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Knowledge-based planning and controlling with methods of artificial intelligence to increase efficiency in IT projects

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AUTHORIZATION OF THE DIRECTORS OF THE THESIS FOR SUBMISSION

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Prof. Dr. Laura Campoy

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son Niclas “Nicel” Brüggen who´s supported me all the time as well as my
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friends during my way in the last decades.

“Bazinga”
Sheldon Cooper B.S. M.S. M.A. PH.D. SC.D.
The Big Bang Theory (2007)

“Your future is whatever you make it, so make it a good one”
Doc Brown
Back to the Future (1985)

Resume

The success of IT projects in companies is increasingly becoming a competitive factor. The aim of this work is to analyze how knowledge management methods in a classic IT project can be supported with the help of artificial intelligence methods in order to carry out the IT project more efficiently. To answer the research questions, a qualitative method in the form of expert interviews is used on the one hand and the creation of a model of a reference architecture on the other hand. The creation of the reference architecture model is based on real-world requirements with the goal of generating a technology-neutral and easy-to-understand blueprint for different IT projects implementing artificial intelligence and knowledge management methods. The reference architecture model is evaluated analytically and with the support of experts in the areas of AI, Knowledge management and project management in the following. The results of this study allow a statement to be made as to whether it makes sense to foster certain tasks in an IT project with the support of AI methods.

Keywords: IT Project Management; Artificial Intelligence; Knowledge Management, Transformation

RESUMEN

El éxito de los proyectos informáticos en las empresas se está convirtiendo cada vez más en un factor competitivo. El objetivo de este trabajo es analizar cómo se pueden apoyar los métodos de gestión del conocimiento en un proyecto informático clásico con la ayuda de métodos de inteligencia artificial para llevar a cabo el proyecto informático de forma más eficiente. Para responder a la pregunta de investigación se utiliza, por un lado, un método cualitativo en forma de entrevistas a expertos y, por otro, la creación de un modelo de arquitectura de referencia. La creación del modelo de arquitectura de referencia se basa en requisitos del mundo real con el objetivo de generar un anteproyecto tecnológicamente neutro y fácil de entender para diferentes proyectos de TI que apliquen métodos de inteligencia artificial y gestión del conocimiento. El modelo de arquitectura de referencia se evalúa analíticamente y con la ayuda de expertos en la materia. Los resultados de este estudio permiten afirmar si tiene sentido apoyar determinadas tareas de un proyecto informático con la ayuda de métodos de IA.

Palabras clave: Gestión de proyectos de TI; Inteligencia Artificial; Gestión del conocimiento, Transformación.

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1 Introduction

1.1 Background and Motivation

Progressive digitization is leading to completely new companies and presenting traditional, established companies with significant challenges as they are undergoing fundamental change (Horváth, 2017, p. 113). The ability to conduct changes in the own organization is one of the most important for companies nowadays. The knowing about the requests from their markets with their participants and the need to offer the right products to the right place, in the right time and quality is essential for the survival of a company. The most companies are researching in these questions and find solutions to improve their chain of economic value added. One of the exciting questions is the forecast of the developing of the so-called Mega trends. Mega trends are global trends that span a period of up to 50 years and are relevant in all social and cultural structures. In addition to health and demographic change, the topics of globalization and digitization also belong to the mega trends and have a considerable influence on development and the economy (Naisbitt and Aburdene, 1990, p. 9).

Recognizing a megatrend is considered the easiest way to conduct futurology and thus brings added value to companies. In recent years, digitization has become increasingly important for companies. The areas Internet of Things, Industry 4.0 or Internet 2.0 ensure that more and more data was generated. According to a forecast by Statista, the annual data volume worldwide will grow from 33 zettabytes in 2018 to 175 zettabytes in 2025 (Statista 2020, 2020). This represents an increase of 430,3% within seven years. The potential for companies to use and to analyze data is available. Although projects have been used as a means of international technology transfer for more than five decades, the results have been rather disappointing. The constant lack of desired results illustrates a simplistic and inaccurate view of technology and its transfer (Oti-Sarpong and Leiringer, 2021).

On the other hand, the pressure on IT departments to implement projects that contribute to the company's success remains high to reach their target in the dimensions of time, quality, and effort. Nevertheless, achieving the project objectives is not an end. A research study in 2019 from Capgemini Germany shows that only 15% of the interviewed companies will decrease their IT budget comparing the previous year. 50% will have an increased budget, and nearly 35% will have the same budget level as last year. In fact, the main target of the IT budget, with 72%, will be digitizing the processes and increasing the organization's efficiency (Dumslaff and Heiman, 2018). Another examination confirmed this

ongoing trend in 2020. A study conducted by Capgemini in 2020 shows that management's four most important demands on their IT departments are to expand digitization, increase efficiency, reduce costs, and develop new, innovative IT products and services (Roth & Heimann, 2020, p. 11). A similar result came from the examination in 2018. In this investigation was asked the question of why IT projects fail. The two significant reasons are given in the fact that there are not enough human resources in the IT and project departments (68%) as well as the missing know-how for the new topics. The need to manage their knowledge in the organization is fully aware of importance by most managers (Dose, 2018). This result is supported by The Standish Group International from 2015 which shows that only 11% of all large projects were completed as planned (The Standish Group International, Inc, 2015, p. 3). In fact, a 2022 study states that nearly half of the world's projects have failed in the last 50 years (Strang and Vajjhala, 2022). These facts illustrate the importance of efficient and effective IT project management.

Caused of the increasing cost pressure in most organizations, it is essential to search for new possibilities to work more efficiently. In the foreground are the internal processes, which are valuable to investigate. Most propositions in companies have high integrated relevance to the area of information technologies, e.g., the introduction of a new customer relationship software, the learning of financial processes, or to implementation of a new enterprise strategy. Tiemeyer points out that IT is involved in all of the strategic considerations of the companies (Tiemeyer, 2020, p. 22).

In all these examples,' IT is highly involved and is often a critical resource to achieve company targets. Because competitors have similar intentions, the capability to implement IT projects is a valuable competitive advantage. The critical question is which of the companies can transfer the inside- and outside requirements into action in the given time, quality, and budget.

1.2 Research goal

This dissertation examines the extent to which the use of selected artificial intelligence methods and knowledge management approaches can increase the efficiency of IT projects. At this point, it is necessary to restrict specifically selected methods of AI and knowledge management. Technology research and development are being carried out at an increasing pace worldwide. The selection of the chosen methods is based on their degree of familiarity, practical benefits, and potential to be defined as new tools for solving known problems. The respective criteria are mentioned for the following models and use cases and reflect the individual applicability. The variables include classical project management dimensions such as time, cost, and quality.

However, other dimensions can also be used, if necessary, e.g., the quantity corresponding to the functionalities in a software project. The research question aims at the two substantial phases in projects, planning and controlling, whereby likewise, the execution is in the foreground. As a basis for the investigation, the different models of knowledge management are used, which are examined in this dissertation. No previous investigation offers a generic combination that supports the aspects of knowledge and project management through artificial intelligence. This research gap will be the subject of this investigation. Generic" here means not only defined by a project management standard like PMI or IPMA but a method of project management that can be used universally. Another research question is about the preferred knowledge management methods and artificial intelligence tools. The study will also explore what conditions are needed to use these methods to enhance planning and control. Chapter 5.1 lists the relevant research questions. A generic framework would make it easier to apply them in IT project management and would have these benefits:

1. The importance of answering this question is particularly significant for companies with a high level of competition because these companies who will execute their projects in the requested time, quality, and budget to reach the aims will have a competitive advantage. Taylor already pointed out that a generic model helps to reduce cycle times by more than 30% (Taylor, 2012, pp. 75–80).

2. A circumstance that should not be underestimated is that in each IT Project that more or less finished successfully, new knowledge and experiences were gained. The firms' ability and their project responsibilities can be used as a form of

knowledge transfer. Knowledge transfer is an exchange of facts, experiences, and insights from one person to another (SAGE Journals, 2020, p. 843).

3. Concerning the advantages of using technology in the research question, it is a fact that computers can solve complex calculations with a large amount of data nowadays. Nevertheless, artificial intelligence can only deliver relevant results if a human correctly applies and monitors these procedures. The proliferation of various applications of artificial intelligence is responsible because the roles of the users of this technology are also changing. Humans are therefore being integrated into higher-level roles while technology can take over the corresponding tasks (Ong and Uddin, 2020, p. 2).

1.3 Research method

Because this dissertation aims to answer questions of a qualitative nature on the one hand and questions of a quantitative nature on the other, two different research methods are applied.

1.3.1 Qualitative data analysis (QDA)

For the questions of qualitative nature, the methodology of expert interviews is planned. The research project first provides for selecting relevant experts, e.g., CIOs., CEOs, heads of Project management, and high-level decision-makers. The interviews will be analyzed by QDA, according to Mayring (Mayring, 2015, p. 5). The interviews will be conducted as semi-structured interviews to be able to respond spontaneously to the development of the interview. To maintain a high degree of objectivity, reliability, and validity, each role is interviewed twice with different interviewees, if possible, to obtain possible differences within a role. The results will use in the following discussion to underline similarities and deviations.

1.3.2 Creation of a reference model NICEL

In addition, the model of a reference architecture is created to apply theoretically and later evaluate the possible applications of artificial intelligence and knowledge management methods on this basis. The reference architecture model is intended to facilitate development and serves as a blueprint for the development of individual application scenarios. However, the term reference architecture is not clearly defined in literature and practice (Fernandez, Monge, & Hashizume, 2016). Therefore, in the related chapters, the general approach is presented first, in order to create a model of a reference architecture based on the requirements in the further course. How the development of a reference architecture works, in general, is shown in Chapter 6 before the NICEL reference architecture is used to answer the research hypotheses or to be able to use a practical framework. The name of the architectural model NICEL refers to the nickname of the author's son Niclas and is the abbreviation for Novelty through the approach to multiple views of use cases, integration of the subject areas AI, KM, and PM, complexity through projects, efficiency in the use of the reference model, and Language, which refers to the communication of multiple actors in projects.

With a combination of the results by expert interviews and simulation will the research question be answered.

1.4 Structure of the dissertation

Chamoni and Gluchowski state that only through mature information logistics can the required information be available on time, in the necessary quality, at the right place, and at the right time (Gluchowski and Chamoni, 2015, p. 4). Like any profit-maximizing company, processes along the value chain must be designed to be as effective and efficient as possible, which is especially true for the planning and implementation of IT projects.

To classify the theoretical principles as well as the state of research in the relevant areas, chapter 2 examines the approaches and models of knowledge management as well as the different forms in which knowledge can occur. This forms the theoretical basis for the knowledge-based tasks in IT projects, which are an essential building block for this study.

The different project management phases, the requirement analysis, the planning of resources, budget, and expenditure, are examined in chapter 3. In addition, the project control phase with the complementary approaches and

instruments will be discussed. The risk management and current approaches to the test and quality management of software are likewise treated. The subchapters of the various project procedure models form the conclusion of this chapter.

The fourth chapter forms the last theoretical component by which selected artificial intelligence methods are examined. A selection is made of the techniques that best serve to answer the research question. These are listed in the chapter accordingly and examined in detail.

The derivation of the hypotheses occurs of the research questions, which are listed in chapter 5. The practical investigations to answer the research questions and hypotheses are conducted using expert interviews (QDA) and creating a reference model will be also the topic of this chapter. The evaluations of the model of the reference architecture will be presented in chapter 6. The results of the studies are discussed, and the answers to the research questions and hypotheses are carried out in chapter 7 with as a conclusion, the limitation of this thesis, and with an outlook on further research possibilities resulting from this thesis.

1.5 Scope and limitations

The scope of this dissertation refers to the use of a qualitative method QDA and creating a model of a reference architecture to answer the questions listed in the research questions and hypotheses. The core of the research relates to whether the use of artificial intelligence in IT projects is applicable under efficiency points in given dimensions. The scope also refers to what prerequisites must be met and what consequences this may entail.

Possible legal or compliance-specific requirements or rules are explicitly not part of this work. Likewise, only their methods are used in selecting artificial intelligence, and no company or product recommendations.

2 Knowledge Management

This chapter presents the fundamentals of knowledge management to understand why the topic has become increasingly important over the years and in which research areas knowledge management plays a central role. Furthermore, definitions of the most influential authors who have shaped this topic follow. In the following subchapters, the various knowledge management models are presented and put into context with this research topic.

Many organizations are transforming from an industrial to a knowledge-based economy (Testa, Brown-Grant, & Bedford, 2019). In addition to the effects of knowledge-based leadership on project success, which succeeds with the help of team cohesion and with moderating roles that honor the appreciation of people, the focus is on the use of knowledge management methods (Mariam et al., 2022). One of the key challenges for organizations is to uncover the logical from the illogical through knowledge management strategies, thereby improving the efficiency and scale of their knowledge management infrastructure (Weed-Schertzer, 2020, p. 12). The importance of Knowledge Management in the scientific literature is still given. A query in the Web of Science for the topic "Knowledge Management" showed an increase in published papers from 2010 to 2020 of 145%. The research areas in which the topic "Knowledge Management" is most frequently represented are Business Economics, Computer Science, Information Science / Library Science, and Engineering (Clarivate, 2021). Knowledge-based organizational support is considered a precursor to project management and project performance. In addition, project management and project performance play a mediating role between knowledge-based organizational support and organizational performance (Sepúlveda-Rivillas, Alegre, & Oltra, 2022). A fundamental challenge specifically for interorganizational projects is to harness the knowledge, expertise, and perspectives of different actors to address the situation-specific requirements of complex innovations. Innovation progress depends on the extent to which knowledge is used and synthesized to address emerging and situation-specific requirements of the innovation (Nisula et al., 2022).

The development and further handling of knowledge in companies is of particular importance for this work and will be treated with appropriate focus. Using the evolutionary perspective, the positive gossip and knowledge-based view serves as the explanatory basis in the knowledge sharing behavior. This helps to establish the relationship between positive gossip in the workplace and IT project success (Shah, Hashmi, & Naz, 2021). In organizational theory, the paradigm has

long been assumed that the organization processes the information or knowledge or serves to solve problems. The central component is the efficient handling of these resources (Ikujiro Nonaka, 1994, p. 1). To unify a notion of knowledge for this work, several models are presented below. Probst et al. define knowledge as follows: knowledge refers to the totality of knowledge and skills that individuals use to solve problems. This includes both theoretical knowledge and practical everyday rules and instructions for action. Knowledge is based on data and information, but it is always tied to individuals in contrast to these. It is constructed by individuals and represents their expectations about cause-effect relationships (G. J. B. Probst, Raub, & Romhardt, 2012, p. 23). This has resulted in further research related to the relationships between top management team formation and performance, as well as the mediating role of ambidexterity (Chang et al., 2022, p. 8), which can also be adapted to project teams. In addition, Hetemi et. al. notes that while extensive research exists in the information technology field, little is known about the knowledge work practices required for IT projects to coalesce and be implemented as temporary organizational structures (Hetemi, Pushkina, & Zerjav, 2022).

2.1 Theoretical models of Knowledge Management

Knowledge automation today cited as a critical success factor in knowledge management (Shaikh, 2022). This statement is supported by a study from 2021, which identifies a trend in which companies are moving from non-automated knowledge management to automated knowledge (Shaikh and Bhutto, 2021). This chapter explains an overview of the most common knowledge management models. In order to select which knowledge management models are used to answer the research hypotheses, the focus must be placed on those models that have the greatest practical benefit. In addition, the models must not be too theoretical in nature, as otherwise the practical benefit cannot be guaranteed. In addition, the models must have a certain degree of familiarity in order to be used effectively and efficiently. It must also be established that knowledge management models can be used not only for individuals but also for organizations. The following knowledge management models all have these characteristics and are included in part in this study. However, due to its practical implementation, the Building Block model by Probst, Raub, and Romhardt is used the most for the research hypotheses. As was made clear in the previous chapter, the concept of knowledge management has resulted in various focuses and models in recent years. Accordingly, it is not surprising that there are different views on the subject. Since the models each have different approaches and emphases, it is necessary to

introduce them before they are incorporated into the research topics - as far as their suitability - in the following chapters. A community of practice (CoP) is considered a driving force for knowledge creation, but can hinder knowledge sharing across boundaries (Matsuo and Aihara, 2022).

Riempp divides the views of knowledge management into strategic, process-oriented, and system-oriented approaches. He also speaks of design areas, which are subdivided into human-oriented, technology-oriented, and interaction-oriented approaches. In the early days of knowledge management, the technology-oriented approaches were in the foreground. Nowadays, the human-oriented and interaction-oriented approaches are more common in the literature and practice (Riempp, 2004, pp. 75–78). Supporting this, the two reinforcing mechanisms for knowledge development in the knowledge ecosystem are the given structures and the openness of knowledge holders crucial, for further development of knowledge (Öberg and Lundberg, 2022).

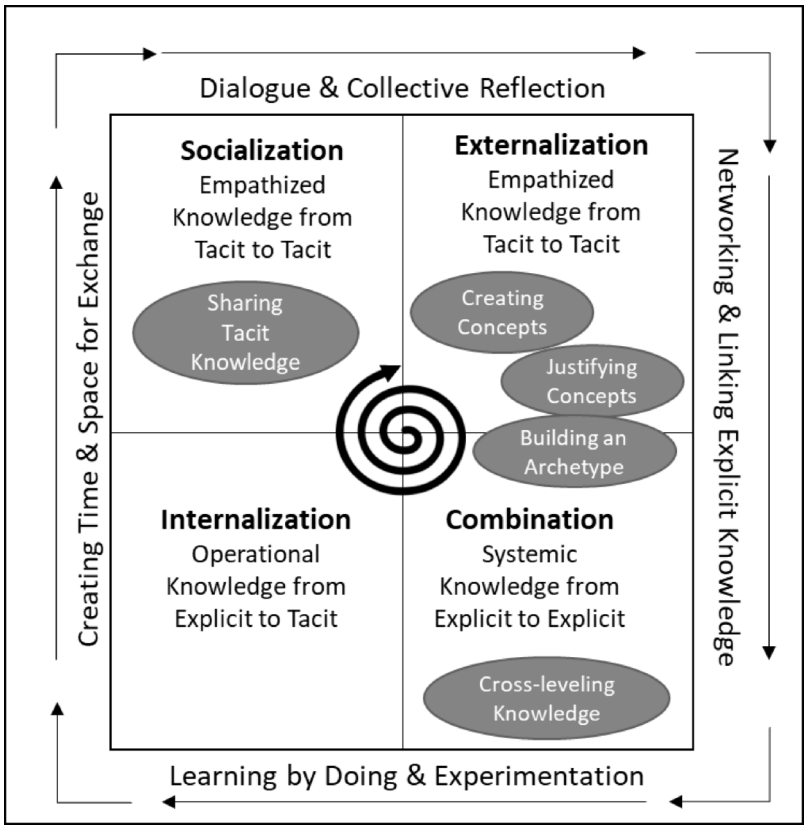
On the other hand, if the view of companies is considered, three areas can be distinguished here. Concerning people, the design of communication and learning platforms is understood. The focus of organizational design lies in the organizational view and, about technology, the view of knowledge management as the design of system-supported knowledge distribution and knowledge retention. In order to consider holistic knowledge management, all three of the areas mentioned above must be taken into account (Frey-Luxemburger, 2014, p. 40). On the other hand, research continues the impact of communication and learning platforms. For example, the study by Nikulina et. al. points out that true collaboration is complex, especially in the communicative domain, and equal attention must be paid to formal and relational relationships for collaboration to be successful (Nikulina, Volker, & Bosch-Rekveldt, 2022). Against this background, knowledge management serves, among other things, to make better decisions based on tacit knowledge from components, systems and modules, which are crucial for the development of organizational capabilities (Parente et al., 2022).

2.1.1 The model of knowledge spiral of Nonaka

The spiral model of knowledge, also known as the SECI model, describes knowledge creation, transmission, and development. In addition, Nonaka and Takeuchi classify explicit knowledge as objective, codified and transferable, and formal in nature. On the other hand, tacit knowledge is generated from experience and is difficult or impossible to transfer. The basis of tacit knowledge is experience, culture, emotions, and values or action routines (Ikujirō Nonaka & Takeuchi, 1995).

North states that explicating an implicit context for creating new knowledge is a fundamental requirement (North, 1998). The processual development of four different forms of knowledge transformation at the individual level is essential to the approach. The SECI model (Socialization - Externalization - Combination - Internalization) is shown in Figure 2-1.

Figure 2-1: Model of knowledge spiral of Nonaka (SECI)



Note: Adapted from Ikujirō Nonaka & Takeuchi (1995)

The goal of knowledge-based management is to generate knowledge from information and to convert this knowledge into sustainable competitive advantages that can be measured as business success (North, 1998, p. 39). As shown in Figure 1, the exchange of experience in horizontal communication and vertical transmission is called socialization. Without this being consciously made clear, the exchange of experiences or things experienced in conversations or through imitation is knowledge. According to the spiral model, when unconscious

knowledge is transformed into conscious knowledge, it is considered the externalization phase. This can be expressed by pictures, instructions, or models to be understood by third parties. The result of externalization is called conceptual knowledge. Existing explicit knowledge is combined with other cognitive content to form new explicit knowledge. A combination leads to the so-called systemic knowledge. Here, knowledge is made available to the organization in retrievable form. Nonaka and Takeuchi point out that it is not the knowledge base of a company that is expanded, but only the scope of application. The ability to transfer learned processes to other problems is one example (Ikujirō Nonaka and Takeuchi, 1995, p. 28). Internalization is the reverse process when conscious knowledge is transferred to unconscious knowledge. Experiences and knowledge gained through previous socialization, externalization, or combination are integrated into individual mental models. This is called operational knowledge (C. Müller, 2008, p. 21). The exchange of tacit knowledge can be positively influenced for the work of other project participants. This is the result of a study published in 2022, in which this circumstance was examined among knowledge workers (Albawwat, 2022, p. 8). Nonaka and Takeuchi define five phases in which the knowledge spiral runs. The tacit knowledge is exchanged in the first phase, whereas concepts are created in the second phase to communicate them to others in the third phase. The development of a prototype follows in the fourth phase to transfer the knowledge in the fifth and final phases.

2.1.2 The model “organizational memory” of Walsh and Ungson

In their work, Walsh and Ungson point out that while memory in principle remains one of the core concepts of information and processing theories, this understanding is limited for application across organizations (Walsh and Ungson, 1991, p. 57). In this context, memory is the mental ability to remember and recall past experiences (*The American Heritage Dictionary*, 2021). The two authors describe that ambiguities accompany the extension of the previous concept to the organizational level, and it is questionable which level the organizational memory is located in the organization. One of the reasons for the difficulty in defining organizational memory is that it is unclear whether ideas about information processing can be extended to social and organizational phenomena. The claim that organizations have memory is related to anthropomorphism (Walsh and Ungson, 1991, p. 59). An organization can also exist independently of specific individuals. However, information is acquired during problem-solving or decision-making activities, which can be described as individual cognitive activities that lead to

information acquisition in organizations. Problems and solutions vary from person to person. However, through this process of sharing, an organization can retain its knowledge of the past, even when critical organizational members leave. Interpretations of the past can be embedded in systems and artifacts as well as in people. Organizational memory is thus a construct at both the individual and organizational levels (Walsh and Ungson, 1991, p. 61). Theoretically, it is possible that most of the information related to a decision stimulus and response is part of the organizational memory. The following describes where information can be stored.

2.1.2.1 Retention

The authors assume that five memory locations or repositories form the structure of memory within organizations. In addition, there is another source outside the organization. Two essential elements underlie the concept. First, the storage pattern varies depending on how well decision stimuli and responses can be stored, and second, organizational memory is not stored in only one location. Instead, it may be distributed in different parts of an organization. Next, we consider which aspects of decision information are stored in each bin.

2.1.2.2 Individuals

Individuals have their own memories of what has happened in and about the organization, based on their own direct experiences and observations. This information can be stored in their own memory or incorporated into their belief structures. Own behavior and assumptions about specific facts as well as articulated beliefs are generated from it. In addition, individuals and organizations keep records and files as memory aids. Such information technologies contribute to the formation of organizational memory (Walsh and Ungson, 1991, pp. 63–64).

2.1.2.3 Culture

Cultural experiences, which can be helpful for the future. The cultural aspect was defined as a way of perceiving, thinking about, and communicating problems to members of the organization. Therefore, it is a storage possibility of the organizational memory, which can be stored in language or symbols. In the transmission of information, it is likely that some details and contexts will be omitted or changed when decisions are made, but it is a fact that when they are transmitted, they are stored collectively (Walsh and Ungson, 1991, p. 65).

2.1.2.4 Transformation

The form of transformation is embedded in many areas of the organization. This can be transformation in the form of input, such as new employees or raw material, or the form of output, such as a finished product. Be it the design of the work, the selection, or the socialization up to the budgeting. All these transformations build on past experiences. Recollections of past transformations often guide current transformation processes (Walsh and Ungson, 1991, p. 65).

2.1.2.5 Structures

The organizational structure must be considered in terms of its impact with its environment. Individual roles represent a repository in which organizational information can be stored. Thus, the role concept provides a link between individual and organizational memories (Walsh and Ungson, 1991, p. 66).

2.1.2.6 Ecology

The physical structure of an organization encodes and reveals a lot of information about the organization itself. Employees and their tasks are influenced by the workplace ecology. The workplace ecology thus stores information about an organization and its members (Walsh and Ungson, 1991, p. 67).

2.1.2.7 External archives

The organization is not the only repository for the past. The organization is surrounded by others who track its actions. Although they are not part of an organization's memory, they contain information about the past. Former employees keep much information about an organization, whether they voluntarily resigned, were terminated, or retired. Regulatory or supervisory agencies, news organizations, or even financial services firms collect and retain corporate information (Walsh and Ungson, 1991, p. 67).

Walsh and Ungson describe in their work, contrary to individual opinions, the construct of an organizational memory and show about it, in which areas the memory can take place and is stored inside and outside the organization.

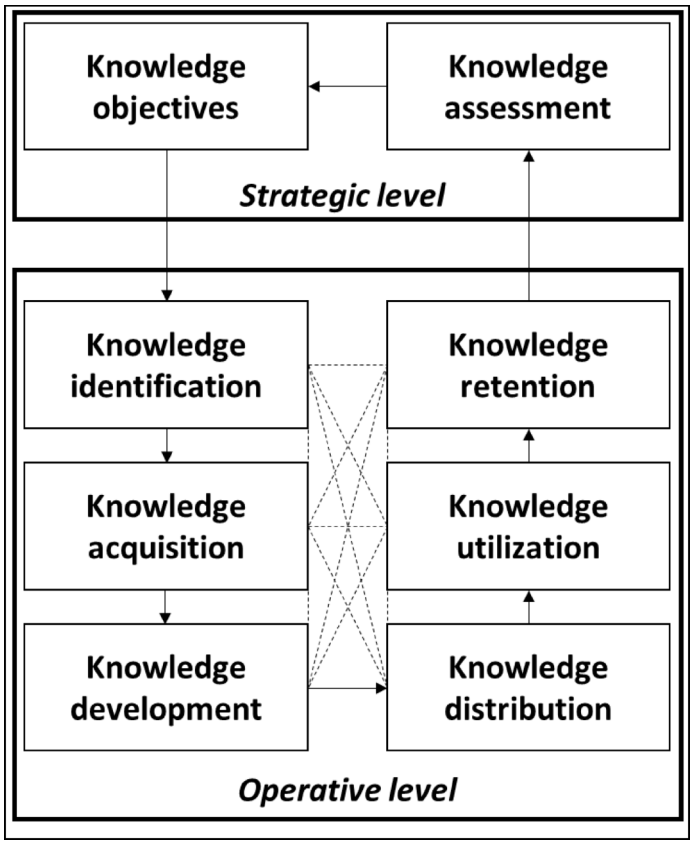
2.1.3 The building block model of Probst, Raub and Romhardt

The building block model was first presented in 1997 and describes the ideal-typical tasks of knowledge management. The model designed for organizations offers a better understanding of potential knowledge problems within organizations (Hippner, 2001, p. 193).

2.1.3.1 Description of the model

The model works with a total of eight building blocks, which represent the activities designed. Probst, Raub and Romhardt integrate the elements individuals, group and organization into their model as well as the goal levels in operational, strategic and normative terms (G. J. B. Probst, Raub, & Romhardt, 2012, p. 42). The following Figure 2-2 illustrates the structure of the building block model.

Figure 2-2: Building block model of Probst, Raub and Romhardt



Note: Adapted from G. J. B. Probst, Raub & Romhardt (2012)

The model represents a traditional management cycle. The underlying elements are goal setting, implementation, and evaluation. The distinction between the strategic management tasks and the implementation is clarified here by separating into an outer and inner cycle. The elements of goal setting and measurement, which are components of the traditional management cycle, are represented in this knowledge model with the building blocks of knowledge objectives and knowledge evaluation, which belong to the external cycle. Supplemented by the building blocks in the inner cycle, the phases of goal setting, implementation, and evaluation mentioned above are completed.

However, the six core activities in the inner cycle of knowledge identification, knowledge acquisition, knowledge development, knowledge sharing, knowledge utilization, and knowledge retention are often where the operational challenges in organizations lie. As already mentioned, the eight building blocks form an interlinked management cycle, and the core activities are indeed interrelated. However, they do not have to be run through in the appropriate sequence, nor do they have to be run through entirely. The authors of this model point out that numerous problems in organizations result from isolated optimization of individual core activities. To prevent this, all core activities should at least be considered.

2.1.3.2 The building blocks

In the following, we will discuss the building blocks of the outer and inner loop and derive the relevance for organizations.

Outer loop

The outer loop describes the anchoring of the knowledge topic in the corporate strategy since an orienting and coordinating framework must be created for the operational area.

2.1.3.2.1 Knowledge objectives

In an organization, it must be determined at which levels skills must be built up. Strategic knowledge goals define organizational core knowledge and describe the need for competencies in the future. Operational knowledge objectives ensure the implementation of knowledge management and ensure the necessary concretization of the objectives (G. J. B. Probst, Raub, & Romhardt, 2012, p. 33).

In this knowledge module, Probst, Gilbert, and Romhardt point out that the measurement of normative, strategic, and operational knowledge goals must be ensured. Since knowledge managers do not have a tried and tested set of measurement methods and indicators, new ways must be found to assess the effectiveness of knowledge measures. This controlling process is a prerequisite for making course corrections in long-term knowledge management interventions (G. J. B. Probst, Raub, & Romhardt, 2012, p. 33).

Inner loop

The inner loop contains the core processes of knowledge management, which also have an impact on other processes in the organization.

2.1.3.2.2 Knowledge identification

The measures of this building block refer to the analysis and description of the company's environment. Lack of transparency of internal and external data, information, and capabilities leads to inefficiencies and uninformed decisions in the organization. Therefore, knowledge management must create a sufficient level of transparency and support individual employees in search activities (G. J. B. Probst, Raub, & Romhardt, 2012, p. 31).

2.1.3.2.3 Knowledge acquisition

Companies draw a considerable part of their knowledge from sources external to their company. These include customers and suppliers, competitors, and partners in cooperative ventures. Likewise, by recruiting experts or acquiring innovative companies, companies can buy in know-how that they would not develop on their own. These potentials may be taken into account in the systematic implementation of knowledge management (G. J. B. Probst, Raub, & Romhardt, 2012, p. 31). The prerequisite for knowledge acquisition is the willingness of knowledge carriers to share it. Self-efficacy, reputation and reciprocity are often at the forefront of knowledge carriers' minds, and these have a significant influence on knowledge-sharing behavior (Nguyen, Ngo, & Gregory, 2022).

2.1.3.2.4 Knowledge development

The knowledge development building block complements the knowledge acquisition building block. This building block focuses on the development of new skills, new products, and better ideas. It encompasses all management activities

that the organization has not yet consciously attempted. Consequently, it can also arise in all areas of the organization, so this building block must examine the company's general approach to new ideas and employee creativity (G. J. B. Probst, Raub, & Romhardt, 2012, p. 31).

2.1.3.2.5 Knowledge distribution

The knowledge distribution module maps the distribution and sharing of knowledge in equal measure and is a mandatory prerequisite for making isolated information or experience usable for the entire organization. The transition of knowledge stocks from the individual level to the group level must be analyzed in particular. This building block, therefore, serves to disseminate already existing knowledge within the organization (G. J. B. Probst, Raub, & Romhardt, 2012, p. 32).

2.1.3.2.6 Knowledge utilization

Successful identification and sharing of knowledge components do not ensure their use in everyday business. Therefore, the building block of knowledge utilization is the goal and purpose of knowledge management. However, the use of external knowledge is limited by several barriers, and the use of valuable skills and knowledge assets must therefore be ensured (G. J. B. Probst, Raub, & Romhardt, 2012, p. 32). Nguyen et. al. also describe in their research that trust and an individual's social interaction have a significant impact on knowledge sharing behavior (Nguyen, Siri, & Malik, 2022).

