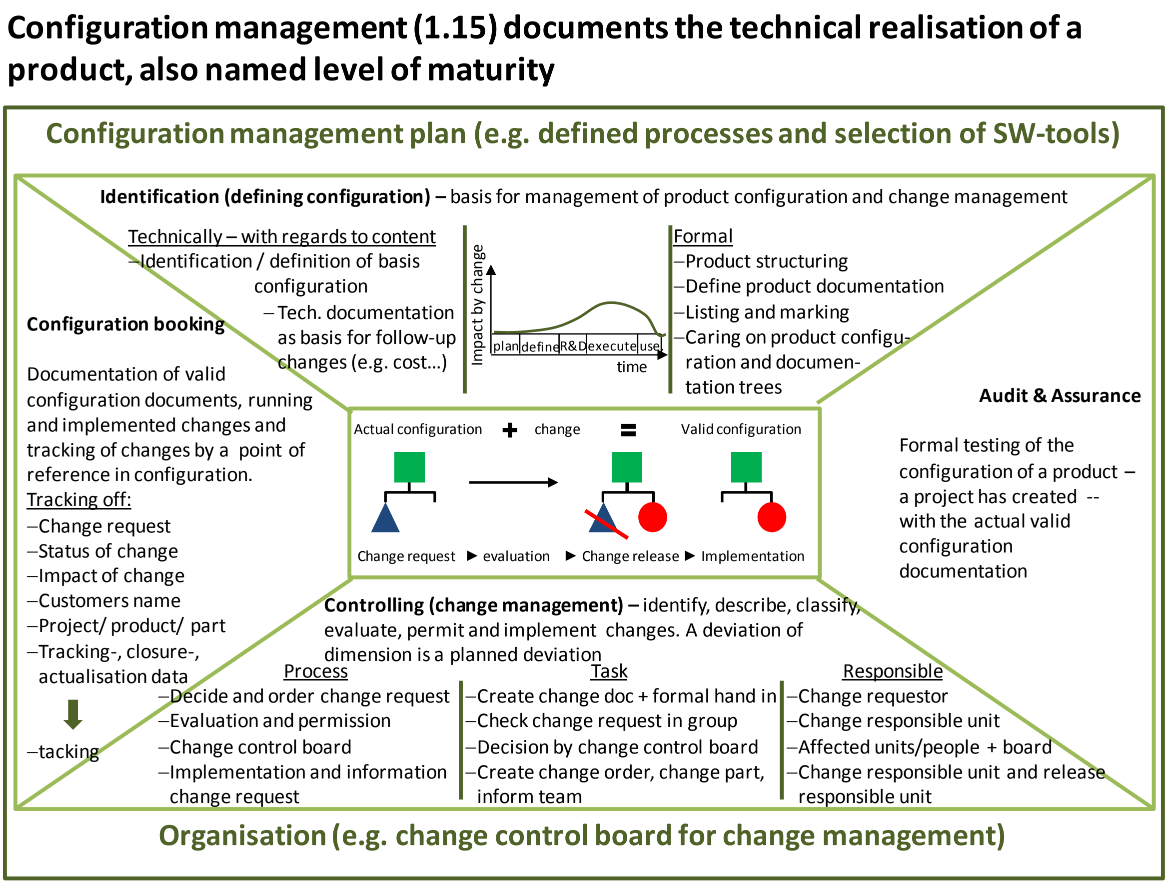


Figure 108: ICB 3.0 - Configuration management (developed by author)

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.

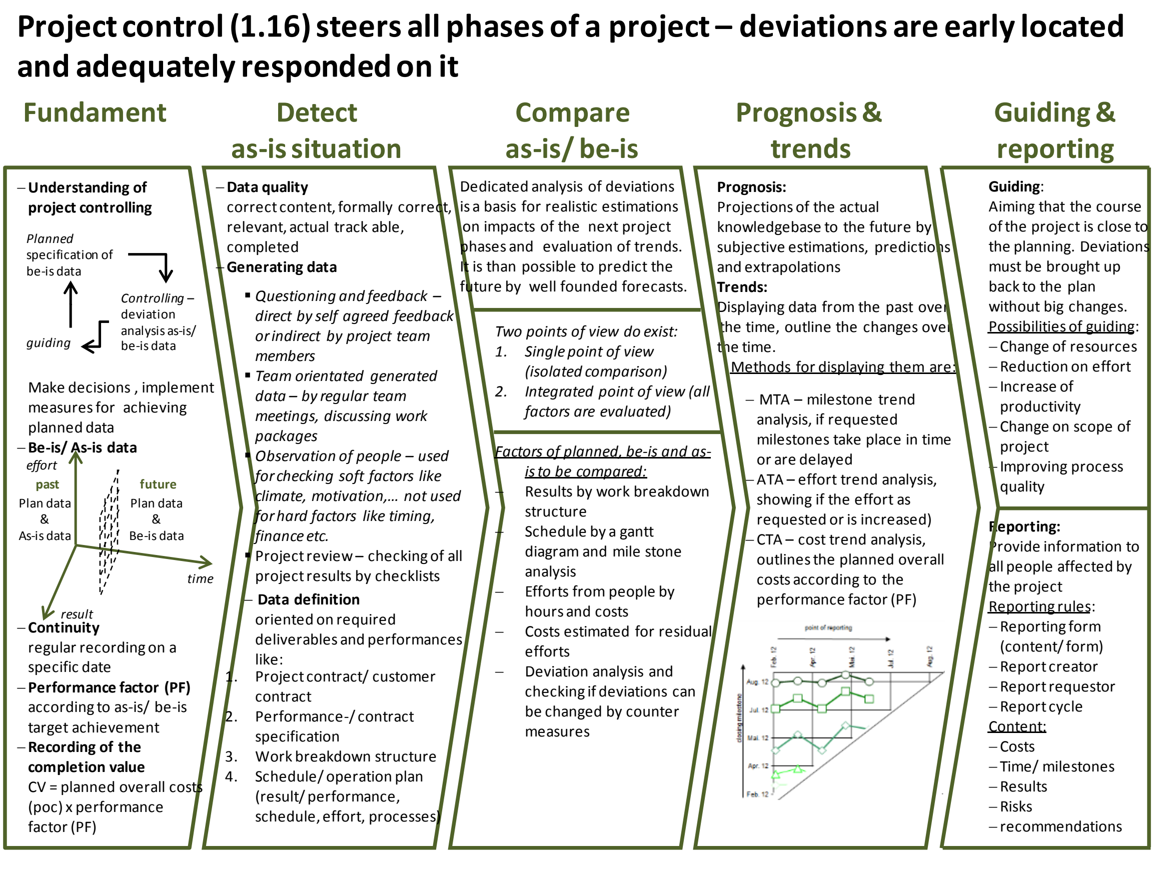


Figure 109: ICB 3.0 - Project control (developed by author)

1.17 – Documentation, information and reporting *(Geckler, 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 from of texts, graphics, formulas, video- or stereo records.

Documents

Project documents:
– project assignment and target (business case, protocols, steering committee, performance specification, project assignment)
– Additional documents (rules, law, contracts)
– Documents of project manager (WBS, team list, project phase plan, schedule, status report, closure report, resources plan, activity plan, presentations)
– Documents of project team (protocols, documentation and changes on project deliverables)

Specific project documents:
– Project presentation documents (overview assignment/ target), organisation (team/ stakeholder), overview schedule (milestones/ phases), benefit)
– Project status report (last steps since the last report, changes on plan and deliverables, cost situation, decisions)
– Documentation of project deliverable
– Changes on project deliverable (change request)
– Changes on work breakdown structure
– Protocols (content, participant, place, date, project, date, creator,…)

Processes

1. **Generating information**
   evaluation and selection of new information. Derived by new arrangement, editing, and linkage of existing information from templates, libraries, references etc.
2. **Verification, release and confirmation**
   Most times defined in standard processes. Major companies use work-flow systems, for tracking the actual status und defining automatically the next step
3. **Publication**
   publishing information with the team by push principle (phone, presentation, email, letter etc.) or pull principle (Blog, wiki, black board, data base, etc)
4. **Archive and research**
   duration for archiving documents is depending on law and customers. It is the brain of a project where it is easy to find and restore all created documents
5. **Decisions within projects**
   1. Preparing for decision
   2. Decision
   3. Implementation
   4. Project documentation

Media

– paper documentation (folder etc.)
– Computer based documentation (texts in word, presentations in PowerPoint, tables in excel, CAD drawings)
– File manager
data are stored in the intranet of the company and access externally is available by the internet
– Document management system
same as file manager only that files are archived, numerated/ versioned and tags can be added
– Blog
endless online document for writing comments
– WIKI
different authors can generate a single document online (e.g. Wikipedia)
– Database systems
– Work-flow system
guiding, steering and tracking of activities/documents in a defined process-flow

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.

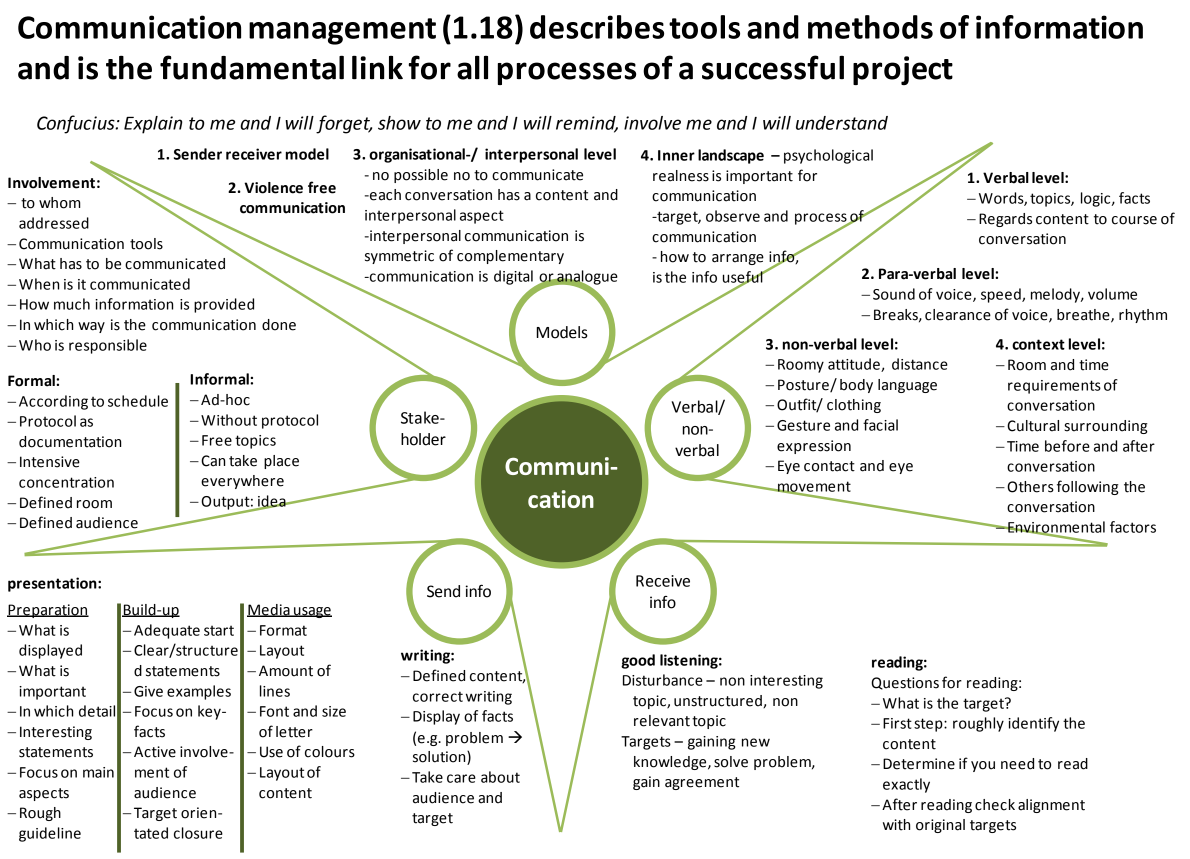


Figure 111: ICB 3.0 - Communication (developed by author)

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.

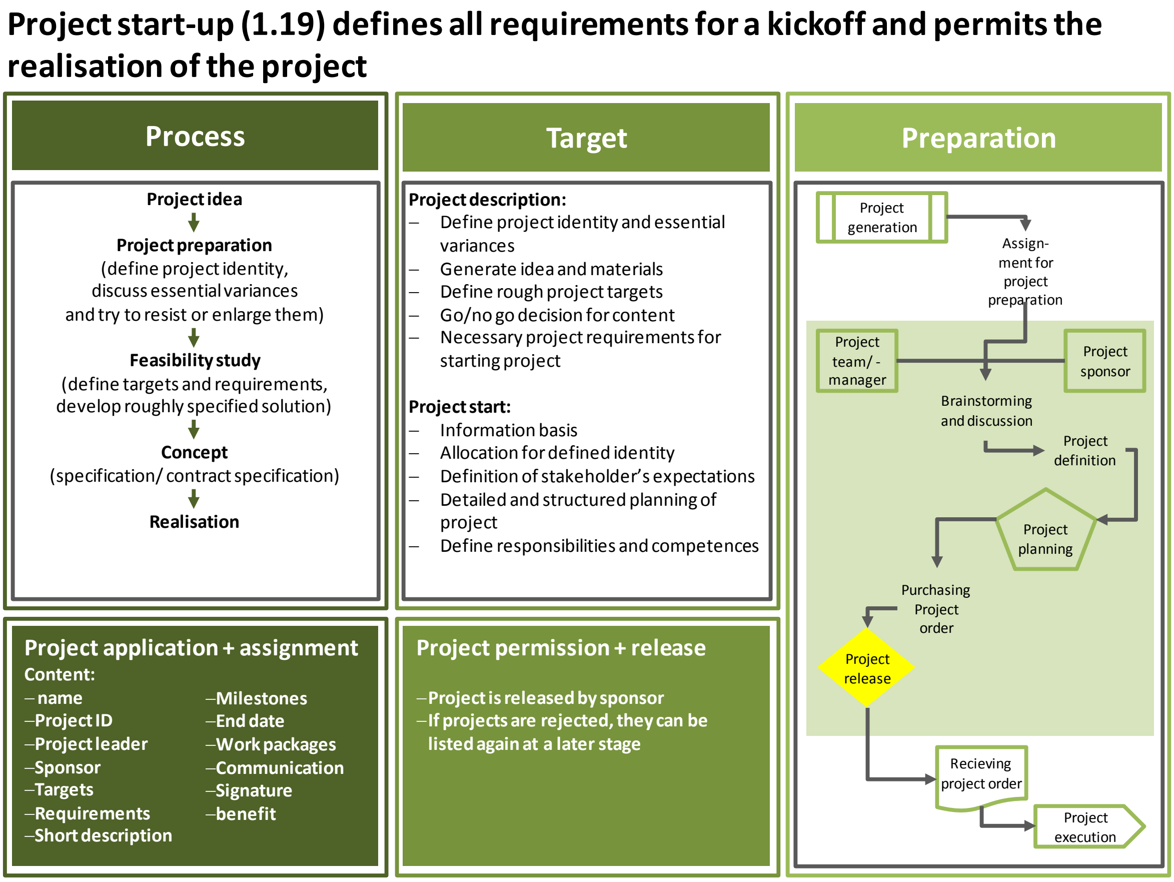


Figure 112: ICB 3.0 - Project start-up (developed by author)

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.

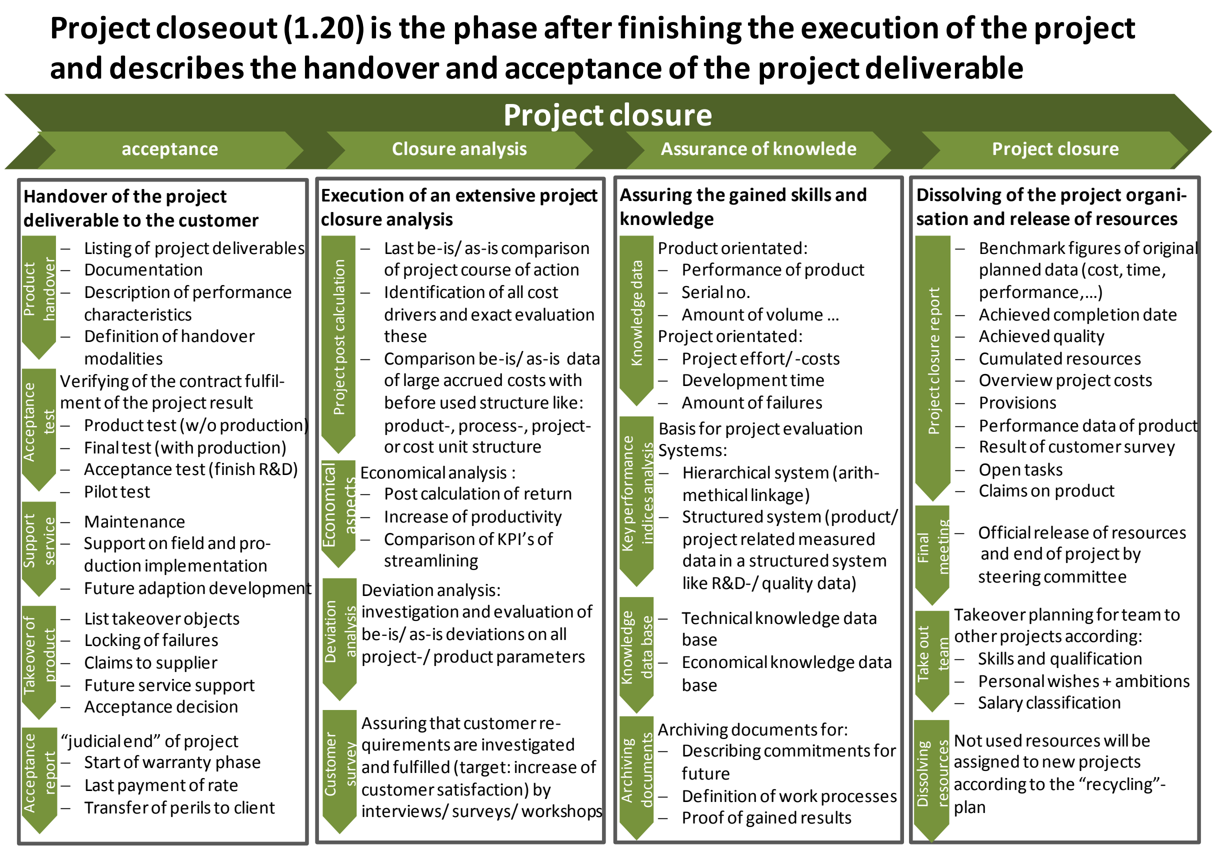


Figure 113: ICB 3.0 - Project closeout (developed by author)

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.

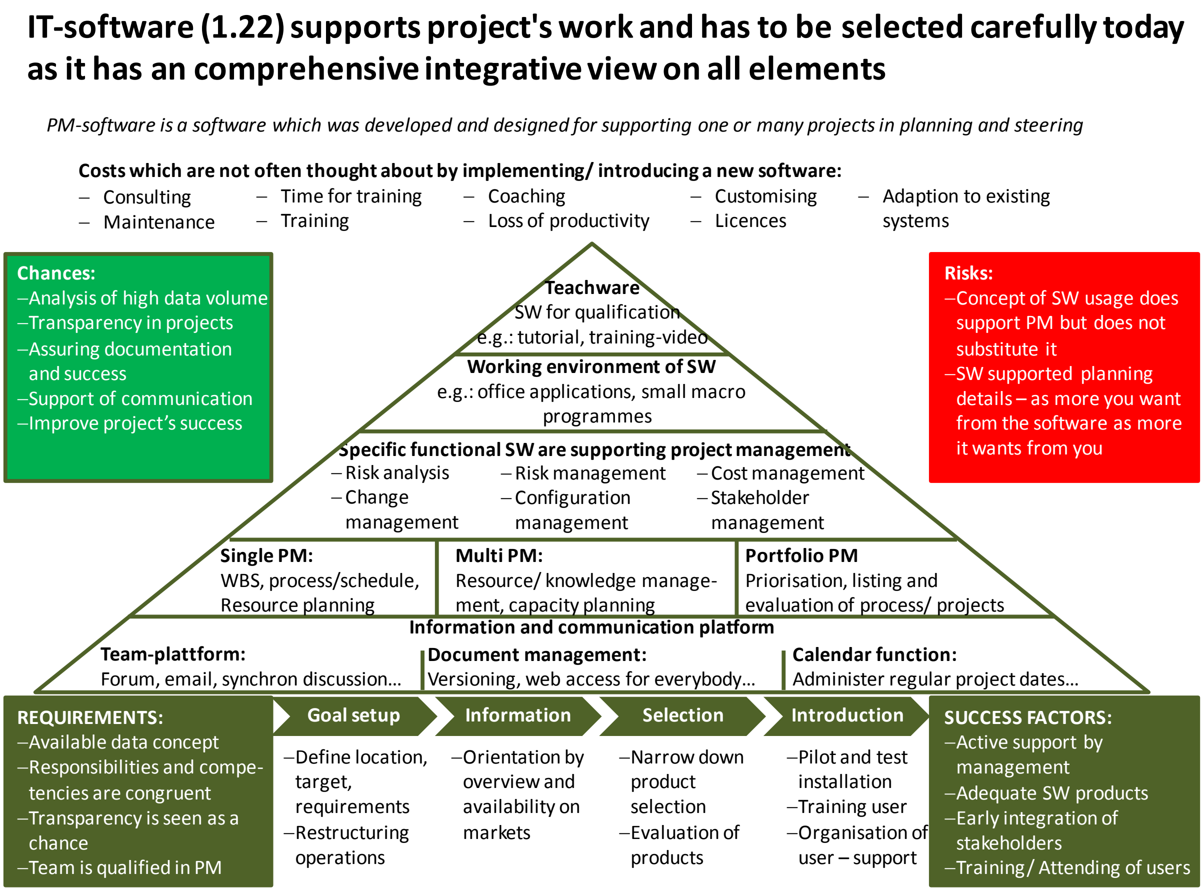


Figure 114: ICB 3.0 - IT-software (developed by author)

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.

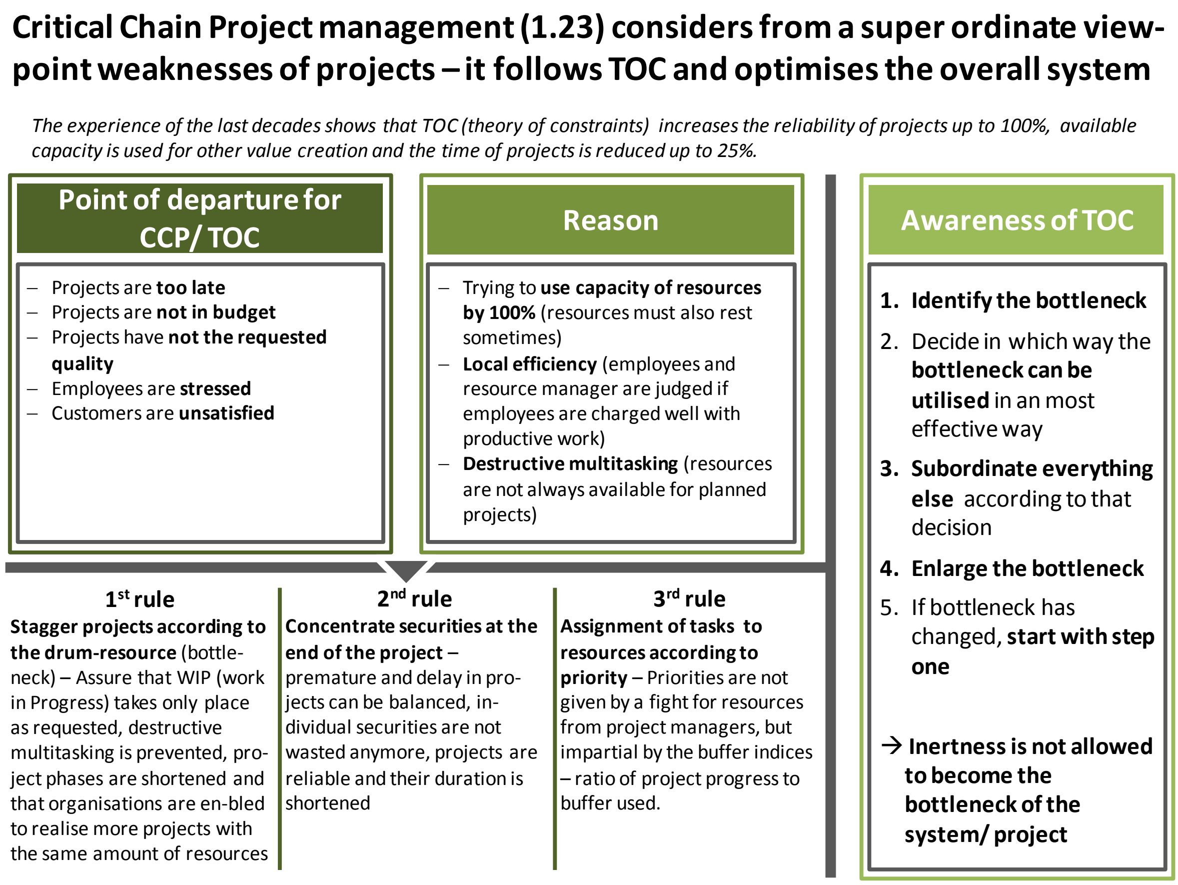


Figure 115: ICB 3.0 - CCP - Critical Chain Project management (developed by author)

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).

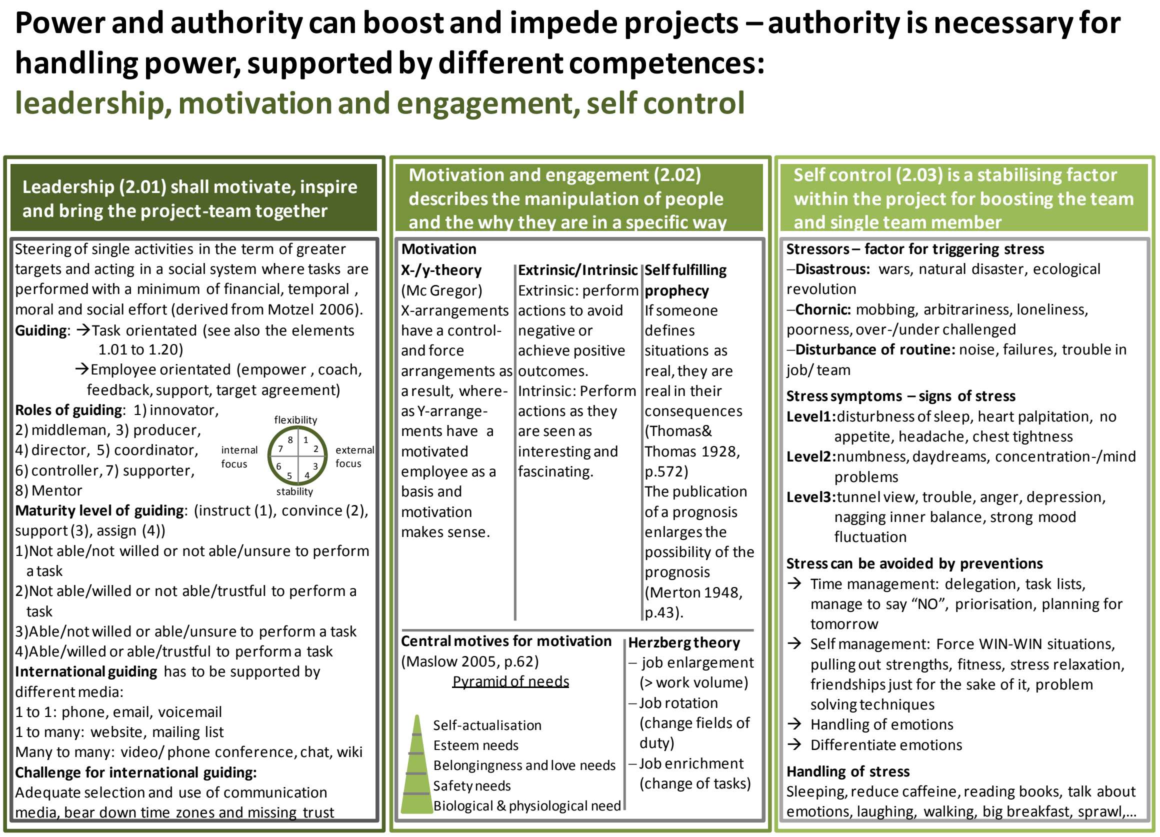


Figure 116: ICB 3.0 - Behavioural competence: leadership, engagement & motivation and self-control (developed by author)

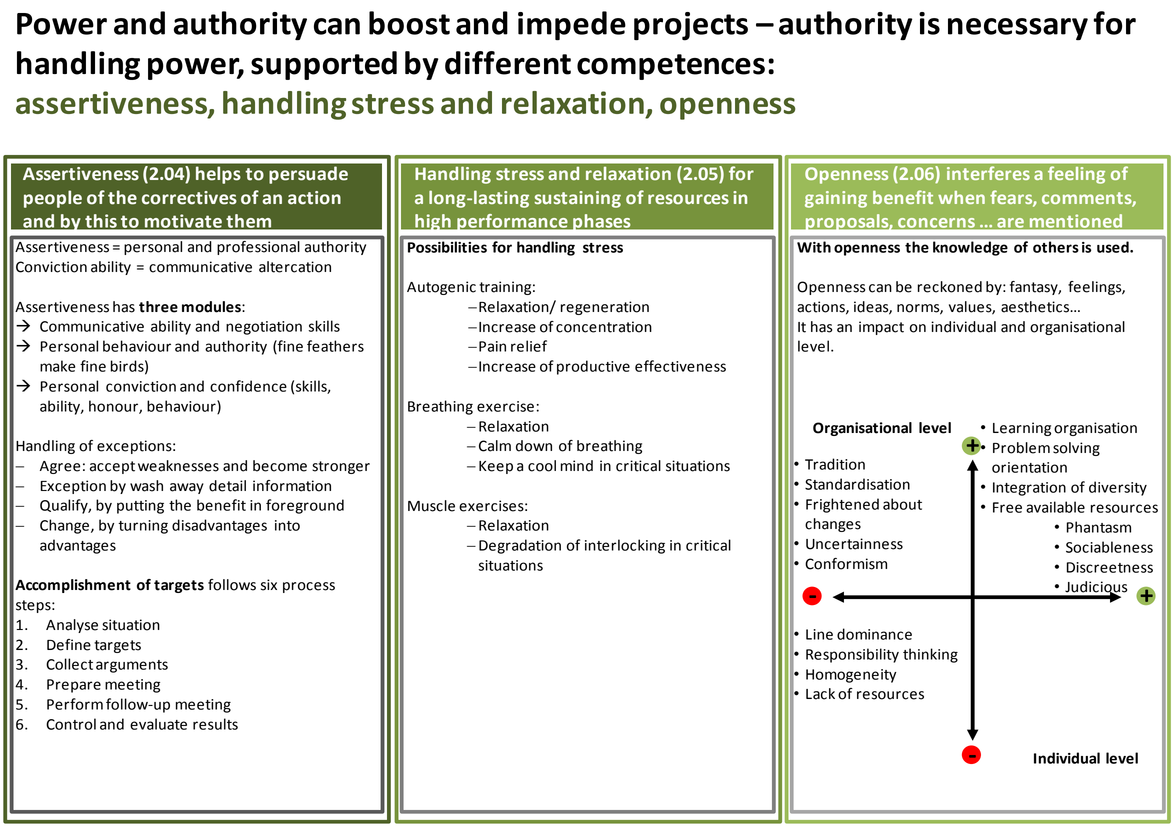


Figure 117: ICB 3.0 - Behavioural competence: assertiveness, relaxation and openness (developed by author)

Power and authority can boost and impede projects – authority is necessary for handling power, supported by different competences: creativity, achievement and orientation, efficiency

Creativity (2.07) is in interaction with other project management activities and has an success critical relevancy

Creativity is a process of developing and expressing novel ideas that are likely to be useful (Leonard & Swap 1999, p.6)

Postulates and factors of creativity:

– Curiosity/ open	– Playful	– Independent on unjustified criticism
– High motivated	– Endurance	– Handling ambiguity
– Risk readiness	– Sensitivity for problems	
– Brave on divergence	– Different viewpoints	

Pros of creativity in a team/ encouragement:

Encouragement:	Team:
– Think tank	– Use diversity of team members
– Retain time	– Animation of each other
– Implement/ use methods	– Supplement/combination of ideas
	– Further development of concepts

Phases of creative processes:

1. Preparation (problem analysing, task definition)
2. Solving of problems
3. Voluntary problem solving idea (enlightenment)
4. Elaboration of idea (verification and concretion)

Creativity techniques:

Association – brain-storming/ brain-writing (6-3-5)
Analogue – classical/ visual synectics
Confrontation – teasing words poster, image map
Analytical – morphological box, observer checklist
Mapping – mind-manager, moderation methods
Advanced – ishikawa, headstand/ gallery method, combination of different methods

Achievement orientation (2.08) – sum of methods, reactions and actions in a project, creating a steady picture

Definition: Acceptance (DIN69905), project target (DIN 69901), Success evidence (DIN 69905), Quality management (ISO 8402)

Colloquial language: benefit, success, earnings, target achievement

Following questions do exist for the achievement orientation:

– What is it?
– Who will do it?
– When has it to be done?
– How often has it to be performed?
– What has to be taken care of?

Influences on achievement orientation in a project:

– Magical triangular (costs, time, performance)
– Project planning cycle (phases)
– Requirements on project leader

Efficiency (2.09) is the basis of a sustainable positive contribution for ecological development and society

Efficiency = do the things right
Effectiveness = do the right things

Appendages on efficiency:

– Target orientation: based on targets with profitable actions
– System orientated: reckoning of organisation and environment
– Management process audit: reckoning of quality of internal organised management processes
– Interactional approach: negotiation of the evaluation on organisational actions between the different parties

Sponsors of efficiency:

– Continuous trust
– Achievement orientation as basis for managerial cognition
– Concentration on efficiency turbo (efficiency is not a coincidence)

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

Consultation (2.10) is a continuous exchange/ matching/ agreement of team members, involving external consultants

Consultation

Consultation	**Consulting**
= Skill to present causes and coherent arguments, listening to other arguments, negotiate and detecting solutions.	= Increase on confidence in decisions and actions by actual problems from customers. This can be done by clearly defined fields of activities (Schwarzer, 2003):
Six steps to get to an solution:	– Standby on handling actual problems
1. Analyse situation and context	– Support in making decisions
2. Investigation on targets and best options	– Creation on clarity and organisation
3. Consideration of targets and listening to arguments of others	– Interpretation/ understanding former knowledge and emotions
4. Detection of commonalities and differences	– Development of competencies for the future
5. Diagnosis of problems, detection of solutions or measures for avoiding the problem	– Demonstration of alternatives
6. Solving disagreements or agreement on differences and solving methods	– Animation of cogitation
	– Outline own strengths
	=> **Good consulting affords explicit preparations**

Projects are preferred places for negotiations (2.11) as most times the human being interacts as an interface

Negotiations are done in project environments (supplier, contractor …) but also in all forms of organisation (line, project, matrix …).
Most negotiation situations are: hierarchy level, duration, time, quality, requirements, interests of stakeholders, communication influences, bottle necks.... Negotiations are based on two aspects:

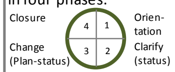
Conduct of negotiations

In five steps regarding to the Havard concept derived by the training paper from Goerner):

1. Clarify alternatives -> alternative for negotiation ->decision alternative for negotiation
2. Treat people and problems separately search questions <-> problems; personality <-> create relationship
3. Investigate interests and needs
4. WIN-WIN situation, develop options for balancing interests
5. Fair treatment and criteria

Chairmanship

Meetings are performed in four phases:



– These phases are guided by basic techniques:
– Active listening (listening, observe, hidden feedback…)
– Self-statements (first person statement, no killer phrases or generalisation)
– Questioning techniques (open/ closed questions)
– Recapitulate of results
– Solutions by creating hypothesis

Handling conflicts (2.12) is one of the most important competencies in the social area of the ICB

Conflict = when needs of a person are not respected
It is the main task of conflict management to "avoid conflicts in projects by appropriate prevention measures, to identify Symptoms and danger signals of conflict potentials and react appropriate to them inside the project phases as well as solving conflicts in a creative and cooperative manner (Motzel 2006, p.105).

Symptoms

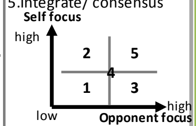
– Destroyed communication
– "problematic" attitude towards work
– Fluctuation
– Absence from work
– Junto creation

prevention

– Build up relationship and interact (social competency, ways of communication, team work)
– Structures and processes in projects (risk management, contract management, networking and linking

Reaction pattern

1. Avoid/ escape
2. Accomplish/ rivalry
3. Subjection/climb down
4. Bargaining/compromise
5. Integrate/ consensus



Cooperative solving

– Cooperative attitude
– Stipulation of enough time
– Self clarification (what do I really want?)
– Change of perspectives (what does the opponent really want?)

Figure 119: ICB 3.0 - Behavioural competence: consultation, negotiation and conflict (developed by author)

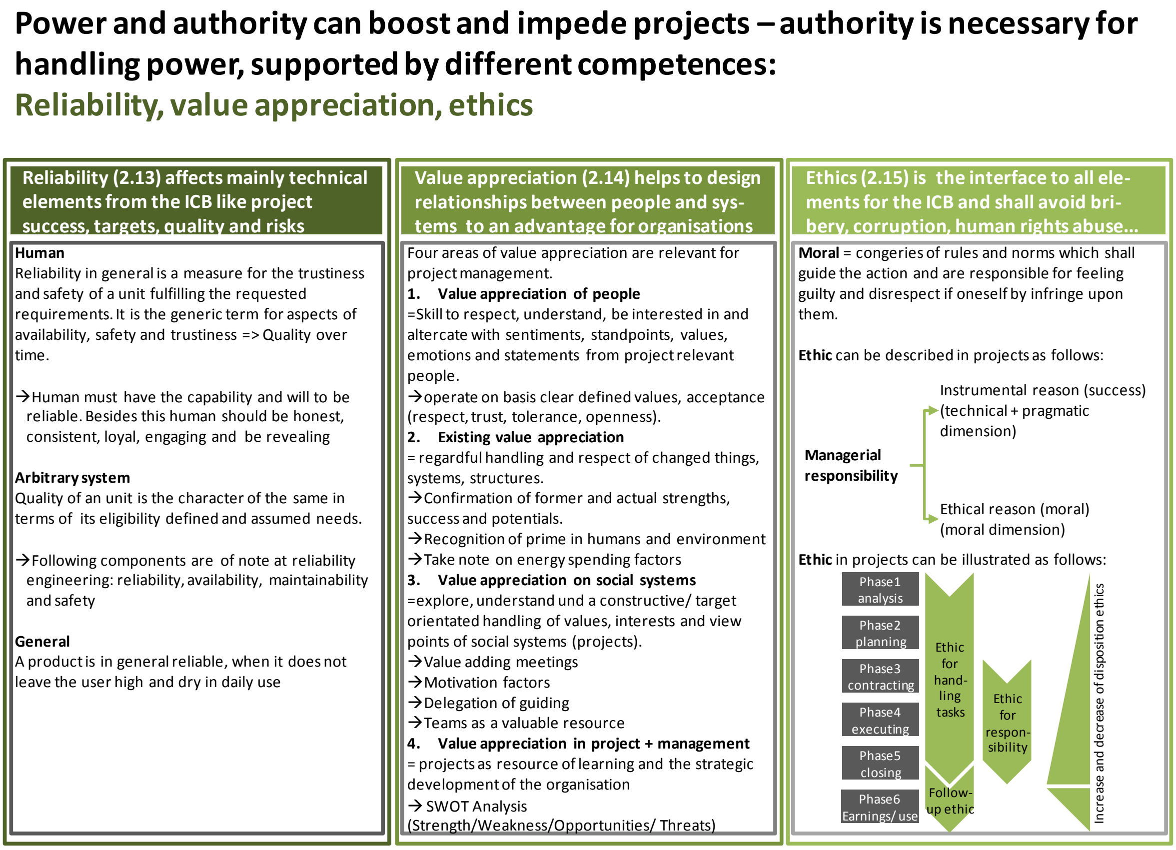


Figure 120: ICB 3.0 - Behavioural competence: values appreciation and ethics (developed by author)

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.

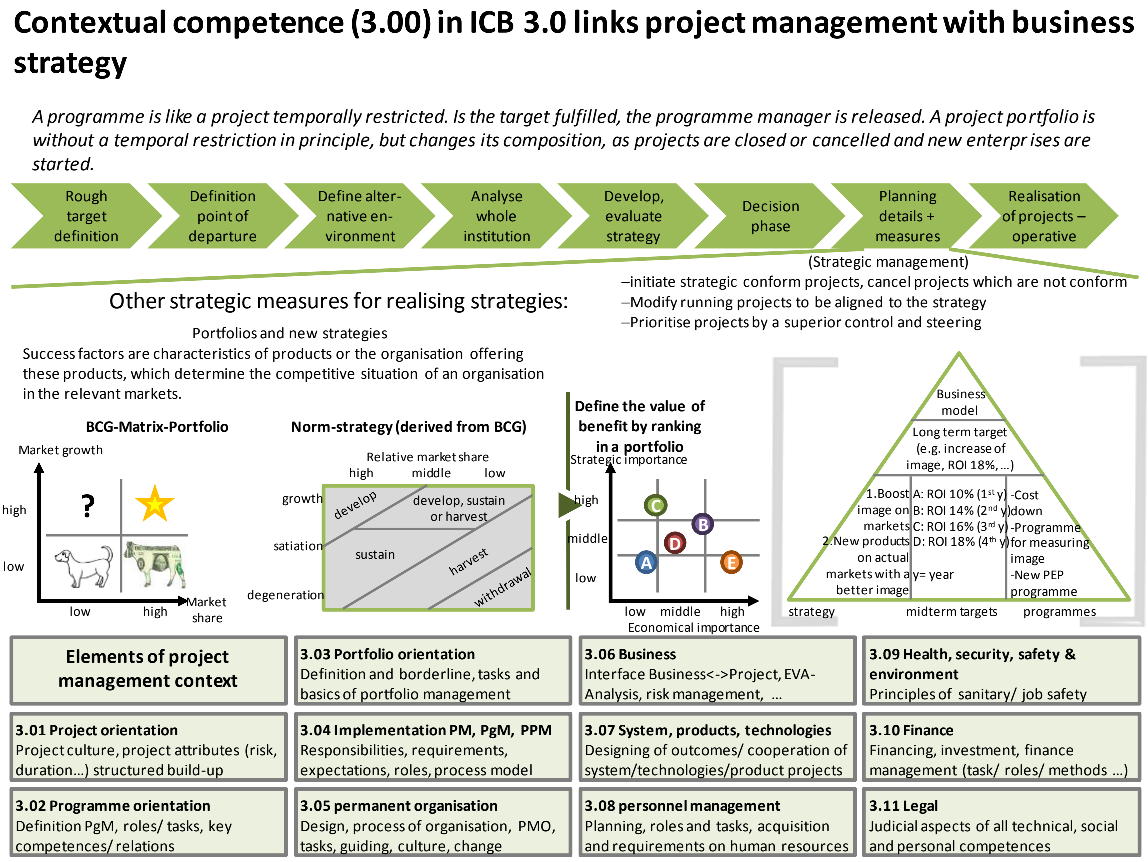


Figure 121: ICB 3.0 - Contextual competence: overview contextual competence (developed by author)

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).

certification level competence	Shortcut	Level D project management	Level C project manager	Level B senior project manager	Level A program director
TECHNICAL COMPETENCE	1.00				
project success criteria	1.01	know	skill	skill	manage
stakeholders and intrested parties	1.02	skill	skill	skill	manage
project objectives and strategies	1.03	skill	skill	skill	skill
risk, threats and opportunities	1.04	skill	skill	skill	manage
project quality	1.05	know	know	skill	manage
project organisation	1.06	skill	skill	skill	manage
teamwork	1.07	skill	skill	skill	manage
problem solving	1.08	know	skill	manage	manage
project scope	1.09	skill	skill	skill	manage
product scope	1.10	know	know	skill	manage
project life cycle, phases and schedule	1.11	skill	skill	skill	manage
resources	1.12	skill	skill	skill	manage
cost and finance	1.13	skill	skill	skill	manage
procurement and contracts	1.14	know	know	skill	manage
change management	1.15	know	know	skill	manage
project control	1.16	know	skill	skill	manage
documentation, information and reporting	1.17	know	skill	skill	manage
communication	1.18	skill	skill	manage	manage
project startup	1.19	skill	skill	skill	manage
project closeout	1.20	know	skill	skill	manage
BEHAVIOURAL COMPETENCE	2.00				
leadership	2.01	know	skill	skill	manage
engagement and motivation	2.02	skill	skill	manage	manage
self-control	2.03	understand	skill	manage	manage
assertiveness	2.04	understand	skill	skill	skill
relaxation	2.05	understand	skill	skill	manage
openness	2.06	understand	skill	skill	skill
creativity	2.07	know	skill	manage	manage
results orientation	2.08	know	skill	skill	manage
efficiency	2.09	understand	skill	skill	manage
consultation	2.10	understand	skill	skill	skill
negotiation	2.11	know	know	skill	manage
conflict	2.12	know	skill	manage	manage
reliability	2.13	know	skill	skill	skill
values appreciation	2.14	understand	skill	skill	skill
ethics	2.15	skill	skill	skill	skill
CONTEXTUAL COMPETENCE	3.00				
project orientation	3.01	know	skill	skill	manage
programme orientation	3.02	understand	know	skill	manage
portfolio orientation	3.03	understand	know	skill	manage
implementation PM/ PgM/ PPM	3.04	understand	know	know	manage
permanent organisation	3.05	know	skill	skill	manage
business	3.06	know	skill	skill	manage
systems, products, technologies	3.07	understand	skill	skill	know
personnel management	3.08	know	skill	skill	manage
health, security, safety and environment	3.09	know	skill	skill	manage
finance	3.10	know	skill	skill	manage
legal	3.11	understand	know	skill	manage

understand	heard about the topic
know	understanding of topic and possibility to follow the cross linking
skill	adopt the acquisitioned knowledge to exercise
manage	tasks are delegated and team is supported by execution and tasks might be checked at the end

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).

Country		Name	Headquarter	www.
Worldwide	IPMA	International Project Management Association	Nijkerk (Netherlands)	www.ipma.ch
Australia	AIPM	Australian Institute of Project Management	Sydney	www.aipm.com.au
Austria	PMA	Projekt Management Austria	Wien	www.a-p-m.at
Azerbaijan	AzPMA	Azerbaijan Project Management Association	Baku	www.ipma.az
Bosnia + Herzegovina	APMinBIH	Association for Project Management in Bosnia and Herzegovian	Sarajevo	www.uup.ba
Brasil	IPMABR	Brazilian Association for Project Management	Belo Horizonte	www.ipmabrasil.org
Bulgaria	BPMA	Bulgarian Project Management Association	Sofia	www.project.bg
Canada	AMPC	Project Management Association of Canada	Winnipeg	www.pmac-ampc.ca
China	PMRC	Project Management Research Committee China	Xi'an	www.pmcc.org.cn
Croatia	CAPM	Croatian Project Management Association	Zagreb	www.capm.hr
Cyprus	CPMS	Cyprus Project Management Association	Zagreb	www.capm.hr
Czech Republic	SPR	Project Management Association Czech Republic	Brno	www.ipma.cz
Danmark	DPMA	Danish Project Management Association. Denmark	Stockholm	www.ipmadanmark.ning.com
Egypt	MES	Management Engineering Society Egypt	Ramsis	www.mes.eg.net
Finland	PMAF	Project Management Association Finland	Helsinki	www.pry.fi
France	AFITEP	L'Association Francophone de Management de Project	Paris	www.afitep.org
France	SMAP	Association Francaise pour l'avancement du Management de Projet.	Le Mensil Le Roi	www.ipmafrancemap.ning.com
Germany	GPM	Gesellschaft für Projektmanagement	Nuernberg	www.gpm-ipma.de
Greece	PM-Greece	Network of Project Managers in Greece	Athen	www.pmgreece.gr
Hungary	FOVOSZ	Project Management Association Hungary	Budapest	www.fovosz.hr
Iceland	VSF	Project Management Association of Iceland	Reykjavik	www.vsf.is
India	IPMAIndia	INDIA Association of project management		www.ipmaindia.ning.com
Iran	IRANPMA	Iran Project Management Association	Theran	www.ipma.ir
Ireland	IPMI	Institute Project Management Ireland	Dublin	www.projectmanagement.ie
Italy	ANIMP	Associazone Nazionale di Impiantistica Industriale	Milan	www.animp.it
Kazakhstan	KPMA	Kazahkstan Project Management Association	Almaty	www.kpma.kz
Kosovo	Kosovo Association for Project Management			www.kosovomanagement.com
Kuwait	KES	Kuwait Society of Engineers	Safat	www.kse.org.kw
Latvia	LNPVA	Latvian National Project Management Association	Riga	www.lnpva.lv
Lithuania	LPVA	Lithuanian Project Management Association	Vilnius	www.lpva.lt
Morocco	MPMA	Moroccan Association Manager of Project		www.mpma.ma
Nepal	PMAN	Project Management Association of Nepal	Kathmandu	www.pman.org.np
Netherlands	IPMA-NL	IPMA-NL_Netherlands	Voorthuizen	www.ipma-nl.nl
Norway	NFP	Norwegian Association of Project Management	Oslo	www.projektledelse.org
Peru	APDP	Peruvian Project Management Association	Lima	www.apdp.pe
Poland	SPMP	Polish Association of Project Management	Warszwa	www.ipmapoland.ning.com
Portugal	APOGEP	APOGEP - IPMA PORTUGAL	Lisboa	www.apo.gep.pt
Romania	ARPM	Project Management Romania		www.pm.org.ro
Russia	SOVNET	Russian PM Association	Moscow	www.sovnet.ru
Serbia	YUPMA	Serbian Project Management Association	Belgrade	www.yupma.rs
Slovakia	SPPR	PM Association of Slovakia	Trnava	www.sppr.sk
Slovenia	ZPM	Slovenia Project Management Association	Ljubljana	www.zpm-si.com
South Africa	APMSA	Association for Project Management South Africa	Ferndale	www.apmsa.org.za
Spain	AEIPRO	Associacion Espanola de Ingeniera de Proyectos	Madrid	www.ipmaspain.ning.com
Sweden	SPMS	Swedish Project Management Society	Stockholm	www.projektforum.se
Switzerland	SPM	Swiss Project Management Association	Glattbrugg	www.spm.ch
Switzerland	SMP	Société suisse de Management de Projet	Fribourg	www.project-management.ch
Taiwan	TPMA	Taiwan Project Management Association	Taipeh	www.tw-pma.org.tw
Turkey	trpma	Turkish Project Management Association	Ankara	www.trpma.org
Ukraina	UPMA	IPMA community in the Ukraina	Kiev	www.upma.kiev.ua
United Kingdom	APM	Association for Project Management	Buckinghamshire	www.apm.org.uk
United States	ASAPM	American Society for Project Management	Colorado Springs	www.asapm.org
Zambia	PMAZ	Project Management Association of Zambia	Lusaka	www.4cpm.net

Table 34: IPMA member associations worldwide with partly own NCB'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

Year of development/ Foundation	*founded in 1978 as Project Managers Forum (PMF) It converted in 1989 to the Australian Institute of Project Management (AIPM) with the standardeNCSPM.*
Language	*English*
Origin in	*Project Management*
Legal rights by	*The rights of the standard are not at the AIPM, but the Government institutions Innovation & Business Skills Australia (IBSA) and National Training Information System (NTIS)*
Certification	*CPPD (Certified Practising Project Director)* *CCPM (Certified Practising Project Project Manager)* *CPPP (Certified Practising Project Practitioner)*
Standards	*ISO 21500*
Country	*Australia (Northern Territory, Western Australia, South Australia, New South Wales, Tasmanian, Queensland)*
Members worldwide	*>10.000 members worldwide, whereas 3.800 are AQF (Australian Qualification Framework) approved*
Associated companies with NSCPM	*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,…*

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, mangers, and directors 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.

BSB41507 Certificate IV in project management (CPPP)	BSB51407 Diploma of project management (CPPM)	BSB60707 Advanced Diploma of project management (CPPD)
Prerequisites: None, no individual units of competency	**Prerequisites:** Passed BSB41507 or equivalent degrees, no individual units of competency	**Prerequisites:** Passed BSB51407 or equivalent degrees, no individual units of competency
Knowledge areas: BSBPMG602A – **scope** management techniques BSBPMG603 A – **time** management techniques BSBPMG604 A – **cost** management techniques BSBPMG605 A – **quality** management techniques BSBPMG606 A – **human resource** management techniques BSBPMG607 A – **communication** management techniques BSBPMG608 A – **risk** management techniques BSBPMG608 A – **procurement** management techniques + Employability skills	**Knowledge areas:** BSBPMG601A – Manage application of project integrative process BSBPMG602A – Manage project **scope** BSBPMG603 A – Manage project **time** BSBPMG604 A – Manage project **cost** BSBPMG605 A – Manage project **quality** BSBPMG606 A – Manage project **human resource** BSBPMG607 A – Manage project **communication** BSBPMG608 A – Manage project **risk** BSBPMG608 A – Manage project **procurement** + Employability skills	**Knowledge areas:** BSBPMG601A – direct the **integration** of projects BSBPMG602A – Direct the **scope** of a project programme BSBPMG603 A – Direct the **time** of a project programme BSBPMG604 A – Direct the **cost** of a project programme BSBPMG605 A – Direct the **quality** of a project programme BSBPMG606 A – Direct the **human resource** of a project programme BSBPMG607 A – Direct the **communication** of a project programme BSBPMG608 A – Direct the **risk** of a project programme BSBPMG608 A – Direct **procurement** and contracting for a project programme + Employability skills
Project team members and project management practitioners	Project leader	Branch section leader (programme manager)

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.

certification level	Certified Practising Project Practitioner (CPPP)		Certified Practising Project Manager (CPPM)		Certified Practising Project Director (CPPD)	
Knowledge area	No°	process	No°	process	No°	process
Integration			1	agree and establish life cycle reporting and measurement systems	1	direct integration of all function of project management
			2	manage integration of all project management functions	2	direct the internal programme/ project environment to meet external needs and expectations
			3	coordinate internal and external environments	3	guide and direct programme/ projects throughout project life cycles
			4	implement project activities throughout life cycle		
			5	assess project integration outcomes		
Scope	1	contribute to scope definition	6	define the project context	4	define, plan and direct programme/ project scope throughout life cycle
	2	apply project scope controls	7	guide the development of project scope definition activities	5	direct programme/ project scope
			8	implement scope controls	6	direct scope change activities
Time	3	contribute to the development of project schedules	9	determine project schedule	8	develop project/ programme schedules
	4	monitor agreed schedule	10	implement project schedule	9	direct project/ programme schedules
	5	update agreed schedule	11	assess time management outcomes	10	analyse time managemengt outcomes
	6	contribute to implementation of project schedules				
	7	participate in assessing time management outcomes				
Cost	8	contribute to the development of project budget	12	determine project budget	11	direct project/ programme budget development
	9	monitor project costs	13	monitor and control projects budget and cost	12	direct project/ programme costs and accounting
	10	contribute to project budget reconciliation process	14	conduct project financial completion activities	13	direct project/ programme budget reconciliation including at completion
Quality	11	contribute to quality planning	15	determine quality requirements	14	identify quality requirements
	12	apply quality policies and procedures	16	implemet quality assurance	15	conduct programme/ project quality assurance
	13	contribute to continious improvement process	17	implement project quality improvements	16	manage the quality management process
Human Resources	14	assist with determination of human resource requirements	18	implement human resource and stakeholder planning activities	17	ensure effective human resource system
	15	establish and maintain productive working relationships	19	implement staff training and development	18	ensure effective system for project management organisation and staffing
	16	contribute to team building	20	manage the project team and stakeholders	19	ensure effective systems for staff performance management process
	17	assist with human resource control	21	assess human resource outcomes	20	manage organisational change implications
	18	contribute to conclusion of human resource practices			21	understand programmes participants and other stakeholders
					22	provide programme team leadership
					23	monitor programme team workload
					24	monitor and maintain programme team and individual performance
					25	build programme team cohesion
					26	develop project staff
					27	assess human resource outcomes

Communication	19 contribute to communications planning 20 conduct information management activities 21 communicate project information 22 contribute to assessment of communications management outcomes	22 plan communication process 23 manage information 24 manage project reporting 25 assess communications management outcomes	28 plan programme/ project communications 29 direct programme/ project information 30 direct programme/ project communications 31 analyse communications management outcomes
Risk	23 assist with risk analysis and planning 24 perform risk control activities 25 contribute to assessing risk management outcomes	26 determine project risk events 27 monitor and manage oportunities 28 monitor and manage project risks 29 assess risk management outcomes	32 plan for the management of risk 33 direct programme/ project risk 34 assess risk management outcomes
Procurement	26 assist with contract and procurement planning 27 contribute to contractor selection process 28 conduct contracting and procurement activities or services 29 conduct finalisation activities	30 determine procurement requirements 31 follow agreed procurement process 32 conduct contracting and procurement activities 33 implement contract and/ or procurement 34 manage contract and procurement finalisation procedures	35 plan programme/ project contracting and procurement 36 direct setup of contract and procurement 37 direct contract and procurement process 38 direct finalisation of contracts

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).

certification level Knowledge area	Certified Practising Project Manager (CPPM)			
	No°	process	No°	sub-process
Integration	1	agree and establish life cycle reporting and measurement systems		
	2	manage integration of all project management functions	2.1	identify project stakeholders and their intrests
	3	coordinate internal and external environments	3.1	established internal working environment for ensuring effectively conduction of work during the PLC
	4	implement project activities throughout life cycle	4.1	agreed project phases, approval and review points defined
	5	assess project integration outcomes		
Scope	6	define the project context		
	7	guide the development of project scope definition activities	7.1	project objectives, deliverables, constraints and principal work is identified
	8	implement scope controls	8.1	agree, implemented scope management processes and procedures
Time	9	determine project schedule	9.1	determine duration, effort, sequence and dependencies
	10	implement project schedule	10.1	mechanism implemented to measure, report and record progress of activities
	11	assess time management outcomes	11.1	review of project outcomes from available records
			11.2	improvements are identified, documented and forwarded to senior management
Cost	12	determine project budget	12.1	determine requirements for each resource
	13	monitor and control projects budget and cost	13.1	develop cost management plan and ensure an clarity of understanding
	14	conduct project financial completion activities	14.1	activities conducted to signify financial completion
Quality	15	determine quality requirements	15.1	objectives are determined as basis for outcomes and quality management plan
	16	implemet quality assurance	16.1	results are documented and measured throughout PLC
	17	implement project quality improvements	17.1	process is reviewed, agreed changes are implemented throughout PLC

Human Resources	18 implement human resource and stakeholder planning activities	18.1 individual tasks and requirements are determined -> staffing level and required competencies
	19 implement staff training and development	19.1 staff responsibilities, authority and individual performance measurement criteria are communicated
	20 manage the project team and stakeholders	20.1 process and actions to promote continious improvement of staff
	21 assess human resource outcomes	
Communication	22 plan communication process	22.1 Identify information requirements, document and analyse them
	23 manage information	23.1 generate, gather, store, retrieve, analyse and disseminate informations
	24 manage project reporting	24.1 identify problems and implement agreed remedial actions
	25 assess communications management outcomes	25.1 conduct finalisation activities to ensure agreed ownership, responsibility for collected informations
Risk	26 determine project risk events	26.1 identify, analyse and document risk in consultation with stakeholder
	27 monitor and manage oportunities	
	28 monitor and manage project risks	28.1 manage project with established risk management plan
	29 assess risk management outcomes	29.1 review outcome to determine effectiveness of risk management
Procurement	30 determine procurement requirements	30.1 identify procurement requirements together with stakeholder
	31 follow agreed procurement process	31.1 determine how objectives can be met and fulfilling of procurement requirements is capable
	32 conduct contracting and procurement activities	32.1 comunicate agreed proposals to prospective contractors or suppliers
	33 implement contract and/ or procurement	33.1 implement established procurment plans
	34 manage contract and procurement finalisation procedures	34.1 conduct finalisation activities to ensure contractual requirements are met

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).

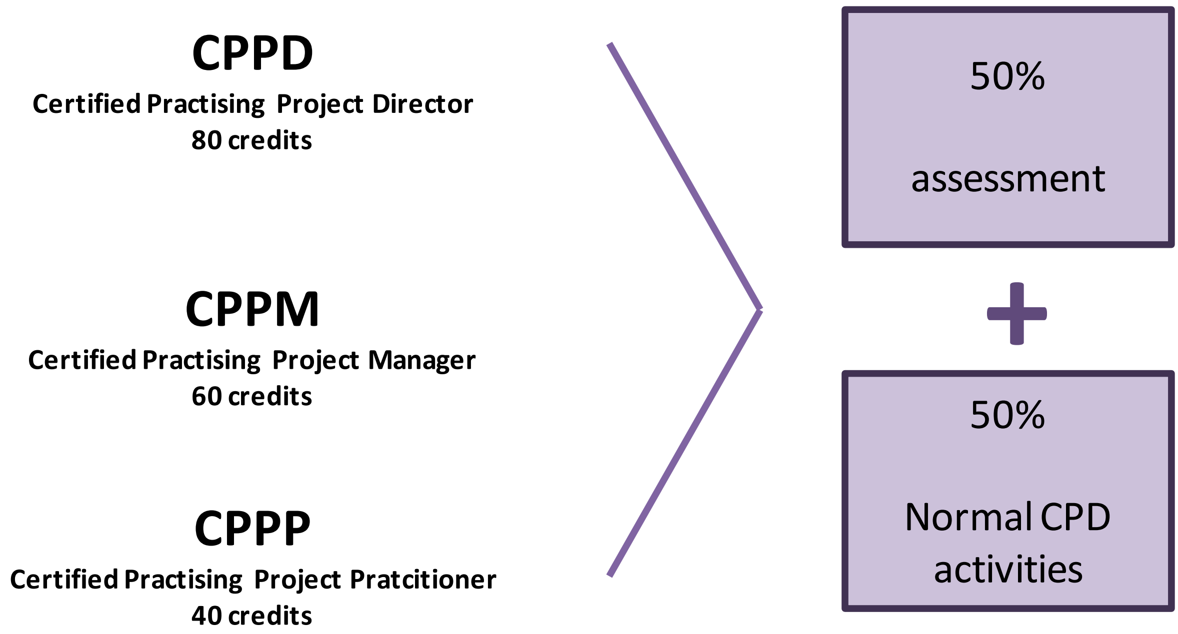


Figure 123: AIPM - recertification requirements in a three-year cycle (developed by author)

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 maintenance 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

YEAR OF DEVELOPMENT/ FOUNDATION	*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).*
LANGUAGE	*ENGLISH*
ORIGIN IN	*PROJECT MANAGEMENT*
LEGAL RIGHTS BY	*SOUTH AFRICAN QUALIFICATION AUTHORITY (SAQA)*
CERTIFICATION	*ACCORDING TO NATIONAL QUALIFICATION FRAMEWORK (NQF):* *LEVEL 3: PROJECT SUPPORT SERVICE CERTIFICATE* *LEVEL 4: GENERIC PROJECT MANAGEMENT CERTIFICATE* *LEVEL 5: PROJECT MANAGEMENT DIPLOMA*
STANDARDS	*ISO 21500*
COUNTRY	*SOUTH AFRICA WITH BRANCHES IN:* *KWA ZULU-NATAL, WESTERN CAPE, JOHANNESBURG, TSHWANE*
MEMBERS WORLDWIDE	*1.200 (STATUS 2003)*
ASSOCIATED COMPANIES WITH PMSGB	-

Project Management Standards Generating Body (PMSGB) – South Africa – History

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).