2.1.3.2.7 Knowledge retention

Once a capability has been acquired, it is not automatically available to the same extent in the future. The targeted preservation of experience and information requires management efforts in selecting essential processes, appropriate storage, and regular updating. Therefore, knowledge retention is based on the efficient use of a wide variety of organizational storage media for knowledge (G. J. B. Probst, Raub, & Romhardt, 2012, p. 34).

2.1.4 The Munic model of Reinmann-Rothmeier

The Munich model starts from two perspectives of knowledge. On the one hand, in the nearness of the information concept and on the other hand in the nearness of the action concept. This results in two-directional forms or also states of knowledge (Reinmann-Rothmeier, 2001, p. 15).

Salomon distinguishes the following distinctions concerning information knowledge (Salomon, 2000, p. 78):

- Information knowledge can appear individually, whereas action knowledge occurs only in meaningful networks of meaning.
- Information knowledge can be passed on; action knowledge must be constructed as a network of meaningful connections.
- Information knowledge does not need a context, whereas action knowledge must always have a reference.
- With information knowledge, it is possible to build action knowledge. Action knowledge, on the other hand, brings knowledge to action.
- Information knowledge can be proved by reproduction, and to prove action knowledge succeeds only by the application in a new context.

Reinmann-Rothmeier defines knowledge management as the attempt to influence knowledge processes in tension between information and action. The knowledge process can be forced, supported, or facilitated by framework conditions in the organization. However, knowledge management can only have a limited influence on knowledge movements, i.e., between the states of information and action. Furthermore, a distinction is made between information-related knowledge (information knowledge), which can be explicitly documented and passed on in writing or electronically. Knowledge close to the action (action knowledge) is bound to situations or persons and can only be articulated with difficulty or not at all and is thus closely connected to human action. The hybrid state form of knowledge is the partly explicit and sometimes implicit form of knowledge, which can be influenced and shaped from the outside to a greater or lesser extent (Reinmann-Rothmeier, 2001, p. 18).

2.1.4.1 Four knowledge processes of the model

The Munich Model has four core areas, each of which bundles knowledge for management and makes it more manageable for sharing knowledge movements. To understand knowledge movements, psychological processes must also be considered.

Knowledge representation processes

Knowledge presentation describes making knowledge visible, tangible, and accessible. This makes it transportable and comprehensible to third parties to a certain extent. The technical possibilities also play a role here, and information management is an important cooperation partner in this process. Knowledge representation is also an integral approach for the organization since knowledge can be found more quickly and efficiently under such conditions, thus reducing the risk of knowledge loss.

From a psychological point of view, there must be a willingness of the knowledge bearers to disclose their knowledge and the ability to put knowledge into a format that makes it possible for others to deal with it at all. A high degree of meta-knowledge about one's knowledge base, possible gaps in knowledge, and verbalization skills must also be considered (Reinmann-Rothmeier, 2001, pp. 22–23).

Process of knowledge utilization

Knowledge utilization describes the process of making knowledge applicable and thus making decisions and actions follow. This process can potentially bring the knowledge holder into a state in which the associated context can no longer be separated from it, as the knowledge leads to action. Converting knowledge into visible results through knowledge utilization is essential for an organization because merely possessing knowledge is not enough to ensure the organization's future. Moreover, the process of knowledge utilization is the essential prerequisite for innovation.

From a psychological perspective, Renkl points out that people are willing to overcome the inertia of knowledge. Ingrained routines and habits can have an inhibiting effect here. A problem in organizations is often the limited scope for action, making it impossible or difficult to implement existing knowledge (Reinmann-Rothmeier, 2001, pp. 23–24).

Knowledge communication process

Exchanging and sharing existing knowledge is the focus of the knowledge communication process. In the process, knowledge should also be distributed and networked to ultimately put it into observable motion. This can be done with or without technical support. It is essential for the organization because this is the only way to ensure that valuable knowledge is disseminated and grows. In addition, it is a prerequisite that knowledge can also be passed on to several potential knowledge carriers. The more knowledge is used in communication, the more intensive the interaction between people and organizations becomes.

From a psychological point of view, people must feel that the exchange is a mutual give-and-take and ultimately serves their benefit. Lack of trust or even global mistrust, contact and interaction thresholds, or team incapacity can impair communication processes and even make them impossible (Reinmann-Rothmeier, 2001, pp. 24–25).

Processes of knowledge generation

Here, the "raw material" information plays an essential role in processing action-relevant knowledge. Building up new knowledge and thereby generating innovative ideas is the decisive criterion here. This process is essential for the organization because it is the only way to ensure that it continues to develop. Knowledge generation must be the crucial part of innovation, directly related to knowledge utilization and the dissemination of new knowledge.

Psychologically, knowledge generation is only possible because people can learn. They can make unexpected discoveries from experience and curiosity and produce novel thoughts through their creative potential. The extent to which knowledge carriers possess metaknowledge and are thus able to share their knowledge with others and use it to create synergy effects for the development of knowledge also plays a role in knowledge generation. The lack of confidence in one's learning, thinking, and problem-solving potential can also be an obstacle here (Reinmann-Rothmeier, 2001, pp. 25–26).

The unique position of communities in the Munich Model is primarily because communities strengthen integrative objectives of knowledge management. At the same time, the psychological aspects are better understood. In addition, knowledge movements that occur and are intended are more likely to be demanded and shaped.

2.1.4.2 The role of communities in the model

In addition to the four processes mentioned above, the communities in the Munich Model are decisive. Reinmann-Rohtmeier defines informal and self-organized communities of interest that open unique opportunities for various knowledge processes. In the Munich Model, these are also recognized as the "nucleus" of knowledge management. Likewise, communities can also be understood as networks of people. The drivers of communities are common interests or problems. Mutual learning is the central process in a community. Conspicuous in the forms are ownership, self-direction, and an everyday basis of understanding. In this model, the distinction is made between innovation-oriented communities, primarily concerned with creating new knowledge, and communication-oriented communities, which focus on collaborative learning processes and knowledge sharing. Many communities are also hybrid forms, as no clear focus of the forms above can be identified. In many communities, communication and exchange are based on technical tools, regarded as information and communication technology tools (Reinmann-Rothmeier, 2001, pp. 26–28).

The communities can also be divided into further functions (Reinmann-Rothmeier, 2001, pp. 30–31):

- Communities can act as hubs for communication on specific topics. In this function, knowledge can be shared in an unbureaucratic manner.
- Communities can serve as a forum for mutual learning. "Best-practice" approaches and experiences play an essential role here.
- Communities can become drivers of innovation. Open exchange generates synergy effects and impulses, mainly through interaction between different experts.
- Communities can act as culture changes by promoting knowledge and learning culture. A culture of communication and cooperation thus serves as a prerequisite for successful knowledge management.
- Communities can act as identity creators, providing a counterbalance to lose network relationships and fragile value systems. In the Munich Model, it is primarily psychological implications in managing knowledge that are considered and promoted with this function.

2.1.5 The Potsdam knowledge management model

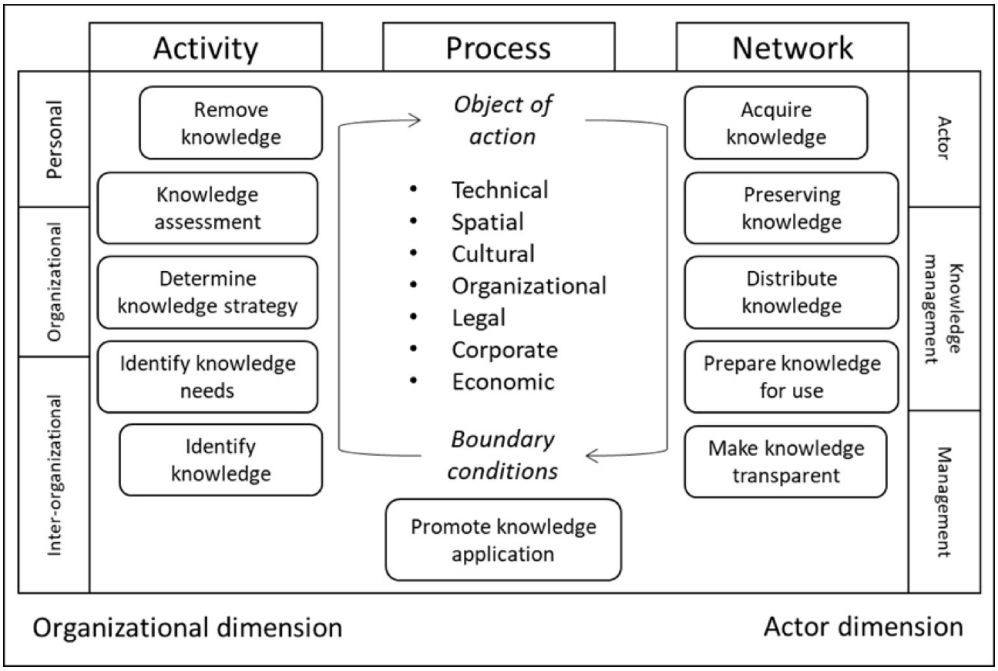
The goal of the Potsdam Knowledge Management Model is to define a holistic understanding of knowledge management, which sees the starting point in the need to be able to clearly distinguish the activities of a knowledge worker from the tasks of knowledge management. Different expectations can arise due to the lack of a frame of reference. Starting from communication problems due to different conceptual understandings or fuzzy demarcations in a project environment. The central elements of the Potsdam Knowledge Management Model include:

- The definition of the term knowledge
- The definition of the term knowledge management
- The eleven tasks of knowledge management
- The classification system for knowledge management tasks
- The different types of frameworks and objects of action that knowledge management tasks deal with.

The model is based on the statement that knowledge is person-bound and is generated and applied by persons. According to Loermans, knowledge can be based on data and information and represents a mixture of experience, value concepts, contextual information, and expert insight (Loermans, 2002).

Operational knowledge management is characterized by the stimulation of a sustainable and efficient transformation of knowledge. This also includes the dissemination of and access to knowledge in organizations. The eleven tasks of knowledge management mentioned at the beginning can be differentiated by three characteristics. These are to be distinguished according to the process-organizational, the structure-organizational and the personnel range. Each measure is subject to different framework conditions, which in turn can be the object of action of the measure. The tasks are realized by the measures, which influence the design scope of knowledge management in an individual way, as illustrated in the following Figure 2-3:

Figure 2-3: Potsdam Knowledge Management Model



Note: Adapted from Loermans (2002)

The measures are neither fully implementable nor free from interactions with each other. At the same time, they form the interface to knowledge activities. Knowledge activities are carried out by actors as an integrated part of business processes. They describe the operational handling of knowledge (Davenport and Prusak, 1999).

2.2 Conclusion for this research

The focus of this dissertation is on the investigation of knowledge-based activities within IT projects. Therefore, this chapter will provide an overview of the main knowledge management models that will be considered in the following studies. These knowledge management models will also serve as possible explanatory approaches for the results of the expert interviews and the discrete event simulation. A further aspect within the investigations to be carried out is the question of the extent to which the presented sub-areas of the knowledge management models are applied in the IT projects and whether patterns emerge

from this that can lead to further knowledge gain. The knowledge management models presented are not equally suitable for answering the research questions posed above. Due to the clearly definable and already defined sub-areas of the Probst et al. building block model, this model is used in the further explanations of this dissertation.

The other advantage of Probst's building block model over other knowledge management models is the structuring of the management process. In particular, the structure in logical phases enables a comprehensible process and a systematic approach. The model also offers room for intervention. This means that with the help of this model, knowledge problems within an organization can be better classified, understood, and solved. In addition, the model offers a search option for root cause analysis. This allows targeted measures to be taken to improve the organization's knowledge base. These possibilities are offered by the building block model of Probst et al. and make it the most suitable knowledge model for answering the research questions. Other knowledge management models, such as the MOT model and the 3-pillar model or North's knowledge ladder, cannot be considered. They are either designed for a small group of users or focus on people as objects. Although people are an essential factor in knowledge management, they are not suitable for these research purposes, as technical factors also play a major role and must therefore be given overriding consideration.

3 Project Management

This chapter deals with project management and the associated areas. To gain a better understanding of the nature of project management, various definitions are explained below. The globally recognized American standard in project management, the Project Management Institute, describes a project as follows: A time-defined and limited endeavor with the goal of creating a unique product, service, or result (Project Management Institute Inc., 2021, p. 246). The term project management will be described as follow: The application of knowledge, skills, tools, and methods to project activities so that project requirements are met (Project Management Institute Inc., 2021, p. 247). In addition to the American standard, there is another international standard, the International Project Management Association (IPMA) with its German offshoot, the Gesellschaft für Projektmanagement (GPM). The IPMA Individual Competence Baseline (IPMA ICB) describes a project as a one-time, time-limited, interdisciplinary, and organized effort to achieve specified work results within the framework of predefined requirements and constraints. To achieve these project goals, these deliverables must meet certain requirements, including numerous constraints such as schedule, time, cost, resources, and those resulting from quality standards or their requirements (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 51). In addition to the two globally recognized project management standards, there is also the definition of the German Industry Standard. The German industry standard (DIN 69901-5) defines a project as an undertaking that is essentially characterized by uniqueness of conditions in its entirety. The following examples are attached: Target, time, financial, personnel or other limitations.

Likewise, the term project management is described as the totality of management tasks, organization, techniques and tools for the initiation, definition, planning, control and completion of projects (DIN). However, McGrath and Whitty point out in their 2019 research that the use of governance terminology is handled very differently in management and project management documents (McGrath and Whitty, 2019, p. 164). To avoid misunderstandings in this work, the definitions according to the standard of the German Industry Standard 69901.

3.1 Phases in project management

At this point, a distinction must be made between project phases and project management phases, as these are sometimes used synonymously in practice, although fundamental differences exist.

3.1.1 Project management phases

The project management phases differ depending on the project standard.

- DIN 69901-2 defines the phases: initialization, definition, planning, control, and completion.

- PMBook-Guide, on the other hand, defines the phases: initiation, planning, execution, monitoring and control.

- PRINCE2 defines the phases of preparing, initiating, guiding, controlling, managing product delivery, managing phase transitions, and completing a project.

At this point we will also discuss the process-based PRINCE2 method, as it is of great importance in practice. PRINCE2 is a process-based method for effective project management and equips you with all the basic knowledge you need to be successful in project management. PRINCE stands for “PRojects IN Controlled Environments” and is recognized and used worldwide. PRINCE2 is fully scalable and can now be more easily customized to all your projects thanks to the latest update to the framework (Axelos - PeopleCert, 2024). All definitions have the approach that is also described in the PMBook: A collection of logically linked project activities that ends with the completion of one or more deliverables (Project Management Institute Inc., 2021, p. 247).

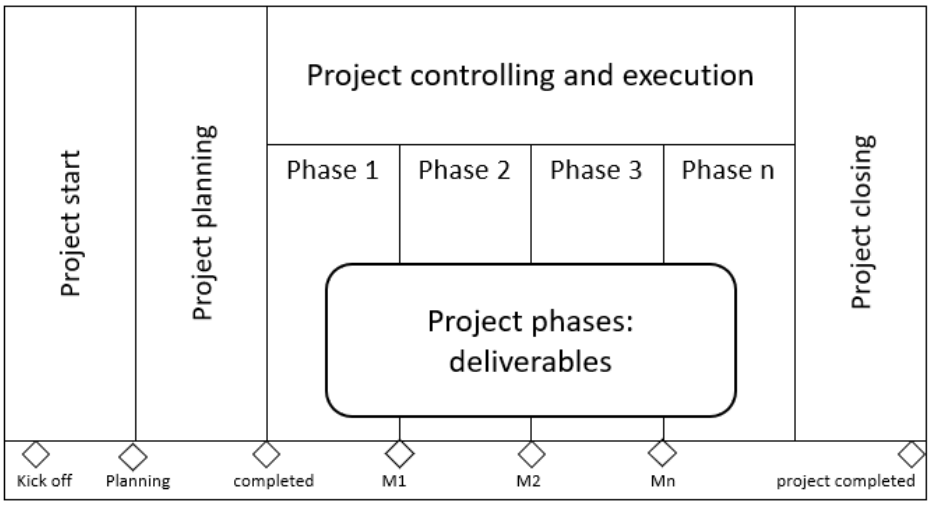
The relationship between early project management phases and project success was studied by authors Sohi, Bosch-Rekveldt et al. in 2019. The authors concluded that the flexibility of the "how-attitude" and the "how-organization" have a significant effect on project performance. The higher the flexibility of the two factors, which come into play in the early phases of projects, the better the project outcome (Jalali Sohi, Bosch-Rekveldt, & Hertogh, 2020, p. 23). "How-attitude" included interactive decision-making, strong stakeholder involvement, open information exchange between different project groups, and contingency planning. "How-organization" includes visualized project planning and progress reporting, continuous learning, management support, and project team self-steering (Jalali Sohi, Bosch-Rekveldt, & Hertogh, 2020, p. 19). This research shows that it is important for the project outcome to retain some flexibility in the early project management phases.

Another important context is the fact that there is little research on the mediating role of project managers. The authors Kahn et al. have investigated this relationship and find dependencies (Ahmed, Khan, & Philbin, 2022, p. 5).

3.1.2 Project phases

Project phases subdivide the project life cycle into temporally and thus reflect the course of the project with the content activities from the perspective of the activities from the point of view of the respective organization. Each phase consists of specific work steps and is completed by reaching a milestone (MS). A milestone is a key event of particular importance. Milestones are planned events and are marked with a date (DIN). The following Figure 3-1 illustrates the interaction of the project management phases, the project phases and the milestones. The relevance lies in the interaction of these phases. The content of project phases may differ from project to project, but not the project management phases if the same process model is used.

Figure 3-1: Project Management Phases vs. Project Phases



Note: Adapted from Pohl & Rupp (2009)

However, it must be mentioned that not every project management model is equally suitable for every project. McGrath and Whitty show in their 2020 research that not every project method is suitable for every type of project. PRINCE2, for example, is difficult to apply to engineering infrastructure projects (McGrath and

Whitty, 2020, p. 347). Therefore, the project standard German Industry Standard 69901 (DIN 69901) is used in this work for all further steps, as it represents detailed project management phases including project tasks compared to the others.

3.2 Project planning

This chapter deals with the essential tasks around the planning of projects. These tasks are usually performed by the project manager himself, with the advice of the project members. Projects that belong to multi-project management such as programs, portfolios or series of change and development projects are to be seen separately (Martinsuo and Ahola, 2022).PMI defines planning as the organization, development, and coordination of project work throughout the project. The effective execution of these activities should lead to the following desirable outcomes (Project Management Institute Inc., 2021, pp. 51–53):

- The project is progressing in an organized, coordinated, and deliberate manner.
- There is a holistic approach to delivering the project outcomes.
- It builds on evolving information to produce the deliverables and outcomes for which the project was undertaken.
- The time spent on planning is appropriate to the situation.
- The planning information is sufficient to manage stakeholder expectations.
- There are opportunities throughout the process to adjust plans based on emerging or changing needs or circumstances.

Therefore, the purpose of planning is to develop an approach to creating project deliverables proactively. The project deliverables are crucial for the results to be achieved by the project (Project Management Institute Inc., 2021, p. 55). Before going into the classic components of project planning, a frequently underestimated area is explained. Requirements management should be the starting point for achieving the project results, explained in more detail below.

3.2.1 Requirement engineering

The requirements and objectives define the "why" for the project and define what goals must be achieved. Benefits must be realized, and stakeholder requirements must be met according to the project mission. They are derived from the needs, expectations, requirements, and strategic organizational goals of the stakeholders (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1041). Motzel and Möller define requirements as defined or expected characteristics and usability of the services to be provided in the project. These result from the needs of the stakeholders and the project purpose and thus relate to the project. They are recorded and managed at various levels, particularly requirements from strategy and society for the project and project execution and project requirements for the contractual fulfillment of the service providers and suppliers (Motzel and Möller, 2017b, p. 56). The IEEE standard defines a requirement as a condition or capability needed by a user, person, or system, to solve a problem or achieve a goal. It can also be understood as the capability that a system or subsystem must meet or possess to comply with a contract, standard, specification, or another formally specified document (IEEE Standard Glossary of Software Engineering Terminology). In the following, requirement engineering will be explained in detail.

Requirements Engineering is a systematic and disciplined approach to the specification and management of requirements with the following objectives (Pohl and Rupp, 2009, p. 4):

- Know the relevant requirements, establish consensus among stakeholders on the requirements, document the requirements in conformance with specified standards, and systematically manage the requirements.

- Understand, document stakeholder wants and needs, and specify and manage requirements to minimize the risk that the system will not meet stakeholder wants and needs.

In this context, it would of course be advantageous if requirements could be predicted before they actually arise. Perdana and Arief's study showed that the accuracy of requirements management predictions can be improved via several strategies (Perdana and Arief, 2021, p. 8). However, not all requirements are of the

same nature and meeting these requirements does not necessarily result in an increased level of satisfaction for the client. The Kano model divides customer requirements into three categories (Kano et al., 1978):

Basic factors

These characteristics, often taken for granted, represent unconscious knowledge. These requirements must be met in full in any case, as they are elementary for the stakeholder. Basic factors are usually characterized by existing systems or features whose benefits are so self-evident that they are no longer consciously perceived. The basic factors, however, do not create a positive basic mood but harbor a danger if they are not fulfilled.

Performance functions

Performance factors can be well-identified through survey techniques. These are considered to be deliberate requirements since the stakeholders explicitly formulate them. The absence of these features can lead to acceptance, but satisfaction can decrease with each missing performance factor.

Enthusiasm factors

These requirements are featuring whose value a stakeholder does not consciously perceive. However, he notices an added value when presented to him, or he can try them out. Often this is discovered as a proper surprise.

However, Ebert points out that there are different approaches to requirements engineering, which should be applied accordingly depending on the information status of the project (Ebert, 2008, p. 305).

Stringent Requirement Engineering

Stringent requirement engineering assumes that the requirements are known for the most part before the project starts. All essential, as well as performance factors, must be known to the requirement engineer. This development process has clearly defined phases and milestones that always consider the system's progress from specification to an executable product. However, being stringent does not mean that requirements must be frozen. It is more important to assess at an early stage which requirements may change and align the project architecture

accordingly. The uncompromising approach with precise requirements is advantageous for a large project where many service providers must agree on various standards. In this case, it is advantageous to agree on these standards before the start of the project, to which all partners commit themselves. Milestones within the requirement engineering phase ensure that partial results are synchronized and one partner's failure does not question the overall progress (Ebert, 2008, p. 305).

Iterative Requirement Engineering

Suppose the requirements are relatively unknown and must evolve during the requirement engineering process. In that case, the process model takes this volatility into account. An incremental, iterative, or evolutionary procedure can be selected in this case. An iterative approach is used in a range of different development paradigms, e.g., prototyping or the definition of iterations, which are evaluated step by step by the customer before they are finally accepted (Ebert, 2008, p. 309).

Agile Requirement Engineering

In order to survive in global competition, companies have increasingly focused on efficiency in their projects. This means shorter project times, faster implementation of innovations, and cost reduction in the entire process. Requirement engineering must therefore optimize two aspects. On the one hand, the customer or the user must focus on processing only those requirements that generate a sustainable and economically measurable value. On the other hand, the approach should be adjusted repeatedly throughout the project since requirements can change over time. Agility in this context is necessary in order not to lose focus on the product delivery of the project even in times of changing requirements. Agile requirement engineering has in common with the other process models in that the requirements are determined and analyzed in an everyday context as far as possible (Ebert, 2008, p. 312). In addition, it is worth mentioning that a Project Management Office (PMO) can help categorize and align requirements across project boundaries to unify any identical requirements from different projects (Carden and Brace, 2022, p. 7).

3.2.2 Resource planning

The current chapter Resource Planning deals with the planning of project staff and the creation of project teams as well as the effort estimation and financial resources of IT projects. Resource planning is described as a group coordination strategy that includes technological resources, human IT resources, and organizational resources to execute a successful information systems project (Yu and Hsiao, 2022).

Personnel planning

A large part of success is influenced by personnel factors, as personnel selection forms the basis for IT project teams. Based on this, team development and the optimal framework conditions for the project members are summarized, as these exist from the beginning of the project until its dissolution (Tiemeyer, 2018, p. 240). The Project Management Institute points out that servant leaders allow the project team to self-organize whenever possible, thereby increasing the degree of autonomy by giving project members appropriate decision-making opportunities (Project Management Institute Inc., 2021, p. 18). In addition, the following aspects are mentioned in the development of project teams. These include the visions and goals of a project, which should be communicated repeatedly during the project so that the entire project team deals with them. The same applies to roles and responsibilities. However, this also includes the recognition and deficits in knowledge and skills and strategies to be able to eliminate them. Processes in the project team and guidance of the team so that all members can agree on the same goal and approach. Identifying where the project team is performing well and improving will also help the team grow (Project Management Institute Inc., 2021, p. 19). Banks-Grasedyck et al. share this thought and point out that setting up an efficient project organization and project structure and staffing the teams with qualified employees requires much attention. If it is not regulated, who is responsible for which tasks and how this is done can already be considered a risk in the project (*Erfolgreiche SAP-Projekte*, 2016, p. 102).

Effort estimation and financial resources

It must be ensured that the project is planned and controlled economically. Therefore, it is necessary to estimate how many financial resources will be needed to carry out the project when planning project. According to Schweitzer and Küpper, costs are the valued objective-related consumption of goods in an

accounting period (Schweitzer et al., 2016, p. 13). Estimating these costs is a challenge at the beginning of the project. For this purpose, The Project Management Institute refers to three basic estimation methods:

Deterministic and probability estimation

This estimate simply represents a number or quantity. Probability estimates contain a range of estimates and the associated probabilities within that range.

Absolute and relative estimation

Absolute estimates are specific information and use actual numbers. Absolute estimates are therefore specific, while relative estimates are given in comparison to other estimates. Relative estimates therefore have meaning only in a specific context.

Flow-based estimation

This type of estimate is generated by determining cycle time and throughput. Cycle time is the total elapsed time it takes a unit to complete a process. Throughput is the number of units that can complete a process in a given amount of time. These two values can provide an estimate for completing a given amount of work (Project Management Institute Inc., 2021, p. 57).Tiemeyer describes the effort estimation as a precondition for the profitability analysis. Effort estimation, in turn, requires that the planned product be specified in as much detail as possible. Here the problem becomes clear that in the apron of the project execution must be certain, what the result costs for example the product of a project. Likewise, a delayed project result (product) can also lose value (Tiemeyer, 2018, p. 291).

3.2.3 Project teams

The Project Management Institute describes the activities and project team functions associated with the individuals responsible for creating project deliverables to realize business results. The project team is led by the project manager, who performs a mediating and moderating role (Mir, Rafique, & Mubarak, 2021). Effective execution should result in the following desired outcomes (Project Management Institute Inc., 2021, p. 16):

- Shared sense of responsibility
- A high performing team
- All team members demonstrate appropriate leadership skills

The IPMA Individual Competence Baseline (IPMA ICB) points out that many inventions, discoveries, and outstanding achievements have been made possible by the worldwide networking of specialists. Thus, teams usually enable more successful processes in production or development (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 737). Livari states that projects, which are temporary organizations, are in part simultaneously contradictory and can even be mutually exclusive. This also reinforces the need to set up project teams accordingly from this point of view (Iivari, 2021). In this regard, Thompson describes the activities and project team functions associated with the individuals responsible for creating project deliverables to realize business results (Thompson, 2018, p. 7). In this context, Brodbeck et al. found that teams can be differentiated by task and person. In the process, the working climate and the duration of practical cooperation have also been described (Brodbeck, Anderson, & West, 2000, p. 15). Ultimately, the development of the project team is also relevant to the success of a project. In addition, the project team should have some type of project resilience, as coping with the negative consequences of disruption is a major challenge (Rahi and Bourgault, 2022). Tuckman examined the team development process as early as 1965 (Tuckman, 1965). The sequence of phases in team development can be described as follows:

Forming

This phase refers to the initial phase of a project. The future project team initially merely embodies a group and is initially concerned with orientation. In the process, boundaries of interpersonal behavior and the areas of responsibility are explored and identified. Still, the team members behave pretty independently.

Storming

In this phase, different people can compete for consideration and positioning in the team. The team as such strengthens and gains trust among its members. However, as previously described, conflicts and polarization can occur on interpersonal issues.

Norming

The creation of norms, guidelines, methods, and tools are the focus of this phase. Effectiveness increases, and the team begins to develop an identity and a sense of "we".

Performing

The project team recognizes that it can only act as a unit. Task structures are agreed upon, and roles are exercised flexibly and functionally. The team gets the job done smoothly and effectively without inappropriate conflict or the need for external supervision.

Adjourning

The project is terminated at this stage, and the team disbands. Behavior can vary significantly at this stage, as some members may experience a sense of loss or fear as a potentially uncertain future loom. Furthermore, this is mainly dependent on the environment of the projects undertaken. However, Radhakrisknan 2021 notes a need for more research on the determinants of project agility in the existing literature. To this end, the authors evaluated the impact of project team characteristics on agility and project success (Radhakrishnan et al., 2021). Nevertheless, not only the project's approach can influence the project result. A 2021 study examined how and when project manager frustration and anxiety affect the behavior of project team members in an organization (Wang, Lin, & Jiang, 2021). In this context, Khosravi et al. studied how emotional intelligence among project members affects performance and project outcomes (Khosravi, Rezvani, & Ashkanasy, 2020). Alkhudary and Gardiner present another challenge in which

they examine the career development of project managers. Despite the extensive literature, there is no professional career planning for project managers. This can also influence a project team accordingly (Alkhudary and Gardiner, 2021). A similar conclusion is reached by Cabot and Gagnon, who examine the concept of career anchors as a reference model for human resource management (HRM) practices in information technology (IT) (Cabot and Gagnon, 2021).

Also, the reference to project managers' motivational factors was made in 2022 in terms of salary and extrinsic rewards (Carden, 2022). For the qualification to lead projects, the project person certifications serve in principle. The business community plays a leading role in this process, which also has an impact on other areas of society (Wagner, Huemann, & Radujković, 2022).

3.2.4 Stakeholders

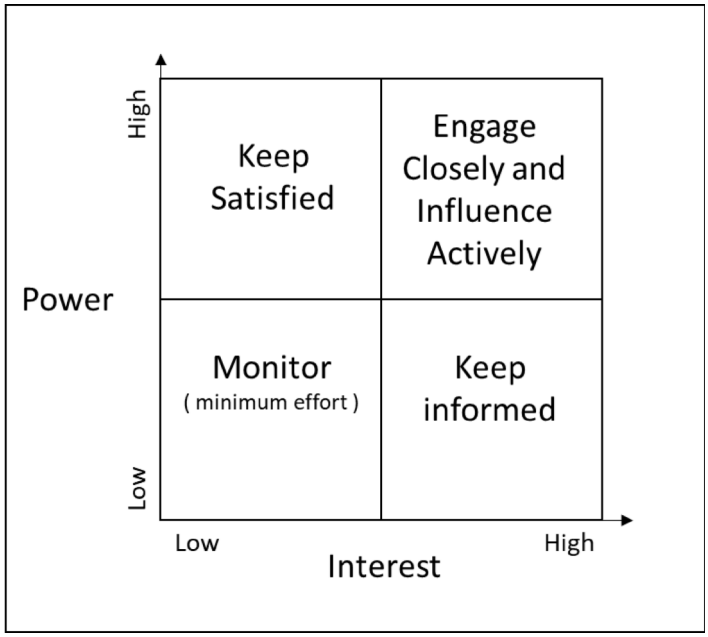
The term stakeholder can be defined in various ways. On the one hand, there is a broad and narrow understanding of the term in the literature. In the narrow definition, the stakeholders are limited to the customers, the employees, the state or the authorities, and the company's owners. The broad definition includes every person, group, and institution that is either directly affected or can demonstrate a legitimate interest. It excludes only those who have no power or claim over the company (Pöschl, 2013, p. 128). Möller and Dörrenberg distinguish stakeholders into three groups. On the one hand, the promoters of a project act as advocates. On the other hand, some opponents are covertly or openly opposed to a project. The third group comprises those who are initially more neutral and can change their attitude toward the project (Möller and Dörrenberg, 2010, p. 124).

At this point, it is worth mentioning that there are also groups of stakeholders. Galvin et. al. describes in their study the effects of collaboration and opportunism in large projects. In contrast to individual stakeholders, these groups may in turn have different interests than those described above (Galvin, Tywoniak, & Sutherland, 2021).

Here, the categories of power and interest play a decisive role in how stakeholders or stakeholder groups deal with them. However, according to a study by van Marrewijk et. al. it must be pointed out that power is crucial in interorganizational strategic projects used to implement strategic change.

However, this is not always sufficiently understood in projects (van Marrewijk and van Ende, 2022). The following Figure 3-2 shows the different strategies for performing stakeholder management.