Project Management Standards Generating Body (PMSGB) – South Africa – Motivation

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).

Project Management Standards Generating Body (PMSGB) – South Africa – Method

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.

Level 3 Fundamental Component	Level 3 Core Component	Level 3 Elective Component
Credits: 36	**Credits:** 88	**Credits:** 12
Components: • Accommodate audience and context needs in oral/signed communication • Demonstrate an understanding of the use of different number bases and measurement units and an awareness of error in the context of relevant calculations • Describe, apply, analyse and calculate shape and motion in 2- and 3-dimensional space in different contexts • Interpret and use information from texts • Investigate life and work related problems using data and probabilities • Use language and communication in occupational learning programmes • Use mathematics to investigate and monitor the financial aspects of personal, business and national issues • Write/present/sign texts for a range of communicative contexts	**Components:** • Apply basic business ethics in environment • Apply health and safety to a work area • Demonstrate an understanding of HIV/AIDS and its implications • Understand/ apply personal values and ethics • Demonstrate an understanding of and provide assistance for risk analysis functions • Demonstrate knowledge and understanding of the project and the project support services environment • Demonstrate understanding of employment relations in an organisation • Explain and apply quality control procedures • Explain and provide assistance for project estimating service functions • Explain the quality, time and cost parameter of project/ obtain change request authorisations • Gather information and provide assistance for project planning and scheduling functions • Manage time and the work process in a business environment • Measure and plan own performance and behaviour in line with roles and responsibilities in a project team • Provide assistance for cost control functions • Describe and apply the management functions of an organization / Function in a team	**Components:** • Identify and maintain the types of records required in own industry and understand why it is necessary to create evidence and maintain confidentiality • Maintain an existing information system in a business environment • Demonstrate basic accounting concepts • Plan, monitor and control an information system in a business environment • Use a Graphical User Interface (GUI)-based presentation application to enhance presentation appearance • Use a Graphical User Interface (GUI)-based spreadsheet application to solve a given problem • Use a GUI-based word processor to create merged documents • Use a GUI-based word processor to enhance a document through the use of tables and columns

Table 37: PMSGB - content level 3 qualification (source: derived from South African Qualification Authority 2011b)

– **Level 4** – 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.

Level 4 Fundamental Component	Level 4 Core Component	Level 4 Elective Component
Credits: n.a.	**Credits:** n.a.	**Credits:** n.a.
Components: • Accommodate audience and context needs in oral communication • Interpret/use information from texts • Use language and communication in occupational learning programmes • Write texts for a range of communicative contexts • Apply knowledge of statistics and probability to critically interrogate and effectively communicate findings on life related problems • Engage in sustained oral communication and evaluate spoken texts • Measure, estimate & calculate physical quantities & explore, critique & prove geometrical relationships in 2 and 3 dimensional space in the life and workplace of adult with increasing responsibilities • Read, analyse, respond to variety of texts • Use language and communication in occupational learning programmes • Use mathematics to investigate and monitor the financial aspects of personal, business, national and international issues • Write for a wide range of contexts	**Components:** • Provide assistance in implementing and assuring project work is conducted in accordance with the project quality plan • Apply a range of project management tools • Conduct project documentation management to support project processes • Contribute to project initiation, scope definition and scope change control • Contribute to the management of project risk within own field of expertise • Fulfil procurement activities and supervise procurement administration • Identify, organise and co-ordinate project life cycle phases for control purposes • Identify, suggest and implement corrective actions to improve quality • Implement required project administration • Monitor, evaluate and communicate project schedules • Participate in the estimation and preparation of cost budgets for an element of work and monitor and control actual cost against budget • Plan, organise and support project meetings and workshops • Schedule project activities for effective execution • Work as a project team member • Evaluate/ improve the project team's performance	**Components:** • Supervise a project team of a business project to deliver project objectives • Supervise a project team of a developmental project to deliver project objectives • Supervise a project team of a technical project to deliver project objectives

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.

Level 5 Fundamental Component
Credits: up to 17
Components: • Access, process, adapt and use data from a wide range of texts • Provide and respond to feedback • Use communication techniques effectively

Level 5 Core Component	Level 5 Elective Component
Credits: 164	**Credits:** 66 – 120
Components: • Demonstrate knowledge/ application of ethical conduct • Coordinate closure of a simple/moderately complex project • Demonstrate understanding of stress for applying strategy achieving optimal stress levels in personal/work situations • Demonstrate and apply an understanding of the Basic Conditions of Employment Act (Act 75 of 1997) • Determine the work required to accomplish objectives and organise scope of a simple/ moderately complex project • Develop a preliminary project scope statement for a simple to moderately complex project • Develop a project cost/ quality/ risk/ integration management plan for a simple to moderately complex project • Develop an optimised work and resource schedule for a simple to moderately complex project • Establish a project or project phase and its processes for a simple to moderately complex project • Evaluate and improve the project team's performance • Identify and interpret related legislation and its impact on the team, department or division and ensure compliance • Manage project communication for a project Manage stakeholder relations on a project • Manage procurement process for simple/complex project • Monitor/ control execution of project management plan for a simple/ moderately complex project • Monitor team members /measure performance effectiveness • Negotiate agreements in simple to moderately complex situations	**Components:** • Apply Functional Value to Engineering Design • Apply the principles of change management in the workplace • Apply the principles of Employment Equity to dealing with terminal or chronic illnesses (HIV/Aids) in the workplace • Build teams to meet set goals and objectives • Create and use a range of resources to effectively manage teams, sections, departments or divisions • Determine project cost and schedule performance using earned value management techniques • Develop/ implement a strategy/ action plans for a team, dept. • Develop holistic productivity improvement strategies and plans • Devise/ apply strategies to establish/maintain relationships • Draft an employment contract • Facilitate meetings/workshops effectively to achieve organisational outcomes • Harness diversity/ build on strengths for working environment • Identify, select and co-ordinate value engineering PLC phase • Implement codes of conduct in the team, department or division • Implement training needs for teams/ individuals to upgrade skills • Institute disciplinary action • Interpret and manage conflicts within the workplace • Manage diversity in the workplace • Manage staff development • Optimise safety, health and environmental protection system • Prepare and conduct staff selection interviews • Promote a productivity improvement strategy • Recruit and select candidates to fill defined positions

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.

certification level compnent level	level 3	level 4	level 5
fundamental component (FC)	FC3.1 - Accommodate audience and context needs in oral/ signed communication	FC4.1 - Accommodate audience and context needs in oral communication	FC5.1 - Access, process, adapt and use data from a wide range of texts
	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	FC4.2 - Interpret/ use information from texts	FC5.2 - Provide and respond to feedback
	FC3.3 - Describe, apply, analyse and calculate shape and motion in 2-and 3-dimensional space in different contexts	FC4.3 - Use language and communication in occupational learning programmes	FC5.3 - Use communication techniques effectively
	FC3.4 - Interpret and use information from texts	FC4.4 - Write texts for a range of communicative contexts	
	FC3.5 - Investigate life and work related problems using data and probabilities	FC4.5 - Apply knowledge of statistics and probability to critically interrogate and effectively communicate findings on life related problems	
	FC3.6 - Use language and communication in occupational learning programmes	FC4.6 - Engage in sustained oral communication and evaluate spoken texts	
	FC3.7 - Use mathematics to investigate and monitor the financial aspects of personal, business and national issues	FC4.7 - Measure, estimate & calculate physical quantities & explore, critique & prove geometrical relationships in 2 and 3 dimensional space in the life and workplace of adult with increasing responsibilities	
	FC3.8 - Write/ present/ sign texts for a range of communicative contexts	FC4.8 - Read, analyse, respond to variety of texts	
		FC4.9 - Use language and communication in occupational learning programmes	
		FC4.10 - Use mathematics to investigate and monitor the financial aspects of personal, business, national and international issues	
		FC4.11 - Write for a wide range of contexts	
core component (CC)	CC3.1 - Apply basic business ethics in environment	CC4.1 - Provide assistance in implementing and assuring project work is conducted in accordance with the project quality plan	CC5.1 - Demonstrate knowledge/ application of ethical conduct
	CC3.2 - Apply health and safety to a work area	CC4.2 - Apply a range of project management tools	CC5.2 - Coordinate closure of a simple/ moderately complex project
	CC3.3 - Demonstrate an understanding of HIV/ AIDS and its implications	CC4.3 - Conduct project documentation management to support project processes	CC5.3 - Demonstrate understanding of stress for applying strategy achieving optimal stress levels in personal/ work situations
	CC3.4 - Understand/ apply personal values and ethics	CC4.4 - Contribute to project initiation, scope definition and scope change control	CC5.4 - Demonstrate and apply an understanding of the Basic Conditions of Employment Act (Act 75 of 1997)
	CC3.5 - Demonstrate an understanding of and provide assistance for risk analysis functions	CC4.5 - Contribute to the management of project risk within own field of expertise	CC5.5 - Determine the work required to accomplish objectives and organise scope of a simple/ moderately complex project
	CC3.6 - Demonstrate knowledge and understanding of the project and the project support services environment	CC4.6 - Fulfil procurement activities and supervise procurement administration	CC5.6 - Develop a preliminary project scope statement for a simple to moderately complex project
	CC3.7 - Demonstrate understanding of employment relations in an organisation	CC4.7 - Identify, organise and coordinate project life cycle phases for control purposes	CC5.7 - Develop a project cost/ quality/ risk/ integration management plan for a simple to moderately complex project
	CC3.8 - Explain and apply quality control procedures	CC4.8 - Identify, suggest and implement corrective actions to improve quality	CC5.8 - Develop an optimised work and resource schedule for a simple to moderately complex project
	CC3.9 - Explain and provide assistance for project estimating service functions	CC4.9 - Implement required project administration	CC5.9 - Establish a project or project phase and its processes for a simple to moderately complex project
	CC3.10 - Explain the quality, time and cost parameter of project/ obtain change request authorisations	CC4.10 - Monitor, evaluate and communicate project schedules	CC5.10 - Evaluate and improve the project team's performance
	CC3.11 - Gather information and provide assistance for project planning and scheduling functions	CC4.11 - Participate in the estimation and preparation of cost budgets for an element of work and monitor and control actual cost against budget	CC5.11 - Identify and interpret related legislation and its impact on the team, department or division and ensure compliance
	CC3.12 - Manage time and the work process in a business environment	CC4.12 - Plan, organise and support project meetings and workshops	CC5.12 - Manage project communication for a project Manage stakeholder relations on a project
	CC3.13 - Measure and plan own performance and behaviour in line with roles and responsibilities in a project team	CC4.13 - Schedule project activities for effective execution	CC5.13 - Manage procurement process for simple/ complex project
	CC3.14 - Provide assistance for cost control functions	CC4.15 - Work as a project team member	CC5.14 - Monitor/ control execution of project management plan for a simple/ moderately complex project
	CC3.15 - Describe and apply the management functions of an organization/ function in a team	CC4.16 - Evaluate/ improve the project team's performance	CC5.15 - Monitor team members/ measure performance effectiveness
			CC5.16 - Negotiate agreements in simple to moderately complex situations

elective component (EC)	EC3.1 - Identify and maintain the types of records required in own industry and understand why it is necessary to create evidence and maintain confidentiality	EC4.1 - Supervise a project team of a business project to deliver project objectives	EC5.1 - Apply functional value to engineering design
	EC3.2 - Maintain an existing information system in a business environment	EC4.2 - Supervise a project team of a developmental project to deliver project objectives	EC5.2 - Apply the principles of change management in the workplace
	EC3.3 - Demonstrate basic accounting concepts	EC4.3 - Supervise a project team of a technical project to deliver project objectives	EC5.3 - Apply the principles of employment equity to dealing with terminal or chronic illnesses (HIV/ Aids) in the workplace
	EC3.4 - Plan, monitor and control an information system in a business environment		EC5.4 - Build teams to meet set goals and objectives
	EC3.5 - Use a Graphical User Interface (GUI)-based presentation application to enhance presentation appearance		EC5.5 - Create and use a range of resources to effectively manage teams, sections, departments or divisions
	EC3.6 - Use a Graphical User Interface (GUI)-based spreadsheet application to solve a given problem		EC5.6 - Determine project cost and schedule performance using earned value management techniques
	EC3.7 - Use a Graphical User Interface GUI-based word processor to create merged documents		EC5.7 - Develop/ implement a strategy/ action plans for a team, dept.
	EC3.8 - Use a Graphical User Interface GUI-based word processor to enhance a document through the use of tables and columns		EC5.8 - Develop holistic productivity improvement strategies and plans
			EC5.9 - Devise/ apply strategies to establish/ maintain relationships
			EC5.10 - Draft an employment contract
			EC5.11 - Facilitate meetings/ workshops effectively to achieve organisational outcomes
			EC5.12 - Harness diversity/ build on strengths for working environment
			EC5.13 - Identify, select and co-ordinate value engineering PLC phase
			EC5.14 - Implement codes of conduct in the team, department or division
			EC5.15 - Implement training needs for teams/ individuals to upgrade skills
			EC5.16 - Institute disciplinary action
			EC5.17 - Interpret and manage conflicts within the workplace
			EC5.18 - Manage diversity in the workplace
			EC5.19 - Manage staff development
			EC5.20 - Optimise safety, health and environmental protection system
			EC5.21 - Prepare and conduct staff selection interviews
			EC5.22 - Promote a productivity improvement strategy
			EC5.23 - Recruit and select candidates to fill defined positions

Table 40: Overview of components on PMSGB certification levels (developed by author)

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.

PMSGB		NCSPM
Level 3 Project Support Service Certificate	• Demonstrate some responsibility for own learning within a supervised learning environment	**Certificate III** Senior Secondary
Level 4 Generic Project Management Certificate	• Operate within clearly defined contexts with limited scope for personal decision making and responsibility • Learn within a well-structured and managed environment • Evaluate own performance against given criteria	**Certificate IV** Certified Practising Project Practitioner
Level 5 Project Management Diploma	• Operate within well-defined contexts requiring some personal responsibility and initiative • Learn within a structured environment • Identify own learning needs within defined contexts	**Diploma of Project Management** Certified Practising Project Manager
Level 6 Bachelor in Programme Management (not yet developed)	• Operate in contexts where the task is not always well-defined, requiring personal responsibility, initiative and decision-making • Accurately evaluate own learning • Identify and address own learning needs by independently accessing learning resources • Be aware of the ethical implications of applying knowledge to particular contexts	**Advanced Diploma of Project Management** Certified Practising Project Director

Figure 124: PMSGB - similarities to NCSPM certification levels (source: derived from Crawford, 2002)

Project Management Standards Generating Body (PMSGB) – South Africa – Target

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).

Target of Level 3 qualification	Target of Level 4 qualification	Target of Level 5 qualification
Prerequisites: none	**Prerequisites:** Level 3 or equivalent accepted by the SAQA	**Prerequisites:** Level 4 or equivalent accepted by the SAQA
Primary purpose: • An understanding of self-management and personal behaviour in an organisational environment. • An understanding of business ethics and practices and how to function as a team member. • Competence to perform support service functions in a project team.	**Primary purpose:** • A foundation of basic project management skills which can be used to build further project management related competencies. • Competence to be an effective project team member Competence to execute small, simple projects. • Competence to provide assistance to a project manager of large projects.	**Primary purpose:** • Plan, establish and manage a simple to moderately complex project and project team whilst using a variety of routine and non-routine processes. • Select from a wide choice of standard and non-standard procedures. • Take full responsibility for the nature, quantity and quality of output. • Take responsibility for group output as required. • Show possession of a wide range of scholastic and/or technical skills applicable in the field of project management.
Target group: • People who work in the Project Support Services environment. • Understanding and awareness of challenges facing in the process of providing support to a project.	**Target group**: • Working as a contributing team member on a medium to large project • Working as a leader in the context of a small project / sub-project involving few resources • person may be working part time or full time with projects	**Target group**: • people with prior project work experience. • add value to learners operating their own business. • person to manage, co-ordinate or support simple to moderately complex projects in any sector. • project leaders/coordinators and project managers.

Table 41: PMSGB - Targets and focus groups (source: South African Qualification Authority 2011a, 2011b, 2011c)

Appendix XVI – Project Management Method "Deutsches Institut für Normung – DIN69900 and DIN69901"

Deutsches Institut für Normung – DIN69900 und DIN69901 – Facts

Year of development/ Foundation	*In 1917 the NADI (Norm-Ausschuss der Deutschen Industrie) was founded. In 1975 NADI was renamed to DIN (Deutsches Institut für Normung). In 1987 the DIN69901 for project management was released, the actual version was published in 2009.*
Language	*German*
Origin in	-
Legal rights by	*The legal rights are DIN e.V.*
Certification	*none*
Standards	*DIN69900, DIN69901, DIN ISO 10007, DIN ISO 10006*
Country	*Germany, but with a strong acceptance in European and international associated organisations*
Members worldwide	-
Associated companies with DIN69900 and DIN 69901	-

Deutsche Industrie Norm – DIN69900 and DIN69901– History

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 197,5 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 Zertifizierungsgrundlagen) (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).

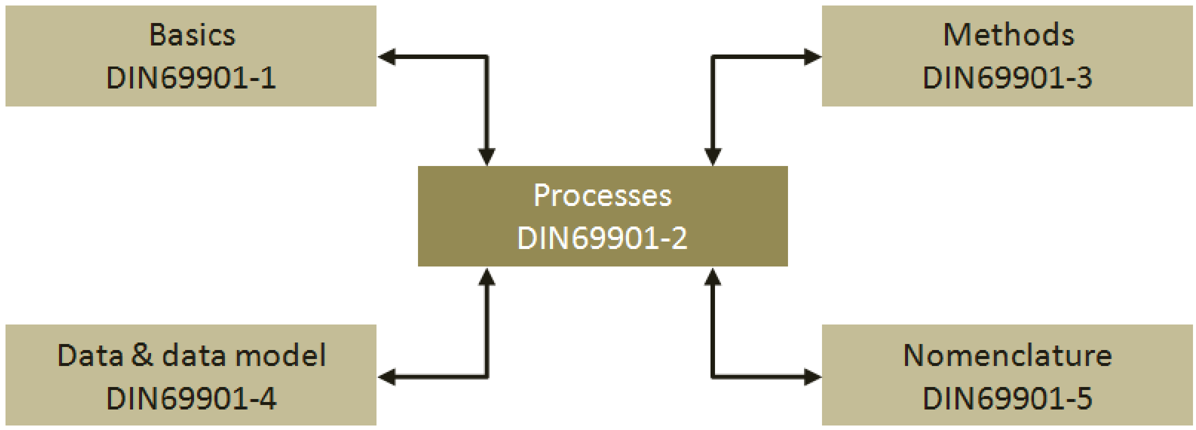


Figure 125: DIN69901 - linking of single parts of the DIN (source: DIN, 2009)

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, expectance 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

Process group Knowledge area	initiating	definition	planning	steering	closure
Schedule		D.1.1 define milestone	P.1.1 plan activities P.1.2 create schedule P.1.3 create project plan	S.1.1 start activities S.1.2 guide and control target dates	
changees			P.2.1 plan handling of changes	S.2.1 guide and control changes	
information/ documentation/ communication	I.3.1 issue release	D.3.1 define information, communication and reporting D.3.2 define project marketing D.3.3 issue release	P.3.1 plan information, communication and reporting P.3.2 issue release	S.3.1 guide and control information, communication and reporting S.3.2 issue acceptance	A.3.1 create project finalisation documentation A.3.2 archieve project documentation
cost and finance		D.4.1 rough estimation of costs	P.4.1. create finance and cost planning	S.4.1 guide and control costs and finance	A.4.1 create final project calculation for project closure
organisation	I.5.1 clarify responsibilities I.5.2 select project management processes	D.5.1 form project core team	P.5.1 plan project organisation	S.5.1 perform project kick-off S.5.2 form project team S.5.3 develop project team	A.5.1 perform final project closure meeting A.5.2 recognise and value project performance A.5.3 dissolve project organisation
quality		D.6.1 define success criteria	P.6.1 plan quality assurance	P.6.1 perform quality control	A.6.1 safe experience of project
ressources			P.7.1 create human ressource planning	S.7.1 manage and monitor human ressources	A.7.1 recycle human ressources
risk		D.8.1 define handling of risks D.8.2 analyse stakeholder and project environment D.8.3 evaluate feasability	P.8.1 analyse risks P.8.2 plan counter measures for risks	S.8.1 control and monitor risks	
project structure (WBS)		D.9.1 create rough structure	P.9.1 create work break down structure (WBS) P.9.2 describe work packages P.9.3 describe activities		
contract and claims		D10.1 define handling of contracts D.10.2 define content of contracts with customers	P.10.1 define content of contracts with suppliers	S.10.1 conduct contracts with customers and suppliers S.10.2 monitor and control claims	A.10.1 close contracts
targets	I11.1 scetch targets	D.11.1 define targets D11.2 define project content		S11.1 manage, control and monitor target achievement	

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

Year of development/ Foundation	*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.*
Language	*English*
Origin in	-
Legal rights by	*The legal rights are at the Bristish Standard Institute*
Certification	*none*
Standards	*BS6079-1, BS6079-2, BS6079-3, BS6079-4*
Country	*Great Britain but influences other standards worldwide*
Members worldwide	-
Associated companies with BS6079	-

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):

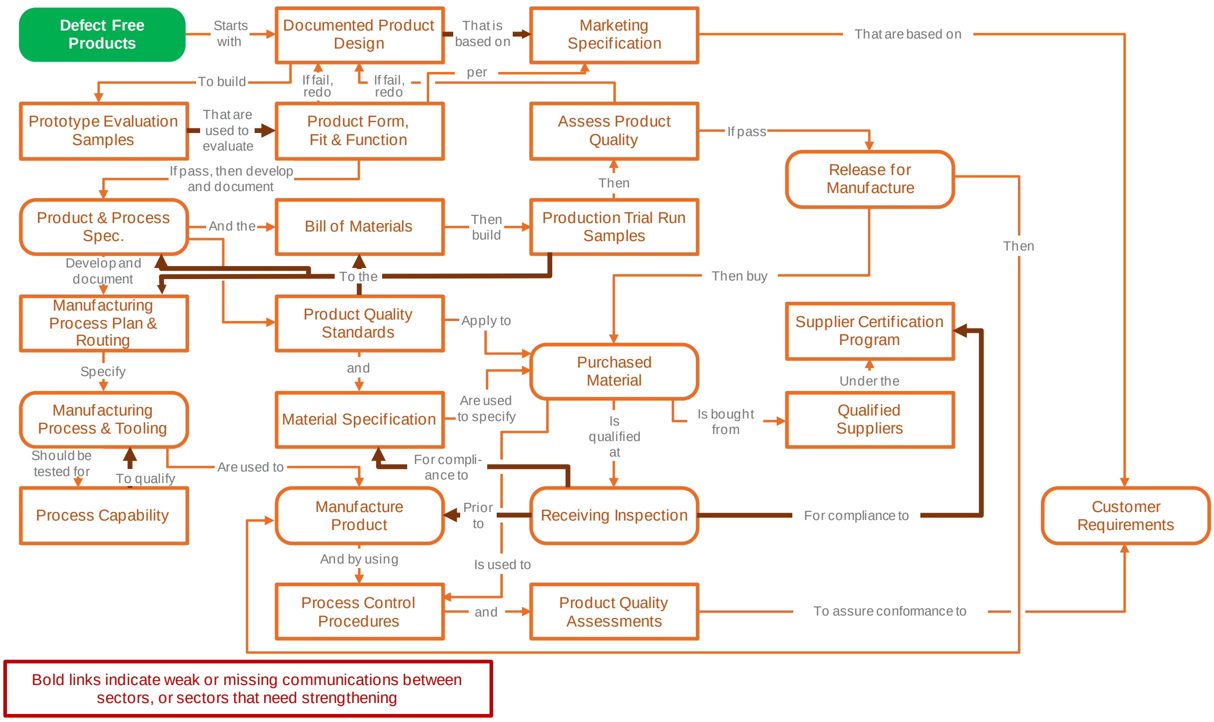


Figure 127: CMAP structure of a NY company illustrating communication problems (source: Novak, 2010)

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).

[redacted]

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).

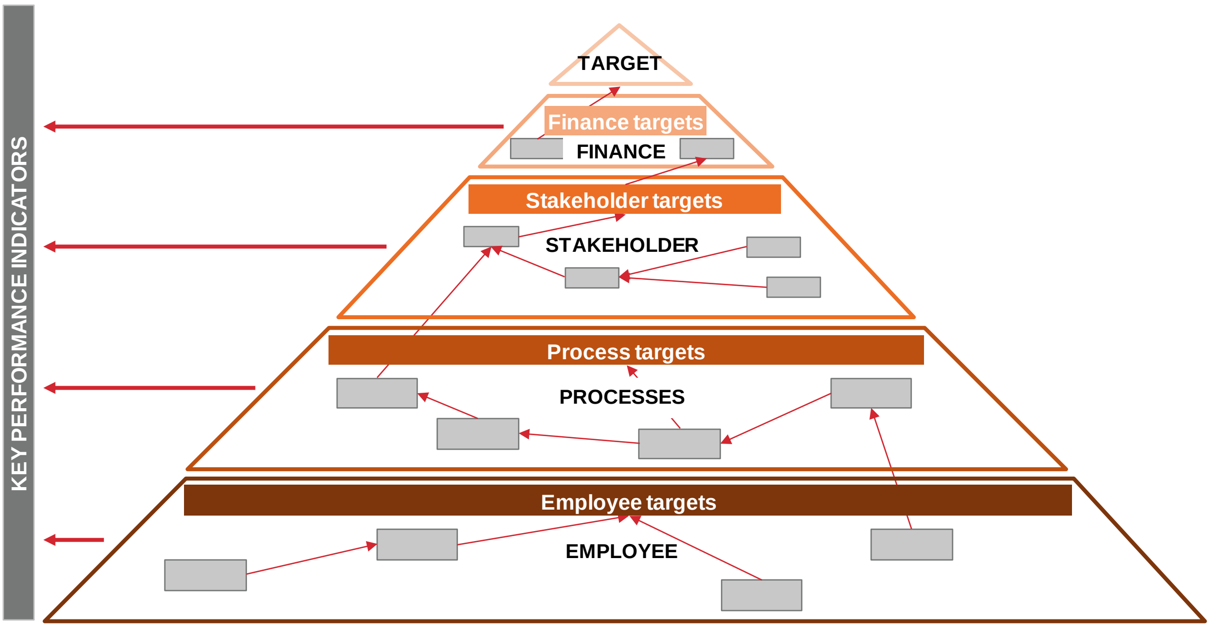


Figure 129: Schematically graph of a KPI system according to the BSC (source: Kapici, 2005)

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).

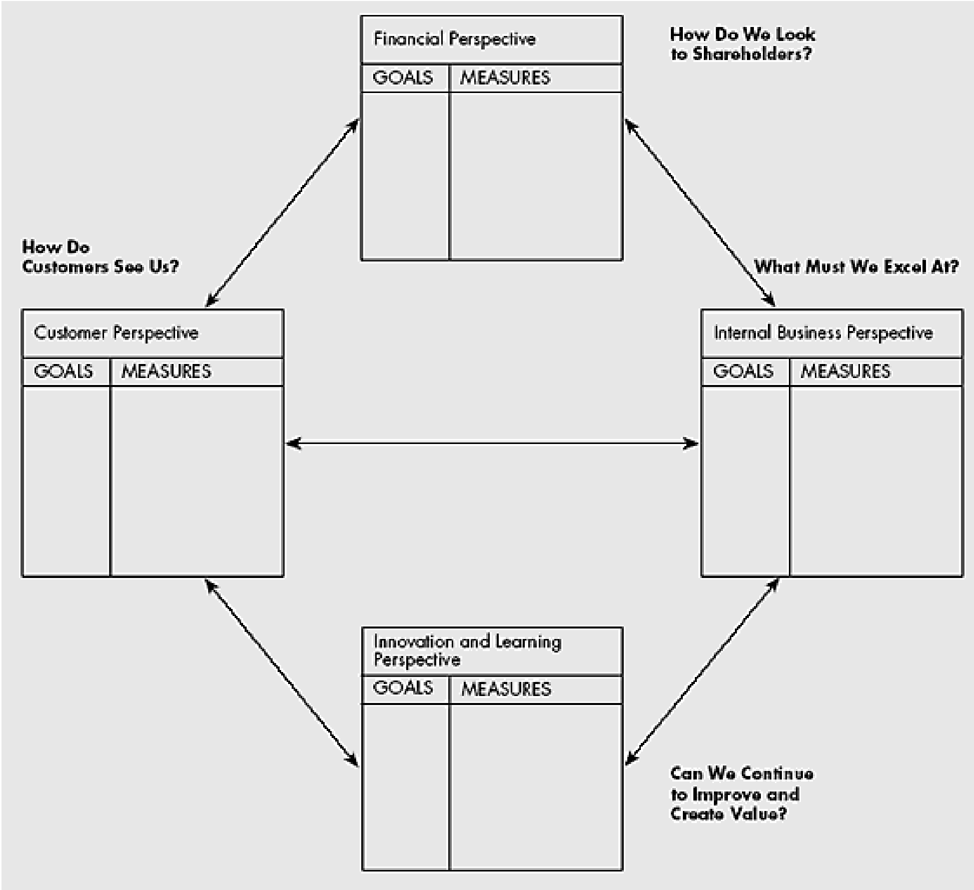


Figure 130: Balanced Scorecard (source: Kaplan & Norton, 1992)

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 redcuing 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). Stewards 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 copes with highly complex and intertwined product architectures (Marti, 2007). Approaching the problem top-down and a stepwise knockdown, DSM generates a classification and cluster (Dörner, 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).

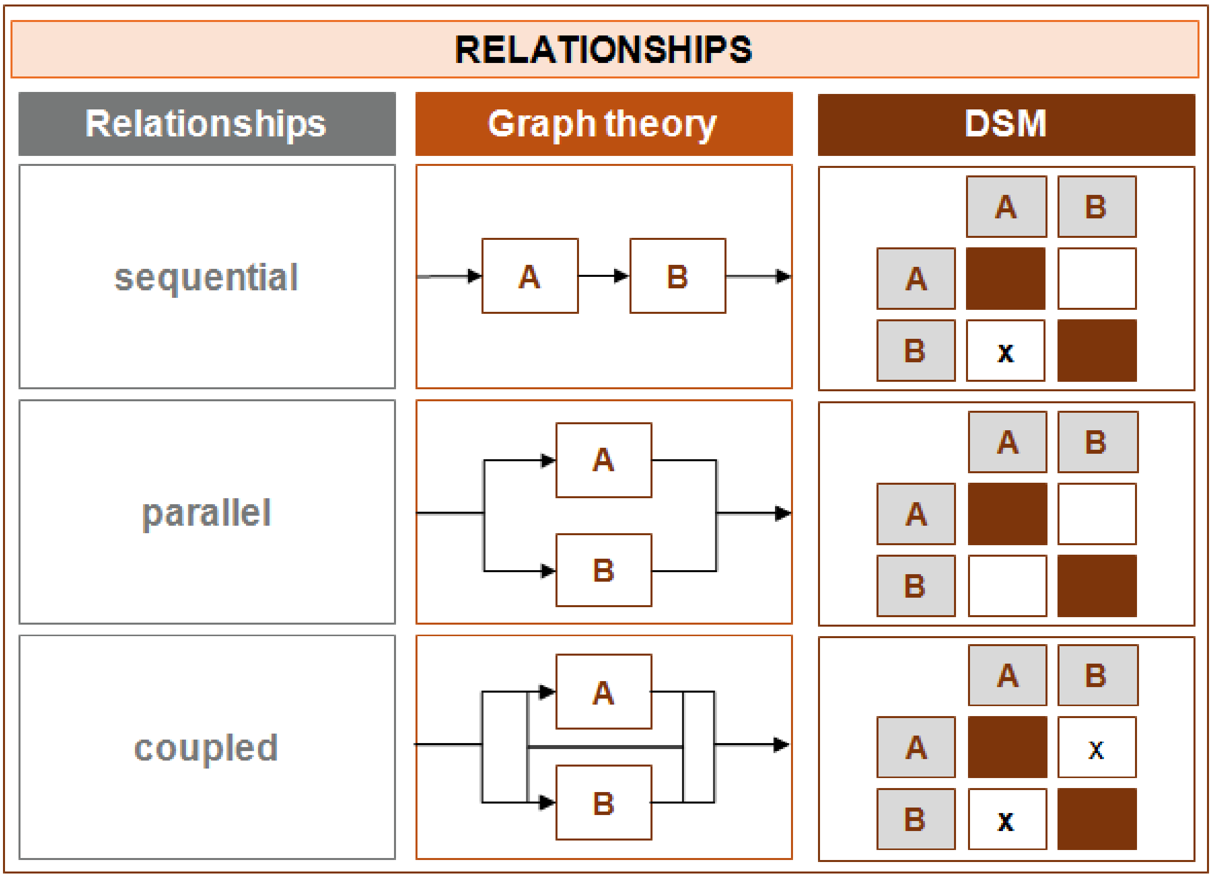


Figure 131: Relationships in graph theory and DSM (source: Browning, 1998; Eppinger, 1991)

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).

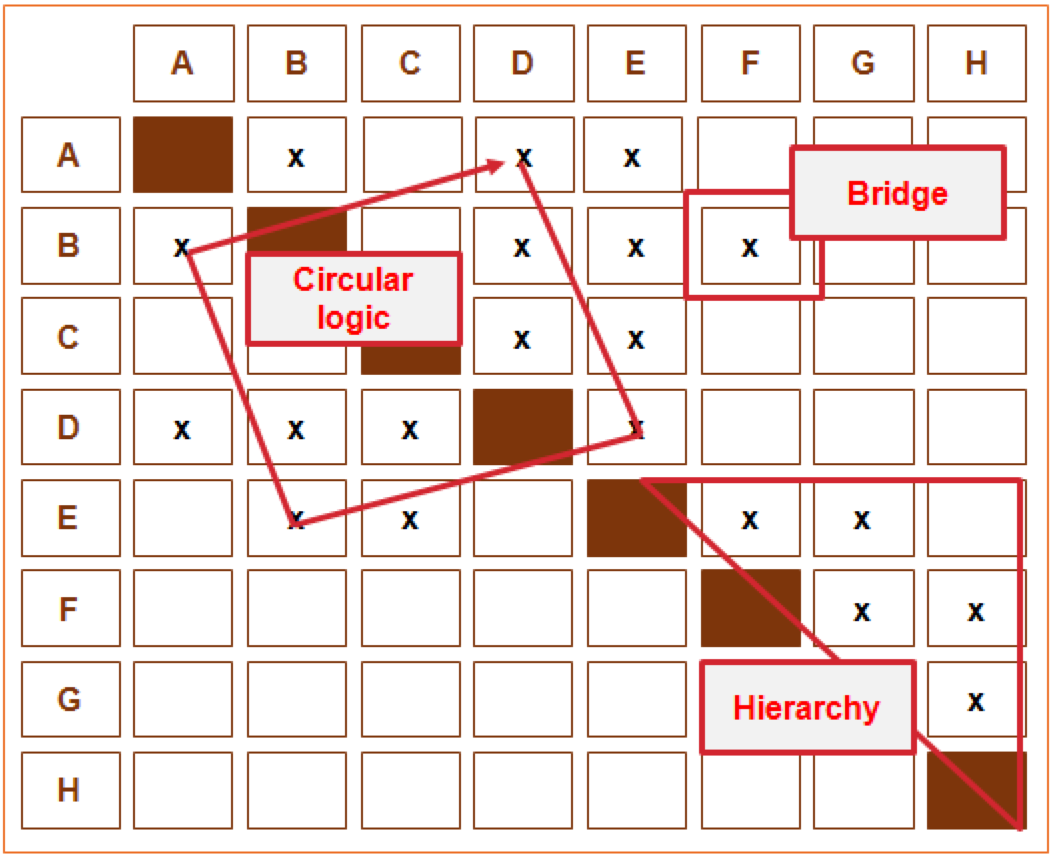


Figure 132: Special structure characteristics of a DSM (source: Lindemann, 2001)

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.

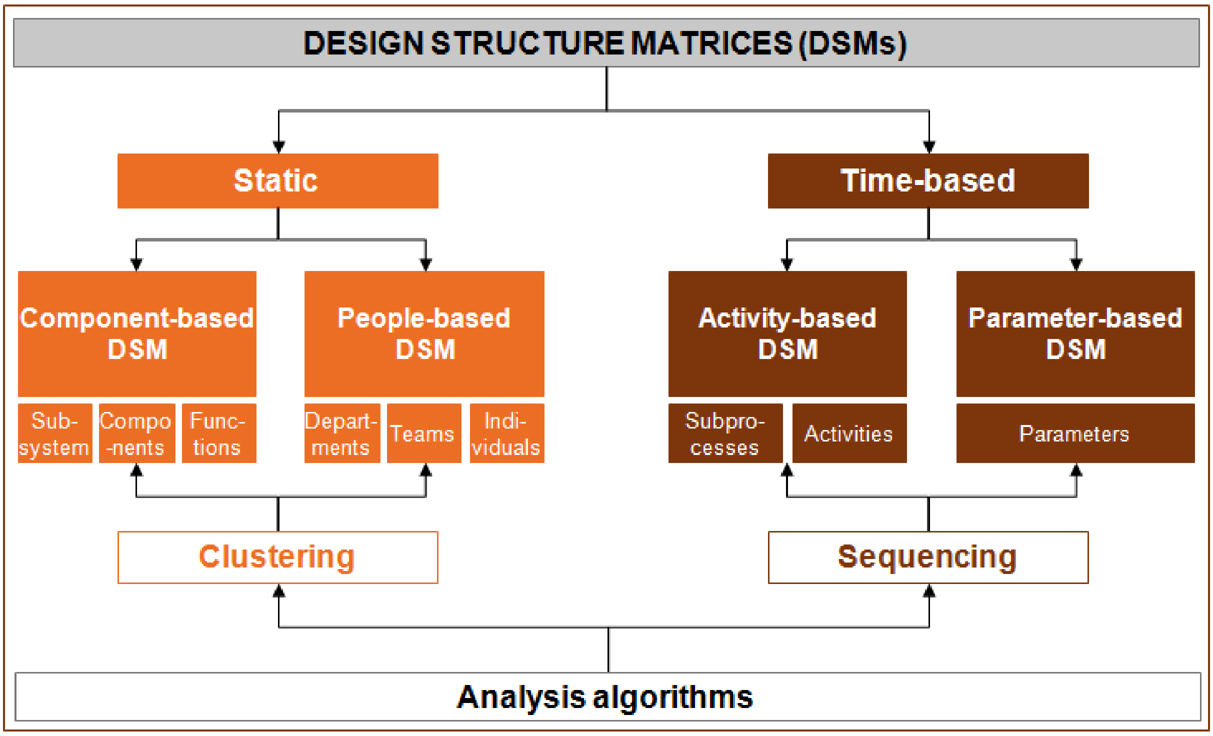


Figure 133: Classification of DSMs and algorithms (source: U. Lindemann et al., 2009)

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.

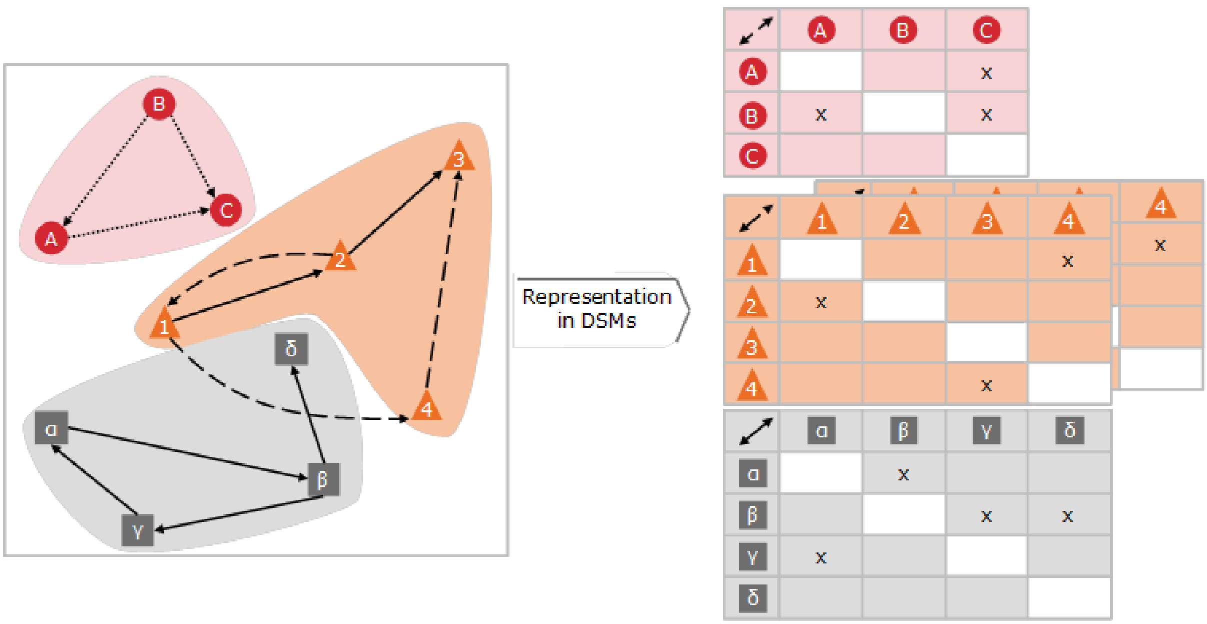


Figure 134: Graphic for a domain structure matrix (DSM) (source: Maurer, 2007)

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, 2012). 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):

Considering caveats on different DSMs		
Component DSM	**People DSM**	**Activity DSM**
– **Boundaries** of the system shall be defined for a better understanding of it and it becomes evident if components must be included or excluded. – Different marks, values or colours might help to understand the **kind of interaction**, as sometimes the interaction between components might not be well defined like vibrations, heat, magnetic fields etc. – Considering the **strength of interaction** by using a numerical DSM (values, letters, colours, graphics etc.) helps to understand varied levels of interactions. – Great richness in **granularity inside the DSM** would be too complex and limiting it would make it simple and meaningless. A size of 20-50 components is an approach for a manageable trade-off. – The **identification of relationships** might be partially described in handbooks, requirement specifications but it is almost de rigueur to ask experts to show the tacit and system-level know-how which is not documented.	– Great richness in **granularity inside the DSM** would be too complex and limiting it would make it simple and meaningless. Mostly it is done on team or individual level. A size of 20-50 components is an approach for a manageable trade-off. – **Data collection of communication interactions** should not only be focused on one individual like the team leader. This viewpoint should be always validated by a second opinion or even the full team. – To increase the **accuracy of the DSM**, both parties sender and receiver should be interviewed. If differences occur, these can be easily resolved by bringing both parties together. – Considering the **strength of interaction** by using a numerical DSM (values, letters, colours, graphics etc.) helps to understand varied levels of interactions. – For **dynamic** reason, as people hop on or off a project over time, it is helpful to consider a time frame desired in the DSM when collecting data.	– Considering the **strength of interaction** by using the probability/ impact of an activity in an numerical DSM (values, letters, colours, graphics etc.). – **Modelling as-is process first** for having a valid baseline to start from and implement improvements. – **Building and verifying the DSM model** by asking the activity owner of their input (mark of rows) and their output (mark of columns). – Great richness in **granularity inside the DSM** would be too complex and limiting it would make it simple and meaningless. A size of 30-70 components is an approach for a manageable trade-off. – **Internal/ external input should be presented** by using additional rows and coloumns. – **Additional attributes/ activities/ interactions** like maturity, requirements etc. should be considered carefully as effort increases – **Validation of DSM** by review with process owners and workers

Figure 135: Caveats on DSM types (source: derived from Eppinger & Browning, 2012)

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.

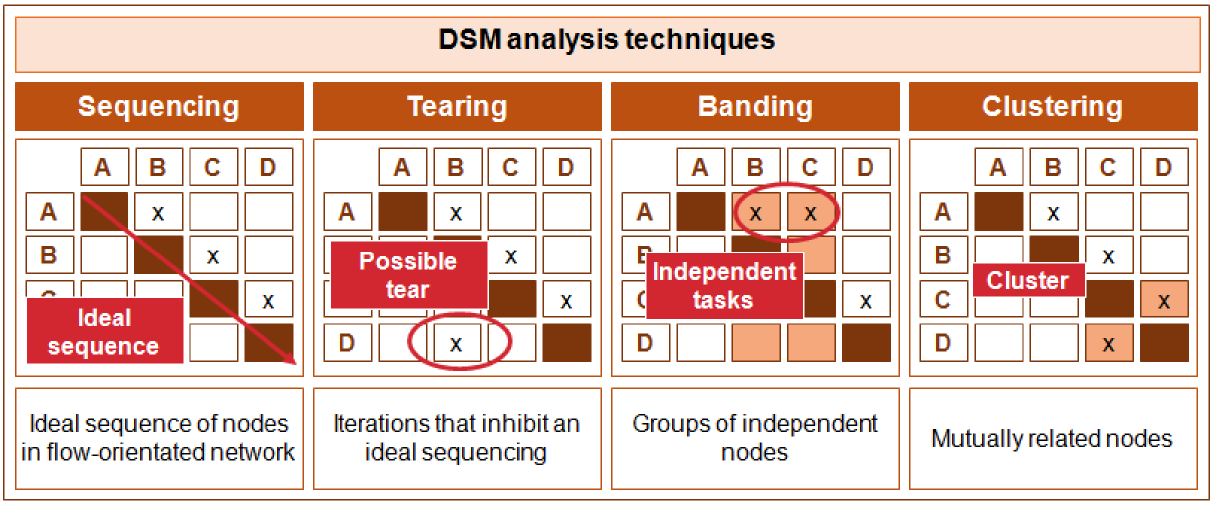


Figure 136: DSM analysis techniques (source: derived from Kreimeyer & Lindemann, (2011))

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).

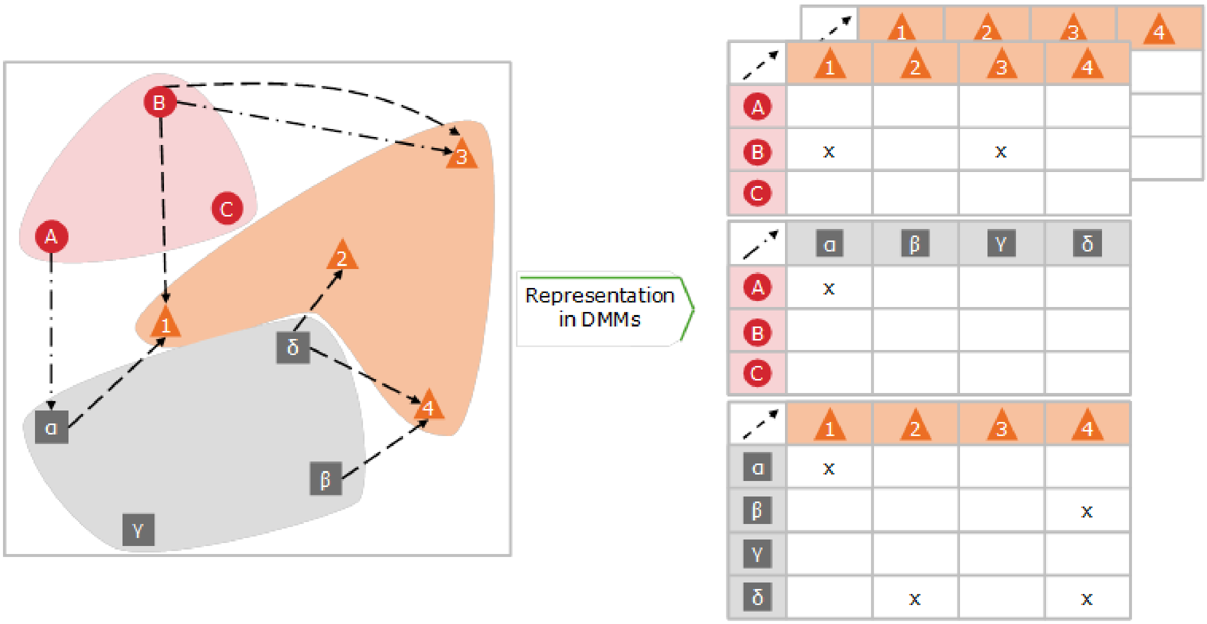


Figure 137: Graphic for a domain mapping matrix (DMM) (source: Maurer, 2007)

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.

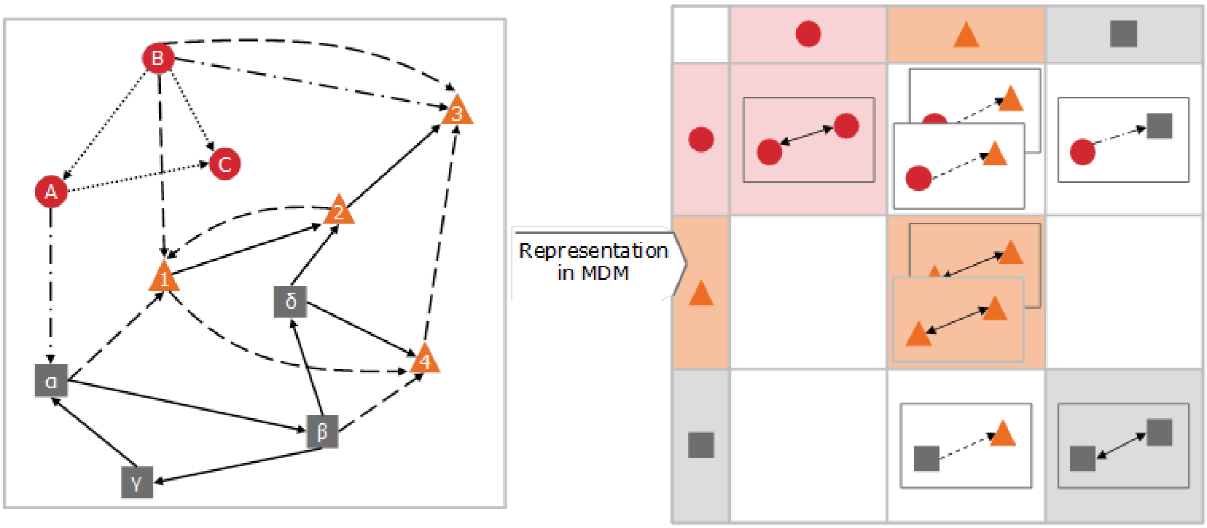


Figure 138: Graphic for a multiple domain matrix (MDM) (source: Maurer, 2007)

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.

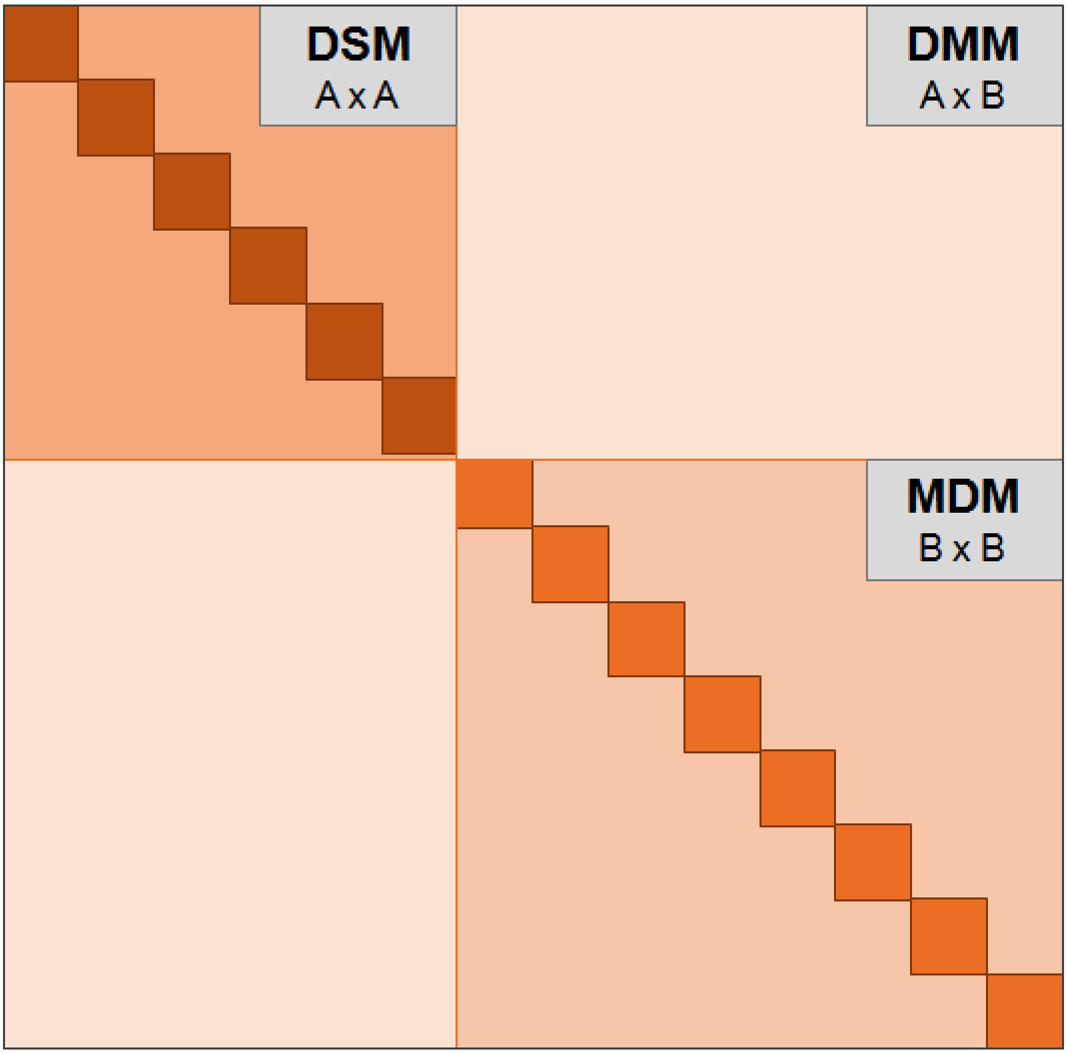


Figure 139: Arrangement of DSM, DMM and MDM (source: Eppinger & Browning, 2012)

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).

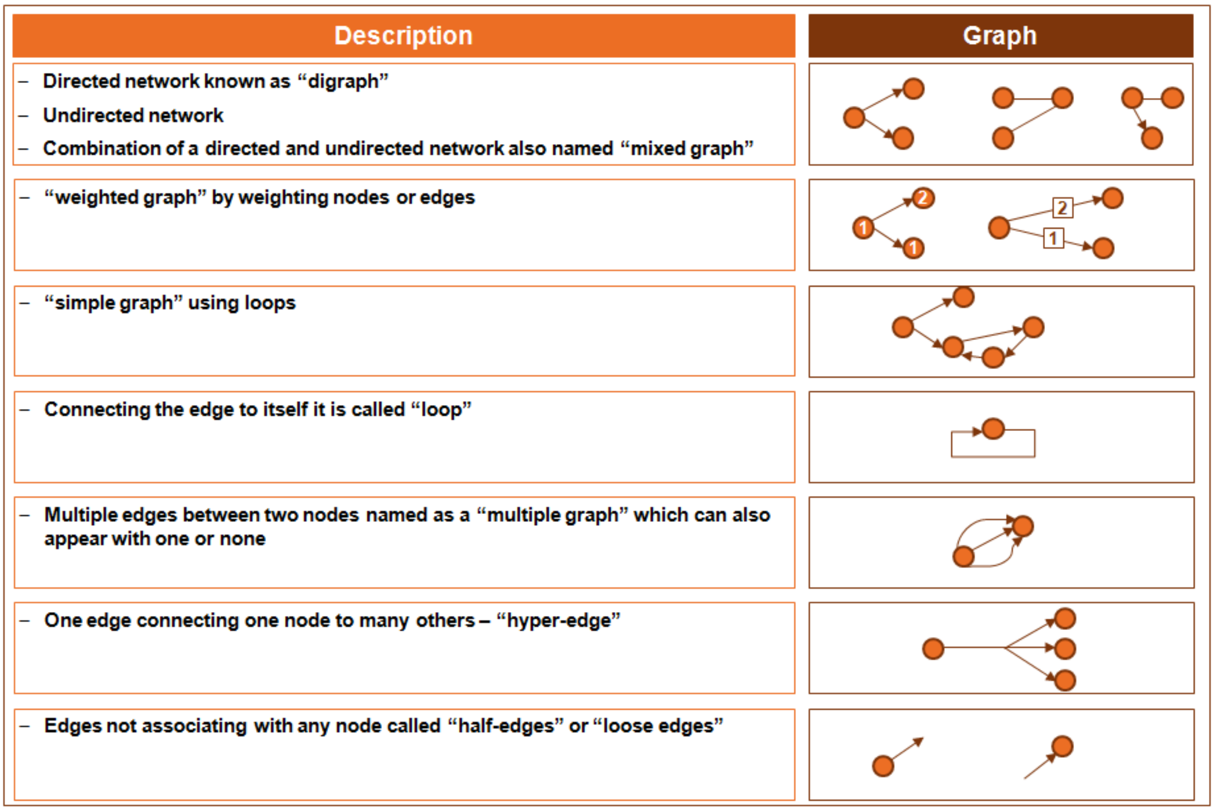


Figure 140: Basic properties of the graph theory (source: derived from Kreymeyer & Lindemann, 2011)

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 (Tscheulin, 2000). The ANP follows four axioms

(Blockus, 2010; Dellmann & Diehm, 2002; Peters, 2008; Saaty, 2001; H.-J. Zimmermann & Gutsche, 1991):

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).

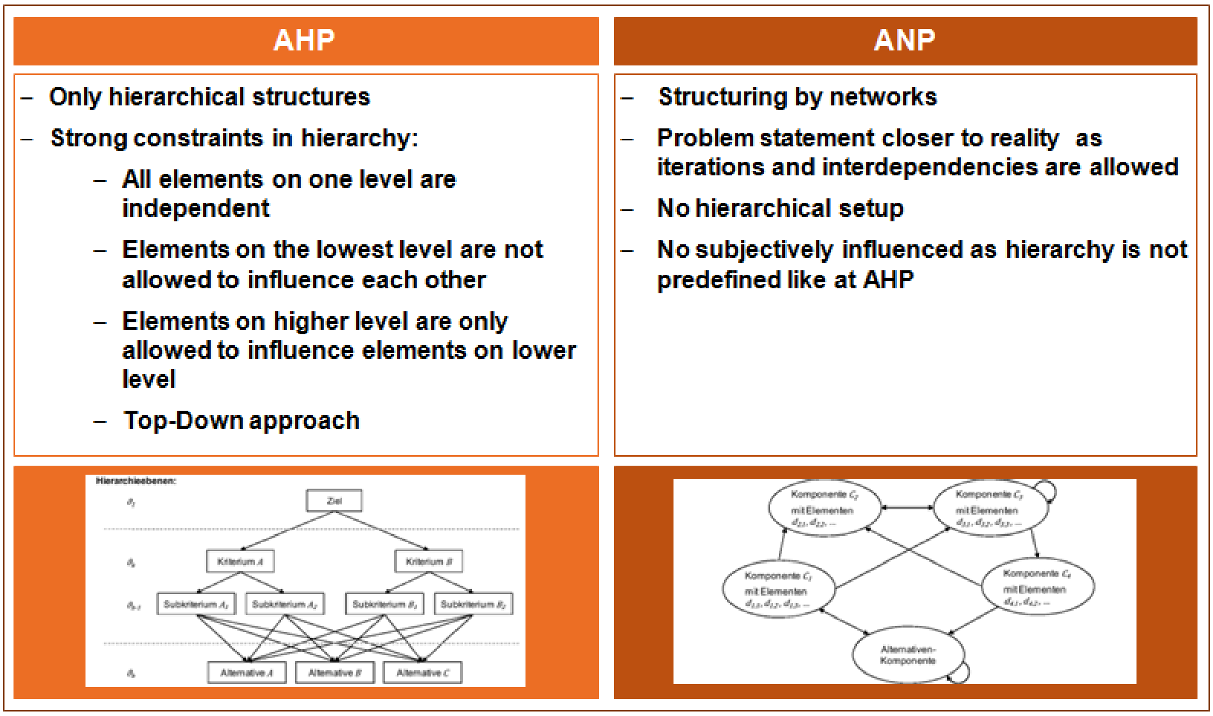


Figure 141: Differences between AHP and ANP (source: derived from Blockus, 2010; Dellmann & Diehm, 2002; Peters, 2008; Saaty, 2001; H.-J. Zimmermann & Gutsche, 1991)

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.