Figure 3-2: Stakeholder analysis



Note: Adapted from Pohl & Rupp (2009)

To ensure the success of a project is maintained, attention should also be paid to possible coalitions within the stakeholder groups so that countermeasures can be initiated at an early stage. Ellmann describes the division of stakeholders into active involvement and passive involvement in the project. Active involvement includes all personal interactions, such as in jour fixe meetings or regular participation in status meetings or training sessions. Passive engagement includes adding relevant stakeholders to email distribution lists or sending them a regular newsletter (Ellmann, 2008, p. 426).

IPMA recommends creating a clear communication plan as part of the stakeholder scanning process. The stakeholder action matrix shows which of the project members is responsible for which actions towards which stakeholder. It also shows the intervals at which communication or information is to be provided. Each stakeholder or stakeholder group has different information needs. The individual responsible for the measures must ensure that the agreed measures also satisfy the

relevant stakeholders (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1606). The Project Management Institute also defines the project team as a group of stakeholders engaging other stakeholders to understand and respond to their interests, needs, and opinions. In addition, social competencies are addressed, such as taking the initiative, integrity, honesty, and cooperation. These skills and attitudes can help all stakeholders adapt to the work and each other, increasing the likelihood of project success (Project Management Institute Inc., 2021, p. 33).

However, the relationships between project success and stakeholder management are also being studied in other types of projects, such as construction. For example, Mok et al. examined mega-construction projects in the context of stakeholder management to address the conflicting interests of stakeholders, as previous research in the area has tended to focus on smaller construction projects (Mok, Shen, & Yang, 2015). Research has also been conducted on stakeholder engagement in innovation management and entrepreneurship development (Leonidou et al., 2020). An often-underestimated influencing factor in international projects is cultural differences. A 2020 study identifies several issues - political, social, historical, personal, and technical - that can have a negative impact because project members have different cultural backgrounds (Tchumtcha Wembe, 2020). Other challenges were published in a study examining stakeholder management with the result that in practice a more extensive analysis is needed than the operational stakeholder map. High complexity, uncertainties among stakeholders, dynamics during the project and the institutional context are the challenges that stakeholder management brings (Tampio, Haapasalo, & Ali, 2022).

3.2.5 Quality in the sense of projects

The Project Management Institute describes quality as focusing on the level of performance that must be met. The requirements for quality can be captured in the completion criteria, the Definition of Done, the statement of work, or the documentation of requirements. It also points out that the costs associated with the quality requirements must be balanced with the output (Project Management Institute Inc., 2021, p. 87). The German Industrial Standard (DIN) defines quality as the condition of a unit with regard to its suitability to fulfill specified and presupposed requirements (DIN). Holistically, project management quality can be considered as realizing the agreed performance, at the agreed time, at the agreed price to the satisfaction of the customer and the own employees (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1247). Another definition of quality describes it with the help of the characteristic’s 'usability' and

'maintainability'. Usability' describes the quality of the product developed in the project from the user's point of view. It includes the suitability of the product for a specific application and thus all quality characteristics required in product use. Usability' is a decisive factor for the acceptance of the product by customers.

Maintainability' describes the quality of the product from the point of view of the developers or the ongoing operation. It includes the product's suitability for use in a specific system environment and modification or adaptation to new requirements. Maintainability' is a decisive factor for the economic service life of a product (Tiemeyer, 2018, p. 490). As described above, the costs for quality management should be in proportion to the output. A model to find an appropriate balance is proposed by the Project Management Institute, and four cost categories are distinguished (Project Management Institute Inc., 2021, p. 88).

Prevention

Prevention costs are spent to avoid defects and deficiencies and, thus, quality problems in a product. These are planned and incurred prior to actual implementation. They are associated with the quality management system's design, implementation, and maintenance.

Testing

Testing costs are incurred in determining the degree of conformity to quality requirements. Inspection costs relate to quality measurement and monitoring activities. These costs may be associated with evaluating purchased materials, processes, products, and services to ensure their conformance to specifications.

Internal errors

Internal error costs refer to finding and correcting errors before the customer receives the product. These costs arise when the work results do not meet the planned quality standards.

External errors

External failure costs occur when products or services that do not meet planned quality standards are not delivered to the customer until after the handover. External error costs arise from errors found after the customer has received the product and its rectification. For a holistic view of these errors, the

project's product must be considered at the time of delivery and its operation months or years later.

The later the errors are discovered in the current project, the more expensive it will be to correct them. This is because design and development work are usually already carried out based on faulty components. In addition, it is more costly to modify processes later in the lifecycle since more stakeholders are affected.

The German Association for Project Management also distinguishes quality management in projects in two different orientations. On the one hand, it is about the quality of the project process, i.e., the way the project is organized. This concerns the development, introduction, and review of Standards. On the other hand, it is about the management, assurance and control of the quality of the results of the project (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1248). In this latter context, Ning and Shang explored quality management approaches based on resilience theory using innovative construction projects as examples (Ning and Gao, 2021).

Another study aims to determine how Big Data has a positive impact on project performance or how these impacts improving the quality of construction projects. As a result, it was found that it facilitated the development of technological capabilities, leading to significant quality performance (Sang et al., 2021). A quality feature that could become increasingly important in the future is to be able to achieve the required quality with principles of sustainability. Ershadi and Goodarzi studied this circumstance in more detail in the context of construction projects in 2021 (Ershadi and Goodarzi, 2021).

3.2.6 Risk management

The involvement of risk management should be considered in project planning, possibly to identify potential risks before the start of the project and to take appropriate measures. The risks can arise before the start of a project, during the ongoing project, or a change request. This chapter deals with threats in general and particularly for IT projects, and it then goes into the specific need to clearly define the project scope to minimize risks.

Müller defines risk as the mathematical product of the potential loss or damage and the probability of occurrence due to a latent threat. He states that the damage potential or the extent of a threat can also be quoted in financial terms as a

percentage of profit. He refers to this view as the gross risk because the security measures involved are not considered (K.-R. Müller, 2014, p. 140).

Motzel, on the other hand, defines risk as possible unplanned events or situations with negative effects or damage. Here, no reference is made to the possible safety measures, but here the focus is instead on the unplanned events or situations (Motzel and Möller, 2017a, p. 191). Nevertheless, both authors have the negative effects of risks in common in their definitions. Since these negative effects should be avoided wherever possible, effective risk management must be established.

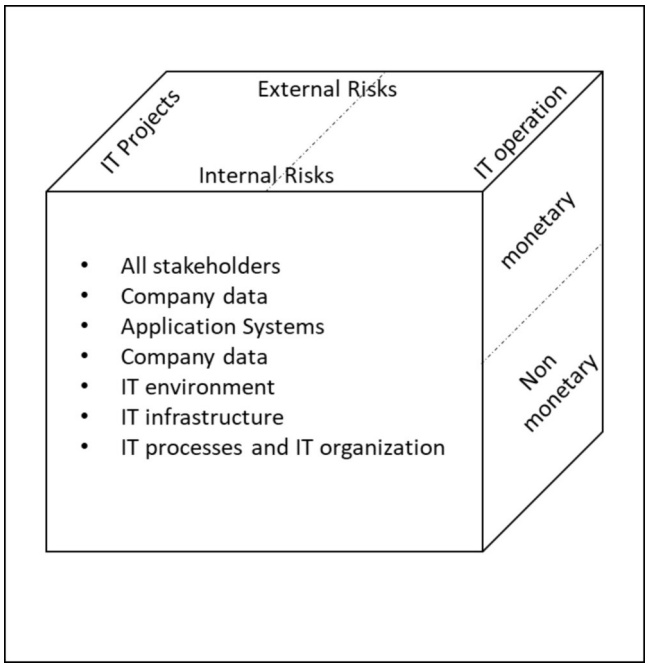
The German Association for Project Management defines risk management as, an ongoing process during all phases of the project life cycle, from the initial idea to project completion. At project completion, the experience gained in risk and opportunity management during the course of the project represents an important contribution to the success of future projects (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 187). From this definition, it is clear that risk management must be established not only in phases, but over the entire duration. The following steps represent a systematic approach to minimizing risks (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 191):

- Identify or analyze risks
- Evaluate risks before acting
- Plan measures
- Evaluate situation after measures
- Make decisions about measures
- Plan, implement and monitor measures
- Evaluate experience and make it useful for future risks

In general, according to Knoll and Böhm, IT risk management can be divided into several dimensions, which can be categorized according to internal or external risk, monetary or non-monetary effects, and information system elements and their

vulnerabilities. Thus, the point of origin can be either internal, within an IT project or IT operations, or with an external IT service provider. These can result in monetary or non-monetary effects. The third dimension can be, for example, the company's stakeholders, the company data, the IT infrastructure, the processes, and the organization. All these areas have their vulnerabilities, which can be defined as risks (Knoll and Böhm, 2014, p. 95). This categorization is illustrated in the Figure 3-3 below.

Figure 3-3: Cube of IT risk management



Note: Adapted from Knoll & Böhm (2014)

The treatment of risks must be considered differently in each case, considering business management principles. There are four risk strategies, which will be explained in detail (Knoll, 2017, p. 15):

Avoidance of risks

Avoiding risks is usually associated with preceding benefits or opportunities. However, the option also prevents the generation of added value for the company and is, therefore, only used in exceptional situations.

Decrease / Reduce / Mitigate

This strategy can be applied to the two central points of the probability of occurrence or amount of damage. Reductions can be achieved, for example, through preventive measures or corrective actions.

Transfer

Transferring the risk to a third party can help reduce the risk. However, the responsibility remains with the transferring company. Therefore, this option is also understood as risk-sharing. In this context, third parties can be, for example, suppliers, external companies, or insurance companies.

Accept

Risk and consequences can also be accepted considering one's risk propensity. However, this is primarily subject to personal, subjective feelings.

Often risks arise in the ongoing project, which results from unclear requirements concerning the system and its limits. Therefore, it is necessary to define the system and context boundaries from the beginning of the project. Pohl and Rupp define the system context as part of the system environment relevant for defining and understanding the system requirements under consideration. On the other hand, system boundaries separate the planned system from its environment. They delimit the part of reality that can be designed and changed from aspects of the environment that the development process must not change. The context boundary separates the relevant part of the environment of a planned system from the irrelevant part. This means the part of the environment that does not influence the planned system and, therefore no influence on the requirements of this system

(Pohl and Rupp, 2009, pp. 15–16).The German Association for Project Management also points out that The German Association for Project Management also points out that there are also legal regulations that prescribe risk management. In Germany, for example, the "Law on Control and Transparency in the Corporate Sector" (KonTraG), which was created as a supplement to the German Stock Corporation Act, also applies to large limited liability companies (GmbH). The law requires the creation of a monitoring system for the early detection of developments that pose a threat to the company as a going concern, as well as the creation of communication structures to decision-makers so that appropriate countermeasures can be initiated. Risks arising from projects that may pose a threat to the company as a going concern are naturally also covered by these regulations.

Further legal provisions are similarly found in the Generally Accepted Accounting Principles (US GAAP), which are derived from the International Financial Reporting Standards (IFRS). Their general aim is to create early transparency regarding the economic and financial developments of a company (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1550). In addition, findings from a study by Yu suggest that different types of risks put pressure on internal project teams to re-evaluate the vulnerabilities and resource allocation in a project, as well as the possible solutions to potential problems (Yu and Lin, 2022).

3.3 Project controlling

This chapter deals with the basics of project controlling, its methods, and its objectives. The German Industrial Standard 69901-3 (DIN 69901-3) defines the term project controlling as ensuring the achievement of project goals by Target/actual comparisons, determination of deviations, evaluation of consequences and suggestion of corrective measures, participation in the planning of measures, and control of implementation. The Project Management Institute describes the monitoring and control processes as processes required to track, review, and regulate the progress and performance of the project and to identify necessary changes to the plan and take appropriate corrective action (Project Management Institute Inc., 2021, p. 252). In their study, Kauffmann et al. consider the causal effect of project management effort on project profitability in customer order projects. The focus here is on the intention to generate profit with the actual implementation of the project (Kaufmann and Kock, 2022). This approach will not be pursued in the remainder of this paper, as it is basically also dependent on the successful progress of the project and therefore does not need to be considered separately.

3.3.1 Levels of Project controlling

Projects and especially IT projects, typically pose particular challenges to project controlling. The reasons for this can be found in many participants and influencing factors, the absolute novelty due to the technologies and processes used, and the complex interaction of technical systems, organizations, and people. To better understand and narrow down the focus of the terminology of project controlling, the different terminologies are explained below.

As a result of the objectives and the particular challenges, IT project controlling has to take place at several levels of the corporate hierarchy with different time references (Tiemeyer, 2018, p. 334).

Strategic IT project controlling

Strategic IT project controlling focuses on classifying IT projects in the overall context and coordination with corporate strategy. This also includes providing and preparing information and tools for project evaluation and selection.

Individual project controlling

Individual project control supports project management in the execution of IT projects concerning quality, costs, and time. Appropriate phase-specific and cross-phase instruments must be made available here.

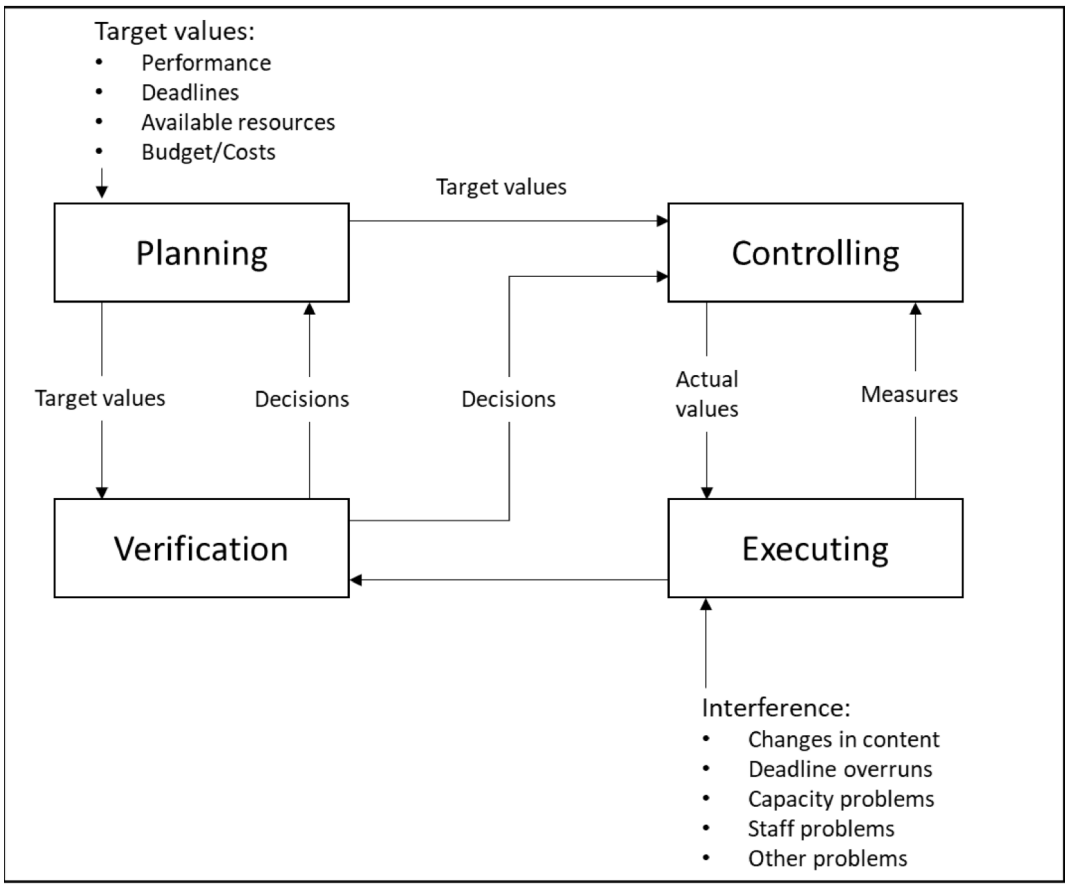
The multi-project controlling

Multi-project controlling looks at several interrelated projects regarding content access to shared resources or need to be coordinated with the corporate strategy. Here, particular attention must be paid to time dependencies, and results from one project must make available to another.

3.3.2 Control cycle of project controlling

Project controlling is to be understood as a control loop. The defined target values are defined from the project order for the planning. The actual values originate from the ongoing project control. Both values are compared at regular intervals. However, external factors must be considered, often influencing the result as disturbance variables. In case of deviations from the plan, appropriate measures must be initiated. These correlations are shown in Figure 3-4 (Litke, 2007, p. 112).

Figure 3-4: Cycle of project controlling



Note: Adapted from Litke (2007)

Tiemeyer explains that planning reliability increases as the project progresses. The collection and analysis of actual values and their comparison with

the planning target can be an increasingly better estimate of the expected project duration and costs. One goal of project management is to reduce uncertainties in planning and estimate the actual values as early as possible in the project (Tiemeyer, 2018, p. 340).

However, Ahlemann still points out the following psychological factors that can influence or complicate the management of projects (Ahlemann, 2004, p. 98).

Planning Faith

When the project plan is created, it is often assumed that the requirements are all valid and known. This assumption may change, or change based on newer or more detailed information. However, orders and plans should not change too frequently but only when achieving the originally agreed project goal no longer seems realistic or relevant. Therefore, project controlling should also be allowed to question project plans accordingly.

Control sensitivity

The majority of people do not like to be monitored. Therefore, project control should be carried out with great sensitivity. The choice of control instruments is essential here. The more power and responsibility the project team members have, the more inclined they are to comply with the requirements.

Risk aversion

Project controlling has the task of realistically assessing risks and managing them accordingly. Innovative IT projects typically involve high risks due to uncertainty about developments and the low controllability of technologies. Therefore, caution is required in planning, but this must not lead to the provision of excessive buffers or the definition of project results that are not very demanding.

Perfectionism

Projects are complex undertakings whose results are subject to numerous influences and often challenging to control. Therefore, finding a compromise between optimal development and a justifiable effort can be common. Thus, pursuing perfectionism must not lead to more resources that will no longer significantly improve the project outcome.

3.3.3 Cost Management Systems

A cost management approach must extend the traditional project cost controlling it. Due to increasingly competitive conditions, which lead to increased cost and performance pressure for organizations, this also impacts project management and, thus, cost planning and controlling (Bröchner, 2021, p. 9). The following cost accounting approaches are presented.

Activity-based costing

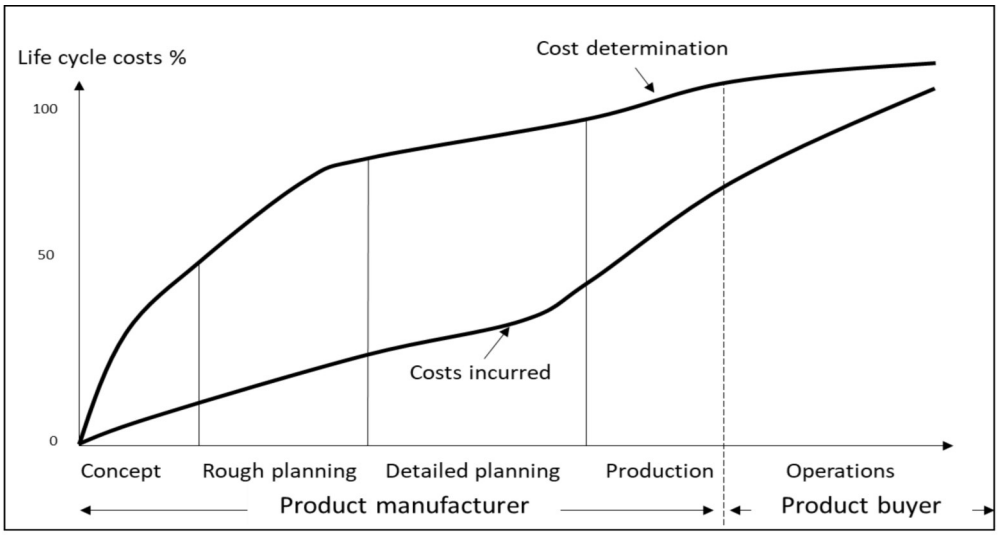
According to Bea et al., a project involves many preparatory, planning, and controlling activities, some of which may involve indirect service areas. Research and development, procurement, quality management, production planning, or sales. In this procedure, the costs are no longer booked to originating cost centers but assigned to operational primary and sub-processes. The costs are then allocated to the project according to the utilization of these processes by the project. The more differentiated view of costs at the process level enables better management of overhead costs at the project level as well (Franz, Bea and Scheurer, 2011, pp. 205–210).

However, Beste and Klakegg point out that not only the actual project costs should be considered, but also the costs incurred on the project portfolio line. These must also be considered in the overall context (Beste and Klakegg, 2022, p. 10). Geraldi et.al. support this statement with their research in which project-based theories were developed by companies (Geraldi, Teerikangas, & Birollo, 2022).

The Life Cycle Costing

Many projects incur significant upfront costs even in the initial project phases. This means that cost planning must consider all costs over the entire life cycle. A lifecycle-oriented view is an important prerequisite for effective cost control. In the first life cycle phases, a large part of the total costs is already determined in the life cycle with a relatively low-cost incidence. Figure 3-5 shows the relationship between cost determination and actual cost incurrence.

Figure 3-5: Life cycling closing



For this reason, the cost management aspect should play a significant role in the early phases of the project. Due to the importance of the more long-term issues, life cycle costing was developed as a cost management tool. (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1323)

The Target Costing

As shown in the previous figure, the highest costs are generated in the first phases of the project. In the planning and conception of a product, sensible technical solutions are worked out, which can later have a lasting influence on the further procedure in development and production. From an economic point of view, technical solutions only make sense if the customer uses them. Therefore, project costing should be oriented to the desired combinations of product functionalities and target costs from the customer's point of view. The starting

point for these considerations is the product's market price and the functionality that the customer wants at this price. In cost controlling, it must then be checked whether the desired functionalities can be implemented in the project (Franz X. Bea and Scheurer, 2011, p. 215).

3.3.4 Success factors for project controlling

Project controlling can make an essential contribution to the success and goal achievement of a project. As a monitoring and controlling function, it can identify undesirable developments early and propose or initiate corrective measures. In the following, criteria are described that make project controlling effective and practical (Tiemeyer, 2018, p. 365):

Clear responsibilities

The responsibilities of project management, steering committee, and project controlling must be clearly formulated and implemented in this way. Top management support should support and accept the distribution of roles.

Strategic positioning of the projects

The strategic positioning of projects is not an original task of project controlling, but it is an essential prerequisite for target-oriented project work. Projects and goals should be aligned with corporate strategies and have clear priorities.

Synchronization between project planning and project control

Project planning is often outperformed by project control. Plans have little effect if their adherence is not tracked. Planning must also be controlled during the ongoing project. Agreements among the project members must also be implemented. Non-compliance must be questioned and tracked.

Quality of the plans

Time, resource, and cost plans must be realistic. Careful consideration of all relevant factors, such as external factors or life cycle costs, is required in order to be able to create feasible plans. Estimates must not be too optimistic but should also not include large buffers.

Setting standards for project controlling

All project management processes should be formalized and use standardized methods. This way, experiential knowledge can be used as a basis, and their use becomes more efficient and effective. Guidelines can be used to document projects, and the formal structure of controlling reports can support this.

Use of critical figures and indicators

In addition to resource utilization and costs, project quality and progress indicators should also be determined. Clearly defined and quickly interpretable key figures can support efficient project controlling. An essential performance indicator handbook can document the parameters mentioned above and provide all stakeholders with an overview of the project.

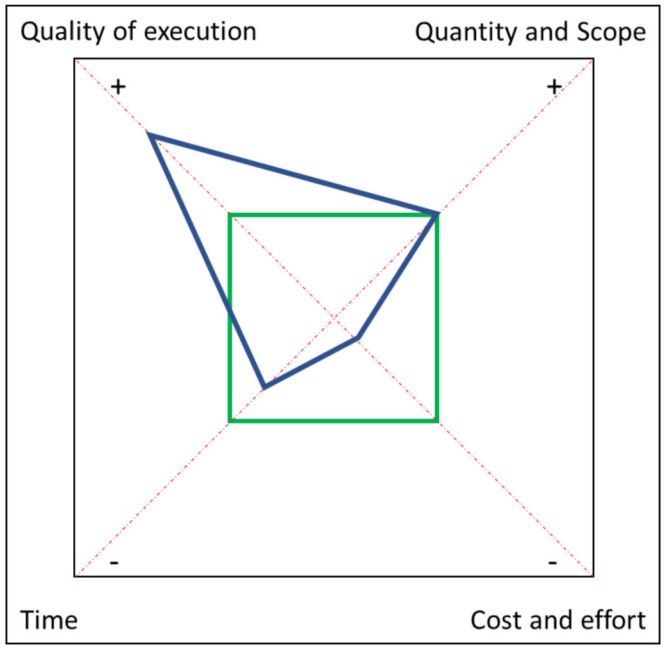
Practical project controlling requires an exchange between organizations and people in their project roles. Methods and tools can be supportive, but only the ongoing alignment between strategy, goals, and interests can lead a project to success. Consistency in pursuing goals, adherence to agreements, and applying defined standards are prerequisites for the effective management of projects.

3.3.5 Devil´s square

Basically, the three most important metrics are used in projects to measure performance. In relation to individual projects, these are the project performance to be measured in the form of the key figures time, costs and quality (Bukoye et al., 2022, p. 2). The controlling of projects can also be carried out with the so-called devil's square of Sneed. Critically, however, it must be noted that the Devil's Square tends to represent correlations with an invariant approach to the four criteria. Nevertheless, this model illustrates the dependencies of the criteria now presented. Here, the four dimensions cost, time, quality, and performance stand for the project's scope—the four dimensions conflict with each other. Cost is the project budget, which is usually fixed at the beginning. The time aspect is also set as a fixed point in time and defines the completion of the project. Although this is usually a fixed date, it can vary for various reasons. Quality is defined by target criteria and must be accepted by the client at the end of the project. The performance in the project tends to increase during the project duration (Sneed, 1987, p. 43).

As explained in Section 3.2.1, requirements are subject to uncertainties at the beginning in terms of scope and level of detail. The following Figure 3-6 illustrates the devil's square.

Figure 3-6: Devil´s square of Project Management



Note: Adapted from Sneed (1987)

These four dimensions are related to each other within the framework of this model and are represented in two squares. The green square is formed from the four dimensions and shows the productivity achieved with the given dimensions. Furthermore, all four dimensions are in harmony with each other, which corresponds to the project's initial planning. On the other hand, the blue shape represents a change within the course of the project, as quality takes on a higher priority than initially planned. As a result, the costs and duration of the project increase. The quality of the project remains unaffected and does not change. Even if the blue shape has changed in Figure 3-6, the area remains identical to the green square because the dimensions balance out altogether. Accordingly, the devil's square can be used for project control and as a possibility for risk detection.

The idea of Sneed, in which the four dimensions are interrelated, is also found in other works as a basis. Lutteroth et al. use Sneed's model to develop a maturity

model for computer science education. The authors use the dimensions and adapt them according to educational institutions' requirements to deliver high-quality education (*A Maturity Model for Computing Education*, 2007).

For example, Deuter and Engels used Sneed's model as a basis to optimize output in software development and to representatively map source code-based metrics (Deuter and Engels, 2014 - 2014). Also, in software development, Nadir et al. have used the devil's square to optimize the prediction of software defects and associated changes. The description of errors helps in various quality assurance and control phases, such as a software development project (Nadir, Streitferdt, & Burggraf, 2016).

3.3.6 IT project Balanced Scorecard

In this chapter, the IT Balanced Scorecard is discussed. The origin and the history of development are shown as well as the advantage of classical key figure systems. In the following, the structure and functionality will be explained. The limitations of the IT Balance Scorecard are discussed at the end of this chapter.

3.3.6.1 Use and origin of the Balanced Scorecard

The Du Pont key figure system is considered one of the oldest critical figure systems in the world. It is used for balance sheet analysis and corporate management and was developed in 1919 by an American chemical company. The focus is on the return on assets, which reflects the rate of return on capital employed. Many of today's performance measurement systems are based on the basic idea of the Du Pont scheme (Botta, 1997, p. 15). The advantage of the Du Ponts system is that the key figures are primarily drawn from accounting, making it possible to compare the company with other companies and measure it. In contrast to the Balanced Scorecard, one disadvantage is that it is based on past performance (H.-J. Probst, 2008, p. 27). In 1990, the research institution of KPMG in the USA had a corporate study conducted, which was approached to analyze the possibility of performance measurement in the future organization. The essential monograph on the Balanced Scorecard was written by R.S. Kaplan and D.P. Norton in 1996, entitled ' The Balanced Scorecard: Translating Strategy into Action.' The first noteworthy mention became popular only in 1997 with the translation of the monograph by Kaplan and Norton in Germany (Uebel and Helmke, 2018, p. 38). The advantages of the Balanced Scorecard have not gone unnoticed by companies that have increasingly adopted this system. The decisive advantage lies both in the

possibility of depicting financial critical figures related to the past as usual as well as factors that will become important for future areas (Kaplan and Norton, 1997, p. 8). However, Kaplan and Norton deliberately decided on four perspectives, which other perspectives can supplement. This flexibility is another advantage over rigid and hierarchically structured pure KPI systems. Due to the disadvantages of KPI systems, Morganski states that due to their past orientation, any undesirable developments are often recognized too late or, in extreme cases, not at all (Morganski, 2003, p. 37).

3.3.6.2 Object and goals of IT controlling

IT controlling can be seen as a system for preparing decisions within the framework of the deployment and use of IT resources (Gadatsch, 2021, p. 1). Becker and Winkelmann describe IT controlling as the procurement, preparation, and analysis of data to prepare target-oriented decisions in the acquisition, implementation, and operation of hardware and software (Becker and Winkelmann, 2004, p. 214). Both statements agree concerning the object of action - IT resources - and thus define a critical building block in the management of IT systems and for achieving the goals of the IT strategy. The IT strategy is derived from corporate goals and visions and is the prerequisite for strategic IT planning and operational IT management. In addition, the IT strategy provides the basis for forward-looking planning of future actions. It is the basis for implementing and monitoring the task packages to realize the strategic corporate goals (Gadatsch, 2021, p. 7). Gadatsch defines the essential contents as follows:

- Formulation of a target state
- Listing of the need for action.
- Pointing out options for action
- Setting goals and defining measures
- Naming the responsible parties
- Determination of measurement parameters for target monitoring

The answers to these points are closely related to the characteristics of the IT strategy. According to Heinrich et al., these can be designed either aggressively, moderately, or defensively. An aggressive IT strategy pursues the goal of leadership in the technology approach, and the primary goal here is to be faster than the competition (L. Heinrich, Riedl, & Stelzer, 2014, p. 130).

3.3.6.3 Structure of an IT balanced scorecard

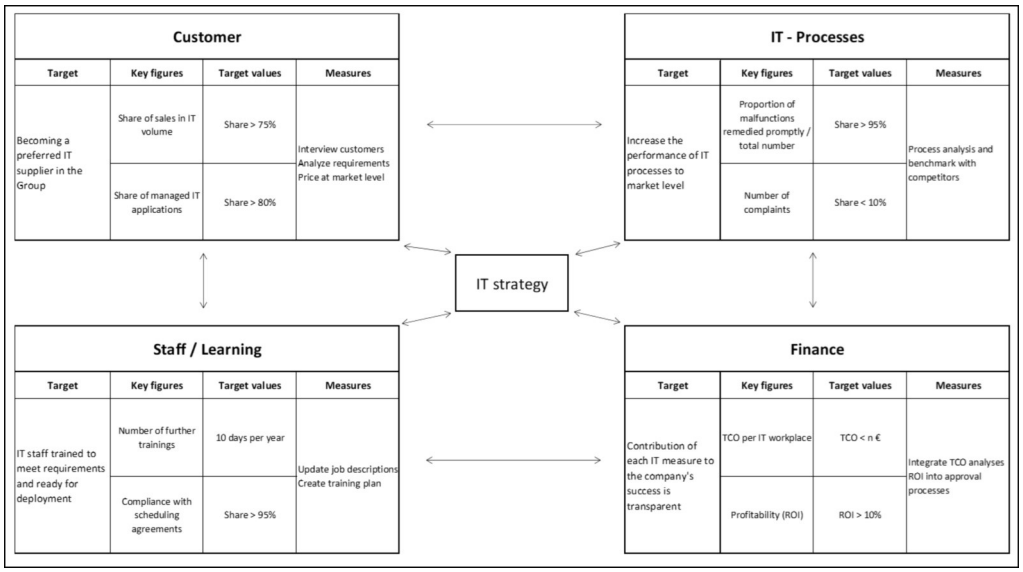
The IT balanced scorecard follows the same approaches and objectives as any other balanced scorecard in a company. The only differences are the perspectives to be defined and their interrelationships. In principle, the perspectives in the IT environment can also be used for customers, IT processes, personnel and finances (Gadatsch, 2021, p. 11).

The financial perspective clarifies, for example, the question of what contribution IT can make to financial success or how IT process costs can be reduced, which will impact IT processes. The process perspective can ask how the use of IT can increase process quality and how these can be made more efficient. Also of interest are the throughput rates of the processes. The potential that IT employees have or should have, the level of employee satisfaction, or the professional and social competence questions the employee perspective should answer.