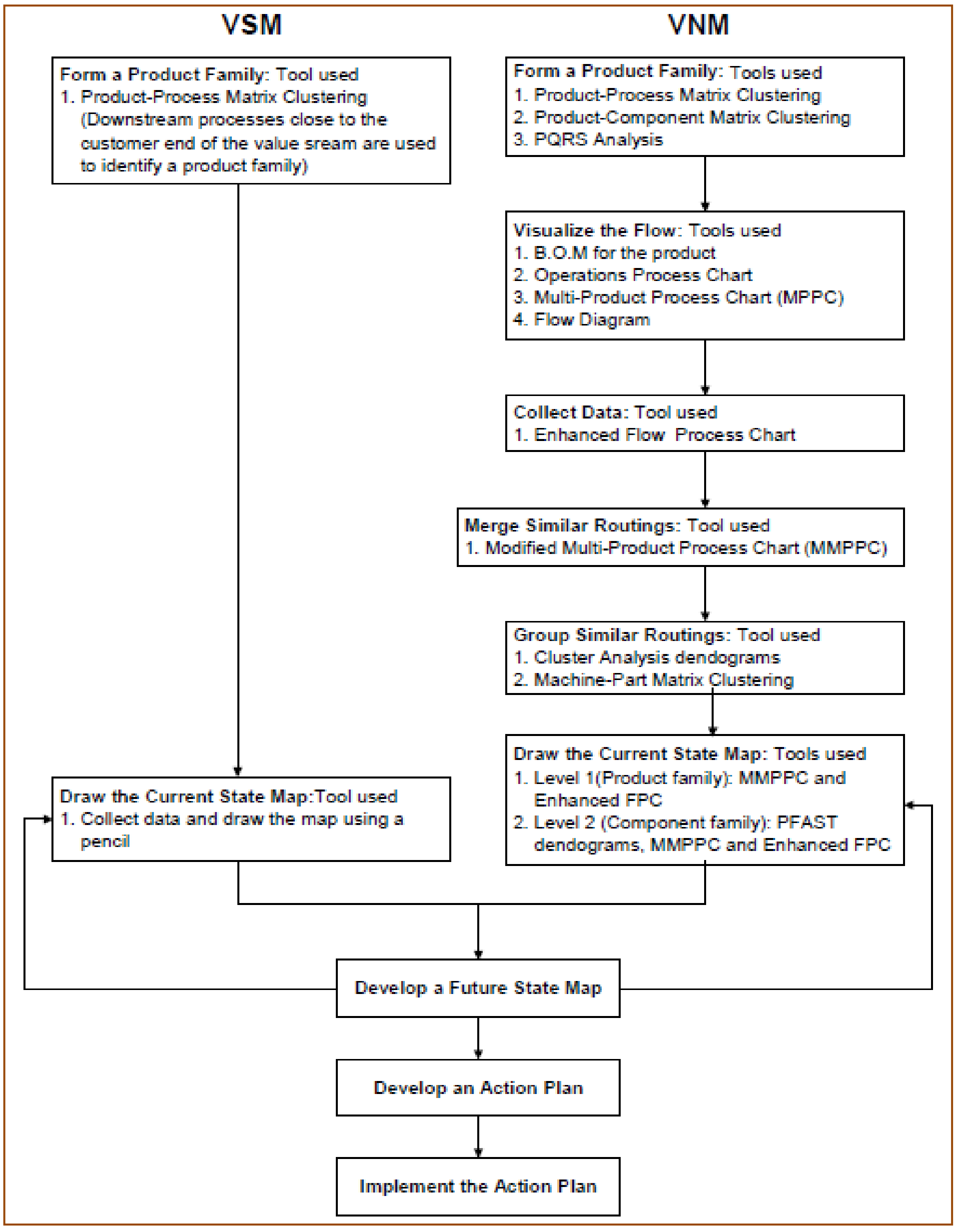


Figure 142: Comparison of Value Stream Mapping (VSM) and Value Network Mapping (VNM) (source: Khaswala & Shahrukh, 2001)

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).

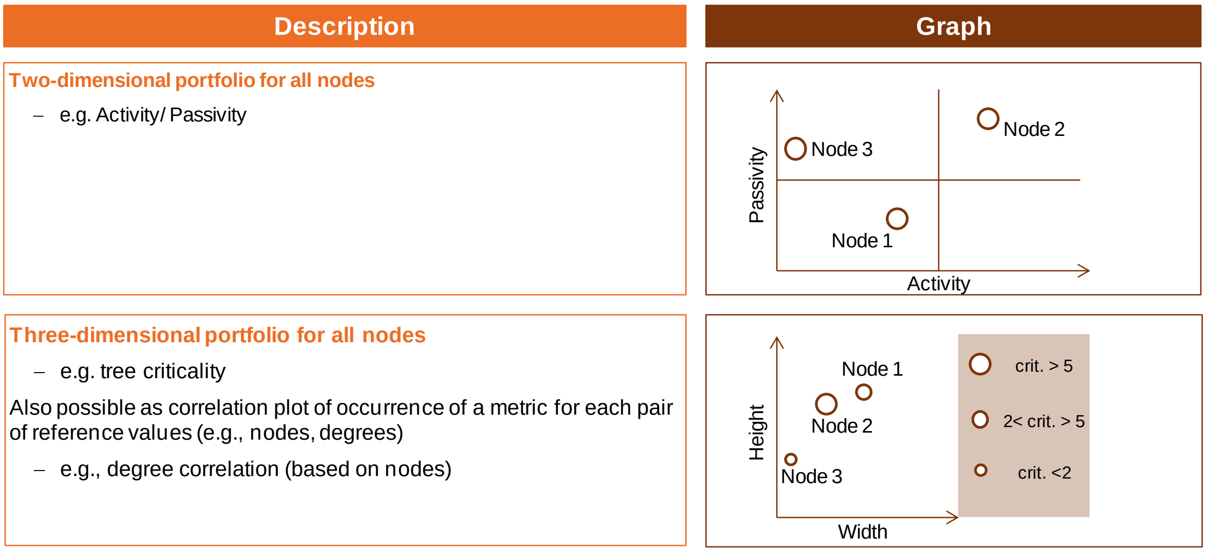


Figure 143: 2D/ 3D Portfolio (source: Kreimeyer & Lindemann, 2011)

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).

APPENDIX XXVI – RESULTS PILOT-TEST: ONLINE SURVEY

	Test person I	Test person II	Test person III	Test person IV	Test person V	Test person VI	Test person VII	Test person VIII	Test person IX
CTT-1 - project and project manager: Specific questions about the own project and project manager									
Q1: Typing error … an credential …	✗		✗						✗
Q6: Understanding Definition of sub-project is missing						✗			
Q7: Typing error Your project is placed in ? → is placed in …							✗		
Q8: Typing error …want to anser… → answer			✗				✗		✗
Q10: Grammar …and **finally** success? → …and **final** success							✗		
Q10: Understanding …overall success of project/ knowledge area?	✗								
CTT-2 - complexity enablers: Influence and impact of complexity enablers									
Q11: Typing error … ofthe… → of the	✗		✗	✗			✗		✗
Q11: Grammar **„enabler“** no BE-word → **strengtheners**						✗			
Q11: Typing error … time/ schedule → …time schedule	✗								
Q11: Understanding Time limited actuality → ephemerality	✗						✗		
Q11: Typing error Amount of stakeholder → …of stakeholders					✗				✗
Q11: Logic Question 11 & 12 are not thematically linked					✗				
CTT-3 - Linkage complexity/ PM standards: Linkage and management of complexity with standard PM methods									
Q14: Understanding Cognitive…inferentiation → implication	✗								
Q14: Set-up Changed order in answer options					✗				
Q14: Grammar Phrase continuation not logical (e.g. cognitive)					✗				

	Test person I	Test person II	Test person III	Test person IV	Test person V	Test person VI	Test person VII	Test person VIII	Test person IX
CTT-4 - vulnerable blocks for complexity: Project management vulnerable blocks for complexity									
Q16/17: Typing error Project carter → Project charter		x	x		x		x		
Q16/17: Q-arrangement Start with most vulnerable processes				x					
Q16: Grammar …10 least processes → …least **vulnerable** …					x		x		
Q17: Grammar …10 most processes → …most **vulnerable** …					x		x		
Q16/17: Function Shall not be a mandatory question		x							
CTT-5 - Complexity specific skills and methods: Complexity specific skills and methods for successful management									
Q18: Logic Choosing no answer or no, questions proceed			x						
Q19: Typing error Chritical chain method → Critical chain method	x								
Q19: Typing error WBS + Dictionary → … + **WBS** dictionary	x								
Q19: Typing error Resouce leveling → Resource levelling	x								
Q20: Understanding … other tools do … → …tools/ **methods** …	x					x			
Q24: Typing error …feed-back … → … feedback …			x				x		

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.

CTT-1 - project and project manager: Specific questions about the own project and project manager

Question1:

Are you a credential holder of the PMP (PMI)?
Choose one of the following answers

- ○ Yes
- ○ No
- ○ No answer

Question2:

Since when do you hold the PMP (PMI) certification?
Choose one of the following answers

Please choose...

Question3:

Do you hold other certifications for project management except PMP (PMI)?
Check any that apply

- ☐ None
- ☐ PMSA (Project Management South Africa) by SAQA (South African Qualification Authority)
- ☐ PRINCE2 (PRoject IN Controlled ENvironment) by OGC (Office of Government Commerce)
- ☐ P2M (Project and Programme Management for Entreprise Innovation) by PMAJ (Project Management Association of Japan)
- ☐ NCSPM (National Competency Standard for Project Management by AIPM (Australian Institute of Project Management)
- ☐ ICB3.0 (International Competence Baseline) by IPMA (International Project Management Association)
- ☐ BS6079 (Bristish Standard for Project Management) by BSI (British Standard Institute)
- ☐ Other:

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

Question7:

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
- Extorital organisation
- Other:

Question8:

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.

Question9:

How would you categorize the size of your project?
Choose one of the following answers

small | medium | large | major

Question10:

How do you estimate the quality of your project according to the PMI knowledge areas and final success?

	poor	weak	neutral	good	very good	No answer
Integration management						
Scope management						
Schedule management						
Cost management						
Quality management						
Human resouce management						
Communication management						
Risk management						
Procurement management						
Overall project's success						

CTT-2 - complexity enablers: Influence and impact of complexity enablers

Question 11:

Which of the following strengthener (multiplier) for complexity affects your project? Mark your top five items.
Please select between 0 and 5 answers

- ☐ Virtuell techniques
- ☐ Incompatible systems/ tools
- ☐ Laws/ norms/ regulations
- ☐ Size of project/ organisation
- ☐ Internationality (countries/ facilities)
- ☐ Int./ ext. interfaces
- ☐ Technical-/ product diversity
- ☐ Amount of stakeholders
- ☐ Changes in time schedule
- ☐ Partitionment of work/ competency/ responsibility
- ☐ Market dynamics (flexibility)
- ☐ Organisational changes
- ☐ Time limited actuality (ephemerality)
- ☐ Communication/ decision process
- ☐ Cultural diversity
- ☐ Customer requirements
- ☐ Other:

Question 12:

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

	1 (= low)	2	3	4	5 (= high)
Complexity	○	○	○	○	○

CTT-3 - Linkage complexity/ PM standards: Linkage and management of complexity with standard PM methods

Question 13:

How do you manage complexity?
Check any that apply

- ☐ Eliminate
- ☐ Reduce
- ☐ Not at all
- ☐ Control

Question 14 (optional depending on selected answer in question 13):

How do you control complexity? By...
Choose one of the following answers

- ○ 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-viously planned
- ○ EVOLUTIONARY, 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, proofing 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 realizedand the actual situation is observed for involving it into the future
- ○ CONSTRUCTIVISTIC, making rational decisions for problem solutions: target 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 ...
Choose one of the following answers

- ○ 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).
Please select between 0 and 10 answers

- ☐ Create project charter
- ☐ Identify stakeholder
- ☐ Develop project management plan
- ☐ Collect requirements
- ☐ Define scope
- ☐ Create work breakdown structure
- ☐ Define activities
- ☐ Sequence activities
- ☐ Estimate resources
- ☐ Estimate duration
- ☐ Define schedule
- ☐ Estimate costs
- ☐ Determine budget
- ☐ Plan quality/ develop QM plan
- ☐ Develop human resource plan
- ☐ Plan communication
- ☐ Plan risk management
- ☐ Identify risks
- ☐ Perform qualitative risk management
- ☐ Perform quantitative risk management
- ☐ Plan risk responsibilities
- ☐ Plan procurement
- ☐ Direct + manage project execution
- ☐ Perform quality assurance
- ☐ Acquire project team
- ☐ Develop project team
- ☐ Manage team
- ☐ Distribute information
- ☐ Manage stakeholder
- ☐ Conduct procurement
- ☐ Monitor and control project work
- ☐ Perform integrated change control
- ☐ Verify scope
- ☐ Control scope
- ☐ Control schedule
- ☐ Control costs
- ☐ Control quality
- ☐ Report performance
- ☐ Control and monitor risks
- ☐ Administer procurement
- ☐ Close project or phase
- ☐ Close procurements

Question 17

Name the processes vulnerable to complexity in your project. Mark the 10 least vulnerable processes (PMI standard).
Please select between 0 and 10 answers

- ☐ Create project charter
- ☐ Identify stakeholder
- ☐ Develop project management plan
- ☐ Collect requirements
- ☐ Define scope
- ☐ Create work breakdown structure
- ☐ Define activities
- ☐ Sequence activities
- ☐ Estimate resources
- ☐ Estimate duration
- ☐ Define schedule
- ☐ Estimate costs
- ☐ Determine budget
- ☐ Plan quality/ develop QM plan
- ☐ Develop human resource plan
- ☐ Plan communication
- ☐ Plan risk management
- ☐ Identify risks
- ☐ Perform qualitative risk management
- ☐ Perform quantitative risk management
- ☐ Plan risk responsibilities
- ☐ Plan procurement
- ☐ Direct + manage project execution
- ☐ Perform quality assurance
- ☐ Acquire project team
- ☐ Develop project team
- ☐ Manage team
- ☐ Distribute information
- ☐ Manage stakeholder
- ☐ Conduct procurement
- ☐ Monitor and control project work
- ☐ Perform integrated change control
- ☐ Verify scope
- ☐ Control scope
- ☐ Control schedule
- ☐ Control costs
- ☐ Control quality
- ☐ Report performance
- ☐ Control and monitor risks
- ☐ Administer procurement
- ☐ Close project or phase
- ☐ Close procurements

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?
Choose one of the following answers

- ○ 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?
Check any that apply

- ☐ Critical path method
- ☐ Mindmap
- ☐ RBS (resource breakdown structure)
- ☐ Scatter diagram
- ☐ Control-, flow-and run charts
- ☐ Trend analysis
- ☐ Performance reviews
- ☐ SWOT analysis
- ☐ Risk audits
- ☐ WBS + WBS Dictionary
- ☐ Change control meetings
- ☐ PM informa-tion systems
- ☐ Benchmark
- ☐ PERT analysis
- ☐ Product analysis (breakdown/ system analysis)
- ☐ Stakeholderanalysis
- ☐ Record mngt. system (cost/schedule/ HR/ quality etc)
- ☐ Network diagram
- ☐ Make/ buy analysis
- ☐ Project management plan
- ☐ Process analysis
- ☐ Variance analysis
- ☐ Requirement traceability matrix
- ☐ Checklists
- ☐ Procurement audits
- ☐ Quality audits
- ☐ Earned value mgnt.
- ☐ Rolling wave planning
- ☐ Schedule compression
- ☐ Project charter
- ☐ Resouce levelling
- ☐ Risk register
- ☐ RASI Chart
- ☐ Issue log
- ☐ Project scope statement
- ☐ Precedence diagram-ming method
- ☐ Pareto diagram
- ☐ Reserve analysis
- ☐ No Answer
- ☐ Communication analysis (channels)
- ☐ Cause-effect diagram
- ☐ Adjusting leads and lags
- ☐ Performance reports
- ☐ Scenario analysis
- ☐ Critical chain method
- ☐ SWOT analysis
- ☐ Monte Carlo analysis
- ☐ Conflict management
- ☐ Authorizationsystems

CTT-5 - Complexity specific skills and methods: Complexity specific skills and methods for successful management

Question20 (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

Question21:

Would you prefer a separate chapter for managing complexity in PM standards?
Choose one of the following answers

- ○ Yes
- ○ No
- ◉ No answer

Question22:

Which method would you implement in the PM standard to handle complexity?
Please select at least one answer

- [ ] Balanced Score Card
- [ ] Fuzzy logic
- [ ] Portfolio
- [ ] None
- [ ] Mindmap
- [ ] Concept map
- [ ] Scenario analysis
- [ ] Graph theory – network/ arrow
- [ ] Data structural matrix
- [ ] Graph theory – Gantt/ Pert/ CPM
- [ ] Rich picture
- [ ] Other:

Question23:

If you would like to recieve my findings on this research, please add your email adress. Results are expected by end of 2014.

Question24:

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 regrads
Christian Tresselt

APPENDIX XXVIII – RESULTS PILOT-TEST: FOCUS GROUP INTERVIEW

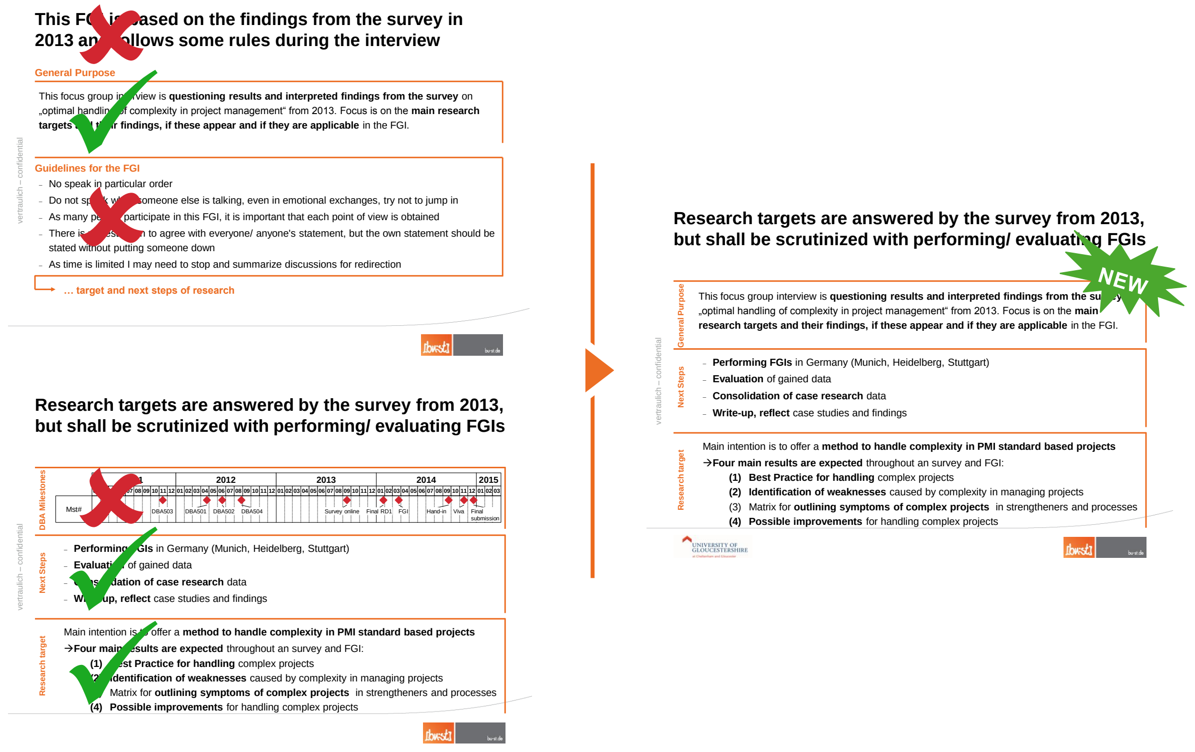


Figure 145: Changes in FGI guide - introduction (developed by author)

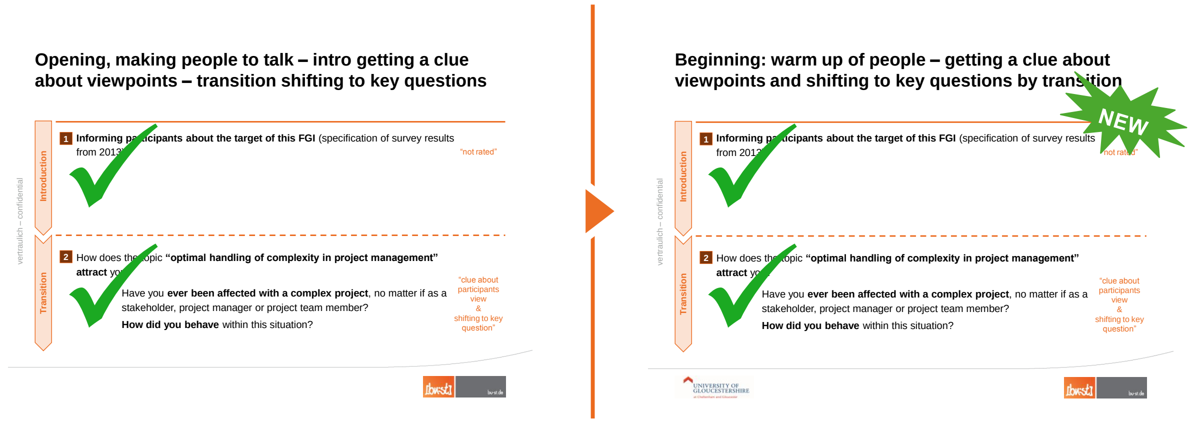


Figure 146: Changes in FGI guide – initiation/ transition (developed by author)

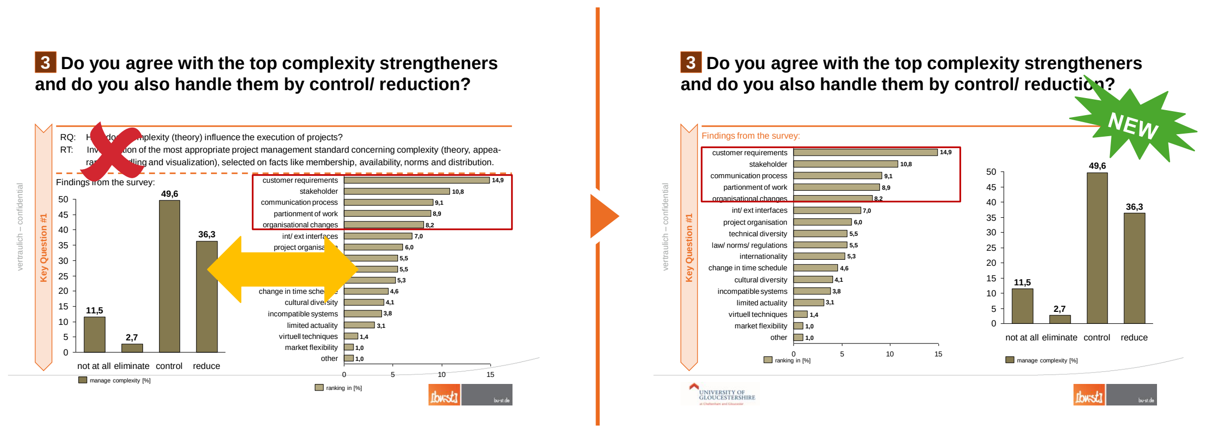


Figure 147: Changes in FGI guide - key question #1 (developed by author)

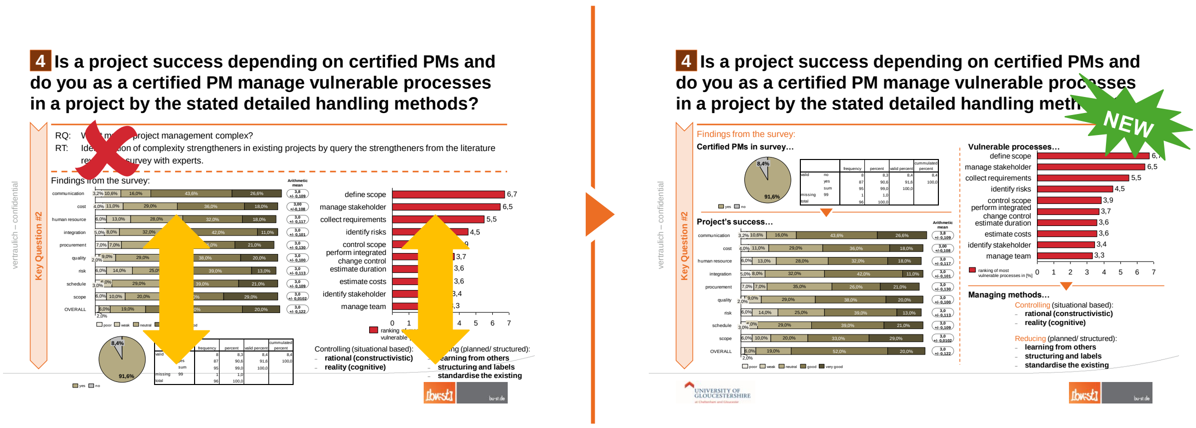


Figure 148: Changes in FGI guide - key question #2 (developed by author)

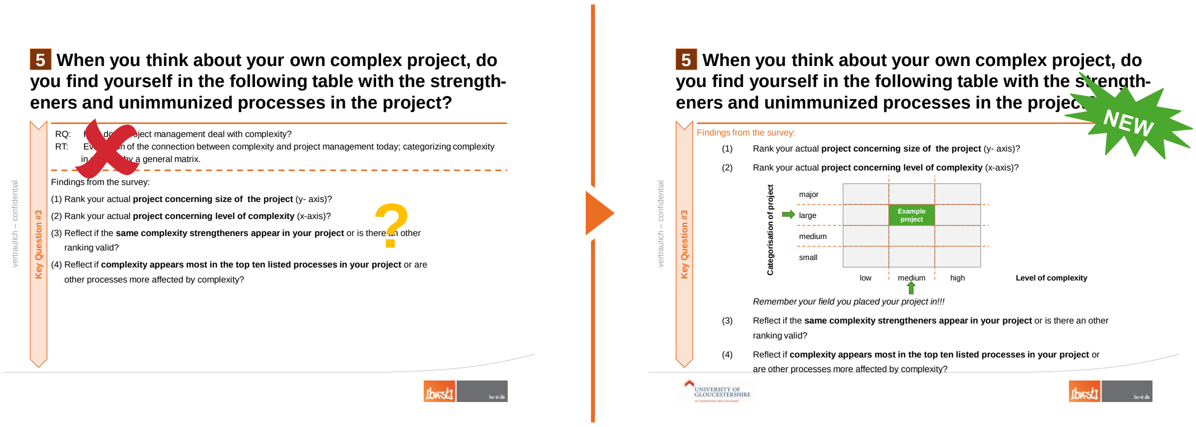


Figure 149: Changes in FGI guide - key question #3, categorisation (developed by author)

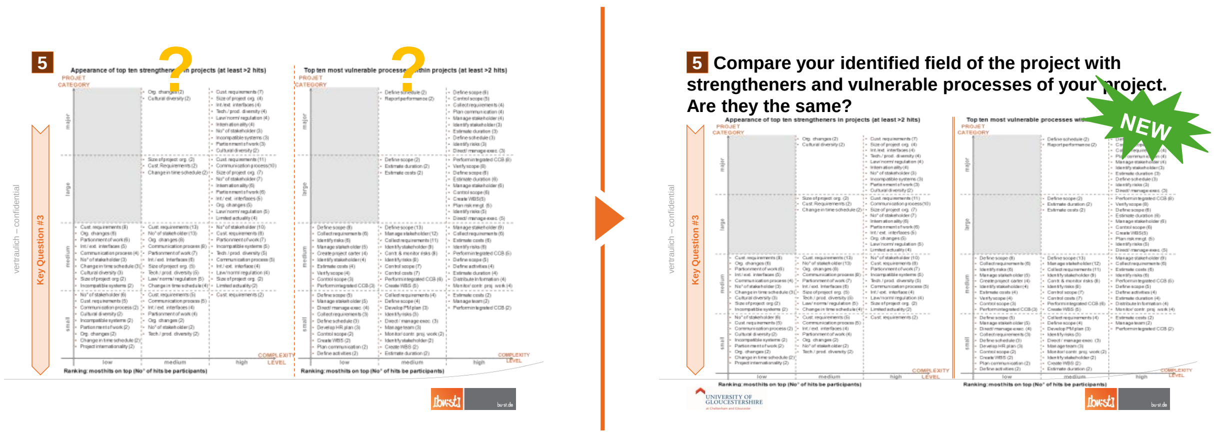


Figure 150: Changes in FGI guide - key question #3, comparison (developed by author)

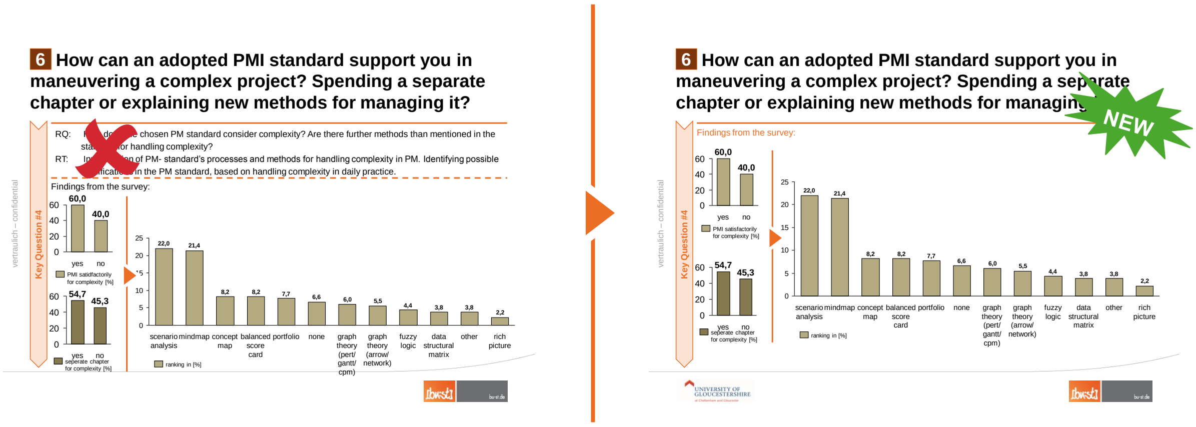


Figure 151: Changes in FGI guide - key question #4 (developed by author)

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.

Figure 152: FGI guide, page 1 (developed by author)

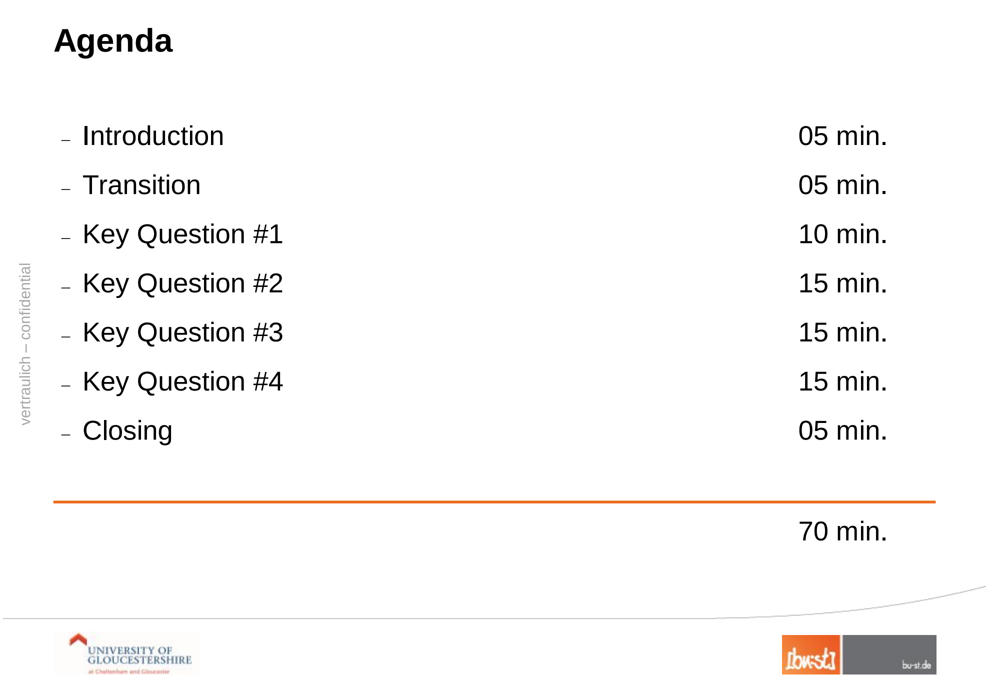


Figure 153: FGI guide, page 2 (developed by author)

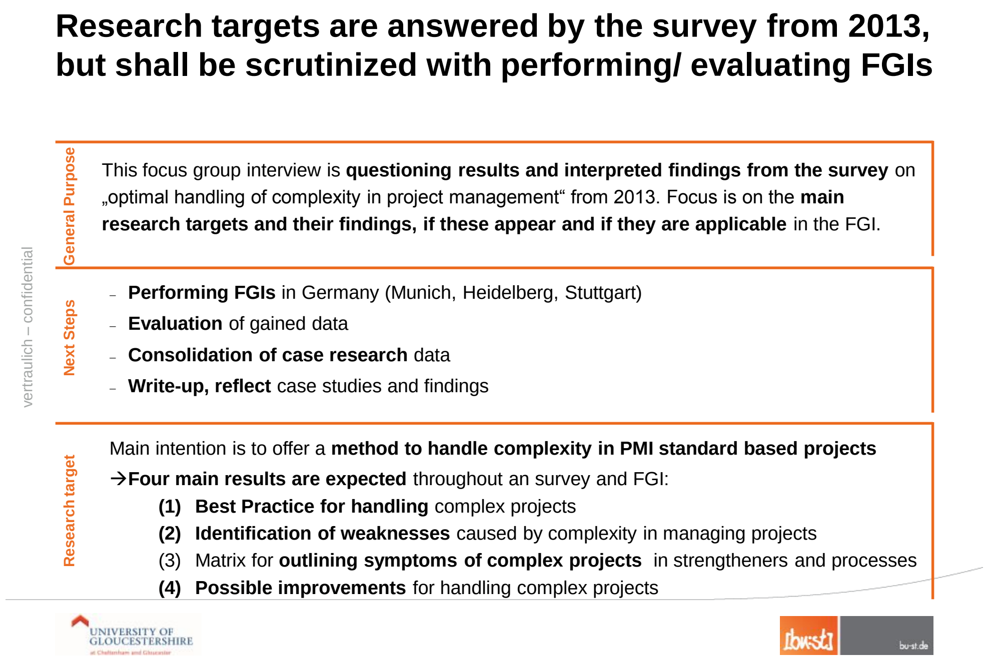


Figure 154: FGI guide, page 3 (developed by author)

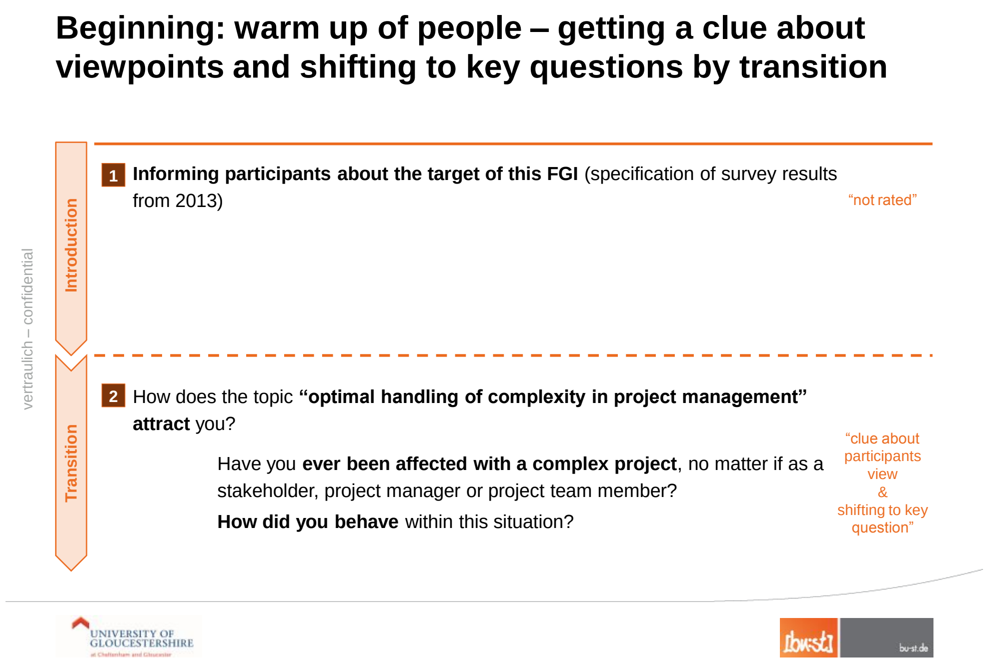


Figure 155: FGI guide, page 4 (developed by author)

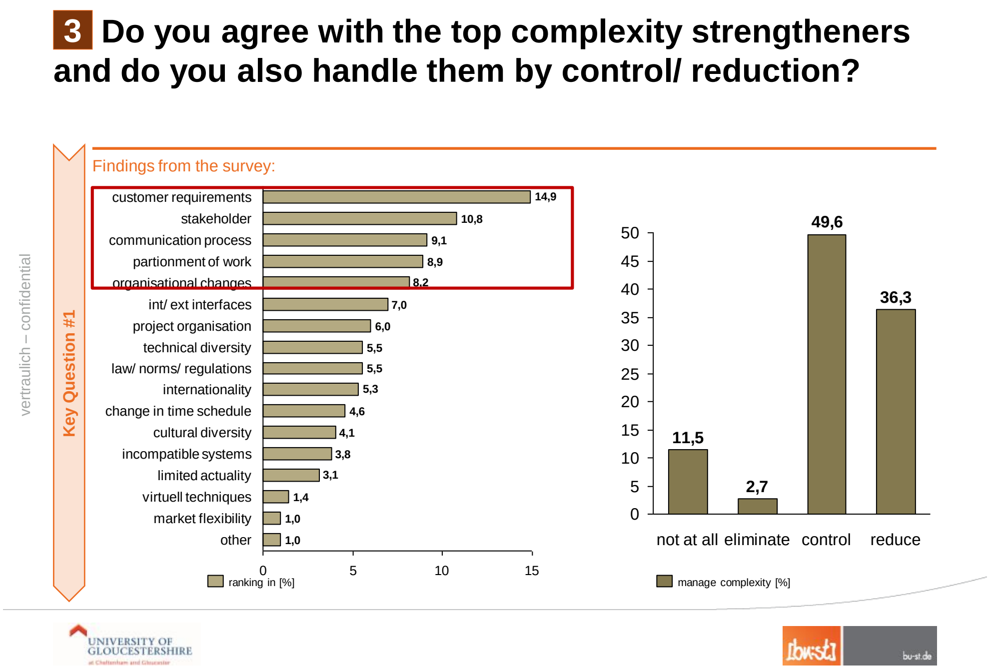


Figure 156: FGI guide, page 5 (developed by author)

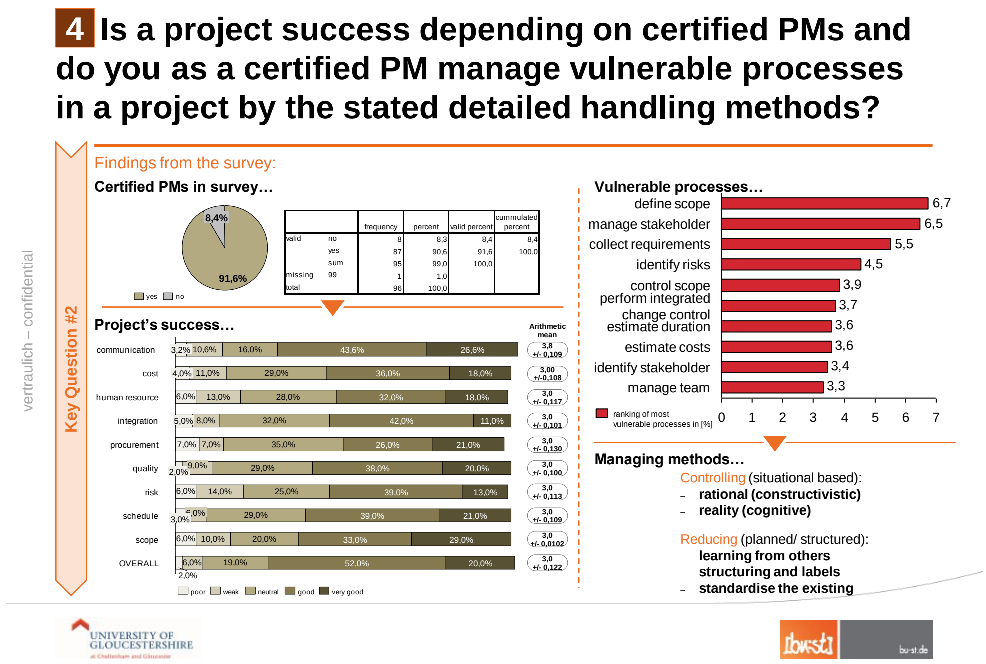


Figure 157: FGI guide, page 6 (developed by author)

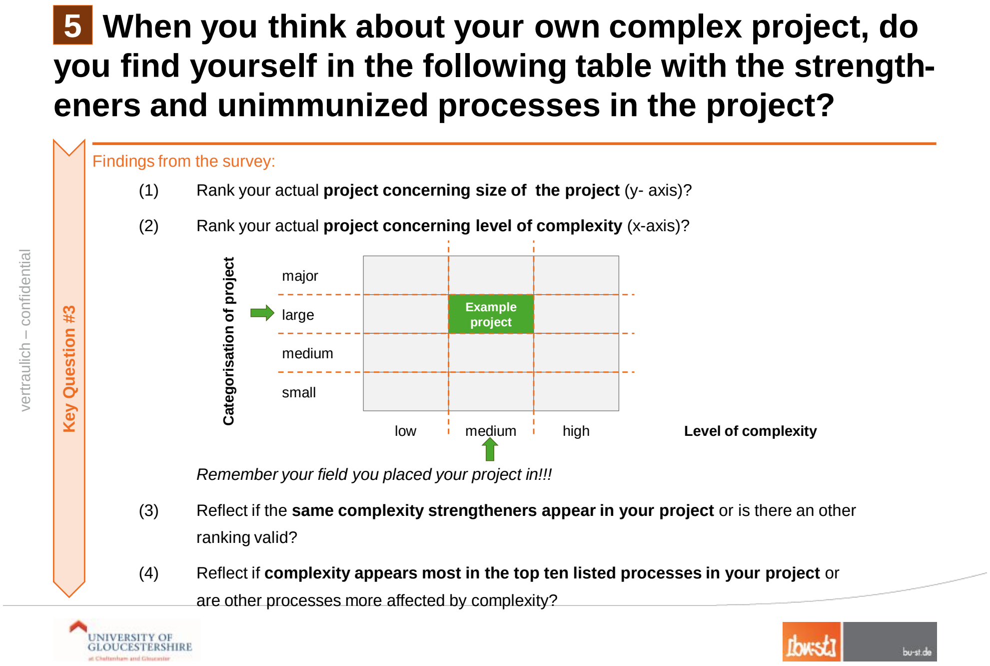


Figure 158: FGI guide, page 7 (developed by author)

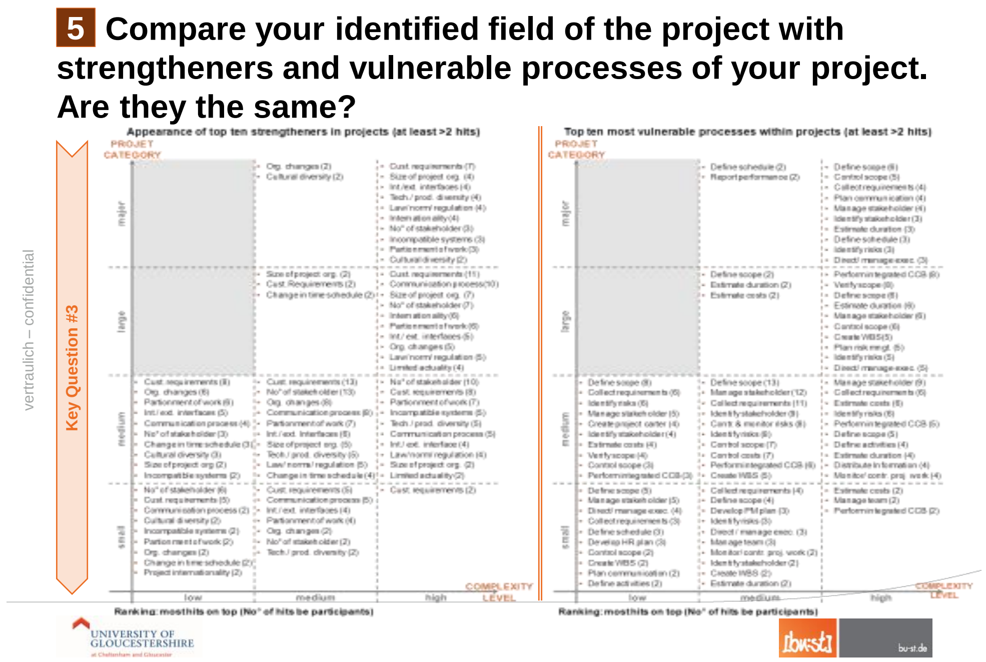


Figure 159: FGI guide, page 8 (developed by author)

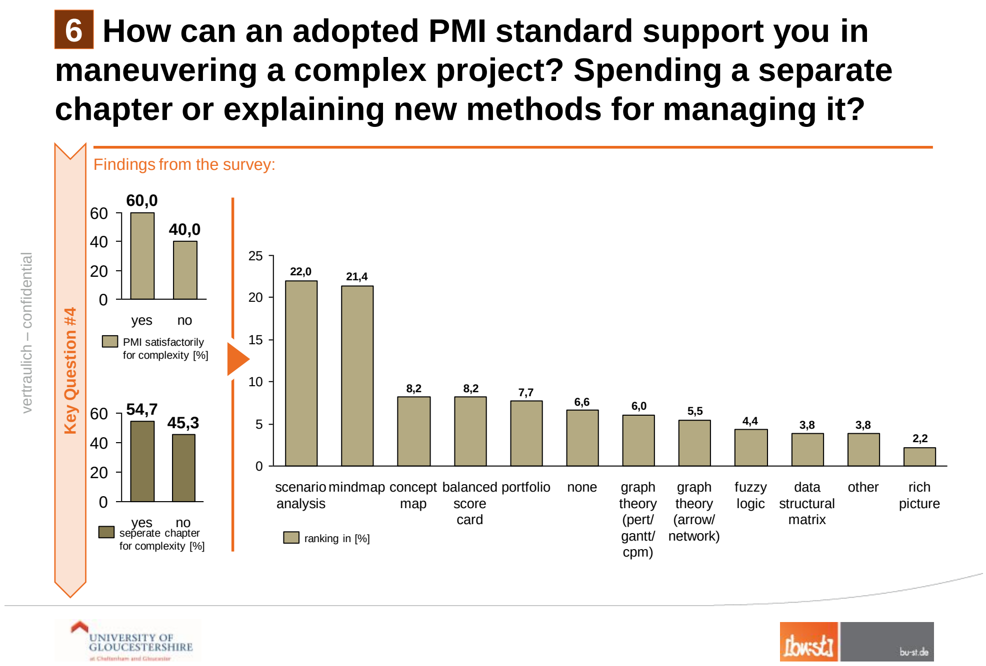


Figure 160: FGI guide, page 9 (developed by author)

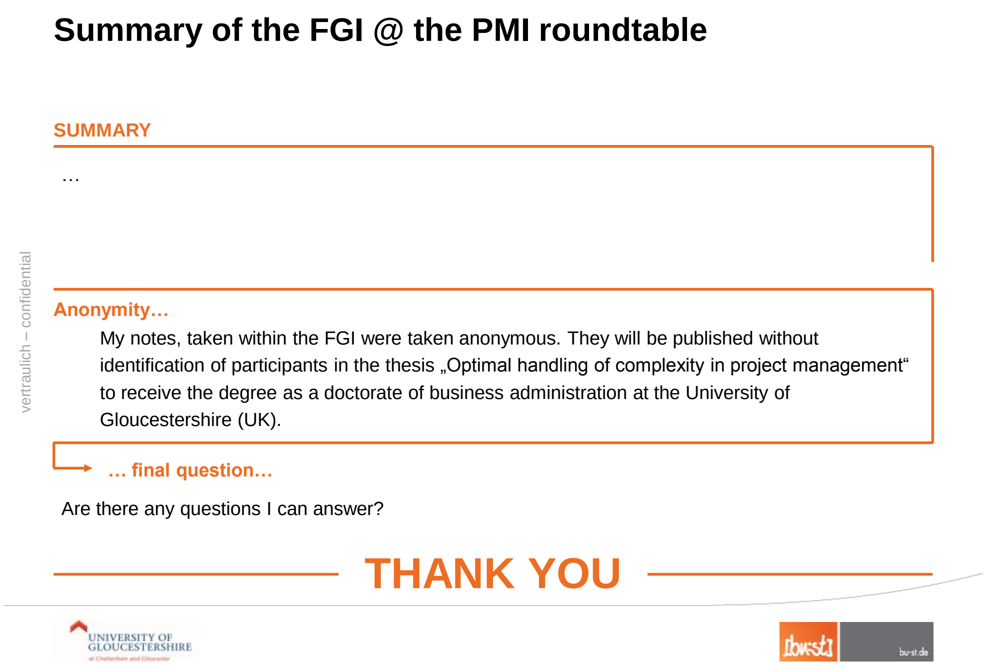


Figure 161: FGI guide, page 10 (developed by author)

Reference List

Abdelkafi, N. (2008). *Variety induced complexity in mass customization: concepts and management* (Vol. 7). Berlin, DE: Erich Schmidt Verlag.

AFITEP. (2011). L'Association Francophone de Management de Project. Retrieved January 2, 2012, from http://www.afitep.org/

Afuah, A. (2003). *Business models: a strategic management approach* (1st ed.). New York, NY, US: McGraw-Hill.

Aichele, C. (2006). *Intelligentes Projektmanagement* (1st ed.). Stuttgart, DE: W. Kohlhammer GmbH.

Alisch, K., Winter, E., & Arentzen, U. (2004). *Gabler Wirtschaftslexikon* (16th ed.). Wiesbaden, DE: Gabler.

Amberg, M., Prinz, W., Sandrina-Arndt, B., & Thomas, R. L. (2009). Project Management Office (PMO) als strategischer Katalysator für erfolgreiche Unternehmen. *Projekt management aktuell*, *20*(5), 34–40.

American Project Management Group. (2011). APMG-International - What is Prince2. Retrieved from http://www.apmg-international.com/APMG-UK/PRINCE2/AboutPRINCE2/WhatIsPRINCE2.asp

American Society for the Advancement of Project Management. (2011a). American Society for the Advancement of Project Management. Retrieved from http://www.asapm.org/

American Society for the Advancement of Project Management. (2011b). ASAPM.org/mission. Retrieved from http://www.asapm.org/a_mission.asp

American Society for the Advancement of Project Management. (2011c). ASAPM.org/whoweare. Retrieved June 4, 2011, from http://www.asapm.org/a_home.asp

ANIMP. (2011). Associazone Nazionale di Impiantistica Industriale. Retrieved from http://www.animp.it/chisiamo.aspx

Antoni, M., & Riekhof, H.-C. (1990). Strategieentwicklung mittels Portfolioanalyse. In *Strategieentwicklung*. Stuttgart, DE: Poeschel.

APDP. (2011). Peruvian Project Management Association. Retrieved from http://www.apdp.pe/Bienvenida.php

APOGEP. (2011). APOGEP - IPMA PORTUGAL. Retrieved from http://apogep.pt/

Ashby, R. W. (1956). *An introduction to cybernetics*. New York, NY, USA: Wiley Publishing.

Association for Project Management. (2011). Association for Project Management. Retrieved from http://www.apm.org.uk/History

Association for Project Management in Bosnia and Herzegovian. (2011). Association for Project Management in Bosnia and Herzegovian. Retrieved from http://www.uup.ba/

Association for Project Management South Africa. (2011). Association for Project Management South Africa. Retrieved from http://www.apmsa.org.za/pages/page.php?pid=7

Australian Government - Department of Education and Training. (2010). BSB07 Business Services training package: Introduction, qualification guide, assessment guidelines. Australian Government - Department of Education and Training. Retrieved from http://www.totaltrainingsolutions.com.au/Business%20Services/BSB07_1.pdf

Australian Institute of Project Management. (2011a). AIPM course endorsement. Retrieved from https://www.aipm.com.au/html/infoproviders.cfm

Australian Institute of Project Management. (2011b). AIPM CPD. Retrieved from https://www.aipm.com.au/html/cpd.cfm

Australian Institute of Project Management. (2011c). AIPM National Australian Competency Standard. Retrieved from https://www.aipm.com.au/html/ncspm.cfm?CFID=9656255&CFTOKEN=50089189

Australian Institute of Project Management. (2011d). AIPM Professional Competency Standards for Project Management. Retrieved from https://www.aipm.com.au/html/pcspm.cfm

Australian Institute of Project Management. (2011e). AIPM strategic alliances. Retrieved from https://www.aipm.com.au/html/aipm_alliances.cfm

Australian Institute of Project Management. (2011f). Australian Institute of Project Management. Retrieved from https://www.aipm.com.au/html/aipm_alliances.cfm

Australian National Training Authority. (2003a). NCSB guideline level4 (Draft). Australian National Training Authority. Retrieved from https://www.aipm.com.au/resource/draft_compstand_level4.pdf

Australian National Training Authority. (2003b). NCSB guideline level5 (Draft). Australian National Training Authority. Retrieved from https://www.aipm.com.au/resource/draft_compstand_level5.pdf

Australian National Training Authority. (2003c). NCSB guideline level6 (Draft). Australian National Training Authority. Retrieved from https://www.aipm.com.au/resource/draft_compstand_level6.pdf

Azerbaijan Project Management Association. (2011). Azerbaijan Project Management Association. Retrieved from http://www.ipma.az/aboutAzPMA.html

Baecker, D. (1997). *Einfache Komplexität (Elementary Complexity)* (1st ed.). Suhrkamp Verlag KG.

Baker, P. (1985). Focus group interviewing: The real constituency. *Journal of Data Collection*, *25*(2), 14–23.

Balani, B., & Jujjuru, D. (2008, October). Governing agile projects using CMMI. *Journal of the Quality Assurance Institue*, *22*(4), 4.

Bales, R. (1965). The equilibrium problem in small groups. In *Small groups: studies in social interaction*. New York, NY, US: Knopf.

Bandte, H. (2007). *Komplexität in Organisationen* (1st ed.). Wiesbaden, DE: GWV Fachverlage GmbH.

Barrett, R. (2003). *Vocational business: training, developing and motivating people* (1st ed.). Cheltenham, UK: Nelson Thornes Ltd.

Bartsch-Beuerlein, S., & Frerichs, E. (2009). Competence based project management - project quality. In *Competence based project management* (Vol. 2, pp. 247–292). Nuernberg, DE: GPM.

Bedford, C. (1998). The case of chaos. *Mathematics Teachers Magazine*, *91*(4), 276–281.

Benkenstein, M. (2001). *Entscheidungsorientiertes Marketing* (1st ed.). Wiesbaden, DE: Gabler.

Bentley, C. (2010). *PRINCE2: A practical handbook* (3rd ed.). Burlington, MA, US: Elsevier Ltd.

Beuth. (2011a). DIN 69901-2:2009-01 - Inhalt. Retrieved January 3, 2012, from http://www.beuth.de/cmd%3Bjsessionid=E659F6C3EB2B0947AF48AD231A843F6C.1?workflowname=infoInstantdownload&docname=1498907&contextid=beuth&servicerefname=beuth&ixos=toc

Beuth. (2011b). DIN 69901-3:2009-01 - Inhalt. Retrieved January 3, 2012, from http://www.beuth.de/cmd%3Bjsessionid=E659F6C3EB2B0947AF48AD231A843F6C.1?workflowname=infoInstantdownload&docname=1498921&contextid=beuth&servicerefname=beuth&ixos=toc

Beuth. (2011c). DIN 69901-4:2009-01 - Inhalt. Retrieved January 3, 2012, from http://www.beuth.de/cmd%3Bjsessionid=E659F6C3EB2B0947AF48AD231A843F6C.1?workflowname=infoInstantdownload&docname=1498910&contextid=beuth&servicerefname=beuth&ixos=toc

Beuth. (2011d). DIN 69901-5:2009-01 - Inhalt. Retrieved January 3, 2012, from http://www.beuth.de/cmd%3Bjsessionid=E659F6C3EB2B0947AF48AD231A843F6C.1?work-flowname=infoInstantdownload&docname=1498911&contextid=beuth&servicerefname=beuth&ixos=toc

Beuth. (2012a). DIN 69901-1:2009-01 - Inhalt. Retrieved January 3, 2012, from http://www.beuth.de/cmd%3Bjsessionid=E659F6C3EB2B0947AF48AD231A843F6C.1?work-flowname=infoInstantdownload&docname=1498906&contextid=beuth&servicerefname=beuth&ixos=toc

Beuth. (2012b). DIN 69901-1:2009-01 Projektmanagement - Projektmanagementsysteme - Teil 1: Grundlagen. Retrieved January 3, 2012, from http://www.beuth.de/de/norm/din-69901-1/113428320;jsessionid=E659F6C3EB2B0947AF48AD231A843F6C.1?SearchID=278221263

Beyerchen, A. (1992). Clausewitz, Nonlinearity and the Unpredictability of War. *International Security*, *17*(3), 59–90.

Bick, W., & Drexl-Wittbecker, S. (2008). *Komplexität reduzieren: Konzept. Methoden. Praxis.* Stuttgart, DE: LOG-X.

Bidarra, J., Guimaraes, N., & Kommers, P. (2000). Handling Hypermedia Complexity: Fractal Hyperscapes and Mind Mapping. Presented at the 8. ACM Multimedia Conference, Los Angeles, CA, US.

Blockus, M.-O. (2010). *Komplexität in Dienstleistungsunternehmen* (1st ed.). Wiesbaden, DE: Gabler Verlag.

Bohne, F. (1998). *Komplexitätskostenmanagement in der Automobilindustrie: Identifizierung und Gestaltung vielfaltsinduzierter Kosten*. Wiesbaden, DE: Deutscher Universitäts-Verlag.

Bolles, D., & Hubbard, D. (2007). Power of enterprise-wide project management. In *Power of enterprise-wide project management* (p. 311). New York, NY, US: AMACOM.

Bosch-Rekveldt, M., Hermanides, S., Mooi, H., Bakker, H., & Verbraeck, A. (2010). The Influence of Project Front-end Management and Project Complexity on Project Success: A Contingency Approach in Project Management Research. Presented at the PMI Research and Education Conference, Washington, D.C., USA: Project Management Institute.

Bozarth, C., Warsing, D., Flynn, B., & Flynn, J. (2009). The Impact of Supply Chain Complexity on Manufacturing Plant Performance. *Journal of Operations Management*, *27*, 78–93.

Brace, I. (2008). *Questionnaire design* (2nd ed.). London, UK: Kogan Page.

Bradburn, N., & Sudman, S. (1979). *Improving interview method and questionaire design*. San Francisco, CA, US: Jossey-Bass Inc., Publishers.

Bradburn, N., Sudman, S., & Wansink, B. (2004). *Asking questions* (1st ed.). San Francisco, CA, US: Jossey-Bass Inc., Publishers.

Brandes, D. (2002). *Einfach managen*. Frankfurt, DE: Wirtschaftsverlag Carl Ueberreuter.

Brandon, D. (2006). *Project management for modern information systems* (1st ed.). Hershey, PA, USA: IRM Press.

Brazilian Association for Project Management. (2011). Brazilian Association for Project Management. Retrieved from https://sites.google.com/a/ipmabrasil.org/ipmabr/project-definition

Brightman, J. (2003). Mapping Methods for Qualitative Data Structuring (QDS). Presented at the IOE Conference, London, UK: Institute of Education. Retrieved from http://www.banxia.com/pdf/de/Map_for_qual_data_struct.pdf

British Standard Institute. (2010). *BS6079-1:2010*. London, UK: BSI.

British Standard Institute. (2011a). About BSI Standards. Retrieved from http://www.bsigroup.com/en/Standards-and-Publications/About-BSI-British-Standards/

British Standard Institute. (2011b). BSI History. Retrieved from http://www.bsigroup.com/en/Standards-and-Publications/About-BSI-British-Standards/History/

Bronner, A. (2003). *Handbuch der Rationalisierung* (2nd ed.). Renningen, DE: expert Verlag.

Bronner, R. (1999). *Planung und Entscheidung: Grundlagen - Methoden - Fallstudien* (1st ed.). München, DE: Oldenbourg Wissenschaftsverlag GmbH.

Browning, T. (1988). *Modeling and Analyzing Cost, Schedule and Performance in Complex System Product development*. Massachusetts Institute of Technology, Cambridge, MA, US.

Browning, T. (2000). Using the DSM for Process Integration (Vol. 34, pp. 131–140). Presented at the Annual Government Electronics and Information Technology Association (GEIA) Engineering & Technical Management Conference, Dallas, TX, US.

Browning, T. (2001). Applying the Design Structure Matrix to System. Decomposition and Integration Problems: A Review and New Directions. *IEEE Transaction on Engineering Management*, *48*(3), 292–306.

Browning, T., & Eppinger, S. (2002). Modeling Impacts of Process Architecture on Cost and Schedule Risk in Product Development. *IEEE Transaction on Engineering Management*, *49*(4), 428–442.

Brudney, J., O´Toole, L., & Rainey, H. (2008). *Advancing public management: new developments in theory, methods and practice*. Washington, D.C., US: Georgetown University Press.

Bruns, F., & Scholles, K. (2008). *Moderne Projektmanagement-Methoden im Vergleich*. Workingpaper, FH Hannover. Retrieved from http://www.fakultaet4.fh-hannover.de/fileadmin/media/doc/f4/Aktivitaeten/Veroeffentlichungen/2008/198.pdf

Buchenau, G., & Rietz, S. (2009). *Geschäftsprozesse im Projektmanagement: Best Practices der Implementierung*. Hamburg, DE: Diplomica Verlag GmbH.

Buhr, O. (2002). Projektmanagement mit Prince2. *projektmagazin*, (16), 5.

Bulgarian Project Management Association. (2011). Bulgarian Project Management Association. Retrieved from http://project.bg/

Burghardt, M. (2002). *Projektmanagement: Leitfaden für die Planung, Überwachung und Steuerung von Entwicklungsprojekten* (6th ed.). Erlangen, DE: Publicis Corporate Publishing.

Burghardt, M. (2009). Competence based project management - project closeout. In *Competence based project management* (Vol. 2, pp. 1203–1298). Nuernberg, DE: GPM.

Buzan, T. (1974). *Use both sides of your brain*. New York, NY, US: E.P. Dutton.

Buzan, T., & Buzan, B. (1995). *The mind map book* (2nd ed.). London, UK: BBC Books.

Buzan, T., & Buzan, B. (2002). *Das Mind-map-Buch: Die beste Methode zur Steigerung Ihres geistigen Potenzials* (5th ed.). Frankfurt am Main, DE: Mvg.

Cagle, R. (2004). *Your successful project management career* (1st ed.). New York, NY, US: AMACOM.

Casti, J. (1986). On system complexity: identification, measurement and management. In *Complexity language and life: Mathematical approaches* (pp. 146–173). Berlin, DE: Springer-Verlag.

Checkland, P. (1979). Techniques in "soft" Systems Practice: Part I Systems Diagrams - Some Tentative Guidelines. *Journal of Applied Systems Analysis*, *6*, 33–40.