In particular, the training of young project managers is the focus of the study by Hefley et al., which concludes that although many university graduates are entrusted with project management, they are generally underprepared for it (Hefley and Bottion, 2021).

The customer perspective answers what products or services IT creates for its customers and how they assess them. An IT-balanced scorecard according to the above criteria is shown in Figure 3-7.

Figure 3-7: IT balanced scorecard



Note: Adapted from Gadatsch (2021)

3.3.6.4 Limitations of the Balanced Scorecard

The Balanced Scorecard can be an important tool for strategic management for structuring, implementation, and control. Furthermore, it serves to understand why and why processes in the company are profitable, which is a prerequisite for the strategic management of a company (Jarillo, 2015, p. 319). However, Vanini identifies the following points in a balanced scorecard as potentially problematic (Vanini, 2009, p. 288):

- The determination of the four perspectives is unclear because there is no need for a theoretical rationale. The cause-effect relationship is often only intuitively determined.

- Conflicting goals make it difficult to derive cause-effect relationships that are free of contradictions. Here, goals can be defined in one perspective that contradicts another perspective.

- Qualitative success factors that key figures cannot measure are not considered.

- Different temporal effects, feedback, and interconnections of strategic goals are not considered.

- Too many goals and critical figures can lead to information overload for employees. A Balanced Scorecard should therefore not have more than 25 indicators.

- Often, when used for a more extended period, there is no review of the assumptions and objectives of the data obtained.

Welge and Al-Laham also point out the following additional criticisms. The holistic nature of the approach can lead to a lack of focus on achieving financial success. This can lead to a reversal of the previous finance-heavy reporting. Consequently, this can lead to insufficient attention to or understanding of variances in decision-making. Instead of the strategically important priorities for the company, only the four dimensions are examined, leading to the Balanced Scorecard increasingly being regarded as irrelevant and integration as a strategic control instrument not taking place consistently.

An orientation determined solely by top management can run the risk of neglecting the subordinate management levels. A high transfer loss can occur here in terms of their proximity to the employees. In addition, top management can be misunderstood by the operational level (Welge, 2017, p. 844). A study from 2022 also shows that the size of a project can also be a criticality in planning and control, and therefore different mechanisms need to take effect than for small and medium-sized projects without strong complexity (Denicol, 2022, p. 8).

With all the criticisms, it is clear that the strategic goals of the Balanced Scorecard can be logically causal. However, in some instances, they do not have mathematical causality, as in classical performance measurement systems where a change in one value leads to another.

3.4 Test management

Systematic, integral functional tests are therefore necessary because errors in their nature are unavoidable or almost unavoidable. Methodical complete but possibly application-remote tests, for example, do not automatically make a program more stable or better. By such tests, error conditions occur and are stopped expensively, which do not affect the essential functions of the software, but the program slows down or to new error conditions to lead can (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1279).

Therefore, the developments of testing strategies are necessary. The strategy can be understood as the test framework conditions defined and planned for the project and the individual activities to be derived from them and implemented. Therefore, it cannot only describe the general approach of the project - on the subject of testing - but also contributes to the understanding of which task packages and activities result from this (Vivenzio and Vivenzio, 2013, p. 23). Several test strategies have been developed to reduce many functions, settings, and operating states that can cause the test scope to get out of hand to an appropriate and manageable level.

The risk-based testing approach is the most commonly used among many other testing strategies, briefly explained below. The Risk-Based Testing (RBT) approach is part of ISO 29119, designed to mitigate product risk in the early stages of the project and proactively inform stakeholders of the status.

The approach includes identifying product risks and using risk levels to control the testing process. Therefore, the RBT is an efficient approach to systematically guide a project through risk management (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 1279). The following Table 3-1 depicts the individual steps and activity fields of the RBT approach according to ISO 29119.

Table 3-1: RBT approach by ISO 29119

Steps	**Actions**	**Results**
Actions of the tester	Coordination with the users involved and preparation of the first draft of a risk register	Risk identification performed
Workshop	Discuss risks. Assignment of occurrence and damage values to calculate potential risk	Risk analysis available
Actions of the tester	Formulate objectives for testing as well as documenting Experiences, requirements, costs, and time scope of testing. Assign key performance indicators.	Define risk mitigation
Evaluation and decision	Determine the risk-related scope to be audited. Agree responsibilities and budgets.	Determine scope of audit
Definition of the testing process	Designing a testing process based on the specifications. Finalizing the definition of the test scope.	Definition of the test process is available.

The priority levels of each risk element are evaluated individually. Each risk is associated with the appropriate severity level activities. The checks are now performed according to the order of their risk severity. The severity levels are defined as follows (ISO):

Table 3-2: Severity levels

Severity levels	Description	Level
Critical	The business objectives cannot be achieved.	5
High	Business objectives are significantly undermined	4
Moderate	Business objectives are affected	3
Low	Little effect on the business	2
Negligible	No noticeable effects	1

The continuous risk monitoring process initiated in this way helps to track the identified risks and reduce the impact of the restrictions.

3.5 Procedure models

In this chapter, the different types of project management process models are explained and presented as examples. This serves to clarify the frame of reference for different types of projects. Understanding the project task from an overall view is essential for determining a suitable project management approach. Different perspectives on the project help in the effort to understand the project and to apply suitable project management methods. Winter points out that knowledge of the theory, practical experience, and one's role influence which process model is used for which type of project (Winter, 2009, p. 31).

Oswald et al. suggest analyzing different perspectives, such as integration management, schedule management, cost management, quality management, and risk management, to apply suitable methods within the project management framework depending on their characteristics (Oswald, Köhler, & Schmitt, 2018, p. 47). Apart from the sequential and repetitive procedure models, the bases of the agile procedure models are described since this exhibit a strongly rising portion in connection with software development projects since the 1990er years (Komus,

2018). Rietz and Meier also point out that regardless of the type of process model, each process model consists of a process model, a role model, and methods and tools for the actual application. These can be divided into competency-based, process-oriented, and system-referencing standards (Rietz and Meier, 2020, p. 15).

3.5.1 Classic project management

In this chapter, the classic project management process models are discussed. In this context, classic process models are also defined as sequential process models. In sequential process models, the project object is processed in successive completed phases, whereby overlaps or even parallel phases are not provided. Typically, sequential projects are carried out based on project plans, which already define the goals and requirements in early phases, and these are later used to control the project. Since the middle of the 20th century, considerations have been made about how quality can be integrated into this type of project (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 153). The following two concepts of the sequential approach are presented below.

3.5.1.1 Stage-Gate-Modell

The Stage-Gate model is a very intuitive process model that has to descend sequential and cascading phases. As early as 1956, the model was introduced by Benington with nine phases (Navy Mathematical Computing Advisory Panel and Office of Naval Research, 1956). In 1970, this model was adopted by Royce and formally described with seven phases (Royce, 2021). For each phase, define precisely what needs to be achieved and what documents need to be created. Requirement specifications in the requirements phase or specific design drawings in the design phase can serve as a basis. A subsequent phase does not begin until the previous one has been completed.

The individual phases are run through strictly sequentially. In the end, the transition to regular operation takes place, which is no longer part of the project scope. A disadvantage of the sequential approach is the jump back to a previous phase, for example, if defects are discovered in the test phase and corrected in earlier phases, although they are already fully completed. Depending on the situation, all phases must then be rerun. These phase transitions are called stage gates and correspond to the phases. For the stage gates to be considered fulfilled, criteria must be defined beforehand, which are then checked by committees and

approved if successful. According to Cooper, the stage-gate model can be flexed by the 6 F if necessary (Cooper, 2018):

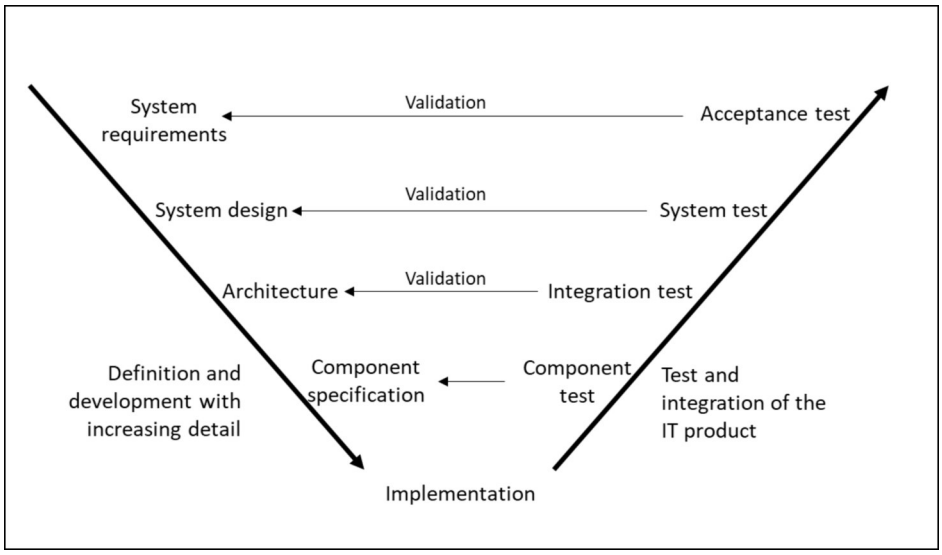
- Flexibility - Deviation from strict separation of phases
- Fuzzy Gates - Fuzzy Phase Separation
- Fluidity - Creeping phase transitions with phase overlapping activities
- Focus - Transition from multi-project to portfolio management
- Facilitation - Use of process managers
- Forever Green - Frontloading and risk management

With this approach, phase transitions are conditionally allowed in the event of incomplete achievement of gate requirements, and partial parallelization of phases is enabled, which can accelerate the project. One danger is that immature phases are left or completed too early, which cannot be made up later.

3.5.1.2 V-Model

The arrangement of the individual project phases is the reason for the naming of the V-model, which is shown in the following Figure 3-8.

Figure 3-8: V-Model



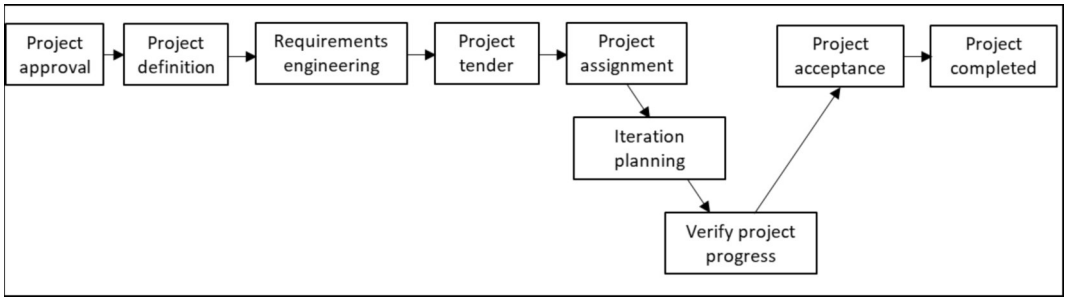
Note: Adapted from GPM. (2019)

On the left side of the model, the project object to be realized is specified further and further from the rough design to the detailed design. After implementation, the right-hand part is run through, testing the individual components up to the fully integrated and tested overall system. The validation of the customer requirements from the requirement specification and the acceptance stands at the end of the validation. Quality assurance is done by the specification of the left part, which has a corresponding test on the right side. This principle replaces the controlled phase transitions of the stage-gate idea (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 156). On the other hand, as in the stage-gate model, the phases are strictly separated from each other, and phase overlaps are not provided for, which can also result in the additional effort if requirements change, or errors are discovered too late.

The V-Modell XT is a version of the V-Modell that can be adapted precisely to the respective project. XT stands for Extreme Tailoring, which shows that this agile approach can be used to customize projects to a large extent. In contrast to the

classic V model, iterations are already planned in advance in the XT variant, as shown in the following Figure 3-9.

Figure 3-9: V Modell XT



Note: Adapted from GPM. (2019)

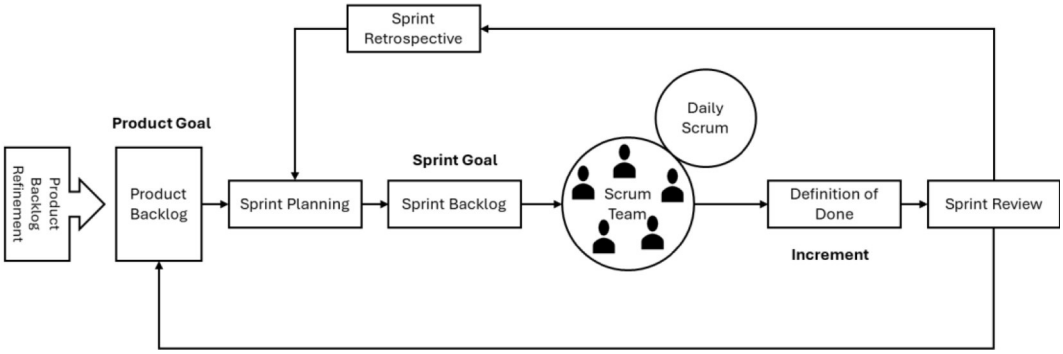
The purpose of this is to ensure that interim results are tested during the project term, thus maintaining the focus on the project objective (Federal Ministry of the Interior and Community [BMI], 2024a).

3.5.2 Agile project management

Agile process models support the application of agile values and principles, thus promoting communication and interaction in higher customer satisfaction or a better product. Of course, agile values and principles can also be practiced with other process models. However, agile process models are structured according to the basic structure, processes, and roles. Conversely, it is also true that agile process models do not necessarily prevent poor communication and result in the poor project outcome. Only the interaction of people acting in an agile manner and a suitable process model can achieve the goals of the agile manifesto (Beck, 2001).

The most widely used agile process models, according to Komus, are Scrum, Kanban, Lean, DevOps, Design Thinking, and Extreme Programming (Komus, 2018). Scrum has strengths in projects that can be implemented iteratively-incrementally, as the process model can handle changes, reviews, and retrospectives very well. Before we discuss the criticisms of Scrum, the Scrum process is illustrated in the following Figure 3-10.

Figure 3-10: Scrum as an agile Framework



Note: Adapted from Scrum.org. (2024)

One of Scrum's weaknesses is that it places high demands on the team's ability to organize itself. As project teams grow more significant, appropriate measures must be taken to maintain communication (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 166). There are now the Scaled Agile Framework SAFe by Mathis (Mathis, 2018) and the Large-Scale Scrum LeSS by Larman et al. (Larman and Vodde, 2017) widespread approaches for larger teams. The SAFe approach has proven itself in many industries (Hassan, Younas, & Bhaumik, 2021). It should also be noted that team autonomy can change in agile projects. Especially in large-scale software development, this circumstance can occur (Gustavsson, Berntzen, & Stray, 2022).

However, with ever-changing technologies and new requirements from customers, many IT projects need to maintain some flexibility without neglecting the business need for predictability and control (Lindskog, 2022). In addition, the study by Zieba et al. confirms that innovativeness and agility positively impact the sustainability of organizations, which is one of the desired effect (Zieba, Durst, & Hinteregger, 2022). Derived from the agile manifesto, agile practices are also used in employee management to give employees more autonomy and decision-making freedom (Dupret and Pultz, 2022). Even though agile leadership in organizations,

especially in IT projects is an interesting topic, it will not be pursued further in this dissertation as this is irrelevant to the research questions.

3.5.3 Hybrid procedure models

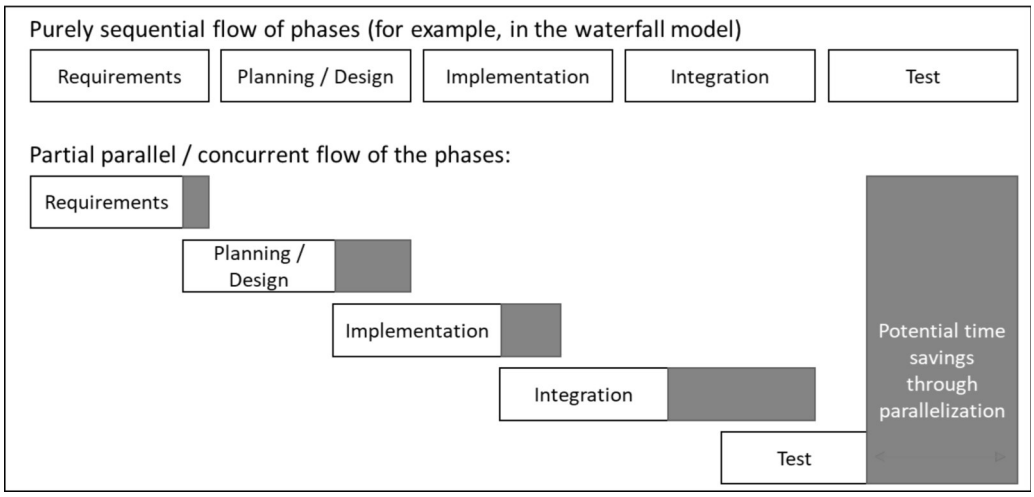
Process models are usually adapted to the company's framework conditions. Therefore, the number of phases, the content to be processed, and other parameters of the process model are adapted according to the requirements (Whitaker, 2014). Accordingly, process models are further differentiated into plan-based hybrid and agile hybrid models. A widely used plan-based hybrid process model consisting of two plan-based models combines the stage-gate model and the V-model. This combination is used to unite the quality assurance elements of the two process models. In addition to the ordered phase transitions with defined results at fixed control points, the project object is systematically verified and validated (Mathis, 2018, p. 52). In addition, hybrid project management is described as an approach that combines traditional and agile project management techniques. The aim is to benefit from the strengths of both approaches while avoiding the weaknesses (Reiff and Schlegel, 2022). The integrated application of Scrum and Kanban is called ScrumBan in the literature, which is considered an agile hybrid process model. A key feature is adopting the flow-oriented task control known from Kanban in the Scrum procedure and applying other principles and practices (Well, 2009).

3.5.4 Parallel process models

In parallel process models, the processes or phases are deliberately planned and executed in parallel sections. Partial parallelization is intended to make it possible to complete projects earlier since the subsequent activities can be started when partial results are available. The coordination process and the knowledge gained from it can be used for the early optimization of the project object and error corrections. The risk associated with the opportunities can lead to the start of follow-up activities even though the necessary input variables have not yet been fully recorded, comprehensively understood, or completed. In this context, input variables are plans, preliminary work, or prototypes. Rework, and later corrections can be the consequence (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 157).

The parallel project approach becomes more complicated if per phase or task packages these are carried out by cooperating organizations. Haniff et. al. investigated the factors that influence the strategy of a project network in this respect (Haniff and Galloway, 2022). The schematic structure of the parallel processes are shown in the following figure 3-11.

Figure 3-11: Parallel process model



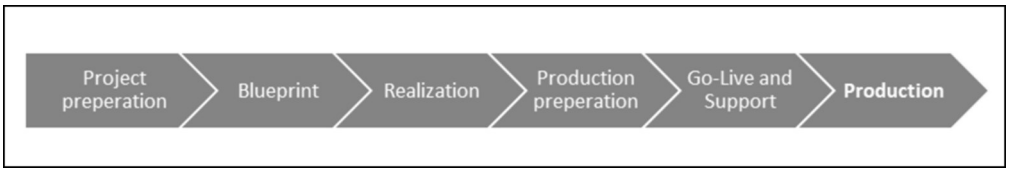
Note: Adapted from GPM (2019)

Careful risk management is an essential factor for the success of parallel process models and the assessments and criteria for when parallelization can occur and when work is more likely to be done sequentially. Another success factor is creating an integrated team of all project participants with regular and close coordination.

3.5.5 ASAP procedure model by SAP

In 1998, SAP SE developed its project procedure model for the numerous SAP implementation projects, called 'Accelerated SAP' or ASAP for short. With ASAP, SAP, as the software developer, has also delivered a method for its implementation. The following Figure 3-12 shows the schematic structure of the procedure method.

Figure 3-12: ASAP model by SAP



Note: Adapted from SAP SE (1998)

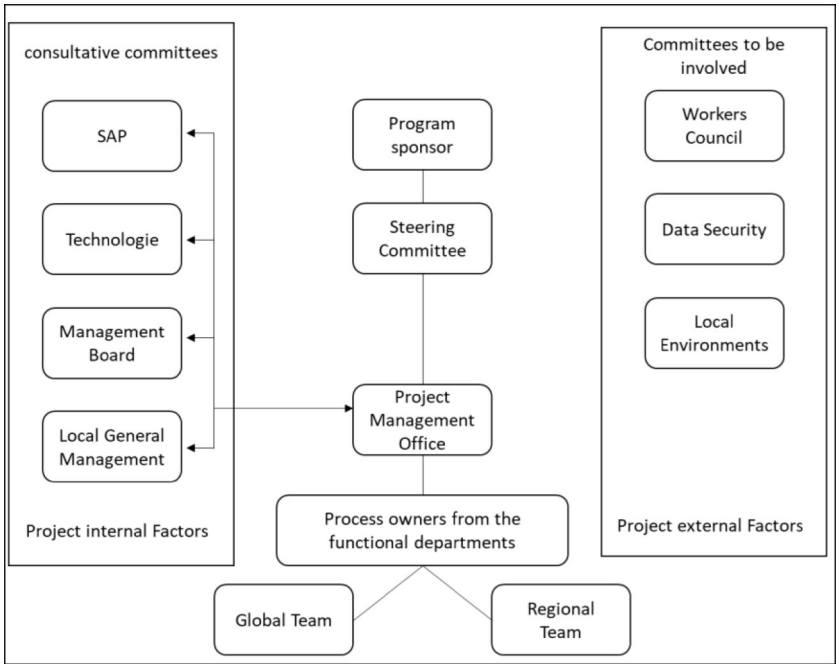
The ASAP method has been further developed in recent years with different variants on different applications. Since the use of the ASAP approach usually involves the integration of an ERP system, in most cases this has implications for the players in a transformation project (Bos-de Vos, Deken, & Kleinsmann, 2022, p. 6). In addition to the challenges of a transformation project, the resilience of the project members also plays a role. Fey and Kock state that resilience increases when adversities arise in the progress of the project (Fey and Kock, 2022). Therefore, there are many different manifestations of this method. Therefore, the traditional ASAP method for implementing SAP ERP is discussed in this context.

3.5.5.1 Phase 1: Project preparation

The first phase begins with the planning and preparation of the project. Planning is of central importance in the project and verifies the assumptions made in the run-up to the project. Planning the individual project phases is a joint task of all subprojects, which is then coordinated across the board. Technical areas such as system infrastructure, development, and technical migration are also included in the planning. During project planning, only the next phase is planned in-depth in detail, and all future phases are planned more overview-like. This grants some flexibility in future milestones.

Likewise, factors internal to the project, as well as factors external to the project, must be considered in the interaction of the project structure. Figure 3-11 illustrates the interrelationships.

Figure 3-13: Project preparation in ASAP



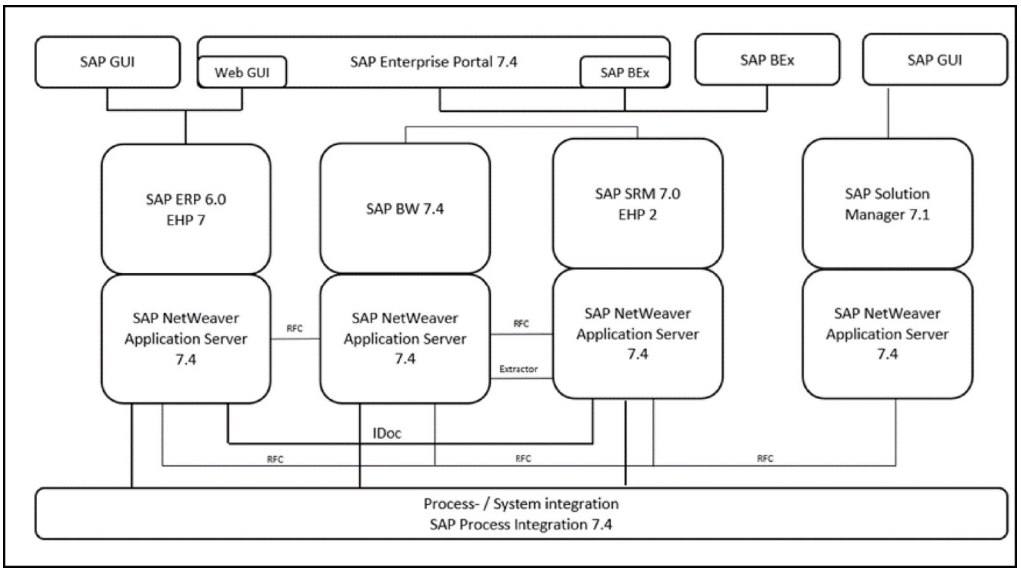
Note: Adapted from SAP SE (1998)

3.5.5.2 Phase 2: Business Blueprint

The actual work begins with the second phase of the ASAP process model, as this is where the framework, content, and interactions with other systems, projects, departments, and the technical implementation are described. It is the most critical part of the content and usually also the most extensive since the development and documentation of the business process requirements is defined here. The business processes of a company can be derived from the business strategy. The business processes can be mapped to a possible IT infrastructure that is also part of the business blueprint. Concerning the system architecture, the ASAP method also follows flexible SAP reference architectures, described as established and proven implementations of SAP components.

Figure 3-14 below shows an example of a reference architecture based on SAP components. The versioning of the individual components or modules is only shown here as an example.

Figure 3-14: Business Blueprint in ASAP



Note: Adapted from SAP SE (2020)

3.5.5.3 Phase 3: Realization

After accepting the blueprint phase, the previously defined prototype is implemented in the realization phase. In the blueprint phase, processes were documented, and the underlying architecture was defined in detail. The realization phase also includes the setup and operation of the project systems and the first basic configuration of the new SAP system. These baseline configurations usually do not change again but require a high level of care. This is followed by customizing in SAP, which is the configuration of the SAP solution. Here, it is essential to focus on end-to-end processes and the interaction between individual processes and consider the processes from start to finish, increasing the overall solution's complexity. Different sub-processes are used more than once.

3.5.5.4 Phase 4: Production preparation

The SAP solutions are planned, set up, developed, and tested in this phase. The processes are tested with data that correspond to the later productive data. The system performance and all requirements meet the SAP system in this phase, and the preparations, planning, and implementation of the transfer to productive operation are pending. Two task packages are also pending, and one is the training of the users and the setup of the productive system landscape.

User training

The key users who accompanied the acceptance test were already trained in the previous phases. In principle, all users should be prepared for the use of the system in training courses, as this increases acceptance by the subsequent end users and is an essential prerequisite for the overall project's success. Integrating tools for documentation, testing, and training can support the project.

Setup of the productive system landscape

Establishing a productive system landscape can be driven forward in parallel with employee training. For the establishment of the productive system landscape, the focus is now on different approaches than for the test or development systems. Flexibility is replaced by the constancy and security of the productive environment. Data security, availability, and performance assurance procedures are also implemented and tested.

Planning for go-live (cut-over planning) includes the following activities:

- Regulating when the last transaction can be entered into the legacy procedures and when the new system will be operationally available.
- Handling the business process during the downtimes.
- Shutdown of the legacy systems
- Decision-making process for going live

- Disaster recovery plan and production downtimes
- System completion and release for transport
- Completion and acceptance of the implemented solution
- Procedure and times for loading data into the SAP system (data migration)
- Acceptance of data migration
- Review and release of processes based on migrated data
- Quality assurance measures (Go-live checks)
- Technical acceptance
- Functional acceptance

In this part of the production preparations, they lay the system-technical foundations for a successful go-live. The basic principles for installation and process logic developed during the previous project are now being applied precisely to the production platform.

3.5.5.5 Phase 5: Go-Live and Support

The final phase of the ASAP project procedure focuses on using the new SAP system. Parallel to working with the system, the results of individual transactions can be analyzed. Small changes can also be made. In the case of change requests with more significant effort, it is recommended to integrate them in a later maintenance release. At the end of the project, the lessons learned can be discussed with the project team about what went well and what could have been done better. This is about constructive and person-independent criticism for improvements in the next project.

For projects with the introduction of system integration components, the planning and implementation is mostly known.

However, little is known about how this task evolves throughout the lifecycle in a project. Disciplined flexibility describes this circumstance and was investigated further in 2022 accordingly (Muruganandan et al., 2022).

3.6 Conclusion for this research

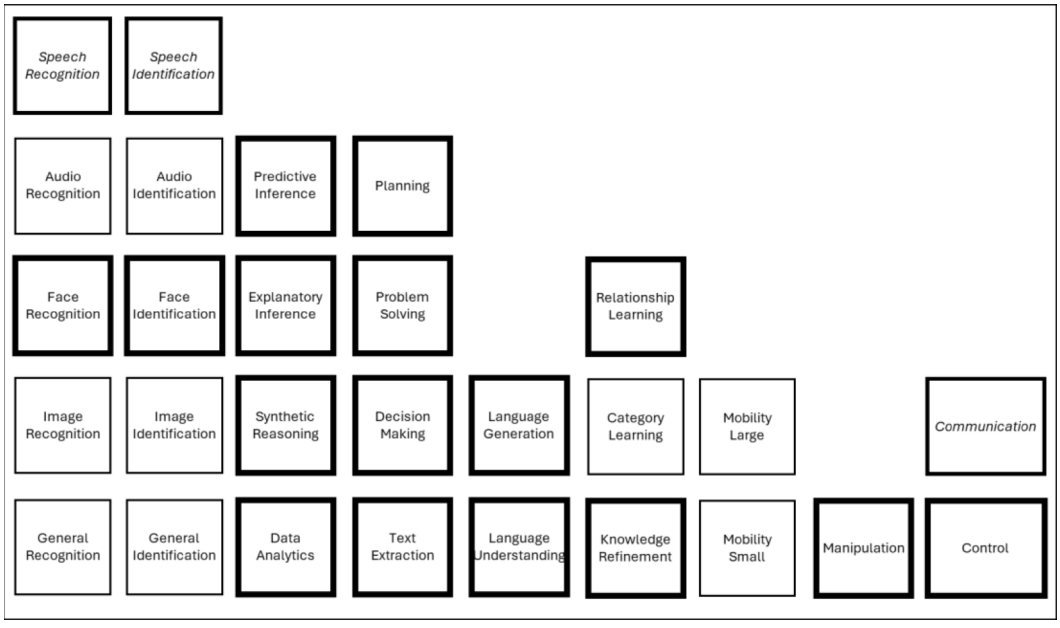
The different approaches for the procedures of a project put relevance in the foreground for the related project to find the right approach or method. As explained in the classical procedure models, the primary methods are applied here, which have already played a role in the early initial phases of project management. Agile and hybrid process models play an increasingly important role in practical applications and are constantly being developed to meet the requirements of the complexity and size of projects. Due to the clearly specified structures of the classical stage-gate model, this project procedure model is still used for this dissertation.

4 Selected methods of artificial intelligence

There used to be a clear separation between tasks performed by machines and tasks performed by humans. Applications of machine learning in speech recognition , image recognition, automatic translation, autonomous driving and medical diagnosis have blurred the classic division between human tasks and machine tasks (van der Aalst, 2021). The dominant account of project risk management pays homage to scientific rationality and presents risk as an objective fact (Holzmann, Zitter, & Peshkess, 2022).

Hammond's Periodic Table of Artificial Intelligence attempts to conceptualize a lingua franca for artificial intelligence based on chemistry's periodic table of elements (Hammond, 2017). It helps to categorize the term AI in the context of business processes and to assess market readiness, effort, required machine training, and knowledge and experience (Bitkom e.V., https://periodensystem-ki.de/). In the following, selected artificial intelligence concepts are introduced using Hammond's Periods System. An overview about the periodic table of AI elements is given in the following figure.

Figure 4-1: Periodic table of AI elements



Note: Adapted from Bitkom e.V., https://periodensystem-ki.de/ (2024)

The selection of the individual AI elements is based on classic project management tasks that humans still perform. For example, the Text Extraction module can extract and summarize relevant information from project status reports. In principle, the individual AI elements must be understood as process modules, as several AI elements in combination can only lead to a solution or support in project management. The individual relevant AI elements are now explained below.

4.1 Face Recognition

Face Recognition [Fr] can be used to recognize the position of faces in photographs. In most cases, these services mark faces by rectangles, although most services can also detect additional information, such as estimated age, gender, or emotional mood. This AI element can be used in security, traffic, or retail or for safety compliance for specific workplaces. Face Recognition [Fr] is a particular case of Image Recognition [Ir] and a prerequisite for the Face Identification [Fi] AI element. The most significant challenge lies in data protection since personal data is processed here.

4.2 Face Identification

This AI component can recognize faces from images or video recordings and assign them to a known person. The actual identification takes place via a pool of comparison images. The application area ranges from person recognition and identification to access authorization or monitoring of persons. Likewise, these AI components help establish identity in video phone calls. Face Identification [Fi] builds on the previously described Face Recognition [Fr] and may have further dependencies on the Communication [Cm] and Control [Cn] Ki components. This component is also questionable from a data protection perspective since personal data must be processed here. Another hurdle is the robustness of the solution since persons with partially obscured faces and from different camera perspectives would have to be reliably recognized.