Checkland, P. (1981). *Systems thinking, systems practice*. New York, NY, US: Wiley Publishing.

Checkland, P., & Scholes, J. (1999). *Soft systems methodology in action*. Chichester, UK: John Wiley & Sons Ltd.

Chick, T. (2006). CMM/ CMMI Level3 or higher. *Defense AT&L*, *35*(8), 42–43.

Christen, M. (1996). *Zweifel am Rande des Chaos*. Bern, Bern, CH. Retrieved from http://www.encyclog.com/_upl/files/liz_total2.pdf

Chronéer, D., & Bergquist, B. (2012). Managerial Complexity in Process Industrial R&D Projects: A Swedish Study. *Project Management Journal*, *43*(2), 21–36.

Cleland, D., & Gareis, R. (2006). *Global project management handbook: Planning, organizing and controlling* (2nd ed.). New York, NY, US: McGraw-Hill.

Cooke-Davies, T. (2007). *The wiley guide to project organisation & project management competencies*. Hoboken, NJ, US: John Wiley & Sons, Inc.

Cooke-Davies, T., Cicmil, S., Crawford, L., & Richardson, K. (2007). We're not in Kansas anymore, Toto: Mapping the Strange Landscape of Complexity Theory, and its Relationship to Project Management. *Project Management Journal*, *38*(2), 50–61.

CPMS, & CAPM. (2011). Cyprus/ Croatian Project Management Society. Retrieved from http://capm.hr/

Crawford, K. (2002). *The project maturity model: providing a proven path to project management excellence*. New York, NY, US: Marcel Dekker Inc.

Crawford, L. (2002). Background paper: Performance based competency standards for project management. Sydney, AU: University of Technology, Sydney.

Crawford, L. (2013). Dancing in the Kaleidoscope: The Challenge of Leading Complex Projects. Presented at the PMI Global Congress Proceedings, Istandbul, TR: Project Management Institute.

Curlee, W., & Gordon, R. (2011). *Complexity theory and project management*. Hoboken, NJ, USA: John Wiley & Sons, Inc.

Danilovic, M., & Browning, T. (2007). Managing Complex Product Development Projects with Design Structure Matrices and Domain Mapping matrices. *International Journal of Project Management*, *25*(3), 300–314.

Danish Project Management Association. (2012). Danish Project Management Association. Denmark. Retrieved from http://ipmadenmark.ning.com/groups

Datar, S., Kekre, S., Mukhopadhyay, T., & Srinivasan, K. (1993). Simultaneous Estimation of Cost Drivers. *The Accounting Review*, *68*(3), 602–614.

de Klerk, M. (2008). *Viadee Vortragsreihe: Prince2*. Retrieved from http://www.viadee.de/fileadmin/pdf/Vortraege/viadee-Vortrag-PRINCE2.pdf

Della Schiava, M., & Rees, W. (1999). *Was Wissensmanagement bringt: Informationsflut bewältigen; mind maps für die Praxis; neue Technologien gezielt einsetzen; Fallbeispiele aus Silicon Valley*. Wien, AT: Signum.

Dellmann, K., & Diehm, S. (2002). Der "Analytic Network Process". Bewerten in komplexen Sachverhalten mit Interdependenzen. *Die Unternehmung*, *56*(4), 247–259.

Denk, R. (2007). Die 5 α des Komplexitätsmanagements. *CFO Aktuell*, *1*(1), 19–22.

Deubzer, F., Kreimeyer, M., Herfeld, U., & Lindemann, U. (2005). A structured holistic approach for the integration of CAD and CAE environments. In *Proceedings: ProSTEP iViP science days 2005 - cross domain engineering* (pp. 244–255). Darmstadt, DE: ProSTEP iViP Association 2005.

Deutsches Institut für Normung. (2009). *DIN-Taschenbuch 472*. Berlin: Beuth Verlag.

Deutsches Institut für Normung. (2011a). About DIN. Retrieved from http://www.din.de/cmd?level=tpl-bereich&menuid=47391&cmsareaid=47391&languageid=de

Deutsches Institut für Normung. (2011b). Chronik. Retrieved from http://www.din.de/cmd?level=tpl-unterrubrik&menuid=47391&cmsareaid=47391&menurubricid=47514&cmsrubid=47514&menusubrubid=47520&cmssubrubid=47520&languageid=de

Deutsches Institut für Normung. (2011c). DIN in der Welt. Retrieved January 3, 2012, from http://www.din.de/cmd?level=tpl-rubrik&menuid=47390&cmsareaid=47390&cmsrubid=47497&menurubricid=47497&languageid=de

Devaney, R. (1992). *First course in chaotic dynamical systems*. Boston, MA, USA: Perseus Books Publishing LLC.

Dinsmore, P., & Cabanis-Brewin, J. (2011). *The AMA handbook of project management* (3rd ed.). New York, NY, US: AMACOM.

Dobiéy, D., Köplin, T., & Mach, W. (2004). *Programm Management- Projekte übergreifend koordinieren und in die Unternehmensstrategie einbinden* (1st ed.). Weinheim, DE: WILEY-VCH GmbH & Co. KG.

Dörner, D. (1998). *Die Logik des Mißlingens: Strategisches Denken in komplexen Situationen* (1st ed.). Reinbeck, DE: Rowohlt.

Duden, K. (1996). *Duden, Rechtschreibung der deutschen Sprache und der Fremdwörter* (19th ed., Vol. 1). Mannheim, DE: Dudenverlag.

Easterby-Smith, M., Thorpe, R., & Jackson, P. (2012). *Management research* (4th ed.). London, UK: Sage Publications Ltd.

Edmonds, B. (1998). What is Complexity? - The philosophy of complexity per se with application to some examples in evolution. In *The evolution of complexity*. Manchester, UK: Manchester Metropolitan University. Retrieved from http://cogprints.org/357/4/evolcomp.pdf

Ehrlenspiel, K. (2009). *Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit*. München, DE: Carl Hanser Verlag.

Ellmann, S., Behrend, F., Huebner, R., & Weitlaner, E. (2009). Competence based project management - stakeholders and intrested parties. In *Competence based project management* (Vol. 2, pp. 86–136). Nuernberg, DE: GPM.

Endsley, M. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Humand Factors*, *37*(1), 32–64.

Englen, W. (2006). *Methoden der Produktentwicklung*. München, DE: Oldenbourg Industrieverlag GmbH.

Eppinger, S. (1991). Model-based Approaches to Managing Concurrent Engineering. *Journal of Engineering Design*, *2*(4), 283–290.

Eppinger, S. (2001). Innovation at the Speed of Information. *Harvard Business Review*, *79*(1), 149–158.

Eppinger, S., & Browning, T. (2012). *Design structure matrix methods and applications*. Cambridge, MA, US: MIT Press.

Eppler, M. (2006). A comparison between concept maps, mind maps, conceptual diagrams, and visual metaphors as complementary tools for knowledge construction and sharing. *Information Visualization*, *5*(3), 202–210.

Erdi, P. (2008). *Complexity explained*. Heidelberg, DE: Springer-Verlag.

Erdogmus, S., Kapanolglu, M., & Koc, E. (2005). Evaluating high-tec alternatives by using analytic network process with BOCR and multiactors. *Evaluation and Program Planning*, *28*(4), 391–399.

Ester, B. (2009). Competence based project management - procurement and contracts. In *Competence based project management* (Vol. 2, pp. 820–916). Nuernberg, DE: GPM.

Faller, M., & Kracht, F. (2006). Komplexitätskostenrechnung für den Mittelstand - Ein zentrales Instrument des Komplexitätsmanagements. In *Einsatz von Controllinginstrumenten im Mittelstand* (1st ed., Vol. 3). Lohmar, DE: Josef EUL Verlag GmbH.

Fassbender, P., & Klein, U. (2010). Rich Picture - eine Methodenskizze. *Organisationsentwicklung*, (4), 74–77.

Feess, E. (2013). *Gabler Wirtschaftslexikon/ Komplexität* (Vol. 18). Wiesbaden, DE: Springer Fachmedien Wiesbaden GmbH.

Firchau, N. (2003). *Variantenoptimierende Produktgestaltung*. Technische Universität Braunschweig, Göttingen, DE.

Fisch, R., & Beck, D. (2004). *Komplexitätsmanagement - Methoden zum Umgang mit komplexen Aufgabenstellungen in Wirtschaft, Regierung und Verwaltung* (1st ed.). Speyer, DE: VS Verlag für Sozialwissenschaften.

Fleig, J. (2009). Komplexität: Wie Unternehmen mit einfachen Regeln in komplexen Märkten gewinnen. *Business-Wissen*. Retrieved from http://www.business-wissen.de/fileadmin/doc/DruckdateiPDF/Komplexitaet.pdf

Flick, U. (1999). *Qualitative Forschung. Theorie, Methoden, Anwendung in Psychologie und Sozialwissenschaften*. Reinbek, DE: Rowohlt.

Flood, R. (1987). Complexity: A definition by construction of a conceptual framework. *Systems Research*, *4*(3), 177–185.

Flood, R., & Carson, E. (1993). *Dealing with complexity: an introduction to the theory and application of systems science* (2nd ed.). New York, NY, US: Plenum Press.

Flückinger, M., & Rauterberg, M. (1995). *Komplexität und Messung von Komplexität* (Technical Report No. IfAP/ETH/CC-01/95) (p. 31). Zurich, CH: ETH. Retrieved from http://www.idemployee.id.tue.nl/g.w.m.rauterberg/publications/COMPLEXITY95paper.pdf

Flyvbjerg, B. (2014). What You Should Know About Megaprojects and Why: An Overview. *Project Management Journal*, *45*(2), 6–19.

Förster, M. (2003). *Variantenmanagement nach Fusionen in Unternhemen des Anlagen- und Maschinenbaus* (Promotion). TUM, München, München. Retrieved from http://tumb1.biblio.tu-muenchen.de/publ/diss/mw/2003/foerster.pdf

Fradkov, A., & Pogromsky, A. (2008). Nonlinear and adaptive control of chaos. In *Handbook of Chaos Control* (pp. 129–156). Weinheim, DE: WILEY-VCH GmbH & Co. KG. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/3527607455.fmatter/summary

Franke, H. J. (1998). Produkt-Variantenvielfalt; Ursachen und Methoden zu Ihrer Bewältigung, effektive Entwicklung und Auftragsabwicklung variantenreicher Produkte. *VDI Berichte*, *1434*.

Franke, H. J., Hesselbach, J., Huch, B., & Firchau, N. L. (2002). *Variantenmanagement in der Einzel- und Kleinserienfertigung*. München, DE: Carl Hanser Verlag.

Frank, H., & Schmidts, U. (2007). Komplexität besser beherrschen. *Elektronik Automotive*, (2), 49–52.

Frank, M., Sadeh, A., & Ashkenasi, S. (2011). The Relationship Among Systems Engineer's Capacity for Engineering Systems Thinking, Project Types, and Project Success. *Project Management Journal*, *42*(5), 31–41. http://doi.org/10.1002/pmj

Frese, M. (1987). A theory of control and complexity. In *Psychological issues of human-computer interaction in the work place*. Amsterdam, NL: Elsevier Science Publishers.

Friebertshäuser, B. (1997). Interviewtechniken - ein Überblick. In *Handbuch Aualitative Forschungsmethoden in der Erziehungswissenschaft* (pp. 371–395). München, DE: Juventa Verlag.

Friedag, H., & Schmidt, W. (2002). *Balanced Scorecard - Mehr als ein Kennzahlensystem* (4th ed.). Freiburg, DE: Rudolf Haufe Verlag.

Friedli, T., Werani, J., Thaler, Stieneker, & Kickuth. (2006). *Operational excellence in the pharmaceutical industry* (1st ed.). Aulendorf, DE: ECV · Editio Cantor Verlag.

Friedrich, S. (2008). *Einsatzmöglichkeiten einer Design-Structure-Matrix im Rahmen des strategischen Projektmanagements* (1st ed.). Berlin, DE: GRIN Verlag.

Friedrich, U., & Schuster, N. (2004). *30 minuten vom mind mapping zum business-mapping* (2nd ed.). Offenbach, DE: GABAL Verlag.

Gaddis, P. (1959). The Project Manager. *Harvard Business Review*, (3).

Gausemeier, J. (2001). *Produktinnovation*. München, DE: Carl Hanser Verlag.

Geckler, D. (1997). *Das Problem der Komplexität im Projektmanagement*. Retrieved from http://dieter-geckler.homepage.t-online.de/Publikationen/Manuskript_2.pdf

Geckler, D. (2009). Competence based project management - documentation, information and reporting. In *Competence based project management* (Vol. 2, pp. 1075–1099). Nuernberg, DE: GPM.

George, M., & Wilson, S. (2004). *Conquering complexity in your business*. Dallas, TX, US: McGraw-Hill.

Gesellschaft für Projektmanagement. (2012). PM Organisations Europe. Retrieved from http://www.gpm-infocenter.de/PMOrganisationen/Europa

Gessler, M. (2009). *Kompetenz basiertes Projektmanagement (PM3)* (Vol. 2). Nuernberg, DE: GPM.

Giammalvo, P., Lopez, C., Damilaville, A., Gowtham, A., Yan, S., & Zhang, Y. (2005). Comparison of PMI, AIPM, AACE, IPMA and PRINCE2 Certifications.

Giddings, L. (2006). Mixed Methods Research - Positivism Dressed in Drag. *Journal of Research in Nursing*, *11*(3), 195–203.

Gleick, J. (2011). *Chaos: making a new science*. New York, NY, US: Open road.

Goette, R. (2005). *Das 1x1 des Portfoliomanagements*. Stuttgart, DE: ibidem-Verlag.

Goff, S., & Doerrenberg, F. (2009). Competence based project management - communication. In *Competence based project management* (Vol. 2, pp. 1100–1162). Nuernberg, DE: GPM.

Golden Pryor, M., & Taneja, S. (2006). Henri Fayol, practitioner and theoretician – revered and reviled. *Emerald Group Publishing Limited*. http://doi.org/10.1108/17511341011073960

Gough, D., Oliver, S., & Thomas, J. (2012). *An introduction to systematic reviews*. Los Angeles, London, New Dehli, Singapore, Washington DC: Sage Publications Ltd.

Grau, N., & Eberhard, T. (2009). Competence based project management - objectives and strategies. In *Competence based project management* (Vol. 2, pp. 137–182). Nuernberg, DE: GPM.

Grice, P. (1975). Logic and conversation. In *Syntax and semantics* (Vol. 3, pp. 41–58). New York, NY, US: Academic Press.

Grimm, R. (2009). *Einfach komplex: Neue Herausforderungen im Projektmanagement* (1st ed.). Wiesbaden, DE: VS Verlag für Sozialwissenschaften.

Grösser, S. (2011). Projekte scheitern wegen dynamischer Komplexität. *projekt management aktuell*, (5), 18–25.

Gross, J., & Yellen, J. (2005). *Graph theory and its applications* (2nd ed.). Boca Raton, FL, US: CRC Press.

Hahn, D. (1990). Zweck und Entwicklung der Portfolio-Konzepte in der strategischen Unternehmensplanung. In *Strategische Unternehmensplanung - strategische Unternehmensführung* (5th ed., pp. 221–253). Heidelberg, DE: Springer-Verlag.

Haller, S. H. M. (2002). *Mappingverfahren zur Wissensorganisation*. Freie Universität Berlin, Berlin, DE.

Hamilton, A. (2004). *Handbook of project management procedures*. London, UK: Thomas Telford Ltd.

Hammer, R. (1992). *Unternehmensplanung: Lehrbuch der Planung und strategischen Unternehmensführung*. München, DE: Oldenbourg Wissenschaftsverlag GmbH.

Hanisch, B. (2011). *Komplexität in Beratungsprojekten*. Oestrich-Winkel, DE: European Business School. Retrieved from http://www.gpm-ipma.de/fileadmin/user_upload/Know-How/studien/Kurzfassung_Studienbericht_Komplexitaet_in_Beratungsprojekten.pdf

Harrison, F., & Lock, D. (2004). *Advanced project management: a structured approach* (4th ed.). Hants, UK: Gower Publishing Limited.

Harter, P. (2007). PMI Credentials Aim to Bring Organizational Success. *Certification Magazine*, *9*(5), 24–38.

Hass, K. (2007). Living on the Edge: Managing Project Complexity. Presented at the PMI Global Congress Proceedings, Atlanta, GA, US: Project Management Institute.

Hass, K. (2009). *Managing complex projects: A new model*. Vienna, VA, US: Management Concepts.

Hass, K., & Lindbergh, L. (2010). The Bottom Line on Project Complexity: Applying a New Complexity Model. Presented at the PMI Global Congress, Washington, D.C., US: Project Management Institue.

Hedeman, B., & Seegers, R. (2009). *Prince2 TM 2009 edition*. Zaltbommel, NL: Van Haren Publishing.

Heidegger, H., & Weerda, K. (2008). Raus aus der Komplexitätsfalle. *Akzente*, 18–23.

Helfferich, C. (2011). *Die Qualität qualitativer Daten* (4th ed.). Wiesbaden, DE: VS Verlag für Sozialwissenschaften.

Hetzler, S. (2010). *Real-Time-Control für das Meistern von Komplexität: Managing Change durch kontinuierlich richtiges Entscheiden* (1st ed.). Frankfurt am Main, DE: Campus Verlag.

Higgins, J., & Green, S. (2008). *Cochrane handbook for systematic reviews of interventions*. Hoboken, NJ, US: John Wiley & Sons, Inc.

Hock, D. (1999). *Birth of the chaordic age*. San Francisco, CA, US: Berrett-Koehler Publishers.

Hofer, A. (2001). *Management von Produktfamilien - Wettbewerbsvorteile durch Plattformen* (1st ed.). Wiesbaden, DE: Gabler.

Holmes, A. (2001). *Failsafe is project delivery*. Burlington, VT, US: Gower.

Holm, K. (1986). *Die Befragung 1* (2nd ed.). Tübingen, DE: Francke.

Hoole, R. (2006). Drive Complexity Out of Your Supply Chain. *Harvard Business Review*, (1), 3–6.

Horvath, P., & Kaufmann, L. (1998). Balanced Scorecard - Werkzeug zur Umsetzung von Strategien. *Harvard Businessmanager*, *4*, 39–38.

Howard, A. (2010). Paradexity the Convergence of Paradox and Complexity. *Management Development*, *29*(3).

Ibbes, W., Reginato, J., & Kwak, Y. (2007). *Developing project management capability: benchmarking, maturity, modeling, gap analysis and ROI studies*. Hoboken, NJ, USA: John Wiley & Sons, Inc.

IBSA (Innovation & Business Skills Australia. (2007). FAQs BSB07 Business Services Training Package. IBSA (Innovation & Business Skills Australia). Retrieved from http://www.ibsa.org.au/LinkClick.aspx?fileticket=3hRvMjMb0fM%3D&tabid=214

Innovation & Business Skills Australia. (2008). BSB07 Business Services Training Package. IBSA (Innovation & Business Skills Australia). Retrieved from http://www.ibsa.org.au/Portals/ibsa.org.au/docs/Training%20Packages/Caseforendorsement/BSB07%20v6/CAT01%20BSB07%20V6.pdf

Institute of Project Management Ireland. (2011). Institute of Project Management Ireland. Retrieved January 2, 2012, from http://www.projectmanagement.ie/default.asp

International Project Management Association. (2011). IPMA NCB Overview. Retrieved January 2, 2012, from http://ipmacod.ning.com/groups/group/listByLocation?location=Member+Associations&sort=mostRecent&page=2

International Project Management Association. (2012). IPMA_Standards. Retrieved January 2, 2012, from http://ipma.ch/resources/standards/

International Project Management Association. (n.d.-a). Certification IPMA. Retrieved June 4, 2011, from http://www.ipma.ch/certification/pages/default.aspx

International Project Management Association. (n.d.-b). History IPMA. Retrieved June 4, 2011, from http://www.ipma.ch/about/Pages/History.aspx

Ireland, L. (2007). Project Complexity: A Brief Exposure To Difficult Situations.

Ireland, L., & Cleland, D. (2006). *Project management - Strategic Design and Implementation* (5th ed.). New York, NY, US: McGraw-Hill.

Jankulik, E., Kuhlang, P., & Pfiff, R. (2005). *Projektmanagement und Prozessmessung* (1st ed.). Erlangen, DE: Pubilcis Corporate Publishing.

Jenny, B. (2009). *Projektmanagement: Das Wissen für eine erfolgreiche Karriere* (3rd ed.). Zurich, CH: vdf Hochsculverlag an der ETH Zuerich.

Johns, T. G. (2008). Simplifying complex projects and programs - The Art of Project Management. Presented at the PMI Global Congress Proceedings, Denver, CO, US: Project Management Institue.

Judgev, K., & Thomas, J. (2002). Project Management Maturity Models: The Silver Bullets of Competitive Advantage. *Project Management Journal*, (33), 4–14.

Kaestner, R., & Rackelmann, G. (2009). Competence based project management - project lifecycle and phases/ schedule (Vol. 2, pp. 611–689). Nuernberg, DE: GPM.

Kaiser, A. (1995). *Integriertes Variantenmanagement mit Hilfe der Prozesskostenrechnung*. Hochschule St. Gallen, St. Gallen, CH.

Kanabar, V., & Warburton, R. (2008). *MBA fundamentals project management*. New York, NY, US: Kaplan Publishing.

Kannicht, L. (2009). *Concept Mapping: Multidisziplinäre Hintergründe zur Visualisierung von Wissen und Concept Mapping konkret mit CmapTools*. Berlin, DE: Humbolt Universität.

Kapici, S. (2005). *Ein stochastisches Risikomodell für komplexe Projekte*. Magdeburg, Magdeburg, DE.

Kaplan, R., & Norton, D. (1992). The Balanced Scorecard - Measures that Drive Performance. *Harvard Business Review*, *70*(1), 71–79.

Kappler, A. (2000). Balanced Scorecard - Werkzeug zur Umsetzung von Strategien. *IO Management*, *69*(7), 34–38.

Kay, R. (2005, January 24). CMMI. *Computerworld*, *39*(4), 28.

Kazakhstan Project Management Association. (2011). Kazakhstan Project Management Association. Retrieved January 2, 2012, from http://www.kpma.kz/pages/about-us.php

Kellert, S. H. (1993). *In the wake of chaos*. Chicago, IL, US: University of Chicago Press.

Kersten, W., Lammers, T., & Skirde, H. (2012). *Komplexitätsanalyse von Distributionssystemen* (No. 16164). Hamburg, DE: Technische Universität Hamburg-Harburg.

Kerzner, H. (2001). *Strategic planning for project management using a project panagement maturity model*. New York, NY, US: John Wiley & Sons, Inc.

Kerzner, H. (2009). *Project management: A systems approach to planning, sheduling and controlling* (10th ed.). Hoboken, NJ, USA: John Wiley & Sons, Inc.

Khaswala, A., & Shahrukh, I. (2001). Value Network Mapping (VNM): Visualization and Analysis of Multiple Flows in Value Stream Maps. Presented at the Lean Management Solutions Conference, St. Louis, MO, US: Ohio State University.

King, S. (2005). Accelerating Complex Projects: Get Concrete Results Fast by Managing the Environment rather than the Details. Presented at the PMI Congress Proceedings, Toronto, CA: Project Management Institute.

Kirchhof, R., & Specht, D. (2003). *Ganzheitliches Komplexitätsmanagement. Grundlagen und Methodik des Umgangs mit Komplexität im Unternehmen.* Wiesbaden, DE: Deutscher Universitäts-Verlag.

Kirckhoff, M. (1998). *Mind mapping: Einführung in eine kreative Arbeitsmethode* (12th ed.). Offenbach, DE: GABAL Verlag.

Klaus, G., & Buhr, M. (1975). *Philosophisches Wörterbuch*. Berlin, DE: Das europäische Buch.

Koch, D. (2008). *Neue Ansätze und Entwicklungen im Projektmanagement (New approaches and developments in project management)*. Hamburg, DE: Diplomica Verlag GmbH.

Koehler. (2006). *PRINCE 2: Das Projektmanagement-Framework* (Vol. 1). Heidelberg, DE: Springer.

Kohn, A., & Lindemann, U. (2010). Approach towards a more flexible handling of domains in complex systems (pp. 333–343). Presented at the 12th international dependency and structure modelling conference, DSM'10, Cambridge, UK: DSM-conference.

Kortler, S., Helms, B., Shea, K., & Lindemann, U. (2011). A More Flexible Way of Modeling Structure With Multiple Domains (pp. 19–29). Presented at the 13th international dependency and structure modelling conference, DSM'11, Cambridge, MA, US: DSM-conference.

Krause, F.-L., Franke, H., & Gausemeier, J. (2007). *Innovationspotenziale in der Produktentwicklung*. München, DE: Carl Hanser Verlag.

Kreimeyer, M., & Lindemann, U. (2011). *Complexity metrics in engineering design: Managing the structure of design processes*. Heidelberg, DE: Springer-Verlag.

Kremer, R., & Rohde, A. (2009). Competence based project management - project organisation. In *Competence based project management* (Vol. 2, pp. 296–350). Nuernberg, DE: GPM.

Kromrey, H. (1995). *Empirische Sozialforschung - Modelle und Methoden der empirischen Datenerhebung und Datenauswertung* (11th ed.). Opladen, DE: Lucius & Lucius.

Krueger, R., & Casey, M. (2009). *Focus groups - a practical guide for applied research* (4th ed.). Thousand Oaks, CA, US: Sage Publications.

Krueger, W. (2009). *Excellence change* (4th ed.). Wiesbaden, DE: GWV Fachverlage GmbH.

Krumm, S., & Rennekamp, M. (2011). Komplexitätsberrschung erfordert gezielte Architekturentscheidungen. *Complexity Management Journal*, (03), 10–14.

Kusiak, A. (1999). *Engineering design: Products, processes and systems* (1st ed.). San Diego, CA, US: Academic Press.

Kuwait Society of Engineers. (2011). Kuwait Society of Engineers. Retrieved from http://www.kse.org.kw/subpage.aspx?sub=29&page=3&title=About%20the%20society

Kvale, S., & Brinkmann, S. (2009). *Interviews* (2nd ed.). London, UK: Sage Publications Ltd.

Latvian National Project Management Association. (2011). Latvian National Project Management Association. Retrieved January 2, 2012, from http://www.lnpva.lv/

Lehmann, O. (2014). Mitglieder PMI in Deutschland.

Lehmann, O., Mikulaschek, W., & Oestereich, B. (2013). Mein Haus, mein Auto, meine Projektmanagement Zertifikate. *Objektspektrum*.

Leonard, A., & Swanepoel, A. (2010). Project portfolio management implementation pitfalls. *South African Journal of Business Management*, *43*(3), 13–22.

Lester, A. (2007). *Project management, planning and control* (5th ed.). Burlington, MA, USA: Butterworth Heinemann.

Levine, H. (2005). *Project portfolio management: A practical guide to selecting projects, manageing portfolios and maximizing benefits* (1st ed.). San Francisco, CA, US: John Wiley & Sons, Inc.

Levin, G., & Ward, J. L. (2013). Reducing Program Management Complexity: A Competency Model. In *2013 PMI Global Congress Proceedings - New Orleans, LA, USA*. New Orleans, LA, US: PMI.

Leybourne, S., Kanabar, V., & Warburton, R. (2010). Understanding and Overcoming Communications Complexity in Projects. Presented at the PMI Global Congress Proceedings, Washington, D.C., US: Project Management Institute.

Lienert, G., & Raatz, U. (1998). *Testaufbau und Testanalyse* (6th ed.). Weinheim, DE: Beltz.

Lindemann, H. (2008). *Systemisch beobachten - lösungsorientiert handeln*. Oldenburg, DE: Ökotopia Verlag.

Lindemann, U., Braun, T., & Maurer, M. (2009). *Structural complexity management - an approach for the field of product design*. Berlin, DE: Springer-Verlag.

Lindemann, U., Reichwald, R., & Zäh, M. (2006). *Individualisierte Produkte - Komplexität beherrschen in Entwicklung und Produktion*. München, DE: Springer.

Lindgren, J., & Kehoe, W. (1981). Focus groups: approaches, procedures and implications. *Journal of Retail Banking*, *3*(4), 16–22.

Linssen, O., & Rachmann, A. (2010). Aktuelle Trends im Projektmanagement. Retrieved from http://liantis.com/fileadmin/downloads/PPM-OPM3-PRINCE2.pdf

Lithuanian Project Management Association. (2011). Lithuanian Project Management Association. Retrieved January 2, 2012, from http://www.lpva.lt/cms/lpva/app;jsessionid=D29B37C668C623A51B426CB11973C9FE.worker?service=direct/1/index/border.border.menuLeft.setLocaleEN

Litke, H. D. (2007). *Projektmanagement: Methoden, Techniken, Verhaltensweisen: Methoden, Techniken, Verhaltensweisen. Evolutionäres Projektmanagement* (5th ed.). München, DE: Carl Hanser Verlag.

Lock, D. (2007). *Project management* (9th ed.). Hampshire, UK: Gower Publishing Limited.

Löfgren, L. (1973). On the formalization of learning and evolution. In *Logic, Methodology and the Philosophy of Science IV*. Amsterdam, NL: North-Holland.

Lomnitz, G. (2001). *Multiprojektmanagement: Projekte planen, vernetzen und steuern* (1st ed.). Landsberg Lech, Germany: Moderne Industrie.

Lösch, J. (2001). *Controlling der Variantenvielfalt: eine koordinationsorientierte Konzeption zur Steuerung von Produktvarianten*. Technische Universität Braunschweig, Aachen, DE.

Lotfi, Z. (1965). Fuzzy sets. *Information and Control*, *8*(3), 338–353.

Luhmann, N. (2002). *Soziale Systeme: Grundriß einer allgemeinen Theorie*. Frankfurt am Main, DE: Suhrkamp Verlag KG.

Maethner, C. (2005). Projektmanagement mit PRINCE2 (p. 21). Maethner-Consulting. Retrieved from http://hitforum.de/prince2/Prince2.pdf

Maisch, J. (2006). *Wissensmanagement am Gymnasium: Anforderungen der Wissensgesellschaft* (1st ed.). Wiesbaden, DE: VS Verlag für Sozialwissenschaften.

Maizlish, B., & Handler, R. (2005). *IT portfolio management step-by-step*. Hoboken, NJ, US: John Wiley & Sons, Inc.

Malik, F. (1998). Komplexität - was ist das? www.managemntkybernetik.com. Retrieved from http://www.kybernetik.ch/dwn/Komplexitaet.pdf

Malik, F. (2003). *Strategie des Managements komplexer Systeme: Ein Beitrag zur Management-Kybernetik evolutionärer Systeme* (8th ed.). Bern, CH: Haupt Verlag.

Malik, F. (2007). *Management: Das A und O des Handwerks* (1st ed., Vol. 1). Frankfurt am Main, DE: Campus Verlag.

Marti, M. (2007). *Complexity Management: Optimizing Product Architecture of Industrial Products*. University of St. Gallen, St. Gallen, CH.

Masing, W., & Pfeifer, T. (2007). *Handbuch Qualitätsmanagement* (5th ed.). München, DE: Carl Hanser Verlag.

Maune, G. (2002). *Möglichkeiten des Komplexitätsmanagements für Automobilhersteller auf Basis IT-gestützter durchgängiger Systeme*. Universität Paderborn, Osnabrück, DE.

Maurer, M. (2007). *Structural Awareness in Complex Product Design*. Technische Universität München, München, DE.

Mauthner, M., Jessop, J., Miller, T., & Birch, M. (2002). *Ethics in qualitative research*. London, UK: Sage Publications.