4.3 Data Analytics

Data Analytics [Da] identifies relevant facts about quantity and quality in data. As with all AI-based applications, the quality of the data is just as important as the quantity. In addition to completeness, inconsistencies within the data are also highly relevant. Therefore, an organization's AI readiness must be examined in

advance, and, in case of doubt, this AI readiness must be established before AI methods can be used. Unlike speech or image recognition, it is a general-purpose artificial intelligence that processes structured and unstructured data sources. The type of facts uncovered depends on the type of information provided. This component offers users two advantages: greater efficiency in data analysis than human experts' exclusive use and the ability to detect previously unknown patterns. Enterprise application scenarios generally fall into two categories: first, identifying and minimizing risks, and second, discovering new opportunities. This avoids business risks by detecting AI warning patterns, e.g., credit risks in the financial sector or quality problems in production. Automatically extracted data patterns provide insights into unknown business areas, e.g., previously forgotten customer groups or new marketing segments. The use of data analysis [Da] requires an adjustment of business processes. For example, it must be determined which steps in the analysis processes can and should be automated. In addition, the intelligent use of automatically generated reports requires user training. Another obstacle is integrating data sources, often scattered across different systems. Merging data from different operational departments and creating an integrated database often involve organizational and technical obstacles.

4.4 Text Extraction

The AI component Text Extraction [Te] recognizes and interprets entities such as persons, organizations, cities, or products and terms in texts. A core capability for Text Extraction [Te] is the resolution of ambiguities in names and terms. The ambiguity is resolved by linking to the appropriate unique entities and concepts in a knowledge base. Such knowledge bases are often constructed to transform each item into a machine-readable entity or concept. The knowledge base must be adapted for use in specific applications or business fields. Text Extraction [Te] assigns unique meanings to names and words.

Text Extraction [Te] is the basis for Language Understanding [Lu]. Entities and concepts in texts act as anchors whose relationships allow Language Understanding [Lu]. For example, in speech-based assistants, Text Extraction [Te] is often preceded by Speech Recognition [Sr], which converts audio signals into text. The complete processing chain is then Speech-to-Text-to-Knowledge [Sr]-[Te]-[Lu]. For some application domains, the full potential of Text Extraction [Te] can only be realized when application knowledge is integrated, and proprietary entities or concepts are introduced into a knowledge base.

4.5 Planning

Planning [Pl] describes the algorithmic search for a sequence of individual steps leading to an acceptable outcome, considering boundary conditions. Individual steps are actions that extend over time and may depend on each other. Different solution paths can be compared to each other. An essential component of planning [Pl] is creating a plan from existing resources and constraints optimized according to selected priorities.

Planning processes to produce a product or provide service in all industrial and commercial enterprises is necessary. This is often due to the complexity of the process, which results from many actors mainly acting independently of each other. In addition, interruptions, and time dependencies in the timing of demand, capacity, and resource availability are essential. Planning is necessary for the production schedule, the procurement and supply of materials and resources, or the delivery of products to customers or markets. Unlike real-time operations management, predictive planning offers significant potential savings by reducing outage costs, shortening lead times, or improving overall plant efficiency.

Typically, planning is characterized by high combinatorial complexity. In practice, in addition to the many influencing factors, there are many planning objects and options. Current solutions do not meet these high requirements. In addition, real-time adaptive planning in dynamic environments adds value, increasing development efforts. Artificial intelligence-based solutions are now considered the best means to overcome these obstacles. Discrete event simulation techniques can be used to test AI-based solutions.

4.6 Problem Solving

Problem Solving [Ps] describes the search for possible ways from a current state to a target state. The transition from the current to the target state is described by individual steps to fulfill framework or boundary conditions. The solution has no direct physical impact but is obtained by abstraction using mathematical models or computer simulations. Problem Solving [Ps] corresponds to the human ability to solve a problem by reasoning. The principled solution is paramount; possible optimization is secondary. One ability of Problem Solving [Ps] is often to decompose a general problem into individual problems. Problem Solving [Ps] is used in finding possible solutions to problems while considering constraints.The result is several possible solutions whose consequences are evaluated concerning clearly defined criteria. However, Problem Solving [Ps] is closest to the AI elements

Planning [Pl] and Decision Making [Dm] since both presents the logical derivation of a found solution. Problem Solving [Ps] is, in principle, preceded by Planning [Pl] and Decision Making [Dm] since a planned action becomes possible only from the consideration of one or more problem solutions.

The high complexity and dynamics of systems in which Problem Solving [Ps] are used pose a significant hurdle. A primary problem is the development of efficient algorithms that provide reasonable solutions on time despite large solution spaces and various constraints—another problem with practical applications in cases where suboptimal solutions cause quality losses.

4.7 Decision Making

Decision Making [Dm] is the automatic selection of one among many possible decisions that lead to real-world consequences. This can be based on data or can be generated by heuristic rules. Decision Making [Dm] provides the best solution to a problem considering all parameters and constraints. More complex decisions are not yet automated on a larger scale today. Predictive Inference [Pi] provides the basis for decisions in combination with Planning [Pl] or Problem Solving [Ps]. Decision Making [Dm] requires the trust of humans in the autonomous decisions of machines. For some time now, this has led to the demand for justification of decisions made by autonomous systems. Intransparency reduces the acceptance of Decision Making [Dm] for many users and its rejection.

It is not uncommon for this AI element to achieve optimal results under controlled conditions that cannot be directly transferred to real-world conditions. Chapter 3.2.6 examined the handling of risks, uncertainties, and vagueness in detail. Depending on the risk class, appropriate risk mitigation measures must be initiated. Successful transfer from the laboratory to practice will remain a hurdle for the foreseeable future. Legal and ethical issues are another inhibition threshold.

4.8 Language Generation

The task of Language Generation [Lg] is to automatically generate a natural language text from the formal logical representation of knowledge. Language Generation [Lg] is used in two central tasks. On the one hand, it generates text output from natural language user interfaces, e.g., speech dialog systems or chatbots. On the other hand, it is used for systems that generate text, e.g., technical documentation, weather reports, or news. In the context of a speech dialog system, Language Generation [Lg] represents the central dialog interface.

Usually, a dialog manager or presentation planner is responsible for the higher-level control function for structuring and executing an interaction flow. The planner creates an abstract representation of the text to be generated, which is then output by Language Generation [Lg] in the natural language text of the target language. The text can then be converted into spoken language by speech synthesis. Language Generation [Lg] is supported by AI elements such as Planning [Pl] and Reasoning [Sy]. Form-based methods that combine fixed text fragments with dynamic content are also frequently used for natural language text generation. The AI element is used in all applications communicating with users through a speech-based interface. The importance of this component continues to grow as voice assistance systems become more widespread. Language Generation [Lg] is becoming increasingly important to ensure that the next generation of such products will find sufficient acceptance in everyday life.

The machine implementation of Language Generation [Lg] is challenging. In addition to tapping existing knowledge sources and generating new ones, quality assurance of the output and translation into different target languages are still high hurdles for a commercial application.

4.9 Language Understanding

Language Understanding [Lu] describes the understanding of the information in the text, i.e., the mapping to meaning. The AI element understands the relationships between entities and concepts meant in texts. It solves two problems: on the one hand, it clarifies which entities and concepts in sentence structures form a relationship; on the other hand, it investigates what meaning this relationship has. Relationships can be expressed in many ways.

Chatbots also use this AI element. Here, the intent of the questions, their various elements, and their relationship to each other must be understood. Chatbots need to understand the context and recall it for further dialog if it goes

beyond simple question-answer construction. In principle, Language Understanding [Lu] allows processing large amounts of text so that knowledge questions can be answered, or decisions can be made automatically. Language Understanding [Lu] often plays together with Text Extraction [Te]: Knowing the meaning of entities and concepts that appear in texts and questions is necessary to recognize the relationships or intent of a question. Language Understanding [Lu] is often downstream of Speech Recognition [Sr] to transform speech into a machine-readable representation of its meaning.

4.10 Predictive Inference

Based on a data basis, forecast models have generated a statistical link between input data and one or more output variables. Only correlations are modeled - not necessarily causalities. Predictive Inference [Pi] thus generates predictions of metric values, scale values, intervals, or classes for existing data. Predictive Inference [Pi] uses supervised learning to generate models that assign classes to data sets in the simplest case. This is called classification.

When discussing Predictive Inference [Pi] in time series, linear regression models are often used. Their purpose is to provide a prediction for time series with some degree of certainty. A typical application of Predictive Inference [Pi] is spam filters that analyze and categorize incoming messages. Predictive Inference [Pi] uses digitized data from images, sound, and film media and combines it with meta, master, and other process data to create predictive models using Data Analytics [Da]. These models are used by the Decision Making [Dm] element, among others, to make automated decisions.

A distinction can be made between technical and organizational hurdles. Technically, a database must be created for Predictive Inference [Pi]. For a forecast, data must be stored at a greater granularity than ERP systems usually provide. Among the organizational hurdles is the correct interpretation of the results. Perception of variances, risks, and assessment of the quality of forecasting procedures are subject to cognitive biases. Humans cannot interpret probabilities correctly without training and cannot simply trust their intuition. Forecasting enterprise data only adds value if it optimizes business processes. Predictive Inference [Pi] must consequently be integrated into existing systems. Integrating stochastic input variables such as order forecasting into production planning and control systems takes much work. Another hurdle is the frequent need for more transparency regarding forecasting models' work. If a forecasting method can provide this, its acceptance in operational use increases.

4.11 Explanatory Inference

Explanatory Inference [Ei] explains how AI systems make decisions. These explanations can, for example, concern the course of a decision chain - from the origin of the data, its derivations (inference), and the calculation of decisions. By understanding a decision, errors are avoided, and confidence in automated decisions is increased. Explanatory Inference [Ei] is particularly relevant in two everyday use cases: Accountability of decisions made (Accountability) and human-in-the-loop learning.

In accountability, different levels depend on the AI system. In assistive AI systems, humans remain the final decision-makers, to the extent that Explanatory Inference [Ei] becomes a tool of trust here to support and justify human decisions. In autonomous decision systems, Explanatory Inference [Ei] becomes a piece of evidence for the plausibility and correctness of decisions made by the AI system. The more AI systems are used in contexts of a high consequence of the decision, e.g., in medicine or self-driving cars, the more often corresponding components for Explanatory Inference [Ei] must be integrated. There is a growing split of beliefs within the AI community regarding learning methods.

Despite its great success, machine learning can reach its limits when dealing with insufficient training data. One possible solution is the additional integration of prior knowledge into the training process, leading to the notion of informed machine learning (Rueden et al., 2021). While the machine learning faction sticks to pure pattern recognition, others advocate a higher explanation of models and mixed learning methods (human-in-the-loop). Newer learning approaches try to a greater extent, to combine machine learning with human intelligence or human knowledge. The connection to prediction is to be able to justify the occurrence of a prediction. For this purpose, the machine processes must be explained better and more transparently via Explanatory Inference [Ei] (WhiteBox AI). Explanatory Inference [Ei] has a close connection to Predictive Inference [Pi] and Synthetic Reasoning [Sy]. Hurdles appear in several forms.

First, implementations for Explanatory Inference [Ei] often require additional effort. Second, quality metrics are needed to measure the quality of automated decisions. Often, powerful algorithms are not explainable because of their complexity. This creates a trade-off: good results are often based on unexplainable mechanisms, whereas explainable algorithms often produce unsatisfactory results. Thus, deep learning networks deliver excellent results in many areas, but their inherent functioning is difficult to understand. The training algorithms and their influence on the explainability of neural network (NN) models are prerequisites for

their acceptance. Reproducibility and, thus, explainability are listed as components of the development phase of the Model Governance Framework proposed by the EU as part of its concept of excellence for AI. Furthermore, reproducibility is a prerequisite for establishing causality in the interpretation of model results and for establishing trust regarding the overwhelming expansion of AI system applications (Federal Office for Security in Information Technology - BSI, 2024).

4.12 Synthetic Reasoning

Synthetic reasoning [Sy] is one of the critical components of intelligent systems. Reasoning refers to the ability to derive new knowledge from data with the help of a model. Synthetic reasoning [Sy] deduces the complex whole from known facts of a situation. Typical fields of application for Synthetic Reasoning [Sy] are business processes and applications that require complex intellectual performance.

This applies, for example, to business intelligence and analytics, where individual results are linked, and new insights are gained. Synthetic Reasoning [Sy] requires that data, rules, and sub models are meaningfully reconciled. Inference, knowledge-based systems, and reasoning have occupied research in AI from the beginning. The boundaries with Explanatory Inference [Ei] and Predictive Inference [Pi] are blurred. Inference techniques use the same basic capabilities but along a temporal or causal axis. Examples include finding the cause of a failure in a plant or a process chain by backward reasoning with Explanatory Inference [Ei] or simulating the consequences of the failure of a machine component by forwarding reasoning Predictive Inference [Pi]. Synthetic Reasoning [Sy], in contrast, works along with a part-whole relationship. Recent research shows a close connection to learning techniques such as Knowledge Refinement [Lt] and Relationship Learning [Rl]. The combination with text extraction techniques Text Extraction [Te] already finds successful applications in practice. Speech and image recognition and sensing provide the knowledge and database for Synthetic Reasoning [Sy].

The response category elements are used to communicate the inferences and implement the knowledge gained. The domain of Synthetic Reasoning [Sy] is intellectual reasoning. This distinguishes Synthetic Reasoning [Sy] from purely perceptual tasks such as image or speech recognition. Synthetic Reasoning [Sy] often operates on application and business-specific expertise. Thus, building Synthetic Reasoning capabilities always incurs effort by modeling enterprise and process knowledge. Synthetic Reasoning [Sy] can help build trust in AI as it can

derive comprehensible and explainable insights even from small amounts of data. Especially in the area of compliance, automated decisions must remain explainable and comprehensible.

4.13 Relationship Learning

Relationship Learning [Lr] identifies qualitative or quantitative relationships between objects or concepts. Relationship Learning [Lr] is often used to find previously unknown relationships between objects in networks, such as social networks, business networks, or communication networks. Wherever network-like structures occur, the AI element can be used to uncover relationships between objects.

In Relationship Learning [Lr], methods from Predictive Inference [Pi], Data Analytics [Da], and Category Learning [Lc] can be used. A barrier to using the element may be the lack of data to develop robust algorithms for Relationship Learning [Lr]. Another obstacle is restrictive data protection rules that make it difficult or forbid the processing of personal network data. However, Haibo et. al. points out that when there is an imbalance in the availability of information and knowledge, through large, complex, and interconnected systems, the problem of imbalanced learning can occur. This is often the case with underrepresented data and strong skewness in class distribution (He and Garcia, 2009).

4.14 Knowledge Refinement

Knowledge Refinement [Lt] refers to the continuous expansion of an existing knowledge base or the underlying model of an AI system. This often happens through feedback on an AI system's current results or users' feedback. This feedback adds new facts, leads to the sharpening of hypotheses, or improves the precision of results. Knowledge Refinement [Lt] uses different learning methods for this purpose. On the one hand, logic-based, on the other hand, statistical methods. The essential properties of learning methods are freedom from contradictions and stability over time. Knowledge Refinement [Lt] usually supplements other AI elements with a fundamental capability and is not an independent element. As a supplement to planning and decision-making systems, it is used, for example, in controlling machines and systems and autonomous driving.

Furthermore, it provides for the refinement or further development of knowledge in engineering applications, e.g., with the goal of predictive

maintenance. Knowledge Refinement [Lt] is generally used in situations requiring a high degree of control and traceability of AI results. Frequently, facts or rules are subject to regular changes, to which the system must be adapted repeatedly. Improving machine learning techniques is considered an important advance in the development of AI in recent years. Machine learning is becoming a technique that is widely available and shows low barriers to entry.

Like knowledge bases, it is now available to all companies without prohibitive investment. Relationship Learning [Lr] is often used for Knowledge Refinement [Lt]. Text Extraction [Te] and Language Understanding [Lu] are often used as upstream functions. In order to perform Knowledge Refinement [Lt], a knowledge base is required first, to which Refinement techniques are then applied. Often the creation of this knowledge base is the genuine hurdle. Most knowledge is usually not available in a structured form but in an unstructured form or even in the users' heads. This knowledge must first be tapped and then presented. Unstructured knowledge can be indexed from documents using Text Extraction [Te] and Language Understanding [Lu].

However, these often need to be more potent for many practical applications. Knowledge indexing can also be done by querying and observing user behavior. Once the knowledge is indexed, it must be represented. A pure classification in taxonomy is often insufficient; instead, relationships between the terms of a knowledge domain must also be represented. These steps are often associated with manual effort and high costs.

4.15 Manipulation

Manipulation [Ma] first describes the physical interaction of a manipulator with its environment and objects. The AI element allows a robot to recognize and successfully grasp previously unknown objects independently. Manipulation [Ma] is used wherever a robot with a camera system automates repetitive handling tasks. Manipulation [Ma] builds on several AI elements. Image identification [Ii], for example, provides data on the perception of the environment, using mainly 2D and 3D cameras, followed by image processing. Planning [Pl], on the one hand, provides gripper planning to determine the point at which contact is made between the gripper and the workpiece.

On the other hand, path planning is performed for the robot arm to calculate a collision-free path for gripping the object and depositing it at the target location. During the execution of manipulation tasks, decisions must also be made

autonomously by Decision Making [Dm]: As with any AI element, the quality of an application increases with the size of the available database. The database for manipulation tasks is significantly smaller than data science applications. Therefore, an essential hurdle to training the AI element is data generation. Other hurdles arise in the high-reliability requirements needed to interact physically with the environment and the requirements for near real-time operation.

4.16 Communication

The Communication [Cm] AI element supports various forms of machine-to-human and machine-to-machine communication. One application example for communication between humans and machines is chatbots, i.e., programs that conduct an automated text-based conversation. Language Understanding [Lu] is upstream of Communication [Cm] when spoken or written language input is processed in a dialog system.

Planning [Pl] and Language Generation [Lg] are used when dialogs need to be planned and implemented naturally. Machine-to-machine communication can be preceded by elements of the Identification and Recognition categories. As with many data-based technologies, strict data protection in Germany and Europe creates hurdles. Where personal data is processed, this results in restrictions on the feasibility of communication solutions. In addition, the diversity of languages in Europe makes it difficult to develop solutions for large markets, as individual models must be developed for each language. In machine-based communication, the diversity of manufacturer-specific protocols and data formats creates hurdles in the cross-machine integration of communication data.

4.17 Control

Control [Cn] derives control commands for external services or devices based on domain knowledge of an application and a given target. This AI element typically composes heterogeneous services and devices without user intervention. Control [Cn] is used wherever dynamic composition of services and devices occurs, such as in the Internet of Things, AI assistants, complex production processes, networked operating rooms, and action planning in service robotics. The AI element is used for service aggregation, i.e., communication between and controlling heterogeneous services and devices. The system receives a task and generates a meaningful sequence of commands and outputs for controlling devices and applications based on the context and other external information. The

increasing interconnectedness of applications, devices, and services in IoT solutions leads to the ever-increasing importance of the Control [Cn] element. Without central orchestration of the connected devices and services, integrated use of these devices and services is not conceivable without user intervention.

To perform its tasks, the Control element acts as a coordinating instance between elements that serve to control and communicate with services and devices in order to process the necessary information in such a way that the desired result is achieved, e.g., Communication [Cm], Manipulation [Ma], Planning [Pl], and Synthetic Reasoning [Sy]. An overarching description of each element and device's capabilities would be necessary for easy integration of devices and services. However, such a description or universally applicable ontology does not currently exist.

Against this background, only closed-isolated solutions can currently be found. The lack of implementation of the Semantic Web idea and the standardized description of devices and services makes efficient implementation of the Control element [Cn] difficult.

4.18 Conclusion for this research

The previously presented methods of artificial intelligence show not only the field of application but also the prerequisites and dependencies to other fields of AI. According to Hammond, the categorization clarifies the methods' different approaches and orientations.

In addition, it is shown that several elements of artificial intelligence are necessary for more complex application scenarios, which must be meaningfully coordinated with each other. In the case of the employees who are in direct contact with the AI, they play a mediating role in the relationships between the results of the AI and the rest of the stakeholders (Arias-Pérez and Vélez-Jaramillo, 2022). Other application areas are also exploring the use of artificial intelligence and data analytics to manage megaprojects in the construction industry. This underlines the importance of these methods in order to use them efficiently in project deployment (Wijayasekera et al., 2022).

5 Research hypothesis and investigations

The dissertation investigates whether selected artificial intelligence methods can efficiently support knowledge management relevant tasks within an IT project in given dimensions. The focus is on project planning, and control since the literature shows that these two phases are crucial for the success of projects. Nonetheless, all project management phases will be addressed in the following as a holistic approach of an IT project is taken. Therefore, the research questions are formulated in chapter 5.1 and from it, the hypotheses in chapter 5.2 are formed.

As this dissertation is intended to demonstrate possible efficiency improvements in projects, the concept of efficiency in the context of project management must also be addressed. DIN EN ISO 9000:2000 describes efficiency as the relationship between the result achieved and the resources used. In most cases, monetary values are used here to make the ratio operable and therefore calculable (Federal Ministry of the Interior and Community - BMI, 2024b).

Efficiency in the context of project management cannot be attributed to one key figure. There are various indicators to measure efficiency, such as the Schedule Performance Index (SPI), the Cost Performance Index (CPI) or the Return on Invest (ROI). The first two key figures, SPI and CPI, represent the relationship between a result and an expense. The basis for calculating the two key figures is planning. The ROI, on the other hand, describes the relationship between an economic result and its expenditure (Project Management Institute Inc., 2021, pp. 66–67).

The importance of answering these questions is particularly significant for companies with a high level of competition. Those companies that carry out their IT projects in the required dimensions of time, quality, and budget to achieve their objectives have a competitive advantage.

5.1 Research questions

According to the existing literature, which has been examined in detail in the previous chapters, there are still unanswered questions that will be part of the investigation:

RQ 1. Are artificial intelligence and knowledge management methods able getting a monetary benefit in planning and controlling of IT projects?

RQ 2. Which methods of them are preferred to use them practically?

RQ 3. What are the prerequisites in order to use these methods?

RQ 4. Is (semi-) automatic planning also usable for IT project portfolio planning or only for individual projects?

RQ 5. Which limitations are given if artificial intelligence and knowledge management methods are using?

RQ 6. What are other effects in companies using artificial intelligence for IT projects? Are there promoting factors or impending factors given?

RQ 7. Are artificial intelligence and knowledge management methods capable of correcting ongoing IT projects if deviations from the original plan are detected?

RQ 8. Are artificial intelligence and knowledge management methods able to detect dependencies between different projects?

RQ 9. Increasingly is the importance that projects have the right fit in line with strategic and economic visions of a company. Are the methods able to bring the projects in the correct prioritization?

RQ 10. Which prerequisites are necessary to use artificial intelligence as an innovation in project documentation, testing and finally in controlling?

5.2 Research hypothesis

Considering the research questions and the knowledge gaps, the following hypotheses are inferable:

H_1: Artificial intelligence, in combination with knowledge management, can have a significant improvement impact on planning and control for IT project management.

H_2: The methods are mature enough to produce high-quality results, so that the role of the human will be only that of a decision maker who receives the alternative suggestions from the artificial intelligence and the knowledge management system in the manner of a decision support system.

H3: The artificial intelligence and knowledge management solutions can improve the communication between the relevant stakeholders due to using the knowledge management-based methods.

H4: Using artificial intelligence and knowledge management solutions will support decisions in IT Project Portfolio Management, which are based on data driven proposals.

5.3 Qualitative data analysis (QDA)

Expert interviews and the qualitative data analysis, which is the qualitative method, will be discussed in the following chapter. The results of the interviews will have a significant influence on creating a model of a reference architecture that will be carried out afterward.

5.3.1 Expert interviews and qualitative data analysis

As mentioned in the previous chapter, several qualitative influencing factors in practice need to be operationalized to calculate a value. To be able to answer the research questions, a qualitative content analysis based on expert interviews will be carried out in the following to satisfy the scientific requirements of objectivity, reliability, and validity. The terminology will first be explained, and the selection

of experts will be justified and presented. The actual execution of the content analysis and the presentation of the results follow.

5.3.2 Definition and approach

Empirical social research is research that examines a specific part of the social world to facilitate the further development of theories. Gläser and Laudel point out that although the research process can be described as empirical, it is based on the theory that considers social reality and draws theoretical conclusions from it. Empirical social studies are usually divided into quantitative and qualitative studies. Qualitative content analysis based on expert interviews was chosen as the instrument to answer the research question.

Nevertheless, qualitative social research is criticized because it would be conducted without theoretical references and arbitrary processes and therefore is not subject to methodological control. The data collection and their evaluations of qualitative social studies are ambiguous and, therefore, cannot be replicated. The criticism made of qualitative social research aims at the fact that the theory and the procedures are not suitable for the interpretations that are supposed to study human action (Gläser and Laudel, 2010, pp. 24–25).

However, the division between purely quantitative and qualitative research methods does not do justice to reality since no research method can only show results with the method of the other. First, qualitative content analysis is explained in more detail to ensure a uniform understanding of the term.

According to Mayring, the goal of content analysis is to analyze material from any communication source. He further points out that it is about the communication content and formal aspects of the communication. As a further challenge, Mayring points out that the results of qualitative content analysis can strongly reflect the author's definitions and are thus too specific to be evaluated as generally valid (Mayring, 2015, p. 11).

In parallel process models, the processes or phases are deliberately planned and executed in parallel sections. Partial parallelization is intended to make it possible to complete projects earlier since the subsequent activities can be started when partial results are available. The coordination process and the knowledge gained from it can be used for the early optimization of the project object and error corrections. The risk associated with the opportunities can lead to the start of follow-up activities even though the necessary input variables still need to be fully recorded, comprehensively understood, or completed. In this context, input

variables are plans, preliminary work, or prototypes. Rework, and later corrections can be the consequence (Deutsche Gesellschaft für Projektmanagement eP.M., 2019, p. 157) As a further challenge, Mayring points out that the results of qualitative content analysis can strongly reflect the author's definitions and are thus too specific to be evaluated as generally valid. Social science content analyses can mainly have the following characteristics (Mayring, 2015, p. 12):

- Communication, that is, the transmission of symbols, is the object of research.
- Communication is fixed and subject to a protocol.
- Content analysis wants to proceed systematically in contrast to hermeneutic procedures.
- The analysis is carried out according to explicit rules.
- The procedure of the analysis must be theory-guided, as well as the individual analysis steps.
- Conclusions about certain aspects of communication, such as the effect of statements, must be possible.

Other authors have different views on social science research methods. According to Kuckartz, qualitative data differs according to its nature and origin. A qualitative analysis of qualitative data, therefore, corresponds to interpretative text evaluation or hermeneutics. On the other hand, pure quantitative methods on qualitative data correspond to the Transformation of written texts into measurable numbers. As an example serves here the classical content analysis or the computation of word frequencies within a text (Kuckartz, 2014, p. 15).

Gläser and Laudel regard the guided interview conducted with experts as a classic social science survey. It is essential to distinguish between two aspects. On the one hand, it is a unique communication process, and on the other, it is a social science survey method that follows the methodological principles of social research (Gläser and Laudel, 2010, p. 111).

5.3.3 Selection of the experts

According to Kuckartz, the quality of the information depends on the selection of the interview participants who take part in the expert interviews or whose answers are subsequently evaluated (Kuckartz, 2014, p. 15). Since the basis of the qualitative content analysis is the expert interviews, the definition of experts is discussed below. The fundamental division of experts can be divided into three areas. On the one hand, there are service experts who have technical knowledge. On the other hand, some experts have process knowledge, which goes hand in hand with informal or hidden knowledge.

The third group of experts consists of interpretive knowledge with ideas, ideologies, and explanatory patterns (Kruse and Schmieder, 2015, p. 176). In this dissertation, however, the primary distinction is deliberately not made, as it would restrict the practical framework too much. Other factors must also be considered concerning the planning of expert interviews. When selecting experts, Gläser and Laudel point out that they must have the relevant information, be able to present it accurately and comprehensibly, and be willing to share it with third parties.

Another critical factor is that these experts must also be available in terms of time and geography (Gläser and Laudel, 2010, p. 117). Experts with different skills are needed to ensure that the research questions and hypotheses can be answered. These include expertise in IT project management, IT management, knowledge management, particularly in IT projects, as well as knowledge of dealing with change and people management and experience with artificial intelligence.

The persons with whom the interviews were conducted are now presented in the following.

Expert 1 (FI): Senior Professional in the SAP Finance environment of one of the largest retail groups in Europe based in Cologne. Initially expert in preparing and analyzing balance sheets and experience in national and international finance projects.

Expert 2 (PM): IT Project Manager and Scrum Master with many years of experience in planning and implementing various IT projects in national and international company. Many years of experience in planning and execution of various IT projects in national and international company. Consulting experience in a variety of industries including consumer goods, electronics manufacturing, public sector, and management consulting.

Expert 3 (MA): Years of IT project experience, starting as an IT consultant and project manager until taking over the team leader position. For about eight years member of the management and for two years managing director of a medium-sized IT and management consultancy. Very high expertise in all aspects of project management.

Expert 4 (PL): Decades of experience managing IT departments and executing major projects in a technical auditing group. Pervasive experience in the SAP area and deep technical understanding of artificial intelligence methods. After conducting the expert interview on his last working day, he took his well-deserved retirement, although he remains available as part of this research.

Expert 5 (MA): Currently working as a freelance IT Manager / CIO / CTO with years of experience in leading IT positions, including CIO of one of the largest hotel portals in Germany and Vice President IT of a large energy company. Extensive experience in implementing and supervising all kinds of large-scale IT projects.

Expert 6 (PL): Certified project manager (IPMA) with extensive experience in managing IT and organizational projects in various industries such as a tourism group, logistics company, and the energy industry.

Expert 7 (FI): Senior Commercial Expert with a lot of experience in finance and controlling across different sectors such as service and industry as well as in public sector. Specialized also in the implementation of projects focusing on IT systems in the environment of corporate finance.

Expert 8 (PL): IT Program and Project Manager focused on IT infrastructure projects with decades of experience with a technical testing services provider. National and international project assignments in all aspects of IT infrastructure.

Expert 9 (PL): Senior Manager at one of the world's largest accounting firms, working in the Consulting Public Sector division. Deep and long experience in SAP Analytics, Business Intelligence, and Artificial Intelligence and in leading project teams and departments.

Expert 10 (MA): Director and therefore responsible for the SAP portfolio for the public sector at one of the largest auditing companies in the consulting sector. Decades of professional experience in the planning and implementation of IT projects around SAP as well as in the management of teams and departments.

The selection of the different roles is intended to ensure that the topic is examined as comprehensively as possible from different perspectives. On the other hand, two experts are interviewed in each of the two roles to determine possible differences and find explanatory approaches. The guiding questions used for the interviews are uniform but vary depending on which role is being interviewed.

"'Expert" describes the specific role of the interviewee as a source of specialized knowledge about the social issues being researched. Expert interviews are a method of inferring this knowledge" (Gläser and Laudel, 2010, p. 12). With this definition, on the one hand, the expert can serve as a medium to access the knowledge. On the other hand, they also serve as 'observers` of processes, attitudes, and experiences. Therefore, the exclusive position of having gathered their knowledge based on their experience makes these interviewees unique.

5.3.4 Selection of interview type and analyze method

In principle, various options for conducting interviews with experts will be discussed for better understanding. The option of guided interviews can be used to restrict the experts too much with prefabricated questions and thus lose valuable information material. Here, the questions are predetermined, but the interviewee can freely vary the answer. The guideline interview thus specifies the topics and a list of questions to be answered but is not fixed in the order. In addition, the exact wording can vary, which allows the interviewer to adapt the questions according to the course of the interview. As Gläser and Laudel state, open interviews specify the topic but are not supported by a guideline. On the one hand, this procedure promotes the natural flow of the conversation, which can lead to the focus of the topic being lost under certain circumstances, which can lead to problems later on when analyzing the interview (Gläser and Laudel, 2010, p. 13). Narrative interviews are introduced by complex questions that prompt the expert to consider the topic holistically and in-depth. Since the goal of the guided interview is to reconstruct social facts, the list of questions ensures the completeness of all topics to be investigated (Kruse and Schmieder, 2015, p. 41).

One of the challenges of qualitative content analysis and expert interviews is that all-important information must be discussed with the experts in a limited amount of time. This requires an efficient method to obtain the desired results promptly. Therefore, the open and narrative interview forms are generally less suitable. After the expert interviews have been conducted, the question arises about the possibility of the analysis method.

Accordingly, Gläser and Laudel distinguish between four alternatives, whereby the three most common methods are presented below:

Coding

The text to be examined is divided into different sections to answer the question, and those parts of the text which appear to be suitable are marked with keywords or sequences of numbers. After the entire text has been subjected to this procedure, the coding can be built up into a network so that, in the end, a content structure for answering the question is visualized.

Sequence analytical method

Combining the thematic and temporal aspects of the texts to be analyzed and their sentences is the core of this method. The main sub-processes of this method

are descriptive analysis, which determines the position and orientation of text parts and text types, and objective hermeneutics, which generates all possible interpretations through systematic interpretation and consistent verification of possible similarities in the text. The advantage of the procedure is that an error in interpretation is almost eliminated. However, the disadvantage of this method is the effort involved, and therefore it is rarely used in practice.

Qualitative content analysis

With the extraction from the text to be analyzed, in this case, the interviews are entirely examined with a systematic procedure with the help of an analysis grid. Categories are assigned to the relevant information, which is processed independently of the further course of the text. The categories can be merged with other information, compared, or discarded. The advantage of this procedure is that the original text remains, and only the extracted, categorized information is processed further. Although the initial sequence analysis also offers itself as a coding method, it is always necessary to refer back to the original text. Another advantage of qualitative content analysis is that the categories' formation can already occur before the text's analysis is examined. This procedure saves a sifting of the text and does not have to be re-examined for the actual analysis. However, this is also possible during the analysis phase if there is a need to change or expand the categories during the text analysis. In addition to the qualitative content analysis, the so-called coding procedure can be additionally applied in parts to evaluate quantitative data such as frequencies or correspondences (Gläser and Laudel, 2010, pp. 44–49)

5.3.5 Analyze of the interviews

This chapter will present the fundamental qualitative content analysis described above. Before that, however, the initial situation of the ten expert interviews in the appendix will be presented. The questions asked in the interview vary depending on the role of the interviewee. Of the questions asked, the core questions were included in the analysis to compare the answers. Of the questions asked, most services in a particular way to answer the research question.

The ten experts recruited were obtained through direct inquiries. Despite several requests, the experts did not receive the guidelines in advance to not influence their spontaneous responses. The interviews were conducted on a voluntary, unpaid basis. The interviews were conducted as semi-structured interviews in order to be able to respond spontaneously to the development of the course of the conversation and to avoid interrupting the flow of speech. A laptop was used to record the conversations after the prior consent of the interview partner. These were then transcribed. To interfere with the reading flow, irrelevant sounds were not transcribed during the conversation.

The following form of analysis is based on Mayring's summarizing content analysis. The categories are transformed into abstract levels of summarizing elements to generalize them step by step. By generalizing the text passages, it is possible to relate and compare them to others to highlight differences or emphasize the same statements (Mayring, 2015, p. 69). The following tables show the summary content analysis for each question and the experts' answers.

The first column lists the individual interview with the associated expert role or expert, the paraphrase created by the answer, and the resulting generalization. The last column shows the reduction of answers per question. For further quantitative analysis, the generalization is enriched by unique coding. Based on the coding, further analysis is performed in the conclusion.

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5.3.5.1 Code configuration system

Before the previously mentioned research questions can be answered with the help of QDA, the presentation of the code configuration is necessary. After conducting the interviews, is the second step in the process, according to Kuckartz. The codes were developed using a deductive research approach based on the investigated text. During the investigation, however, supplementary and for the answer to the research questions, relevant further coding occurred so that these correspond to the inductive approach. A corresponding coding and overview can be found in Table 5-1.

Table 5-1: Overview of the coding for QDA

Main code	**Code**	**Code Frequency**	**in %**	**Inductive / deductive**
Competitive advantage	Competitive advantage without limitations	14	6,25	deductive
Detection differences in Plan	Yes	14	6,25	deductive
Monetary benefit	Yes	13	5,80	deductive
Prerequisites	Complete data	12	5,36	deductive
Identify dependencies between different projects	Yes	10	4,46	deductive
Limitations	Tasks with human interaction	10	4,46	deductive

Prerequisites	Knowledge transfer	10	4,46	deductive
Competitive advantage	Competitive advantage with limitations	9	4,02	deductive
Correct prioritization	Yes	9	4,02	deductive
Project dimensions	Time	9	4,02	deductive
Prerequisites	Stakeholder / employees management	5	2,23	deductive
Prerequisites	Technical infrastructure	4	1,79	deductive
Limitations	Complete new tasks	2	0,89	deductive
Detection differences in Plan	No	1	0,45	deductive
Correct prioritization	No	0	0,00	deductive
Monetary benefit	No	0	0,00	deductive
Project dimensions	Costs / Effort (+)	17	7,59	inductive
Project dimensions	Quality	14	6,25	inductive
Detection differences in Plan	Limitation/Prerequisites	7	3,13	inductive
Correct prioritization	Prerequisite clear criteria	6	2,68	inductive

Importance of communication	Quality improvement	5	2,23	inductive
Enabling factors	Documentation and database	4	1,79	inductive
Limitations	No limitation	4	1,79	inductive
Prerequisites	Trust in AI	4	1,79	inductive
Correct prioritization	Different interests within the Group	3	1,34	inductive
Hindering factors	Lack of acceptance	3	1,34	inductive
Hindering factors	Complex and unknown requirements	3	1,34	inductive
Importance of communication	Yes but only certain type of communication	3	1,34	inductive
Importance of communication	Translation improvement	3	1,34	inductive
Monetary benefit	Partial	3	1,34	inductive
Prerequisites	Approach for improvement	3	1,34	inductive
Correct prioritization	Prerequisite data base	2	0,89	inductive
Enabling factors	Time saving	2	0,89	inductive
Hindering factors	No hindering factors	2	0,89	inductive

Identify dependencies between different projects	Prerequisite database	2	0,89	inductive
Importance of communication	Collaboration improvement	2	0,89	inductive
Limitations	No final decision-making power	2	0,89	inductive
Limitations	Historically grown structures	2	0,89	inductive
Correct prioritization	Partial	1	0,45	inductive
Enabling or hindering factors	Enabling factors	1	0,45	inductive
Hindering factors	Wrong expectations	1	0,45	inductive
Identify dependencies between different projects	Management trust	1	0,45	inductive
Importance of communication	More communication preparation	1	0,45	inductive
Limitations	Individual interests	1	0,45	inductive
Enabling or hindering factors	Hindering factors	0	0,00	inductive

Table 5-1 already shows that most of the codes were created by inductive methods. The inductive codes were assigned 29 times, whereas the deductive codes were derived 16 times.

5.3.5.2 Investigation of the research questions

The research questions will be investigated using the coded segments from the interview. Therefore, each answer to the respective research question is based on the experts' exploratory summaries of the assigned codes. The summary of the statements thus leads to answering the research questions. In the following step, the individual experts and their roles are compared with each other.

5.3.5.2.1 Single-based expert analysis

RQ1: Are methods of artificial intelligence and knowledge management capable of achieving monetary benefits in the planning and control of IT projects?

Table 5-2: Research question 1

Expert	Sub-Code: Partial	Sub-Code: Yes
Expert 1 (FI)	*No values*	Yes, the use of AI in project management has a monetary benefit mainly caused by the accompanying time savings.
Expert 2 (SPM)	*No values*	Yes, the use of AI in project management has monetary benefits. The use of AI can extend to multiple application scenarios in PM.
Expert 3 (MD)	In part, there could be a financial benefit, but it all depends on the data set.	*No values*
Expert 4 (SPM)	There could be a financial benefit but at the moment companies are not ready to use it.	Yes, there is a monetary benefit to using AI in project management. The use of AI can extend to multiple application scenarios in PM, which are repeated repeatedly. It also leads to a reduction in the workload of employees.

Expert 5 (SPM)	*No values*	Yes, there is a monetary benefit to using AI in project management.
Expert 6 (SPM)	There could be a financial benefit but in the agile environment it is difficult and even if the company is not even ready organizationally.	Yes, there is a monetary benefit to using AI in project management.
Expert 7 (FE)	*No values*	Yes, there is a monetary benefit to using AI in project management. The example from various functionalities in the SAP Finance area, i.e. from accounting.
Expert 8 (SPM)	*No values*	Yes, the use of AI in project management has a financial benefit in terms of processes.
Expert 9 (SPM)	*No values*	Yes, the use of AI in project management has in terms of recurring tasks.
Expert 10 (MD)	*No values*	Yes, the use of AI in project management has in terms of recurring tasks that we also already use today.

Answering Research Question 1 (RQ1): The statements of the experts surveyed provide a clear picture that they believe the methods of artificial intelligence and knowledge management have the potential to possess a monetary advantage in project management. However, it is striking that three experts answered the question in the affirmative but at the same time saw significant limitations, such as the fact that companies are not yet ready to use these methods present. In addition, no expert answered the research question in the negative.

RQ2: What are the prerequisites for the use of these methods?

Table 5-3: Research question 2

Expert	**Sub-Code: Complete data**	**Sub-Code: Knowledge transfer**	**Sub-Code: Approach for improvement and Stakeholder / employees management**
Expert 1 (FE)	All information and parameters must be completely available	comprehensive and continuous know-how	*No values*
Expert 2 (SPM)	Precise structured and up-to-date data	Comprehensive and continuous know-how transfer and the possibility to learn in a playful way	That AI and knowledge management can bring about a clear improvement in projects
Expert 3 (MD)	Technical setting and solid qualitative database necessary.	*No values*	*No values*
Expert 4 (SPM)	Data quality and the right AI method	Build knowledge and make it centrally available to all employees	The employees must be informed about the possibilities and take away the fear that they will lose their jobs.
Expert 5 (SPM)	Data quality and the right AI method	*No values*	*No values*
Expert 6 (SPM)	Historical and current data to forecast future scenarios	*No values*	*No values*

Expert 7 (FE)	*No values*	*No values*	Nevertheless, create added value due to investment costs
Expert 8 (SPM)	*No values*	Employees must be trained, knowledge must be made available	Employees must be prepared for the topic and their fears taken seriously.
Expert 9 (SPM)	*No values*	Knowing what you can do with an AI in the first place.	*No values*
Expert 10 (MD)	*No values*	To have the possibility to try out the knowledge and to learn in a playful way. Training courses and starting with small projects and then increasing.	Regular communication with employees is important.

Answering Research Question 2 (RQ2): The vast majority of experts see data availability and high data quality as prerequisites for using AI and KM. This involves the use of current and historical information to forecast future scenarios. The experts see essential prerequisite in communication with the employees. On the one hand, any fears of job loss must be taken seriously and responded to appropriately, and on the other, employees must be trained. This includes content-related training but also knowledge of what AI can do and where its limits are.

RQ3: What are the limitations of using artificial intelligence methods in project management?

Table 5-4: Research question 3

Expert	**Sub-Code: Tasks with human interaction and no final decision-making power**	**Sub-Code: Completely new tasks**	**Sub-Code: No limitation**
Expert 1 (FE)	*No values*	*No values*	In principle no limitation
Expert 2 (SPM)	Tasks in which empathy, compassion and social skills are important.	*No values*	*No values*
Expert 3 (MD)	Decisions made by the AI should be questioned	*No values*	*No values*
Expert 4 (SPM)	No personnel decisions - indications yes but no decisions	*No values*	In principle no limitation
Expert 5 (SPM)	*No values*	Completely new tasks	*No values*
Expert 6 (SPM)	*No values*	*No values*	In principle no limitation
Expert 7 (FE)	Basically, applicable everywhere but still no contacts to important stakeholders	*No values*	In principle no limitation
Expert 8 (SPM)	What cannot replace is the empathic interpersonal conversation	Fulfillment of spontaneous requests	*No values*

Expert 9 (SPM)	When it comes to togetherness and especially when it comes to escalations	*No values*	In principle no limitation
Expert 10 (MD)	when it comes to the assessment of people	*No values*	*No values*

Answering Research Question 3 (RQ3): In general, the experts hardly see any restrictions regarding the technical functionalities of an AI method in project management. However, they are critical of entirely new tasks since the AI usually has to be trained for them and spontaneous requests, which can also lead to problems with the AI. One technically possible implementation that the experts in project management do not recommend is in connection with human interaction. The AI should not perform corresponding tasks where intuition, compassion, and social and emotional intelligence are required. In addition, some experts see the individual interests of individual departments or segments in a company as an obstacle, which either covertly or openly position themselves against the use of AI in project management.

Question 4 (Q4): Are artificial intelligence and knowledge management methods capable of correcting ongoing IT projects when deviations from the original plan are detected?

Table 5-5: Research question 4

Expert:	**Sub-code:** **Limitation/ Prerequisites**	**Sub-code:** **No**	**Sub-code:** **Yes**
Expert 1 (FE)	Prerequisite that all information is available	*No values*	Yes, absolutely
Expert 2 (SPM)	*No values*	Corrections will not be able to make the AI	Yes, and also show different options or show resource constraints
Expert 3 (MD)	Only based on the data fed in and interpersonal problems cannot be solved by AI	*No values*	only on the basis of naturally defined parameters
Expert 4 (SPM)	In principle, yes, but we are not technically ready yet	*No values*	Yes, administrative tasks such as monitoring and the preparation of reports
Expert 5 (SPM)	*No values*	*No values*	Yes, guaranteed. If the original plan is documented
Expert 6 (SPM)	In principle, the AI should only suggest and not carry out itself	*No values*	AI should suggest and then managers have to decide.

Expert 7 (FE)	*No values*	*No values*	theoretically it is possible. In principle, it is only, so if one sees it simply, it is only a delta consideration
Expert 8 (SPM)	*No values*	*No values*	yes, if you set the parameters, yes
Expert 9 (SPM)	Human experience values should be made known as knowledge of AI.	*No values*	I am firmly convinced of this
Expert 10 (MD)	*No values*	*No values*	So yes, I think AI can do that

Answering Research Question 4 (RQ4): The experts agree that artificial intelligence and knowledge management can support ongoing IT projects. These are predominantly project monitoring activities and not the direct implementation of corrections. The fact that it is only possible to detect deviations based on the available data is also mentioned. However, it is also assumed that human experience values can also be made known to AI to be able to propose alternative scenarios.

Question 5 (Q5): It is increasingly important that projects are aligned with a company's strategic and business visions. Are the methods able to put the projects in the right prioritization?

Table 5-6: Research question 5

Expert	**Sub-code: Partial**	**Sub-code: Prerequisite data base**	**Sub-code: Prerequisite clear criteria**	**Sub-code: Different interests within the Group**	**Sub-code: Yes**
Expert 1 (FE)	*No values*	*No values*	*No values*	For individual groups or departments yes, but for an entire company or enterprise it will be difficult.	On a single unit basis, AI can definitely do that. When multiple stakeholders are involved, it becomes more difficult
Expert 2 (SPM)	*No values*	*No values*	Very clear and indisputable criteria	*No values*	yes sure
Expert 3 (MD)	*No values*	*No values*	Efficiency criteria	Various interests in the company and their corporate policies could undermine AI	The AI can give me the indication, but I wouldn't be led by it in the end.

Expert 4 (SPM)	*No values*	The prerequisite is the available database	Specification of strategic goals and criteria with focal points	*No values*	Yes, I think so
Expert 5 (SPM)	*No values*	*No values*	*No values*	*No values*	yes guaranteed in any case.
Expert 6 (SPM)	*No values*	*No values*	*No values*	*No values*	yes but the ki should only suggest and then the managers have to decide.
Expert 7 (FE)	*No values*	*No values*	Precise and pre-defined criteria with a weighting	*No values*	Yes, I already believe that AI can do this
Expert 8 (SPM)	*No values*	The database needs a lot of information from the project plans and from the company goals	hard criteria or key figures that are important	*No values*	Yes, I believe in AI
Expert 9 (SPM)	*No values*	*No values*	*No values*	The defensibility of managers who then	*No values*

				rely on an AI could be a problem	
Expert 10 (MD)	Not complete but better than via existing boards	*No values*	*No values*	*No values*	*No values*

Answering Research Question 5 (RQ5): In this research question, data is also a fundamental requirement. However, the experts also mention a clear definition of criteria in advance of prioritizing IT projects as a prerequisite. In addition, weighting the criteria is advantageous because not all criteria contribute equally to prioritization. Different interest groups within companies or groups of companies are seen as critical of prioritization by an AI. The selection of suitable IT projects by an AI can function on a departmental basis, but different interests could undermine the proposals. The topic of corporate policy has also been mentioned several times. In principle, however, all experts agree that AI and KM can contribute to selecting suitable IT projects to achieve corporate goals.

Question 6 (Q6): What are other effects in companies that use artificial intelligence for IT projects? Are there favoring factors or hindering factors?

Table 5-7: Research question 6

Expert	**Sub-code: Wrong expectations**	**Sub-code: Lack of acceptance**	**Sub-code: No hindering factors**	**Sub-code: Complex and unknown requirements**	**Sub-code: Documentation and database**	**Sub-code: Time saving**
Expert 1 (FE)	*No values*	*No values*	*No values*	Complex and unknown features	*No values*	in any case the time savings
Expert 2 (SPM)	*No values*	*No values*	*No values*	*No values*	*No values*	efficient resources, allocation
Expert 3 (MD)	*No values*	*No values*	No hindering	*No values*	*No values*	*No values*
Expert 4 (SPM)	*No values*	Hindering if no management acceptance available	*No values*	*No values*	*No values*	*No values*
Expert 5 (SPM)	*No values*	Hindering	*No values*	*No values*	Data base	*No values*

Expert 6 (SPM)	*No values*	*No values*	No hindering factors	*No values*	*No values*	*No values*
Expert 7 (FE)	*No values*	Hindering if no management acceptance available	*No values*	*No values*	*No values*	*No values*
Expert 8 (SPM)	*No values*	*No values*	*No values*	Obstacles are very spontaneous, agile projects	Clear structures and complete database	*No values*
Expert 9 (SPM)	*No values*	*No values*	*No values*	Insufficient documentation and unstructured data	Clear structures and complete database	*No values*
Expert 10 (MD)	Wrong expectations	*No values*	*No values*	*No values*	*No values*	*No values*

Answering Research Question 6 (RQ6): The experts see a possible lack of acceptance or support for artificial intelligence in IT project management. This should be ensured in advance. The experts see complex and unknown requirements placed on AI as a further hindering factor. Associated with this is a false expectation of the possibilities of an AI. Apart from these circumstances, no other obstacles were identified. The conducive factors are the need for documented processes and a corresponding database. Time savings are mentioned in connection with the results that an AI can deliver.

Question 7 (Q7): Are artificial intelligence and knowledge management methods capable of identifying dependencies between different projects?

Table 5-8: Research question 7

Expert	**Sub-code: Prerequisite database**	**Sub-code: Management trust**	**Sub-code: Yes**
Expert 1 (FE)	*No values*	*No values*	in any case
Expert 2 (SPM)	*No values*	*No values*	Yes, in any case
Expert 3 (MD)	*No values*	Trust of the top management	For sure,
Expert 4 (SPM)	*No values*	*No values*	It would even be an absolute highlight
Expert 5 (SPM)	*No values*	*No values*	Yes, definitely.
Expert 6 (SPM)	*No values*	*No values*	Yes that would even be a must for me
Expert 7 (FE)	*No values*	*No values*	absolute highlight
Expert 8 (SPM)	*No values*	*No values*	Yes the AI can support you
Expert 9 (SPM)	Prerequisite is complete database	*No values*	Yes
Expert 10 (MD)	Prerequisite is complete database	*No values*	that is one of the strengths of AI

Answering Research Question 7 (RQ7): Identifying dependencies between one or more IT projects is something AI should be able to do in context. All experts agree on this. However, they also point out that management must have confidence in the decision templates that an AI can provide. The complete database is also mentioned as a prerequisite.

Question 8 (Q8): Is artificial intelligence and knowledge management seen as a competitive advantage?

Table 5-9: Research question 8

Expert	**Sub-code:** **Competitive advantage without limitations**	**Sub-code:** **Competitive advantage with limitations**
Expert 1 (FE)	It is the future and is therefore a competitive advantage	Is a competitive advantage but you must first take away the fears of workers that they will not be replaced by AI
Expert 2 (SPM)	only a competitive advantage if it is pursued seriously and consistently.	AI is not consistently implemented by companies
Expert 3 (MD)	*No values*	AI is not consistently implemented by companies but it can still be a competitive advantage. Companies need to implement it
Expert 4 (SPM)	Is a competitive advantage because projects run more efficiently but that costs at the beginning also	*No values*
Expert 5 (SPM)	A competitive advantage when the database is correct	*No values*
Expert 6 (SPM)	*No values*	Not necessarily - it depends on the industry
Expert 7 (FE)	in any case a competitive advantage. Is of course always dependent on whether companies that also exploit	*No values*

Expert 8 (SPM)	Is a competitive advantage because the cost of sick leave or vacation of human labor is eliminated	*No values*
Expert 9 (SPM)	*No values*	I hope there are more and more companies that see it as a competitive advantage and recognize the benefits and don't even see dangers or concerns in it.
Expert 10 (MD)	So yes, I'm very sure AI will be seen as a competitive advantage.	I hope that there are more and more companies that see this as a competitive advantage and recognize the benefits and don't even see dangers or concerns with it..

Answering Research Question 8 (RQ8): All experts fundamentally see AI in conjunction with knowledge management as a competitive advantage. This is justified by increases in efficiency and advantages over saved personnel costs. However, the experts also state that not all companies use this advantage.

Question 9 (Q9): How are the benefits assessed in terms of time, cost, and quality when using AI and KM?

Table 5-10: Research question 9

Expert	**Sub-code: Quality**	**Sub-code: Time**	**Sub-code: Costs / Effort (+)**
Expert 1 (FE)	The quality I think in the medium term already good but in conjunction with the people in any case getting better and better.	So time is definitely a positive factor.	Time savings for the whole project could benefit
Expert 2 (SPM)	Eventually, yes, but not at first, I think.	It could possibly even cost more time	Saving money and time leads to better decisions
Expert 3 (MD)	The AI does not increase the quality	*No values*	License costs and implementation costs but also care and maintenance could become cheaper
Expert 4 (SPM)	The quality will improve as the alignment with other factors will be possible at a speed that was not possible before.	Because I expect exactly that these factors are permanently observed, evaluated and adjusted and optimized via an AI	Because I expect exactly that these factors are permanently observed, evaluated and adjusted and optimized via an AI and, if necessary, also in alignment with other factors that go beyond the project,

Expert 5 (SPM)	I do believe that the quality of project management could improve, for example in terms of estimating the effort required for certain tasks.	*No values*	would lead to a better calculation of what such a project could cost in advance.
Expert 6 (SPM)	*No values*	AI can save time in the area of test management and project planning.	you need less person days, because we are faster
Expert 7 (FE)	As for quality, I'm not so sure, because that's hard to measure.	As far as the time factor is concerned, definitely an improvement. Basically, an AI can also work at night, no matter what exactly is being worked on now, and this can also save costs. No downtime like illness or vacation.	In the beginning, everything will be more expensive. But once the first initial investments have been made, it will be worth it, depending on the quantity, in all three areas.
Expert 8 (SPM)	So you have fewer errors in the points that the AI takes over. And of course you have a better result.	So first, the AI is faster, at least in the areas it takes over.	So you have fewer errors in the points that the AI takes over. And you have a better result as a result, of course. And that automatically saves costs in my opinion.
Expert 9 (SPM)	In the field of quality through automated testing, through yes much more advanced intelligent testing procedures, testing procedures, etc. can significantly increase the quality.	By the fact that automation is perhaps also faster, by the fact that this also has a positive effect.	First of all, it always costs money. So that means it could well mean that the costs will be higher due to the use of AI. But I think the opposite is more likely to be the case.

Expert 10 (MD)	In my view, quality is becoming more exciting at this point. I believe that AI, if used correctly, is also capable of recognizing quality characteristics.	also has a positive effect on costs	The particular challenge in project management is always this issue of monetary expenditure, personnel expenditure, time, this Bermuda triangle, which arises there

Answering Research Question 9 (RQ9): The vast majority expect an increase in quality when using AI and KM in IT projects. This is justified by lower error rates, automated user acceptance tests, and the detection of inferior quality in the delivery object of a project. On the other hand, concerning the project dimension of time, all experts agreed that this would generally be reduced by using AI. This is also seen in connection with the costs incurred in a project, which are also reduced. In addition, the control and monitoring options of an AI are ideal for making the cost dimension more efficient.

Question 10 (Q10): How important is communication in the project, and could AI support it there?

Table 5-11: Research question 10

Expert	**Sub-code:** **More communication preparation**	**Sub-code:** **Yes but only certain type of communication**	**Sub-code:** **Translation improvement**	**Sub-code:** **Collaboration improvement**	**Sub-code:** **Quality improvement**
Expert 1 (FE)	*No values*	*No values*	*No values*	*No values*	Communication improves the quality in the project
Expert 2 (SPM)	*No values*	*No values*	*No values*	AI can assist in collaboration and improve communication in the process	*No values*
Expert 3 (MD)	*No values*	*No values*	Better understanding between the project client and the project team in the implementation and	*No values*	*No values*

			intake of the requirements		
Expert 4 (SPM)	*No values*	Certain communications should not be performed by the AI. Especially if they are tasks of managers.	*No values*	*No values*	AI can support communication - but should not always perform it itself
Expert 5 (SPM)	*No values*	AI can prepare but not execute the communication. For this, a human touch is still needed in most cases.	*No values*	*No values*	*No values*
Expert 6 (SPM)	*No values*	*No values*	*No values*	*No values*	Very critical to success - AI can support well
Expert 7 (FE)	*No values*	*No values*	*No values*	AI can support in collaboration	Information can be provided
Expert 8 (SPM)	*No values*	*No values*	Sending information on specific events -	*No values*	*No values*

			also in other languages		
Expert 9 (SPM)	AI should prepare the actual communication	*No values*	*No values*	*No values*	*No values*
Expert 10 (MD)	*No values*	*No values*	Knowledge management can be used as a catalyst in project management	*No values*	Yes, AI can improve communication in IT projects

Answering Research Question 10 (RQ10): All respondents see communication as an essential tool and success criterion in IT projects. The reasons given are improved collaboration, increased quality, and the ability to understand requirements better and make them understandable through foreign language assistants. Chatbots can offer added value in this context. On the one hand, it is connected with project management tasks but also derived in connection with knowledge management. For example, within an IT project, all requirements for the project deliverables, which represent implicit and explicit knowledge, can be bundled, managed, and retrieved or stored using natural language. This must be done within defined rules, otherwise the chatbot will contain incorrect or incomplete information. This would create a use case for knowledge management within an IT project. However, isolated cases also pointed out that it should be differentiated which type of communication an AI should take over. The human aspect can be advantageous depending on the topic of communication. One expert took a more differentiated view of the issue, stating that an AI should only prepare the communication but not carry it out independently.

5.3.5.2.2 Role-based expert analysis using cross tabulation analysis

In the following, the frequency of the codes for the respective roles of the experts is examined. This reveals possible overlaps and deviations in the number of responses, suggesting a conclusion about the importance of the topic for each role.

Role-based expert analysis for research question 1:
Are methods of artificial intelligence and knowledge management capable of achieving monetary benefits in the planning and control of IT projects?

Table 5-12 shows the role-based expert analysis for research question 1. All experts agree that artificial intelligence and knowledge management can support the monetary achievement in the planning and controlling of IT projects. However, there were also various limitations for most of the experts.

Table 5-12: Role based experts research question 1

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Partial	1	2	0
No	0	0	0
Yes	1	6	2

Role-based expert analysis for research question 2:
What are the prerequisites for the use of these methods?

Table 5-13 shows the role-based expert analysis for research question 2. In particular, the role of the Senior Project Manager is to see the requirements in the completeness of the data and the knowledge transfer. On the other hand, the Managing Directors' role sees the prerequisites in a similar criticality as the financial experts. One explanation could be that the Senior Project Managers encounter a more comprehensive range of essential prerequisites in their day-to-day work than the other two roles

Table 5-13: Role based experts research question 2

Sub codes	**Role: Managing Director**	**Role: Senior Project Manager**	**Role: Financial expert**
Complete data	1	4	1
Knowledge transfer	1	4	1
Approach for improvement	0	1	1
Stakeholder / employees management	1	2	1

Role-based expert analysis for research question 3:

What are the limitations of using artificial intelligence methods in project management?

Table 5-14 shows the role-based expert analysis for research question 3. It is striking that the opinion that AI should not take over tasks in which social and emotional intelligence is necessary is mentioned by all three roles. This shows the importance of this fact. Beyond this, however, no significant similarities between the roles can be identified.

Table 5-14: Role based experts research question 3

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Complete new tasks	0	2	0
No limitation	0	3	1
Tasks with human interaction	1	4	1
No final decision-making power	1	0	0

Role-based expert analysis for research question 4:

Are artificial intelligence and knowledge management methods capable of correcting ongoing IT projects when deviations from the original plan are detected?

Table 5-15 shows the role-based expert analysis for research question 4. All expert roles agree that AI and KM should point out or make corrections to IT projects when they deviate from the plan. Possible limitations and prerequisites that would have to be created are also distributed across all expert roles.

Table 5-15: Role based experts research question 4

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Limitation/ Prerequisites	1	3	1
No	0	1	0
Yes	2	6	2

Role-based expert analysis for research question 5:

It is increasingly important that projects are aligned with a company's strategic and business visions. Are the methods able to put the projects in the right prioritization?

Table 5-16 shows the role-based expert analysis for research question 5. All expert roles agree that AI and KM can prioritize suitable IT projects to support the business strategy. Explicit criteria for selecting IT projects and a complete database were named prerequisites. None of the roles is opposed to this research question.

Table 5-16: Role based experts research question 5

Sub-codes	**Managing Director**	**Senior Project Manager**	**Financial expert**
Partial	1	0	0
Prerequisite data base	0	2	0
Prerequisite clear criteria's	1	3	1
Different interests within the Group	1	1	1
No	0	0	0
Yes	1	5	2

Role-based expert analysis for research question 6:

What are other effects in companies that use artificial intelligence for IT projects? Are there favoring factors or hindering factors?

Table 5-17 shows the role-based expert analysis for research question 6. The role of the Senior Project Manager sees the most hindering factors. These are the lack of acceptance of AI proposals and complex and unknown requirements. On the other hand, the Senior Project Managers see good documentation of the processes and database as absolutely conducive factors. This result can be explained by the fact that this role works in day-to-day project activities and therefore has a practice-oriented view of things, unlike the other roles.

Table 5-17: Role based experts research question 6

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Wrong expectations	1	0	0
Lack of acceptance	0	2	1
No hindering factors	1	1	0
Complex and unknown requirements	0	2	1
Documentation and database	0	3	0
Time saving	0	1	1

Role-based expert analysis for research question 7:

Are artificial intelligence and knowledge management methods capable of identifying dependencies between different projects?

Table 5-18 shows the role-based expert analysis for research question 7. The role of senior project managers is to see opportunities to identify dependencies between different projects via AI. The role of the Managing Directors sees as a prerequisite that the management should trust AI conditionally, whereby, of course, a natural critical questioning of the results should be allowed and carried out. The data basis is also stated as a prerequisite here.

Table 5-18: Role based experts research question 7

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Prerequisite database	1	1	0
Management trust	1	0	0
Yes	2	6	2

Role-based expert analysis for research question 8:

Is artificial intelligence and knowledge management seen as a competitive advantage?

Table 5-19 shows the role-based expert analysis for research question 8. All roles see AI and knowledge management as a competitive advantage. Limitations are also mentioned by all roles referred to in the previous analysis.

Table 5-19: Role based experts research question 8

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Competitive advantage without limitations	1	4	2
Competitive advantage with limitations	2	3	1

Role-based expert analysis for research question 9:

How are the benefits assessed in terms of time, cost, and quality when using AI and KM?

Table 5-20 shows the role-based expert analysis for research question 9. Senior managers are most likely to see an advantage in all three dimensions in using artificial intelligence and knowledge management in IT projects. Finance experts and managing directors also see advantages in all three dimensions. Only in the time dimension do the managers not see as much of an advantage as the other two roles. This can be explained by the fact that this role is generally notified of delays in projects sooner than financial experts.

Table 5-20: Role based experts research question 9

Sub-codes	Managing Director	Senior Project Manager	Financial expert
Quality	2	5	2
Time	1	5	2
Costs / Effort (+)	2	6	2

Role-based expert analysis for research question 10:

How important is communication in the project, and could AI support it there?

Table 5-21 shows the role-based expert analysis for research question 10. Senior managers are the only role that believes AI should not perform all types of communications. While they recognize, as do the other two roles, that there can be benefits in terms of translation and collaboration tasks and improving the quality of communication, they still believe that AI should prepare communication rather than carry it out.

Table 5-21: Role based experts research question 10

Sub-codes	Managing Director	Senior Project Manager	Financial expert
More communication preparation	0	1	0
Yes, but only certain type of communication	0	2	0
Translation improvement	2	1	0
Collaboration improvement	0	1	1
Quality improvement	1	2	2

6 Reference model NICEL

This dissertation aims to develop an artifact with the content of a blueprint for the development of concrete software architecture to support IT projects with the help of knowledge management approaches and methods of artificial intelligence. This should facilitate the creation and implementation of IT projects and, in addition, be used for control and monitoring. Fundamental preliminary work on this topic has been comprehensively examined by Brüggen and Holland. The findings are the basis for this dissertation (Brüggen and Holland, 2022).