Mayer, H. (2004). *Interview und schriftliche Befragung* (2nd ed.). München, DE: Oldenbourg Wissenschaftsverlag GmbH.

Mayer, T., Wald, A., & Gleich, R. (2008). *Advanced project management*. Berlin, DE: LIT Verlag.

Maylor, H., Vidgen, R., & Carver, S. (2008). Managerial complexity in project-based operations: A grounded model and its implications for practice. *Project Management Journal*, *39*(7), 15–26.

Mayo, E., & Proske, R. (1949). *Probleme industrieller Arbeitsbedingungen*. Frankfurt, DE: Verlag der Frankfurter Hefte.

Mayring, P. (2010). *Qualitative Inhaltsanalyse: Grundlagen und Techniken* (11th ed.). Weinheim, DE: Beltz.

Maznevski, M., Steger, U., & Amann, W. (2007). Managing complexity in global organizations. *Perspectives for Managers*, *141*, 1–4.

McKinley, W. (1987). Complexity and Administrative Intensity: The Case of Declining Organisations. *Administrative Science Quarterly*, *32*, 87–105.

McNiff, J., & Whitehead, J. (2011a). *All you need to know about action research*. London, UK: Sage Publications Ltd.

McNiff, J., & Whitehead, J. (2011b). *Doing and writing action research*. London, UK: Sage Publications Ltd.

MES Egypt. (2011). Management Engineering Society - Egypt. Retrieved January 2, 2012, from http://www.mes.eg.net/en/

Meuser, M., & Nagel, U. (2002). Das Experteninterview. In *Hauptbegriffe qualitativer Sozialforschung* (pp. 257–272). Opladen, DE: Leske +Budrich.

Meyer, C. (2007). *Integration des Komplexitätsmanagements in den strategischen Führungsprozess*. Bern, CH.

Meyer, M. (2009). Competence based project management - IT-software. In *Competence based project management* (Vol. 2, pp. 1331–1367). Nuernberg, DE: GPM.

Milling, P. (1981). *Systemtheoretische Grundlagen zur Planung der Unternehmenspolitik*. Berlin, DE: Duncker und Humblot.

Milosevic, D., Martinelli, R., & Waddell, J. (2007). *Program management for improved business results*. Hoboken, NJ, US.

Mind maps a powerful approach to note taking. (2012). London, UK: Mind Tools Ltd.

Mittelstrass, J. (1984). *Enzyklopädie Philosophie und Wissenschaftstheorie*. Mannheim, DE: BI Wissenschaftsverlag.

Moeller, T. (2009). Competence based project management - project success criteria. In *Competence based project management* (Vol. 2, pp. 1–85). Nuernberg, DE: GPM.

Morisawa, T. (2002). *Building performance measurement systems with the balanced scorecard approach* (No. 45). Tokyo, JP: Nomura Research Institute.

Morris, P. (2007a). *The wiley guide to project organisation & project management competencies*. Hoboken, NJ, US: Wiley Publishing.

Morris, P. (2007b). *The wiley guide to project, program and portfolio management*. Hoboken, NJ, US: John Wiley & Sons, Inc.

Morris, P., & Pinto, J. (2007). *The Wiley guide to project organization & project management competencies* (1st ed.). Hoboken, NJ, US: John Wiley & Sons, Inc.

Morris, P., Pinto, J., & Söderlund, J. (2010). *Oxford handbook of project management* (1st ed.). Oxford, UK: Oxford University Press.

Motzel, E., & Felske, P. (2009). Competence based project management - project control. In *Competence based project management* (Vol. 2, pp. 997–1074). Nuernberg, DE: GPM.

Mucchielli, R. (1973). *Das Gruppeninterview*. Salzburg; AT: Otto Müller Verlag.

Müller, Martinsuo, & Blomquist. (2008). Project Portfolio Control and Portfolio Management Performance in Different Contexts. *Project Management Journal*, *39*(3), 28–42. http://doi.org/10.1002/pmj.20053

Murray, A. (2009). Introducing PRINCE2 2009 Seminar at the BPUG Annual Congress 2009. Retrieved from http://www.best-management-practice.tv/bpug-annual-congress-2009

Namrata, O. (2011). Modern Project Management and Chaos Theory. HSBC. Retrieved from http://www.icmis.net/infoms/icoqm10/ICOQM10CD/pdf/P442-Final.pdf

Neumann, W. (2000). *Social research methods: Qualitative and quantitative approaches* (4th ed.). Boston, MA, US: Allyn and Bacon.

Newsham, F. (2005, November). Capability Maturity Model Integration (CMMI): Technical writers needed. *Intercom*, *52*(9), 13–15.

NFP. (2011). Norwegian Association of Project Management. Retrieved January 2, 2012, from http://www.prosjektledelse.org/index.php?c=22&kat=Medlemskap

Nohl, A.-M. (2009). *Interview und dokumentarische Methode* (3rd ed.). Wiesbaden, DE: VS Verlag für Sozialwissenschaften.

Norman, D. (2011). *Living with complexity*. Cambridge, MA, US: MIT Press.

Novak, J. D. (1977). *A theory of education*. Ithaca, NY, US: Cornell University Press.

Novak, J. D. (2010). *Learning creating and using knowledge* (2nd ed.). New York, NY, US: Routledge.

Novak, J. D., & Cañas, A. (2006). The Origin of the Concept Mapping Tool and the Continuing Evolution of the Tool. *Information Visualization*, *5*(3), 175–184.

Nückles, M. (2004). *Mind maps und concept maps: Visualisieren - Organisieren - Kommunizieren*. München, DE: Deutscher Taschenbuch-Verlag.

Obeng, E. (1994). *All change!: the project leader's secret handbook*. London, UK: Financial Times/ Pitman.

Obeng, E. (1996). Putting Strategy to Work. *Financial Times*.

Office of Government Commerce. (2009a). *Erfolgreich Projekte Managen mit Prince2* (5th ed.). The Stationery Office.

Office of Government Commerce. (2009b). Managing and Directing Successfull Projects with Prince2. Retrieved from http://www.best-management-practice.com/gempdf/PRINCE2_2009_Overview_Brochure_June2009.pdf

Office of Government Commerce. (2009c). *PRINCE2 Pocketbook*. London, UK: Stationery Office Books.

Office of Government Commerce. (2011). PRINCE2 definition and history. Retrieved June 4, 2011, from http://www.prince2.com/what-is-prince2.asp

Ohara, S. (2004). *Capability based professional certification guidelines* (2.1 ed.). Sydney, AU: Project Management Association of Japan.

Ohara, S. (2005). *P2M guidebook volume 2* (Vol. 2). Japan, JP: Project Management association of Japan.

Ohara, S. (2006). *P2M guidebook volume 1* (Vol. 1). Japan, JP: Project Management association of Japan.

Ohara, S. (2009). *Project & program management for enterprise innovation (P2M) promoted by the project management association of japan (PMAJ)* (Vol. 1). Japan, JP: PMAJ.

Ohara, S., & Asada, T. (2009). *Japanese project management: KPM - innovation, development and improvement* (3rd ed.). Singapore, SG: World Scientific Publishing Co. Pte. Ltd.

O'Toole, J. (1996). *Leading change: The argument for values-based leadership* (1st ed.). New York, NY, US: Ballentine Books.

Pahl, G., & Beitz, W. (2007). *Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendungen* (7th ed.). Berlin, DE: Springer-Verlag.

Paulk, M. C., Curtis, B., Chrissis, M. B., & Weber, C. V. (1993). *Capability Maturity Model for Software Version 1.1 (technical Report)*. Pittsburgh, PA, USA: Software Engineering Institute; Carnegie Mellon University.

Peitgen, H.-O., Saupe, D., & Jürgens, H. (1992). *Chaos and fractals: New frontiers of science*. New York, NY, USA: Springer-Verlag.

Pennypacker, J., & Dye, L. (2002). *Managing multiple projects*. New York, NY, US: Marcel Dekker Inc.

Pennypacker, J., & Grant, K. P. (2003). Project Management Maturity: An industry benchmark. *Project Management Journal*, (34), 4–11.

Persee, J. (2007). *Project management success with CMMI* (1st ed.). Upper Saddle River, NJ, US: Prentice Hall Press.

Peters, M. (2008). *Vertrauen in Wertschöpfungspartnerschaften zum Transfer von retentivem Wissen: Eine Analyse auf Basis realwissenschaftlicher Theorien und Operationalisierung mithilfe des Fuzzy Analytic Network Process und der Data Envelopment.* Wiesbaden, DE: Gabler Verlag.

Pfetzing, K., & Rohde, A. (2009). *Ganzheitliches Projektmanagement* (Vol. 2). Gießen, DE: Dr. Götz Schmidt Verlag.

Pimmler, T., & Eppinger, S. (1994). Integration analysis of product decompositions. Presented at the ASME Design Theory and Methodology Conference, Minneapolis, MN, US.

Pine, J. (1993). *Mass customizing: The new frontier in business competition*. Boston, MA, US: Harvard Business School Press.

Platz, J., & Platz, K. (2009). Competence based project management - problem solving. In *Competence based project management* (Vol. 2, pp. 431–508). Nuernberg, DE: GPM.

PM Greece. (2011). Network of Project Managers in Greece. Retrieved from http://www.pmgreece.gr/

Popitz, H. (1992). *Phänomene der Macht* (2nd ed.). Tübingen, DE: Mohr Siebeck.

Popper, K. (2002). *Logic of Scientific Discovery*. London, UK: Routledge.

Porst, R. (2011). *Fragenbogen* (3rd ed.). Wiesbaden, DE: VS Verlag für Sozialwissenschaften.

Probst, G. (1987). *Selbstorganisation - Ordnungsprozesse in sozialen Systemen aus ganzheitlicher Sicht*. Berlin, DE: Parey.

Project Management Association Finland. (2012). Project Management Association Finland (PMAF). Retrieved January 2, 2012, from http://www.pry.fi/en/node/106

Project Management Association Hungary. (2011). Project Management Association Hungary. Retrieved January 2, 2012, from http://www.fovosz.hu/index_files/Page352.htm

Project Management Association of Canada. (2011). Project Management Association of Canada. Retrieved January 2, 2012, from http://www.pmac-ampc.ca/node/18

Project Management Association of Iceland. (2011). Project Management Association of Iceland. Retrieved January 2, 2012, from http://www.vsf.is/forsida/

Project Management Association of Japan. (2005, 2007). History - PMAJ - Project Management Association of Japan. Retrieved June 4, 2011, from http://www.pmaj.or.jp/ENG/index.htm

Project Management Association of Nepal. (2011). Project Management Association of Nepal. Retrieved January 2, 2012, from http://pman.org.np/about-us/formation.html

Project Management Association of Slovakia. (2011). Project Management Association of Slovakia. Retrieved January 2, 2012, from http://www.sppr.sk/index.php/sk/o-nas/historia

Project Management Association of Zambia. (2011). Project Management Association of Zambia. Retrieved January 2, 2012, from http://www.4cpm.net/accreditedcentres/centreinfo.asp?id=55

Project Management Austria. (2011). Project Management Austria. Retrieved January 2, 2012, from http://www.p-m-a.at/about-pma/uber-pma.html

Project Management Institute. (2009). Annual Report 2009. Project Management Institue. Retrieved from http://www.pmi.org/About-Us/~/media/PDF/Executive-Legal/PMIAR09-Book-press.ashx

Project Management Institute. (2011a). PMI - Code of Ethics. PMI. Retrieved from http://www.pmi.org/About-Us/Ethics/~/media/PDF/Ethics/ap_pmicodeofethics.ashx

Project Management Institute. (2011b). PMI- core values. Retrieved September 10, 2011, from http://www.pmi.org/About-Us/About-Us-Core-Values.aspx

Project Management Institute. (2011c). PMI- standards. Retrieved September 10, 2011, from http://www.pmi.org/PMBOK-Guide-and-Standards/Standards-Library-of-PMI-Global-Standards.aspx

Project Management Institute. (2013). Pulse of the Profession - The High Cost of Low Performance, (3).

Project Management Institute. (2014). *Navigating complexity - a Practice Guide* (1st ed.). Newtown Square, PA, US: Project Management Institue.

Project Management Research Committee. (2011). Project Management Research Committee China. Retrieved January 2, 2012, from http://www.pmrc.org.cn/do/index.php?&ch=6

Project Management Romania. (2011). Project Management Romania. Retrieved January 2, 2012, from http://www.pm.org.ro/locatie-nou-hv.asp

Project Management South Africa. (2011a). National Qualification Framework (NQF) of SAQA. Retrieved January 3, 2012, from http://www.projectmanagement.org.za/page.aspx?Id=77&CateId=46&Category=PM%20Resources&SubCateId=47&SubCategory=Standards

Project Management South Africa. (2011b). Profile of Project Management South Africa. Retrieved January 3, 2012, from http://www.projectmanagement.org.za/page.aspx?Id=15&CateId=2&Category=About%20Us&SubCateId=15&SubCategory=Profile

Project Management South Africa. (2011c). Standard Generating Body Domains. Retrieved from http://www.projectmanagement.org.za/page.aspx?Id=75&CateId=46&Category=PM%20Resources&SubCateId=47&SubCategory=Standards

Pruckner, M. (2005). *Die Komplexitäts-Falle*. Norderstedt, DE: Books on Demand GmbH.

Prudix, D., & Goerner, M. (2009). Competence based project management - teamwork. In *Competence based project management* (Vol. 2, pp. 351–430). Nuernberg, DE: GPM.

Puhl, H. (1999). *Komplexitätsmanagement: Ein Konzept zur ganzheitlichen Erfassung, Planung und Regelung der Komplexität in Unternehmensprozessen*. Technische Universität Kaiserslautern, Kaiserslautern, DE.

Pulm, U. (2004). *Eine systemtheoretische Betrachtung der Produktentwicklung* (Promotion). TUM, München, DE. Retrieved from http://tumb1.biblio.tu-muenchen.de/publ/diss/mw/2004/pulm.pdf

Purle, E. (2003). *Management von Komplexität in jungen Wachstumsunternehmen* (1st ed.). Regensburg, DE: Josef EUL Verlag GmbH.

Raab-Steiner, E. (2010). *Der Fragebogen* (2nd ed.). Wien, AT: Facultas Verlags- und Buchhandels AG.

Rad, P., & Levin, G. (2008). What is Project Portfolio Management? *AACE International Transactions*, (2008), 1–4.

Rapp, T. (1999). *Produktstrukturierung*. Wiesbaden, DE: Gabler Verlag.

Rathnow, P. J. (1993). *Integriertes Variantenmanagement. Bestimmung, Realisierung und Sicherung der optimalen Produktvielfalt*. Göttingen, DE: Vadenhoeck & Rupprecht.

Reiss, G. (1996). *Programme management demystified: Managing multiple projects successfully*. London, UK: E & FN Spon.

Reiss, G., Anthony, M., Chapman, J., Leigh, G., Pyne, A., & Rayner, P. (2006). *Gower handbook of programme management* (1st ed.). Hampshire, UK: Gower Publishing Limited.

Remington, K., & Pollack, J. (2007). *Tools for complex projects*. Hampshire, UK: Gower.

Richter, M. (2008). Komplexitätsfallen im Projektmanagement. *Trainer-Kontakt-Brief*, (63), 24.

Riedl, R. (2000). *Strukturen der Komplexität: eine Morphologie des Erkennens und Erklärens*. Berlin, DE: Springer.

Rivard, S., & Dupré, R. (2009). Information systems project management in PMJ: A brief history. *Project Management Journal*, *40*(4), 20–30.

Rohrschneider, U., & Spang, K. (2009). Competence based project management - risks, threats and opportunities. In *Competence based project management* (Vol. 2, pp. 183–247). Nuernberg, DE: GPM.

Rother, M. (2009). Prince2 und die Konkurrenten. *Computerwoche*, (31), 6.

Saaty, T. (2001). *The analytic network process: decision making with dependence and feedback*. Pittsburgh, PA, US: RWS Publishing.

Sander, H. (2007). *Varianten- und Komplexitätsmanagement in industriellen Produktionsprozessen* (Diploma). Leuphana, Lüneburg, DE. Retrieved from http://opus.uni-lueneburg.de/opus/volltexte/2008/14159/pdf/Diplomarbeit.pdf

Sanghera, P. (2007). *PgMP: Program management professional exam study guide*. Indianapolis, IN, US: Wiley Publishing.

Sargut, G., & Gunther McGrath, R. (2011). Mit Komplexität leben lernen. *Harvard Business Manager*, *33*(11), 24–34.

Saris, W., & Gallhofer, I. (2007). *Design, evaluation, and analysis of questionnaires for survey research*. Hoboken, NJ, US: John Wiley & Sons, Inc.

Saynisch, M. (2009). Competence based project management - configuration management. In *Competence based project management* (Vol. 2, pp. 917–996). Nuernberg, DE: GPM.

Schaub, H. (1996). Über Fehler und deren Ursachen beim Handeln in Unbestimmtheit und Komplexität. Retrieved from http://hefrweb02.eif.ch/learningpacemaker/demo3/files/FET%3B%20Exception%20error.pdf

Scheiter, S., Scheel, O., & Klink, G. (2007). *Was kostet Komplexität wirklich?* Zurich, CH: A.T. Kearny.

Scheuring, H. (2009a). Competence based project management - project startup. In *Competence based project management* (Vol. 2, pp. 1163–1263). Nuernberg, DE: GPM.

Scheuring, H. (2009b). Competence based project management - resources. In *Competence based project management* (Vol. 2, pp. 699–755). Nuernberg, DE: GPM.

Schnell, R., Hill, B., & Esser, E. (1999). *Methoden der empirischen Sozialforschung*. München, DE: Oldenbourg Wissenschaftsverlag GmbH.

Schoeller, N. (2009). *Internationales Komplexitätsmanagement am Beispiel der Automobilindustrie*. Rheinisch-Westfälischen Technischen Hochschule Aachen, Aachen, DE.

Schrader, R. (2009). Praxisbeispiele zum Komplexitätsmanagements in der Pharma Supply Chain. *APV News*, pp. 8–12. Colbitz, DE.

Schreyögg, G. (2008). *Organisation: Grundlagen moderner Organisationsgestaltung* (5th ed.). Wiesbaden, DE: Gabler.

Schueller, A. (1994). *Komplexität und Managementpraxis*. Stuttgart, DE: ENKE Verlag.

Schuh, G. (2005a). *Produktkomplexität managen* (2nd ed.). München, DE: Carl Hanser Verlag.

Schuh, G. (2005b). *Produktkomplexität managen*. Munich, DE: Carl Hanser Verlag.

Schwaninger, M. (1989). *Integrale Unternehmensplanung (Integral corporate planning)*. Frankfurt, DE: Campus Verlag.

Schwaninger, M., & Koerner, M. (2001). Systematisches Projektmanagement: Ein Instrumentarium für komplexe Veränderungs- und Entwicklungsprojekte (Systematic project management: Instrument for complex change - and development projects). Retrieved from http://www.strategylab.ch/org/Ifb/ifbweb.nsf/SysWebRessources/beitrag43/$FILE/sysprojmgmt.pdf

Schwarz, A. (2011). *Phalinza - Komplexe Situationen erfolgreich managen* (1st ed.). Berlin, DE: epuli GmbH.

Schweiger, S. (2005). *Logistische Komplexität durch Variantenmanagement beherrschen - Wertpotenziale in produzierenden Unternehmen ausschöpfen* -. Konstanz, DE.

Seibert, S. (2009). Competence based project management - cost and finance. In *Competence based project management* (Vol. 2, pp. 755–819). Nuernberg, DE: GPM.

Siegelaub, J. (2006). How PRINCE2® Can Complement the. PMBOK® Guide and Your PMP®. Presented at the PMI Global Congress Proceedings, Buckinghampshire HP13 6DG, UK: APM Group Ltd.

Silverman, D. (2009). *Doing qualitative research: A practical handbook* (3rd ed.). London, UK: Sage Publications Ltd.

Simons, H. (2012). *Case study - research in practice*. London, UK: Sage Publications Ltd.

SMAP. (2011). Association Francaise pour l'avancement du Management de Projet. Retrieved from http://www.smap-asso.eu/

SMP. (2011). Société suisse de Management de Projet. Retrieved from http://www.project-management.ch/portail/pages.php?pg=9

Snowden, D. (2005). Multi-Ontology Sense Making – a New Simplicity in Decision Making. *Informatics in Primary Care*, *13*(1), 45–54.

Software Engineering Institute. (2010, November). CMMI for Development, Version 1.3. Retrieved from http://www.sei.cmu.edu/reports/10tr033.pdf

Software Engineering Institute. (2011). About Us | Overview. Retrieved June 4, 2011, from http://www.sei.cmu.edu/about/

South African Qualifications Authority. (2001). Notice of Publication of Unit Standards-based Qualifications for Public Comment: National Certificate in Project Management - NQF Level 4. *General Notice No. 1206 of 2001*, *437*(22846).

South African Qualifications Authority. (2011a). Registrated Qualification Level 3 - Project Support Service. Retrieved from http://allqs.saqa.org.za/showQualification.php?id=50398

South African Qualifications Authority. (2011b). Registrated Qualification Level 4 - Generic Project Management Ceritifcate. Retrieved from http://allqs.saqa.org.za/showQualification.php?id=21160

South African Qualifications Authority. (2011c). Registrated Qualification Level 5 - Project Management Diploma. Retrieved from http://allqs.saqa.org.za/showQualification.php?id=58309

SOVNET. (2011). Russian PM Association. Retrieved from http://www.sovnet.ru/

SPR. (2011). Project Management Association Czech Republic. Retrieved January 2, 2012, from http://www.ipma.cz/web/spr/profil-spolecnosti.php

Stackpole, C., Rasmussen, K., Grooms, M., Hyman, S., Kestel, J., Malicki, T., … Vitello, K. (2010). *PMBOK Guide* (4th ed.). Newtown Square, PA, USA: PMI Publications.

Stackpole, C., Rassmussen Noll, K., Grooms, M., Hyman, S., Kestel, J., Malicki, T., … Wilfer, M. (2008). *A guide to the project management body of knowledge (4th edition)* (4th ed.). Newtown Square, PA, US: Project Management Institute.

Statistisches Bundesamt. (2008). *Klassifikation der Wirtschaftszweige*. Wiesbaden, DE: SFG - Servicecenter Fachverlage GmbH.

Steward, D. (1981a). *System analysis and management: structure, strategy and design*. New York, NY, US: Petrochelli Books.

Steward, D. (1981b). The Design Structure System: A Method for Managing the Design of Complex System. *IEEE Transaction on Engineering Management*, *28*(3), 79–83.

Stüttgen, M. (2003). *Strategien der Komplexitätsbewältigung in Unternehmen* (2nd ed., Vol. 12). Bern, CH: Haupt Verlag.

Sudman, S., Bradburn, N., & Schwarz, N. (1996). *Thinking about answers. the application of cognitive processes to survey methodology*. San Francisco, CA, US: Jossey-Bass Inc., Publishers.

Swanson, S. (2012). Keeping Chaos Out of Complexity. *PM Network*, *26*(8), 55–59.

Swedish Project Management Society. (2011). Swedish Project Management Society. Retrieved from http://www.projforum.se/

Swiss project management association. (2011). Swiss Project Management Association. Retrieved from http://www.spm.ch/wir-ueber-uns

Szent-Györgyi, A. (1964). Teaching an the Expanding Knowledge: The Simplification that comes With Expanding Knowledge Enables Teaching to Encompass this Knowledge. *Science*, *146*(3649), 1278–1279.

Taiwan Project Management Association. (2011). Taiwan Project Management Association. Retrieved from http://www.tw-pma.org.tw/

Taylor, F. W. (1967). *The principles of scientific management*. New York, NY, US: Norton.

Techt, U. (2009). Competence based project management - chritical chain project management. In *Competence based project management* (Vol. 2, pp. 1368–1422). Nuernberg, DE: GPM.

Thamhain, H. (2013). Managing Risks in Complex Projects. *Project Management Journal*, *44*(2), 20–35. http://doi.org/10.1002/pmj

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.

The Standish Group. (2001). *Chaos Report*. Boston, MA, US: The Standish Group Inc.

The Standish Group. (2010). *Chaos Report 2009*. Boston, MA, US: The Standish Group Inc.

Titcomb, T. J. (1998). Chaos and complexity theory. *Organisational Developmement*, (9807).

Tscheulin, D. (2000). Analytic hierarchy process. In *Marktforschung. Methoden, Anwendungen, Praxisbeispiele* (2nd ed.). Wiesbaden, DE: Gabler Verlag.

Tuckman, B. (1984). “Developmental sequence in small groups” Current Concerns. *Citation Classic*, (34), 14.

Tuckman, B. (2001). Developmental Sequence in Small Groups. *A Research and Applications Journal*, (3), 66–81.

Tuckman, B., & Jensen, M. A. (1977). Stages of Small-Group Development Revisited. *Group & Organisation Studies*, *2*(4), 419–427.

Turkish Project Management Association. (2011). Turkish Project Management Association. Retrieved from http://www.trpma.org/?lan=tr&page=tr/pyk/iletisim.htm

Ulrich, K., & Tung, K. (1991). *Fundamentals of product modularity*. Cambridge, MA, US: Sloan School of Management, Massachusetts Institute of Technology.

UPMA. (2011). IPMA community in the Ukraina. Retrieved January 2, 2012, from http://upma.kiev.ua/index.php?lang=english

Valle, V. (2000). *Chaos, Complexity and Deterrence* (p. 13). Fort Lesley J. McNair, DC, US: National War College.

Van Gigch, J. (1987). *Decision making about decision making: Metamodel and metasystems*. Cambridge, MA, US: Abacus Press.

Vaughn, S., Schumm, J., & Sinagub, J. (1996). *Focus group interviews in education and psychology*. Thousand Oaks, CA, US: Sage Publications.

Vemuri, R. (1978). *Modeling complex system: An introduction*. New York, NY, US: Academic Press.

Verzuh, E. (2008). *The Fast Forward MBA in Project Management* (3rd ed.). Hoboken, NJ, US: John Wiley & Sons, Inc.

Vester, F. (2000). *Die Kunst vernetzt zu denken* (6th ed.). Stuttgart, DE: Deutsche Verlags-Anstalt.

Violette, D., Kestel, J., Clemens, N., Deakin, D., Giotis, T., Gunnerson, M., … Vitello, K. (2013). *A guide to the project management body of knowledge (5th edition)* (5th ed.). Newtown Square, PA, US: Project Management Institute.

von der Eichen, S., & Stahl, K. H. (2003, December). Brauchen wir ein neues Management? *Frankfurter Allgemeine Zeitung*. Frankfurt am Main, DE.

von der Eichen, S., Stahl, K. H., Odenthal, S., & Vollrath, C. (2005). Steuern - statt reduzieren. *Harvard Business Manager*, (12), 114–120.

Wabwoba, F., & Ikoha, A. (2011). Information Technology Research in Developing Nations: Major Research Methods and Publication Outlets. *International Journal of Information and Communication Technology Research*, *1*(6), 253–257.

Waite, M., & Hawker, S. (2009). *Oxford Dictionary* (3rd ed.). Oxford, UK: Oxford University Press.

Ward, L. (2005). Untying the Gordian Knot of Complex Projects - a Structured Approach to Complexity. Presented at the PMI Global Congress Proceedings, Singapore, SG: Project Management Institute.

Warfield, J. (1973). Binary Matrices in Cystem Modeling. *IEEE Transaction on Systems, Management and Cybernetics*, *3*(5), 441–449.

Weatherly, J. (2009). *Handbuch für systematisches Management: Eine Anleitung fuer Praktiker*. Berlin, DE: MWV Medizinisch Wissenschaftliche Verlagsgesellschaft.

Weber, C. (2005). What is "complexity"? In *Proceedings of the 15th International Conference on Engineering Design*. Melbournce, AU: Institution of Engineers 2005.

Wegener, I. (2003). *Komplexitätstheorie* (1st ed.). Berlin, DE: Springer.

Wendler, R. (2009). *Reifegradmodelle für das IT-Projektmanagement (maturity models for IT project management)* (No. 53/09) (p. 60). Dreseden, Germany: TU Dresden.

Werndl, C. (2009). What are the New Implications for Chaos for Unpredictability. *The British Journal for the Philosophy of Science*, *60*(1), 195–220.

Weyer, J., & Schulz-Schaeffler, I. (2009). *Management komplexer Systeme*. Dortmund, DE: Oldenbourg Wissenschaftsverlag GmbH.

Widemann, M. (1990, January). *Total Project Management of Complex Projects - Improving Performance with Modern Techniques*. New Delhi, IN.

Wildemann, H. (1991). Zeit als Wettbewerbsfaktor durch Motivation und Qualifikation. In *Wettbewerbsfaktor Zeit in Produktionsunternehmen* (pp. 339–355). München, DE: Springer-Verlag.

Wildemann, H. (1998). Komplexitätsmanagement durch Prozess- und Produktgestaltung. In *Komplexitätsmanagement* (pp. 47–68). Wiesbaden, DE: Gabler Verlag.

Wildemann, H., Ann, C., Broy, M., Günthner, W., & Lindemann, U. (2007). *Plagiatschutz - Jandlungsspielräume der produzierenden Industrie gegen Produktpiraterie*. München, DE: TWC Transfer-Centrum GmbH & Co. KG.

Williams, G. (1998). Chaos Theory Tamed. *Nature*, *394*(6693), 538.

Williams, T., Klakegg, O. J., Walker, D., Andersen, B., & Magnussen, O. M. (2012). Identifying and Acting on Early Warning Signs in Complex Projects. *Project Management Journal*, *43*(2), 37–53. http://doi.org/10.1002/pmj

Wirtz, B. (2010). *Business Model Management: Design- Instrumente- Erfolgsfaktoren von Geschäftsmodellen* (1st ed.). Wiesbaden, DE: Gabler, Betriebswirt.-Vlg.

Wolff, U., Rosenthaler, C., & Knoepfel, H. (2009). Competence based project management - project scope. In *Competence based project management* (Vol. 2, pp. 509–579). Nuernberg, DE: GPM.

Wolf, M. (2011). *Erfolgsschwung im Projektmanagement*. Presented at the Projekt Management Austria, Wien, AT.

Yang, J. B. (2007). The Body of Knowledge of Procurement Project Management for Construction Projects. Institute of Construction Management, Chung Hua University, Hsinchu, Taiwan.

Yassine, A. (2004). An introduction to modeling and analyzing complex product development processes using the design structure matrix (DSM) method. University of Illinois.

YUPMA. (2011). Serbian Project Management Association. Retrieved from http://www.yupma.rs/yupma/sr/kontakt

Zandhuis, A., Stellingwerf, R., & Newton, S. (2013). *ISO 21500 guidance on project management: A pocket guide* (1st ed.). Zaltbommel, NL: Van Haren Publishing.

Zimmermann, H.-J., & Gutsche, L. (1991). *Multi-Criteria-Analyse: Einführung in die Theorie der Entscheidungen bei Mehrfachzielsetzungen*. Berlin, DE: Springer.

Zimmermann, J. (2010). Für eine Geschichte der Systemwissenschaft. Prof. Dr. Matthies. Retrieved from http://www.usf.uos.de/usf/literatur/beitraege/texte/053-zimmermann.pdf

Zolin, R. (2010). How environmental and organizational complexity affects opportunity recognition and exploitation in development projects. *AGSE*. Retrieved from http://www.swinburne.edu.au/lib/ir/onlineconferences/agse2010/000100.pdf

ZPM. (2011). Slovenia Project Management Association. Retrieved from http://sl.zpm-si.com/o-zpm/kje-nas-najdete/