The name of the reference architecture NICEL is based on the nickname of the author's son and does not stand for an acronym or anything else. However, the term reference architecture must be clearly defined in practice and the literature (Fernandez, Monge, & Hashizume, 2016). The same statement was already made by Angelov in 2009, although the term reference architecture is already clearly recognizable here (S. Angelov, Grefen, & Greefhorst, 2009). However, reference architectures are increasingly taking their place in the literature and practice and are becoming integral to creating information systems.

To be able to explain the creation of this reference architecture in the following chapters, it is necessary to examine and demonstrate the terminology and properties as well as the status of the current scientific discussions on reference architectures in advance. This is to establish a uniform understanding of the creation of the artifacts. In the following chapters, the derivation of the reference architecture is examined, and different points of view regarding the concept of reference architecture are presented and discussed. This is followed by creating the reference architecture for supporting IT projects using knowledge management approaches and artificial intelligence methods.

The structure of this chapter is divided into the following subchapters: in chapter 5.5, the theoretical bases of the different views in the special one of the software architectures, the architecture of a classical reference model, as well as their definition are presented. In chapter 5.6, the methodology for producing reference architecture is discussed, and the methodology used is represented.

6.1 Conceptual and theoretical basics

As shown in the previous chapter, the reference architecture artifact is not uniformly defined in the literature. Different views and the current state of research and the subsequent discussion are essential for understanding the term. For this reason, the basic terminology in the context of the development of a reference architecture is presented and discussed below.

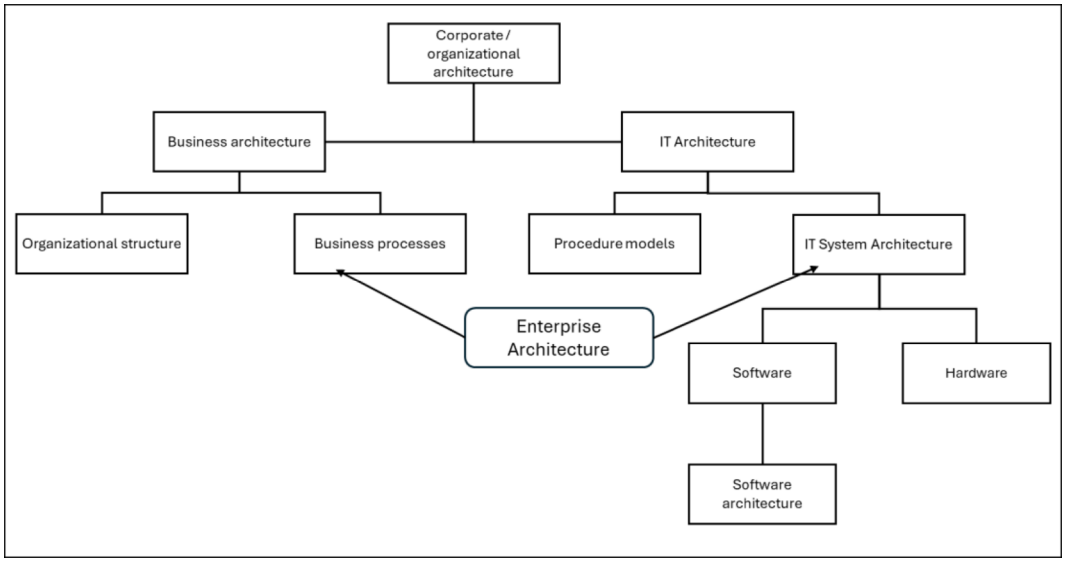
6.1.1 Software Architecture

The creation of software systems is realized with the help of software architectures because concrete decisions are made in the architecture within these structures and thus describe the development and give the project a development framework. In order to define the term software architecture, it is necessary to describe the different levels of an architecture in the context of a company. Balzert points out that the enterprise or organizational architecture is formed in an organization.

This involves the organizational, technical, and psychological aspects in the planning and development of operational socio-technical information systems. The IT architecture, on the other hand, is the structured abstraction of existing or planned IT systems. These can be used as a common communication platform for the planning, development, operation, and maintenance of IT systems. The IT architecture is subordinate to the enterprise architecture.

As part of the IT architecture, the software architecture structures and organizes the system components and establishes relationships between them. Enterprise architecture refers to the structure of information systems and relationships to the supported business processes (Balzert, 2001, pp. 16–20). The following Figure 6-1 shows the relationships between the different levels of architecture in organizations.

Figure 6-1: Dependencies between architectural terms



Note: adapted from Bregenzer (2024)

Bruns and Dunkel define a software architecture as follows: "A software architecture describes the higher-level structure of a software system and its global control structures. It describes the essential software building blocks in the form of components and specifies how they interact and cooperate" (Bruns & Dunkel, 2010). This definition clearly distinguishes between reference architecture and software architecture and their relationships.

6.1.2 Reference model

To standardize the term reference architecture for this dissertation and to explain its content, it is defined analogously by Brocke as follows: „A reference model is an information model that people develop or use to support the construction of application models, where the relationship between the reference model and the application model is characterized by the fact that the subject matter or content of the reference model is reused in the construction of the subject matter or content of the application model“ (vom Brocke).

This definition is necessary for the further course of this work since this terminology is also seen synonymously with a reference architecture. Bass et al. sees a reference architecture as a software-based further development of a reference model (Bass, Clements, & Kazman, 2003). However, vom Brocke and Buddendick argue that a reference model should be based on the specific characteristics of a use case (vom Brocke and Buddendick, 2004). Thus, the definition mentioned above serves best for this thesis, tying in with the specific positioning of reference models in the information model construction process.

6.1.3 Definition reference architecture

Since the term reference architecture is increasingly used in science and practice without being uniformly defined, the different meanings and emphases are presented below. Gallagher defines a reference architecture as follows:

„A reference architecture is the generalized architecture of several end systems that share one or more common domains. The reference architecture defines the infrastructure common to the end systems and the interfaces of components that will be included in the end systems. The reference architecture is then instantiated to create a software architecture of a specific system. The definition of the reference architecture facilitates deriving and extending new software architectures for classes of systems. A reference architecture, therefore, plays a dual role with regard to specific target software architectures.

First, it generalizes and extracts common functions and configurations. Second, it provides a base for instantiating target systems that use that common base more reliably and cost effectively” (Gallagher, 2000, p. 3). This definition focuses instead on a software-technical provision of different systems interacting with interfaces.

Bergey et al. are the first to mention variation points in a reference architecture, which other authors later follow up. This makes it possible to use constraints to make development more efficient since the reference architecture must inevitably be regarded as incomplete. "A reference architecture is an architectural style and design pattern for a specific domain or product line.

It is insufficient for building systems because a style or pattern, by its nature, requires critical unresolved issues. In addition, an architectural style represents a set of constraints on the architectures of individual products to be built as part of the product line. It, therefore, expresses the commonality among the architectures of the different products" (John K. Bergey et al., 2001, p. 32). According to Trefke, variation points represent predefined areas at specific points of architecture to change and extend if the necessities are given quickly (Trefke, 2012, p. 10).

Bass et al. sees a reference architecture as a software-based further development of a reference model (Bass, Clements, & Kazman, 2003, p. 33). This definition separates functions and data streams based on individual software elements. According to Bauer and Nakagawa, this definition is the most frequently used in the literature (Bauer, Boussard, & Meissner, 2013, p. 238) ; (Elisa Y. Nakagawa et al., 2011, p. 1673).

Pohl et al. see a reference architecture as a superordinate structure for several manifestations of a software series. The reusability of specific functionalities and modules stands out here, which is not named in the other definitions.

„The reference architecture is a core architecture that captures the high-level design for the applications of the software product line. The reference architecture includes the variation points and variants documented in the variability model. It limits the architectures of the separate applications, i.e., the application architectures. It determines which components are reusable and thus have to be developed during domain realization (Pohl, 2005, p. 124).

Cloutier et al. definition differs partly from the others because it is based on a system engineering approach. Affected stakeholders represent a central approach because the reference architecture must be consistent and coherent for these persons or groups. In addition, commonalities of system components are presented in more detail. „Reference Architectures capture the essence of existing architectures and the vision of future needs and evolution to provide guidance to assist in developing new system architectures" (Cloutier et al., 2009, p. 17).

Although Vogel et al. also focus on technical requirements and aspects, they also mention aspects of knowledge management. General architectural knowledge

and knowledge with specific requirements for a holistic solution are focused on to the same extent as the technical aspects. This differs fundamentally from the other definitions. „Reference architectures combine general architectural knowledge and experience with specific requirements to form an overall architectural solution for a particular problem area. They document the system's structures, the essential system components, responsibilities, and interactions“ (Vogel et al., 2009, p. 254).

A more abstract definition is provided by the OASIS Committee in which the primary goal is to provide a complete representation of technology-neutral solutions while describing in detail how the elements can be realized. „A reference architecture models the abstract architectural elements in the domain of interest independent of the technologies, protocols, and products used to implement a specific solution for the domain. It differs from a reference model in that a reference model describes the important concepts and relationships in the domain, focusing on what distinguishes the elements of the domain; a reference architecture elaborates further on the model to show a complete picture that includes showing what is involved in realizing the modeled entities while staying independent of any particular solution but instead applies to a class of solutions” (OASIS Technical Committees, 2012, p. 9).

Along with an increasingly specialized application of reference architectures, more specific definitions are also being published. Schleipen, for example, defines the approach of a reference architecture specifically for Industry 4.0.„Model for an architecture description (for Industry 4.0) that is generally used and recognized as fit for purpose (has reference character) (Schleipen, 2016, p. 1). Megow describes in the course of further development the definition of the reference architecture for Industry 4.0 based on national and international standards and simultaneously describes technical and organizational components. „The Reference Architecture Industry 4.0 (RAMI 4.0) is a reference architecture model that was mainly developed by members of the Platform Industry 4.0 and has become part of national standardization and international standardization. It describes a reference model for the architecture of technical components (assets), which enables their description and lifecycle as well as their assignment to technical, but also to organizational hierarchies" (Megow, 2020, p. 6).

In the context of this dissertation and the findings presented, the definition of Reidt et al. is used in this thesis, as it represents a combination of different emphases of the previous definitions: "A reference architecture is an abstract architecture that is intended to make it easier for people to develop systems,

solutions, and applications by providing knowledge and prescribing a framework for development.

The relationship between reference architecture and concrete architecture is characterized by the fact that the object or content of the reference architecture is (re)used in the construction of the respective system to be developed. The reference architecture has a technical focus but combines it with the associated domain expertise. It forms a common framework through its expression and content, where detailed discussions of all stakeholders involved in the development can be conducted" (Reidt, Pfaff, & Krcmar, p. 894).

6.2 Creation of reference architectures

As considered in the previous chapter, there are a large number of definitions of reference architectures. However, there is no uniform standard for creating them. This is justified because a large part of the reference architecture is created ad hoc without a systematic process (Elisa Yumi Nakagawa et al., 2017, p. 5).

The disadvantage of this uncoordinated creation of reference architectures is the insufficient traceability on the one hand and the frequent lack of documentation on the other. These circumstances can lead to complications when evaluating the results (S. A. Angelov, Trienekens, & Kusters, 2014, p. 1). Therefore, showing current methods for creating a reference architecture is necessary. Subsequently, the approach to developing the reference architecture used for this dissertation is presented.

6.2.1 Methodology for the creation of reference architectures

An iterative development approach to create a reference architecture is described by Bayer et al. by mapping generic scenarios based on experience with existing solutions. The formation of commonalities forms the basis for solution approaches. This is achieved by reverse engineering (Bayer et al., 2004). The disadvantage of this approach is that there is no technology neutrality, and only technical aspects are presented.

Also, at a high level of abstraction is the approach of Cloutier et al. Here, the information for creating the reference architecture is mainly generated from existing architectures (Cloutier et al., 2009). For the first time, Galster and Avgeriou recognize that there is no systematic creation of reference architectures (Galster and

Avgeriou, 2011). Their approach is based on the work of Ahlemann and Gastl (Ahlemann and Gastl, 2007) and Karow et al. (Karow, Pfeiffer, & Räckers, 2008). The following six steps are described in short form as follows:

Determination of the reference architecture type

A distinction is made here between two characteristics. Firstly, the goal of the reference architecture, either standardization or support in the development, and secondly, whether the reference architecture can be based on solutions that have already been developed and are therefore suitable for practical use. If solutions that are not yet established are described, this reference architecture would be more appropriate for future research purposes.

Determination of the design concept

Depending on the type, the reference architecture either consists of best practices, experience, and explicit and tacit knowledge, or these must be formed entirely from scratch in the case of a forward-looking orientation.

Empirical generation of data

This step identifies the sources and people who can provide the information needed to create the reference architecture. Research-driven architectures require other types of data due to their uniqueness, which must be newly developed.

Generation of the reference architecture

The modeling of the reference architecture is developed from different views. Common and specific elements based on existing or newly developed information are distinguished. The core elements are those that are identical in all views.

Variability development

As discussed earlier, variation points allow easy modification or extension within the existing reference architecture. Therefore, these are established in this step.

Evaluation of the reference architecture

In the last step, the degree of usefulness is examined. The focus is on efficient adaptation and instantiation, depending on the reference architecture type.

Overall, it can be stated that this concept is generic and abstract to a high degree. On the other hand, it provides a defined framework for creating a reference architecture. However, a weakness of this concept lies in the development of new reference architecture. Although the possibility of a novel, future-oriented research architecture is mentioned, especially in the first three steps, concrete information for implementation is missing. Therefore, this concept can only be considered in parts for the further work of the dissertation. The relevant explorative approaches are lacking for complete using of this concept.

Nakagawa et al. present another way to create reference architectures in their process description ProSA-RA (Process based on Software Architecture -Reference Architecture). In this process, the application domain is defined first, and the four steps are carried out in the following:

Generation of information sources

The first step is to select sources and people who can provide the necessary information about processes and activities. Comprehensive domain knowledge is needed for this. Customers, users, publications, and tacit knowledge can serve as sources.

Identification of requirements for the architecture

Depending on the selection of information sources, the requirements for the reference architecture must be created in this step. A distinction is made between functional and non-functional requirements.

Creation and description of the reference architecture

The actual modeling of the reference architecture is chosen in such a way that many stakeholders can understand it.

Evaluation of the reference architecture

The last step deals with the evaluation of the created reference model. Various tools and procedures can be used for this purpose, whereby the comprehensibility and representation of the reference architecture play a superordinate role.

This procedure is also very generic, although, in contrast to the process of Galster and Avgeriou (2011), the sources and stakeholders are dealt with more concretely in this process. However, the different types of reference architectures are not discussed here either. Along with this, the process of Nakagawa et al. (2014) also serves little purpose for the creation of exploratively generated reference architectures.

6.2.2 Methodology used to create reference architectures

The processes presented for creating a reference architecture in the previous chapter cannot be used entirely due to the lack of guidance for exploratory and research-based approaches. Nonetheless, some systems can provide a framework for creation. Reidt (2019) methodology is a combination of the processes presented with the addition of missing components necessary for creating research-based reference models.

This process is adopted in parts for this dissertation. The steps used are explained in detail:

Defining the target of the reference architecture

The first step is to define the goal of the reference architecture. As in Reidt (2019), the view concept of Kruchten (1995) is recommended for this dissertation since different subordinate goals are to be realized by appropriately adapted views. In conjunction with this, a stakeholder analysis is required to ensure that the users of this reference architecture can also work efficiently. Therefore, their requirements and knowledge should influence the creation and be considered.

This reference architecture aims to create an abstract, technology-neutral, and cross-domain representation of DIN 69901-2 using artificial intelligence and knowledge management methods. In addition, variation points are added to this architecture, ensuring a smooth extension of the architecture. Stakeholders of the reference architecture are all persons involved in its development and use. Stakeholders who are only interested in it are excluded in the context of this

dissertation since they cannot contribute to the creation of the reference architecture.

Determination of information sources

The necessary knowledge sources and basic definitions of artifacts that create a reference architecture have already been explained in detail in the previous chapters. The structure of this knowledge base reflects state art in science, which is relevant to architecture. Further research into related reference architectures has also been carried out as part of this process.

Determination of the requirements

The most important information must be collected, and generalizable requirements created to ensure the practical relevance of a reference architecture. The requirements for the systems, which form the basis of the reference architecture, must come from the relevant subprocesses from practice. This approach is similar to step 3 of Galster and Avgeriou (2011) and the approach of Elisa Yumi Nakagawa et al. (2017), although these approaches are minimal. The domain knowledge is derived from the processes and process subgroups of DIN 69901-2.

Extraction of generic and specific requirements for a reference architecture

The requirements analysis results in the previous steps are divided into generic and optional requirements. Generic requirements are regarded as generally valid and can be generalized within the framework of a process or subprocess and applied to a large number of tasks. Optional requirements, on the other hand, are to be implemented specifically for a use case and are limited by their uniqueness in the overall DIN 69901-2 process.

Conversion of the generic requirements into an n:1 relationship

The generic and optional requirements are categorized into functional modules in this step. Each requirement should be able to be assigned to a module. Suppose a requirement cannot be supported using artificial intelligence and cannot be assigned to any knowledge management approach. In that case, this requirement is also assigned to such a module so that the completeness of the overall DIN 69901-2 process is maintained. The division is carried out according to encapsulation and separation of concerns, according to Laplante (2007). The same division of modules is described in the following chapters.

Creation of reference processes

In this step, the functional view of the reference architecture is created from the created modules. This is done by assigning the modules to particular artificial intelligence methods and knowledge management. The categorizations have already been shown in chapters 2 and 4. Accordingly, each module with its respective processes and process subgroups receives one or more assignments.

Evaluation of the reference architecture

In the context of the evaluation of the reference architecture, a focus group discussion is conducted. In this round, the reference architecture with the corresponding views will be discussed with various experts to highlight the practical benefits, strengths, and weaknesses.

This approach ensures that the reference architecture developed has a high level of practical relevance. On the one hand, DIN 69901-2, which is frequently used in practice as a project management process model, and on the other hand, the systematic categorizations of the methods of artificial intelligence and knowledge management serve as the knowledge base. The empirical basis Galster and Avgeriou (2011) required is thus fulfilled.

6.3 Representation model of the NICEL

6.3.1 Introduction

According to Reidt (2019), the representation of a reference architecture is crucial for its acceptance and strongly influences the way it is worked with. Therefore, the goal of a reference architecture strongly influences the choice of representation. According to Guessi et al., a suitable representation is essential for the success of a reference architecture.

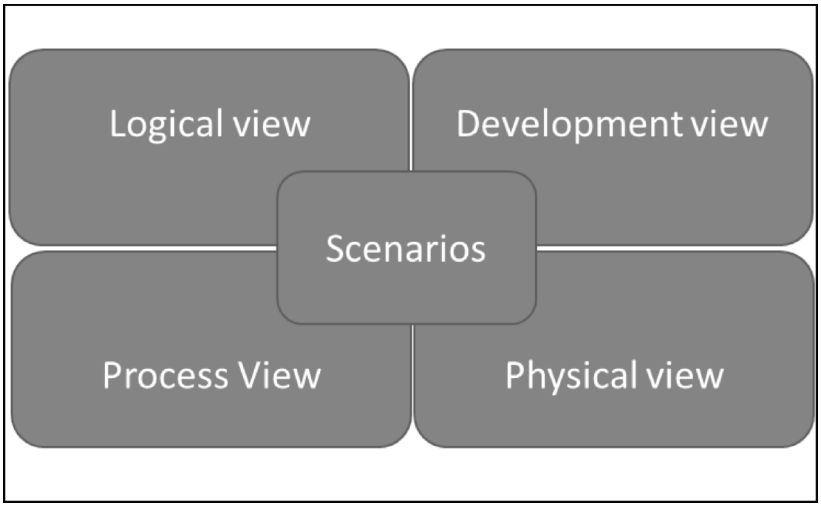
The representation must be understandable for a wide range of stakeholders (Guessi, Oquendo, & Nakagawa, 2014, p. 2). The NICEL selected representation is presented in this chapter. First, however, the forms of representation of reference models are discussed in general to provide the basics for understanding reference models.

6.3.2 Presentation of reference architectures

As Reidt shows, no standardization for the representation of reference architectures is recognizable in the literature (Reidt, 2019, p. 115). Similarly, Nakagawa points out that simple modes of representation exist that do not follow fixed concepts (Elisa Yumi Nakagawa et al., 2017, p. 144). Most reference models are based in their creation on the 4+1 view model for software architecture by Kruchten (1995).

The presentation in a total of 5 layers has the advantage that specific criteria and viewpoints can be highlighted in a target group-specific manner. A stakeholder-centered representation is thus possible; however, all have a common core. Since Kruchten (1995) does not specify the type of notation within the personal views, this aspect provides an optimal basis for representing reference architectures since all stakeholders can understand them without special knowledge of syntax or formal semantics. Figure 6-2 represents the schematic structure of the 4+1 view model for software architectures.

Figure 6-2: Schematic structure of 4+1 view model



Note: Adapted from Kruchten (1995)

As mentioned previously, it is essential to successfully use a reference architecture so all stakeholders can understand its structure and use. Kruchten's 4+1 model uniquely meets this requirement. The logical view, the development view, the process view, and the physical view are assigned to four different stakeholders, in which the individual requirements and necessities are considered. Each stakeholder has a specific perspective on the system to be developed.

The fifth view Scenarios represent the most critical use cases of the architecture, whereby these can be partly redundant with the other views. If required, additional views can be added for further stakeholders. This makes the 4+1 model correspondingly flexible in handling and is not limited to a certain number of views and stakeholders.

6.3.3 Logical view

The logical view describes the functionality that is available to the end user. The system is analyzed and decomposed into a set of fundamental abstractions in creating this view. Then, commonalities and design elements between them are worked out (Kruchten, 1995, p. 44). UML class diagrams, activity diagrams, or sequence diagrams can represent objects or classes. The logical view serves as the basis for the following views.

6.3.4 Development view

The view which is interesting for developers is the development view. This concerns software management, whereby appropriate software components are produced from individual objects and classes.

A division into components and hierarchies, separated over interfaces of each other, supports the development by the possibility of these individual persons or teams to assign.

6.3.5 Process view

The process view illustrates the dynamic aspects of the architecture. The relationships between control flows, communication paths, and the necessary synchronization are shown in detail. Additional non-functional requirements are also illustrated.

6.3.6 Physical view

The physical view deals with the system topology. The distribution of the communication of the different components and the system architecture view is represented in this view.

6.3.7 Scenarios

The fifth view is the scenarios, representing the architecture's most critical use cases. The scenarios can be described graphically or textually as use cases and serve as the basis for creating the application. In part, there may be redundant overlaps with previously described views, but this help to identify and illustrate the processes.

6.4 Adapted view model of NICEL

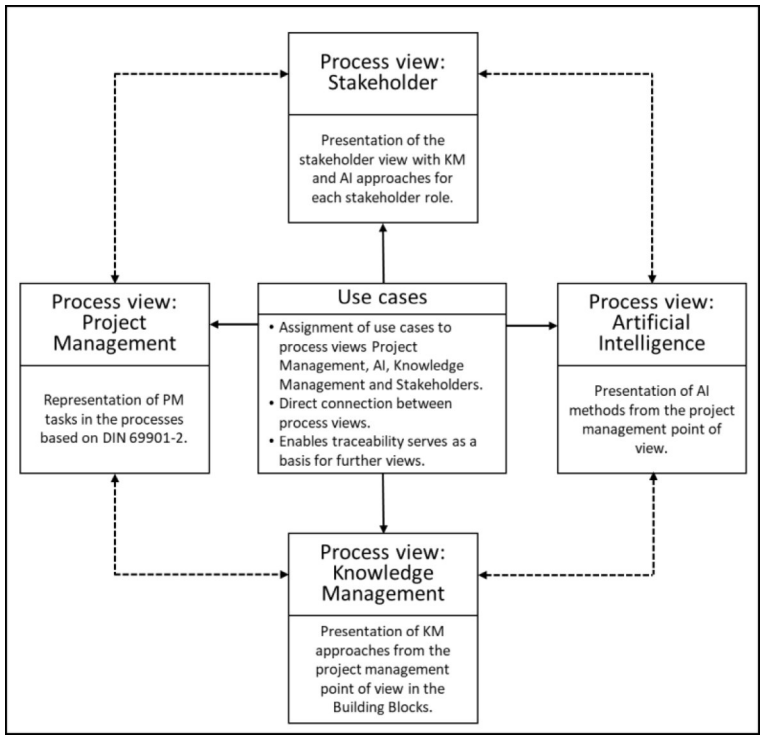
The views presented in the previous chapter cannot be used entirely to create an abstract and technology-neutral reference architecture. This is due to their

purpose of creating a specific reference architecture. Since this is not the goal of this research, the views presented in advance can only serve as a basis.

The requirements for an abstract and technology-neutral reference architecture require a template, which is, however, flexible for individual adaptations. Therefore, the views are adapted to this end. Figure 6-3 represents the views and the connections between them and shows the Use Cases at the center of the various user perspectives on the reference architecture NICEL.

These have a direct influence on the other views, which is represented by the corresponding arrows. However, the different views also influence each other. This is indicated by the dashed arrows.

Figure 6-3: User perspectives views of NICEL



Note: own figure

In this chapter, the various activities of the individual project management phases are examined to determine whether knowledge management components are used.

At the same time, an assignment is made for each activity as to which AI element could be helpful in the implementation. The German industry standard DIN 69901-2 serves as a basis. The assignments of AI methods, the building blocks of knowledge management and the assignment of stakeholders in the following views, have also been evaluated with appropriate experts.

6.4.1 Use case overview

The individual use cases are explained below from a project management perspective. The use cases build on each other and primarily run sequentially. The process subgroups are shown in the first column. The project management phases are listed in the following columns.

The affected processes for each project management phase and process subgroup can be found in the intersections. The individual use cases are described below in

Table 6-1: Use case overview

	Initialization	**Definition**	**Planning**	**Control**	**Closure**
1. Procedure and dates		D.1.1 Milestones Define milestones	P.1.1 Processes plan P.1.2 Schedule create P.1.3 Project plan create	S.1.1 Initiate activities initiate S.1.2 Control deadlines	
2. Changes			P.2.1 Planning handling changes	P.2.1 Managing changes	
3. Information/ Communication/ Documentation	I.3.1 Granting approval	D.3.1 Defining information, commuication and reporting	P.3.1 Plan information, commuication, reporting	S.3.1 Control information, communicatio n, reporting	A.3.1 Create final project report

		D.3.2 Define project marketing D.3.3 Issue approval	and documetation P.3.2 Issue approval	and documetation S.3.2 Issue acceptance	A.3.2 Archive project documentation
4. Costs and finances		D.4.1 Rough estimate of expenses	P.4.1 Draw up a cost and finance plan	S.4.1 Controlling costs and financial resources	A.4.1 post-calculation
5. Organization	I.5.1 Clarify responsibility I.5.2 Select PM processes	D.5.1 Form core project team	P.5.1 Plan project organization	S.5.1 Conduct kick-off S.5.2 Form project team S.5.3 Developing the project team	A.5.1 Conduct final meeting A.5.2 Recognizing achievements A.5.3 Project organization
6 Quality		D.6.1 Define success criteria	P.6.1 Plan quality assurance	S.6.1 Ensure quality	A.6.1 Secure project experience
7 Resources			P.7.1 Creating a resource plan	S.7.1 Controlling resources	A.7.1 Return resources
8. Risk		D.8.1 Determine how to deal with risks D.8.2 Analyze project environment/ stakeholders	P.8.1 Analyze risks P.8.2 Plan countermeasures to risks	S.8.1 Managing risks	

		D.8.3 Assess feasibility			
9 Project structure		D.9.1 Creating a rough structure	P.9.1 Create work breakdown structure P.9.2 Describe work packages P.9.3 Describe activities		
10 Contracts and subsequent claims		D.10.1 Defining the handling of contracts D.10.2 Defining the content of contracts with customers	P.10.1 Defining the content of contracts with suppliers	S.10.1 Processing contracts with customers and suppliers S.10.2 Managing subsequent claims	A.10.1 Terminating contracts
11. Goals	I.11.1 Outline objectives	D.11.1 Define objectives D.11.2 Delineate project content		S.11.1 Achieving objectives	

In the following sub chapters will each use case explained in detail.

6.4.2 Use case: Initialization

Process:	**Grant approval**	**I.3.1**
Process Group:	Information / Communication / Documentation	
Description:	The approval by the client (internal or external) forms the transition from one project management phase to the next. The purpose of the release is to achieve a complete conclusion of the preceding phase so that no open points are carried over into the subsequent phase. This decoupling of the phases increases planning security and, as the project grows in size, is an essential prerequisite for handling the project.	
Predecessor processes:	I.5.2 Select PM processes	
Succession processes:	D.5.1 Form project core team	
Input	Decision template	
Output	• release protocol with list open points • Project order for the • coming phase	
Knowledge Management	-	
AI Method:	• Data Analytics • Text Extraction • Decision Making • Synthetic Reasoning • Knowledge Refinement • Knowledge storage and distribution	
AI Application description	Extracting relevant prerequisites for the project progress and the data analysis for their completeness from a multitude of documents is the first step to creating an AI-supported decision template in this process. Based on the AI methods of Decision Making, Synthetic Reasoning, possible decisions for	

	action can subsequently be suggested by the AI. Likewise, the examination of individual results, which are the result of work packages within the project, can be checked for completeness. On the one hand, a knowledge database can serve as a basis for the preceding AI methods and on the other hand, it can store the results from current projects. Subsequently, this knowledge is available again as a basis for subsequent, similar projects. This circumstance is described with the AI method Knowledge Refinement.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Clarify responsibility**	**I.5.1**
Process Group:	Organization	
Description:	Only an initial idea or a customer inquiry exists in this phase of the project, which must be processed or further elaborated in the following steps. Therefore, the process aims to clarify who is responsible for the first steps in the project and how the project is organized.	
Predecessor processes:	-	
Succession processes:	I.11.1 Outline goals	
Input	• Project idea • Experiences from past projects	
Output	• Designation of the responsible person	

	(Project manager) and if necessary further team members	
Knowledge Management	• Knowledge objectives • Knowledge identification • Knowledge acquisition • Knowledge development • Knowledge distribution • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Decision Making	
AI Application description	The goal of this process is to designate responsibilities. This raises the question of who will take over the project management and which people will be involved in the project. An AI-based approach is to select similar projects from a project or knowledge database with the help of data analytics and text extraction and, with the help of decision making, to select the people best suited for the respective project roles with their skills and abilities.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Select PM processes**	**I.5.2**
Process Group:	Organization	

Description:	Depending on the dimension of the project, it is decided at this point whether only the minimum processes or, in addition, which processes are to be taken into account in the project management of the specific project.
Predecessor processes:	I.11.1 Outline goals
Succession processes:	I.3.1 Issue release
Input	• DIN 69901 • Project goals
Output	• List of processes to be considered • Processes
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Data Analytics • Text Extraction • Decision Making • Knowledge Refinement
AI Application description	In selecting the most suitable project management approach, the project goals, the corresponding tools, or the clarity about how the project goals are achieved can facilitate or determine the selection. For this purpose, various data can be analyzed with the help of data analytics and text extraction of the previously mentioned parameters. These can be compared with a project and knowledge database

	according to comparable completed projects. The decision template, which is the most suitable approach, can be made with the help of Decision Making.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Outline objectives**	**I.11.1**
Process Group:	Objectives	
Description:	In this process, an initial idea is derived from the project idea as to which goals are to be pursued with the project and which prerequisites or boundary conditions apply. Here, the client and the project team must reach an equal understanding of the goals and boundary conditions. Finally, all documents necessary for the release of the project are prepared.	
Predecessor processes:	I.5.1 Clarify responsibility	
Succession processes:	I.5.2 Select PM processes	
Input	• Project idea • Experiences from past • projects	
Output	• Outline of the project goals • Decision template	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development	

	• Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Knowledge Refinement	
AI Application description	From a previously written project idea and past project experiences, framework conditions and prerequisites can be identified with the help of data analytics and text extractions, which are developed and demonstrated via the AI methodology Knowledge Refinement. This is necessary so that the project sponsor and the project team have a common understanding of the goals and constraints. The outcome from the presented AI methods can be the basis for a decision template for the further course of the project management process.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

6.4.3 Use case: Definition

Process:	**Define milestones**	**D.1.1**
Process Group:	Procedure and dates	
Description:	After the project, content has been defined, and the rough structure has been created, this process puts the intermediate events/results in chronological order. This is, among other things, a prerequisite for the estimation of the expenditure and the evaluation	

	of the feasibility and the basis for the production of a schedule.
Predecessor processes:	D.9.1 Create rough structure
Succession processes:	D.4.1 Rough estimate of effort
Input	• Project goals • Project contents • Rough structure
Output	• Description of milestones • Milestone plan
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Data Analytics • Planning • Decision Making • Relationship Learning • Knowledge Refinement
AI Application description	The goal of this process is the description of milestones as well as milestone planning. Written project goals, project contents, or a rough structure can serve as input. From these documents, the first draft of a milestone plan can be designed using data analytics in combination with the AI method Planning. In combination with Decision Making, Relationship Learning can identify relationships between milestones and suggest arrangements or solutions based on available facts. A project and knowledge database can also serve as a basis here.

Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Determine information, communication, and reporting**	**D.3.1**
Process Group:	Information / Communication / Documentation	
Description:	The information, communication and reporting system is the basis for successful project management. To avoid frictional losses, therefore, the basic should be made at an early stage to avoid frictional losses. As the the size of the project, the importance of information, communication and reporting increases.	
Predecessor processes:	D.5.1 Form project core team	
Succession processes:	D.3.2 Define project marketing	
Input	• Project organization • Organization-specific and other requirements regarding documentation	
Output	• Procedures for handling information (e.g. documentation, archiving) • Communication procedures (e.g. communication matrix, regular deadlines, etc.) • Reporting channels and means, and decision-making and escalation paths	

<table>
<tr><td>Knowledge Management</td><td colspan="2">Knowledge objectives
Knowledge acquisition
Knowledge development
Knowledge distribution
Knowledge utilization
Knowledge retention
Knowledge assessment</td></tr>
<tr><td>AI Method:</td><td colspan="2">Speech recognition
Decision Making
Knowledge Refinement
Communication
Control</td></tr>
<tr><td>AI Application description</td><td colspan="2">The introduction of chatbots as an input and output medium for information should be considered to enable the most significant possible support for AI in project communication. The recognition of spoken language, which can also initiate further actions depending on the content, is realized with the AI methods of speech recognition, and understanding as well as AI method control. The AI method Knowledge Refinement, which provides a project and knowledge database, and the AI method Decision Making, can provide support to propose a communication matrix and rule dates or simplify the general handling of documents.</td></tr>
<tr><td rowspan="5">Stakeholder</td><td>Sponsor</td><td>-</td></tr>
<tr><td>Steering Committee</td><td>-</td></tr>
<tr><td>Project Manager</td><td>Accountable / Responsible</td></tr>
<tr><td>Int. Project Team</td><td>-</td></tr>
<tr><td>Ext. Service Supplier</td><td>-</td></tr>
<tr><td>Process:</td><td>Define project marketing</td><td>D.3.2</td></tr>
</table>

Process Group:	Information / Communication / Documentation
Description:	Project marketing aims to provide the relevant stakeholders with information about the project and the intended goals to positively support the project goals. With this process, the goals, contents, means, and ways of project marketing must be defined.
Predecessor processes:	D.3.1 Information, communication, and reporting specify D.8.2 Project environment/stakeholders analyze
Succession processes:	D.3.3 Grant approval
Input	• Project goals • Project environment and stakeholders • Information and communication channels
Output	• Goals and target groups of Project marketing • Means and ways of project marketing (e.g. portal, • articles, newsletters on the project)
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Data Analytics • Planning • Decision Making • Knowledge Refinement • Communication
AI Application description	Informing the relevant stakeholders of the project is the main purpose of this process. On the one hand, data analytics can be used to find out which

	stakeholders are relevant for the project and on the other hand, the AI method Planning can ensure the supply of information to the stakeholders via reporting and information planning. This plan can be supported by the AI method Decision Making in order to define which stakeholders or stakeholder groups are to be informed with which medium and in which detail. The results can then be stored in a project and knowledge database using the AI method Knowledge Refinement and used for later projects.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Grant release**	**D.3.3**
Process Group:	Information / Communication / Documentation	
Description:	The release by the client (internal or external) forms the transition from one project management phase to the next. The purpose of the release is to achieve a complete conclusion of the preceding phase so that no open points are carried over into the subsequent phase. This decoupling of the phases increases planning security and, as the project grows in size, is an essential prerequisite for being able to handle the project over the course of the project.	
Predecessor processes:	D.3.2 Define project marketing D.6.1 Define success criteria	
Succession processes:	P.2.1 Dealing with changes plan	

	P.9.1 Create work breakdown structure	
Input	• Decision template	
Output	• Release protocol with list open points • Project order for the coming phase	
Knowledge Management	• Knowledge utilization	
AI Method:	• Data Analytics • Text Extraction • Decision Making • Synthetic Reasoning • Knowledge Refinement	
AI Application description	Knowledge Refinement in the form of a project and knowledge database can contribute historically comparable projects to the current situation. With the help of data analytics, it is possible to check whether all the criteria for a release have been met. Text Extraction can also support the creation of a release protocol from the existing documents with the closed and open points. This forms the project order for future project phases. Decision Making can also be used to prepare decision templates, whether the next project phase can start or not. Based on this, Synthetic Reasoning can analyze individual results, generating different decision templates.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Roughly estimate effort**	**D.4.1**
Process Group:	Costs and finances	
Description:	The aim is to make an initial statement about the costs for an assumed duration of the project. The rough structure and milestone plan serve as the basis for this estimate. The result of the estimate is incorporated into the feasibility analysis and subsequently facilitates decision-making.	
Predecessor processes:	D.1.1 Define milestones	
Succession processes:	D.10.2 Contract contents with customers	
Input	• Project goals • Rough structure • Milestone plan • Project environment and stakeholders • Experience from past • projects	
Output	• Rough expense estimate	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Relationship Learning	
AI Application description	The AI method of Data Analytics can calculate efforts based on estimated values. The values can come from relationships between project tasks detected with the AI method Relationship Learning. Furthermore, this method can also predict hidden features and derive correlations. The information	

	can be visualized to make it easier for users to understand. From the presentation of complex 3-dimensional models to vision boards in the field of futurology.	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	Informed

Process:	**Form project core team**	**D.5.1**
Process Group:	Organization	
Description:	After approval for the definition phase, the project core team is defined and organized accordingly to achieve the best possible collaboration in this early phase.	
Predecessor processes:	• I.3.1 Issue release	
Succession processes:	• D.3.1 Information, communication, and reporting • specify • D.8.1 Determine how to deal with risks • D.10.1 Dealing with contracts define • D.11.1 Define goals	
Input	• Project idea, goals • Releases	
Output	• (Preliminary) organization chart	
Knowledge Management	• Knowledge identification • Knowledge acquisition	

	• Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Speech recognition • Face Recognition • Text Extraction • Decision Making • Knowledge Refinement	
AI Application description	This process aims to form the project core team and conduct a project start-up workshop. To select the most suitable project staff, AI methods can support Text Extraction and Decision Making to perform the matching between the staff requirements and the available staff. Knowledge Refinement in the form of project and knowledge databases complete this process. In addition, when conducting project start-up workshops, the AI methods Speech recognition can recognize the emotional states of the participants from the spoken language, and with the AI method Face recognition can recognize and evaluate the emotional states of the faces. This can serve as an aid in determining the prevailing mood of the participants so that they can be better addressed during the course of the project.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Informed

Process:	**Define success criteria**	**D.6.1**

Process Group:	Quality
Description:	The success of projects often depends on a few (critical) factors. These should be identified as early as possible and coordinated between all those involved. This focus (on a few success criteria) can improve the efficiency and effectiveness of project management.
Predecessor processes:	D.8.3 Evaluate feasibility
Succession processes:	D.3.3 Grant approval
Input	• Project goals • Project environment and stakeholders • Feasibility analysis • Milestone plan • (Rough) effort estimation
Output	• Presentation of success criteria and their measurands • Decision template for Release
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Text Extraction • Knowledge Refinement
AI Application description	In order to be able to define the success criteria in the project, the documents of the project goals, the project environment and stakeholders, the feasibility analysis, and the milestone planning serve as a basis. The AI method Text Extraction can be used from these documents to suggest which project goals

	make sense. Knowledge Refinement can also provide a project and knowledge database to generate suggestions from historical projects.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	-

Process:	**Determine how to deal with risks**	**D.8.1**
Process Group:	Risk	
Description:	Derived from a company's risk policy, this involves clarifying the key aspects of dealing with risks in the project and defining an appropriate procedure.	
Predecessor processes:	D.5.1 Form project core team	
Succession processes:	D.8.2 Project environment/stakeholders analyze D.11.2 Delimit project contents	
Input	• Project goals • Project organization • Experience from past projects • risk policy	
Output	• Procedure for dealing with Risks • Reporting channels and tools	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization	

	• Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Decision Making	
AI Application description	The handling of project risks is derived from the company's risk policy. In addition, appropriate information should be derived from historical data with comparable projects. Data analytics and text extraction can help obtain the desired information from documents such as project goals, project organization, and a project and knowledge database.	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	Informed

Process:	**Analyze project environment/stakeholders**	**D.8.2**
Process Group:	Risk	
Description:	The aim of the project environment/stakeholder analysis is to identify all possible influences on the project and to analyze their impact on the achievement of objectives. Experience shows that the stakeholders play a prominent role in this process. This information later serves as the basis for the feasibility analysis, further planning and project control.	
Predecessor processes:	D.8.1 Determine how to deal with risks	

Succession processes:	D.3.2 Project marketing define D.9.1 Create rough structure
Input	• Project goals • Project organization • Experience from past projects
Output	• Presentation of the relevant environmental factors and stakeholders including an evaluation of the respective influences and suitable measures
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge distribution • Knowledge utilization • Knowledge assessment
AI Method:	• Data Analytics • Text Extraction • Relationship Learning • Knowledge Refinement
AI Application description	To identify the influences on a project, project environment analyses as well as stakeholder analyses can be applied. To better assess the project environment, data analytics supported by text extraction is able to perform and prioritize appropriate risk assessments. Relationship learning can also help to identify relationships between stakeholders and stakeholder groups and to identify parallel and conflicting expectations for the project. A project and knowledge database can also provide important insights in this regard. These do not have to

	be two separate databases. However, a database that is only logically separated between projects and the associated knowledge can deliver faster results. Two physically separate databases with interfaces also harbor the risk of data inconsistencies.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	-

Process:	**Evaluate feasibility**	**D.8.3**
Process Group:	Risk	
Description:	The evaluation of the project's feasibility prepares a decision on how to proceed. The evaluation is carried out based on the company's strengths and weaknesses and by weighing up the opportunities and risks.	
Predecessor processes:	D.10.2 Contract contents with customers	
Succession processes:	D.6.1 Define success criteria	
Input	• Project goals • Project environment/stakeholders • Rough structure • Milestone plan • Effort estimation • Experience from past projects	
Output	• Evaluation about the • Feasibility	

Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Decision Making • Relationship Learning • Knowledge Refinement	
AI Application description	The strengths and weaknesses, as well as the opportunities and threats, form the basis for evaluating whether the project can be carried out. The AI methods Data Analytics and Text Extraction are suitable for a SWOT analysis since they can extract and weight the parameters from the project goals, the previously performed project environment and stakeholder analysis, the milestone planning, and with the help of a project and knowledge database. Relationship Learning can also identify relationships in the documents and use Decision Making to form decision templates based on them.	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	Informed

Process:	**Create rough structure**	**D.9.1**

Process Group:	Project structure
Description:	The rough structure shows the entire scope as well as the essential components of the project in a clear form and can be further detailed as required. It serves as a better orientation for all parties involved.
Predecessor processes:	D.8.2 Project environment/stakeholders analyze D.11.2 Delimit project contents
Succession processes:	D.1.1 Define milestones
Input	• Project goals • Project content • Project environment/stakeholders • Experience from past • projects
Output	• Rough structure
Knowledge Management	• Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Text Extraction • Planning • Decision Making • Knowledge Refinement
AI Application description	The overall scope as well as the essential components of the project can be obtained from the Project goals documents, the Project content, the Project environment, and stakeholders, as well as from the Experience from past Projects. Text Extraction can extract the necessary information from the documents, and the AI Planning method

	creates a proposal for the rough structure on this basis. When making decisions, the AI method Decision Making can also make suggestions based on the extracted facts. The knowledge from completed projects can also influence here via a project and knowledge database. The visualization of correlations or anomalies can also play an important role in the user's ability to interpret the data.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	-

Process:	**Define handling of contracts**	**D.10.1**
Process Group:	Contracts and claims	
Description:	Ensure systematic handling of all contracts that need to be concluded and handled in the context and processed in the context of the project in order to avoid unnecessary costs and liability cases based on a lack of knowledge of the existing contracts.	
Predecessor processes:	D.5.1 Form project core team	
Succession processes:	D.10.2 Contract contents with customers	
Input	• Project goals • Project contents • Project organization • Organization-specific regulations • on contracts	

<table>
<tr><td>Output</td><td colspan="2">• Procedure for dealing with
• Contracts
• Tasks, competencies and
• Responsibilities (AKV) in the
• handling of contracts</td></tr>
<tr><td>Knowledge Management</td><td colspan="2">• Knowledge objectives
• Knowledge acquisition
• Knowledge development
• Knowledge utilization
• Knowledge assessment</td></tr>
<tr><td>AI Method:</td><td colspan="2">• Text Extraction
• Language Understanding
• Knowledge Refinement
• Communication</td></tr>
<tr><td>AI Application description</td><td colspan="2">The AI method, Text Extraction, can extract critical information from the contracts to be concluded, which should be specifically rechecked to avoid possible liability claims or other risks. Likewise, ambiguous formulations can be searched for to achieve a higher degree of legal certainty. In finding the semantic basis, the AI method Language Understanding can support, in combination with Knowledge Refinement, can provide appropriate suggestions from the project and knowledge database.</td></tr>
<tr><td rowspan="5">Stakeholder</td><td>Sponsor</td><td>Accountable</td></tr>
<tr><td>Steering Committee</td><td>Consulted</td></tr>
<tr><td>Project Manager</td><td>Responsible</td></tr>
<tr><td>Int. Project Team</td><td>Informed</td></tr>
<tr><td>Ext. Service Supplier</td><td>Informed</td></tr>
</table>

Process:	**Determine contract content with customers**	**D.10.2**
Process Group:	Contracts and claims	
Description:	The aim here is to develop a first draft for the contract with the client or customer, which serves as a basis for a decision on the further procedure and, if necessary, further negotiations with the client or customer.	
Predecessor processes:	D.4.1 Rough estimate of effort D.10.1 Dealing with contracts define	
Succession processes:	D.8.3 Evaluate feasibility	
Input	• Project goals • Rough structure • milestone plan • rough effort estimation • Procedure for dealing with • contracts • Tasks, competencies and • responsibilities (AKV) in • handling of contracts • Organization-specific regulations • on contracts	
Output	• Draft contract	
Knowledge Management	• Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction • Language Understanding • Knowledge Refinement	

AI Application description	This process aims to arrive at a formulation of the contract contents that are ready for decision. Implementing the contract contents, e.g., in the form of a specification, also comprises this process. The project goals, the rough structure as well as general handling of procedures with contracts can serve as a basis. The AI method, Text Extraction, can extract critical or ambiguous statements from this. Further processed with Language Understanding, the semantic meaning can be recognized and analyzed. In addition to the visualization of results, it can also be used to generate ontologies. Comparing a project and knowledge database with the AI method of Knowledge Refinement can also support the process.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Define goals**	**D.11.1**
Process Group:	Target	
Description:	Right at the beginning of a project, it is essential to develop a clear understanding of what should be achieved by the project. The project manager initiates this process and involves the client as closely as possible. In this way, misunderstandings and additional expenses can be prevented early.	
Predecessor processes:	D.5.1 Form project core team	
Succession processes:	D.11.2 Delimit project contents	
Input	• Project idea	

	• Outline of the project goals • Experiences from past • projects	
Output	• Description of the project goals	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction • Decision Making • Knowledge Refinement	
AI Application description	The basis for defining goals can be the extraction from the project idea, the project outline, or the experiences from old projects. Since the goals should be formulated as specific and measurable as possible, a sequence and a check for mutually exclusive goals can be realized well. The SMART criteria by Drucker (1978) could be used as a possible criteria system for this measurement. Accordingly, the AI method Text Extraction can extract relevant goals from the documents and provide a suggestion about prioritization with the AI method Decision Making. Knowledge Refinement can provide further insights in the form of a project and knowledge database.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted

	Ext. Service Supplier	-

Process:	**Delimit project content**	**D.11.2**
Process Group:	Target	
Description:	After defining the project goals, it is now necessary to delimit the project contents between the project manager and his client, i.e. to clarify the question of what is and what is not the content of the project. This delimitation increases the decision-making security for all participants and avoids unnecessary conflicts due to unspoken expectations.	
Predecessor processes:	D.8.1 Dealing with risks define D.11.1 Define goals	
Succession processes:	D.9.1 Create rough structure	
Input	• Project goals • Procedures for dealing with risks • Experiences from past • projects	
Output	• Project contents	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	Just as the project's goals must be defined, it should be determined which elements or requirements will not be implemented in the project. This necessitates an appropriate delineation. Extracting from text documents the goals compared to possible requirements can be the first indication of out-of-	

	scope. Likewise, the AI method Relationship Learning can identify relationships to artifacts in the system landscape related to the current project but not noted in the requirements specification. In this case, an agreement must be reached before the project begins. A project and knowledge database in the AI method Knowledge Refinement can also provide information from completed and comparable projects.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Responsible

6.4.4 Use case: Planning

Process:	**Planning operations**	**P.1.1**
Process Group:	Procedure and dates	
Description:	After the processes have been defined and described, they are now brought into a and the times required for each operation are estimated. for each operation are estimated. In this way, overall runtimes, buffer times and critical critical processes can be determined. This information is then incorporated into the schedule.	
Predecessor processes:	P.9.3 Describe processes	
Succession processes:	P.1.2 Create schedule	
Input	• Work breakdown structure • Work package descriptions • Activity descriptions	

Output	• Flowchart, e.g. network • Activity plan	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving • Decision Making • Predictive Inference • Relationship Learning • Knowledge Refinement	
AI Application description	The AI method of Planning can relate the processes to each other and link them logically to a plan. The AI methods Decision Making and Problem Solving can support making possible competing or mutually exclusive operations compatible with each other. Relationship Learning also recognizes relationships between one or more operations, which must either be executed in parallel or consider specific predecessor tasks or mandatory successor tasks. The AI method Predictive Inference can also make simulative predictions based on the project plan.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Create schedule**	**P.1.2**
Process Group:	Procedure and dates	
Description:	The process aims to schedule all project activities on the time axis and visualize them as clearly as possible for those involved. The schedule is a central instrument in project management. With its help, the actual processes, deviations, and changes can be identified and mapped later in the project execution. Deviations and changes can be identified and mapped.	
Predecessor processes:	P.1.1 Plan operations	
Succession processes:	P.6.1 Quality assurance planning P.7.1 Create resource plan	
Input	• Project goals • Milestone plan • Schedule	
Output	• Schedule	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Decision Making • Predictive Inference • Knowledge Refinement	

AI Application description	With the help of the AI method Text Extraction, the milestones can be extracted from the milestone planning. With the help of Data Analytics, the individual operations and tasks can be extrapolated and checked for logic. The Decision Making and Predictive Inference methods can also support the logic check and the chronological order of the individual processes and tasks to detect dependencies between tasks and decide in which order they should be processed. These results can then be combined into a holistic schedule using the AI Planning method.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	-

Process:	**Create project plan**	**P.1.3**
Process Group:	Procedure and dates	
Description:	In the project plan, all individual plans are brought together and checked for consistency. The project plan serves as a central control instrument for the project manager during the central control instrument.	
Predecessor processes:	P.8.2 Plan countermeasures to Plan risks	
Succession processes:	P.10.1 Contract contents with suppliers	
Input	• Project goals • Project structure plan • Time schedule • Resource plan	

	• Cost and budget plan	
Output	• Project plan	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving • Decision Making • Relationship Learning • Knowledge Refinement	
AI Application description	Based on the plans created so far, such as the work breakdown structure, schedule, resource plan, and financial plan, these plans can create a fully comprehensive project plan using the AI Planning method. The AI methods Problem Solving and Decision Making support decisions, and Relationship Learning checks and detects dependencies between the individual components of the project plan. The individual components can be extracted from the other plans using Text Extraction, calculated using Data Analytics, and checked for consistency. The AI method Knowledge Refinement in a project and knowledge database can also provide suggestions and hints from already completed projects.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed

	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Plan for dealing with changes**	**P.2.1**
Process Group:	Changes	
Description:	Despite careful planning, changes can occur especially in complex projects whether intended or unintended. Therefore, there must be reliability that each change (after appropriate examination, evaluation and decision) is implemented on the one hand and on the other hand all interactions in planning and project implementation are taken into account. An appropriate procedure is necessary for this.	
Predecessor processes:	D.3.3 Issue release	
Succession processes:	P.3.1 Information, communication, reporting and documentation	
Input	• Project goals • Project structure plan • Work package descriptions	
Output	• Procedure for dealing with changes (among other things reporting)	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction	

	• Planning • Problem Solving • Decision Making • Relationship Learning • Communication	
AI Application description	Text Extraction can later assist in analyzing the change in the current project. New planning is, therefore, necessary, which can impact every parameter in the project. Therefore, it is essential to identify possible problems in advance. AI methods Decision Making , Problem Solving and Data Analytics can suggest decisions at the point to rule out potential problems in advance. Relationship Learning can also reveal new relationships between operations to act on in advance. The AI planning method can propose a new project plan from the previously described methods. The AI method of Communication supports communication with the relevant stakeholders inside and outside the project.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Plan information, communication, reporting and documentation**	**P.3.1**
Process Group:	Information / Communication / Documentation	
Description:	Communication controls the flow of information within a project by specifying who is to be	

	informed, when, about what, and in what quality. This This includes specifications regarding documentation and reporting.
Predecessor processes:	P.2.1 Dealing with changes plan P.5.1 Plan project organization
Succession processes:	P.8.1 Analyze risks
Input	• Project goals • Project environment and stakeholders • Procedures for handling • Information • Communication procedures • Reporting channels and means
Output	• Plan about information, • communication and • reporting system
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge distribution • Knowledge utilization • Knowledge retention • Knowledge assessment
AI Method:	• Text Extraction • Planning • Decision Making • Relationship Learning • Knowledge Refinement
AI Application description	First, the relevant stakeholders and stakeholder groups must be identified when planning the reporting and information system. For this purpose, the AI method Text Extraction can help to identify them based on the stakeholder analysis. Finding

	dependencies between stakeholders and the degree and content of information can be done using the AI method Relationship Learning. The actual reporting planning can be done using the AI method Planning. A project and knowledge database can also suggest possible historical project reporting approaches.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Grant approval**	**P.3.2**
Process Group:	Information / Communication / Documentation	
Description:	The release by the client (internal or external) forms the transition from one project management phase to the next. The purpose of the release is to achieve a complete conclusion of the preceding phase so that no open points are carried over into the subsequent phase. This decoupling of the phases increases planning security and, as the project grows in size, is an essential prerequisite for controlling the project without conflict throughout the project.	
Predecessor processes:	P.10.1 Contract contents with suppliers	
Succession processes:	S.5.1 Conduct kick-off	
Input	• Decision template	
Output	• Release protocol with list open points • Project order for the coming phase	

Knowledge Management	-	
AI Method:	• Text Extraction • Decision Making • Knowledge Refinement	
AI Application description	Decision Making can suggest whether the prerequisites can be considered fulfilled or which prerequisites might still be missing. In order to check whether all prerequisites for the next project steps are fulfilled, the AI method Text Extraction can extract the success criteria from the project idea, the sketch, and other artifacts and show them. A project and knowledge database can also provide clues.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Informed

Process:	**Create cost and budget plan**	**P.4.1**
Process Group:	Costs and finances	
Description:	This planning process aims to secure the expected project return and the liquidity in the project. To this end, the costs incurred, and the financial resources required to cover the costs are determined based on the schedule and resource planning and mapped in a plan throughout the project. The business plan then calculates the extent to which the required return can be generated.	
Predecessor processes:	P.7.1 Create resource plan	

Succession processes:	P.8.1 Analyze risks	
Input	• Project goals • Project structure plan • time schedule • Quantity structure • Work package descriptions • Experience from past • projects	
Output	• Cost and financial plan • business plan	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Planning • Relationship Learning • Knowledge Refinement	
AI Application description	The AI method Data Analytics and Relationship Learning can analyze and evaluate the expected costs and efforts, the related project return, and its liquidity requirements. Dependencies between tasks and activities are considered as well as any risk premiums. The AI Planning method can determine the respective liquidity requirements in each project phase based on a quantity structure and the schedule. This results in a financial and liquidity plan. Knowledge Refinement can also suggest insights from past and comparable projects.	
Stakeholder	Sponsor	-

	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Informed

Process:	**Planning project organization**	**P.5.1**
Process Group:	Organization	
Description:	After resource planning has been completed, this process plans and describes the essential aspects of the project organization. This should clarify who has which role in the project and how tasks, competencies, and responsibilities are regulated. The latter is particularly important so that there are no unnecessary frictional losses during implementation.	
Predecessor processes:	P.7.1 Create resource plan	
Succession processes:	P.3.1 Information, communication, reporting and documentation	
Input	• Project goals • Resource plan • Organization-specific specifications • for personnel deployment	
Output	• Project organization chart • Function diagram • Function descriptions • (roles)	
Knowledge Management	• Knowledge objectives • Knowledge identification	

	• Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction • Planning • Knowledge Refinement	
AI Application description	Based on the resource plan, it must be clarified who will fill which role in the project. With the help of the AI methods Text Extraction and Planning, roles with the requirement profile of available employees can be found and suggested. A project and knowledge database can also be used to narrow the role descriptions and requirements better.	
Stakeholder	Sponsor	Consulted
	Steering Committee	Consulted
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Plan quality assurance**	**P.6.1**
Process Group:	Quality	
Description:	The essential procedures and instruments for ensuring quality in the project are planned here. Organization-specific requirements and standard regulations must be observed. In this way, it can be ensured during the realization of the project that the objectives are achieved and meet the client's requirements.	
Predecessor processes:	P.1.2 Create schedule	

	P.7.1 Create resource plan
Succession processes:	P.8.1 Analyze risks
Input	• Project goals • Time schedule • project structure plan • Work package descriptions • Standard specifications • Organization-specific specifications • for quality assurance
Output	• Quality assurance plan
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge retention • Knowledge assessment
AI Method:	• Text Extraction • Planning • Problem Solving • Decision Making • Relationship Learning • Knowledge Refinement
AI Application description	Based on standard specifications, work package descriptions, and work breakdown structures, Text Extraction can be used to extract the test scenarios that are crucial for quality assurance. Before the quality assurance measures are carried out, the handling of errors, their correction, and re-testing must be determined. Here, Problem Solving and Decision Making can support and define appropriate parameters. In addition, categorization of defect types can be defined since not every defect

	results in the same impairment. Relationship Learning can detect and analyze the relationships between the different test scopes. Here, the impact of defect detection on the following project tasks can be detected. The AI method Knowledge Refinement can support in the form of a project and knowledge base about similar quality assurance tasks that have already been completed. The AI method Planning can propose a quality assurance plan from the individual components of this process.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Informed

Process:	**Create resource plan**	**P.7.1**
Process Group:	Resources	
Description:	The resource plan provides an overview of all resources required in the project, when they are to be used and whether they are available internally or have to be procured externally. In addition to the schedule, the resource plan is also an important instrument for project control and is closely linked to supplier management.	
Predecessor processes:	P.1.2 Create schedule	
Succession processes:	P.4.1 Create cost and budget plan P.5.1 Plan project organization P.6.1 Plan quality assurance	
Input	• Project structure plan • Work package descriptions	

	• Experiences from previous • projects • Organization-specific specifications • for supplier management	
Output	• Resource plan (resource requirements/ deployment plan, if necessary also list of bottleneck resources) • Specifications for supplier management	
Knowledge Management	• Knowledge identification • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving • Decision Making • Knowledge Refinement	
AI Application description	The resource plan can be created holistically with the AI method Planning and supporting the project information and knowledge database. Using data analytics in conjunction with Text Extraction, information can be extracted from the work breakdown structure, work, activity descriptions, and schedule to determine the necessary resources. In addition, the effort and availabilities can be calculated. Overload and underload can also be detected and regulated using rule-based decisions and problem-solving.	
Stakeholder	Sponsor	-
	Steering Committee	-

	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Analyze risks**	**P.8.1**
Process Group:	Risk	
Description:	Only if it is known which risks can occur in a project can the project deal with the possible effects and prevent or mitigate the damage. This requires the identification and evaluation of potential risks. The broadest possible range of influencing factors must be taken into account. The assessment criteria are derived from an organization's risk policy.	
Predecessor processes:	P.3.1 Information, communication, reporting and documentation P.4.1 Cost and budget plan Create P.6.1 Plan quality assurance	
Succession processes:	P.8.2 Plan countermeasures to Plan risks	
Input	• project contents • Schedule • Information, communication, and Reporting • Resource plan • Cost and financial plan	

	• Business plan • Quality assurance plan • Environment/stakeholder analysis • Experience from previous projects • Procedures for dealing with risks	
Output	• Risk portfolio with the • respective probability of occurrence and the scope	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Decision Making • Relationship Learning • Knowledge Refinement	
AI Application description	The resource plan can be created holistically with the AI method Planning and supporting the project information and knowledge database. Using data analytics in conjunction with Text Extraction, information can be extracted from the work breakdown structure, work, activity descriptions, and schedule to determine the necessary resources. In addition, the effort and availabilities can be calculated. Overload and underload can also be detected and regulated using rule-based decisions and problem solving.	
Stakeholder	Sponsor	Consulted
	Steering Committee	Consulted

	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Plan countermeasures to risks**	**P.8.2**
Process Group:	Risk	
Description:	Even if not all eventualities can be foreseen in the course of the project, suitable measures can still be defined based on the risk analysis, which, on the one hand, reduce the probability of occurrence of the risk or, on the other hand, reduce the damage. However, it should be noted that countermeasures also incur costs, and therefore countermeasures should only be planned after a systematic weighing of costs and benefits.	
Predecessor processes:	P.8.1 Analyze risks	
Succession processes:	P.1.3 Create project plan	
Input	• Project goals • project contents • Schedule • Information, communication, and reporting • Resource plan • Cost and financial plan • Business plan • Quality assurance plan • Environment/stakeholder analysis • Experience from previous projects • Procedures for dealing with risks Risk portfolio with the respective	

Output	• Action plan (if applicable • emergency/crisis plan) • Standards-
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving • Decision Making • Predictive Inference • Relationship Learning • Knowledge Refinement
AI Application description	Proposals to generate suitable measures for risk minimization depend primarily on the analyzed risks in process P.8.1. On this basis, in interaction with the various plans, such as the schedule, resource plan, financial plan, and business plan, the AI methods Text Extraction can evaluate these and calculate a probability of occurrence with the help of data analytics based on defined parameters. The AI method Predictive Inference, which can generate prediction probabilities based on the states of the parameters, can also support this. The handling of the potential risks can then be determined in previously defined models with the help of decision-making and problem-solving. Since risk handling can be volatile, and handling it elsewhere in the project can result in new risks, using relationship learning is helpful since it analyzes the recognition of

	dependencies and relationships. Knowledge Refinement can achieve the support of the whole process through comparable historical projects.	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Consulted
	Int. Project Team	Informed
	Ext. Service Supplier	Informed

Process:	**Create work breakdown structure**	**P.9.1**
Process Group:	Project structure	
Description:	The work breakdown structure shows the components of a project and the relationships between these parts as clearly as possible. On the one hand, this makes it possible to check completeness; on the other hand, the work breakdown structure also serves as an orientation for those involved and helps to reduce the risk of subsequent expansion or modification.	
Predecessor processes:	D.3.3 Grant approval	
Succession processes:	P.9.2 Describe work packages	
Input	• Project goals • Project contents • Rough structure • Milestone plan	
Output	• Work Breakdown Structure (WBS)	
Knowledge Management	• Knowledge acquisition • Knowledge development	

	• Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Decision Making • Knowledge Refinement	
AI Application description	The project content, milestone planning and rough structure documents can be expanded with the help of data analytics and text extraction to such an extent that they can be put into a meaningful order using AI methods for decision-making and planning. With the help of knowledge refinement, historical information from comparable projects can also be taken into account. In ongoing projects, visualization methods can also be used for target/actual comparison in order to make the results more transparent to the user.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Describe work packages**	**P.9.2**
Process Group:	Project structure	
Description:	Work packages represent the smallest unit in the work breakdown structure but can, in turn, comprise several activities or operations. The work package description defines what must be completed, when, and with which resources. Each work package can	

	then later be delegated to one or more project team members.	
Predecessor processes:	P.9.1 Create work breakdown structure	
Succession processes:	P.9.3 Describe processes	
Input	• Project goals • Project contents • Project structure plan • Milestone plan	
Output	• Work package descriptions	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction • Decision Making • Knowledge Refinement	
AI Application description	This process aims to describe the work packages and assign them to the members of the project team. The AI method Text Extraction can suggest identical work packages with the description from the project and the knowledge database from previous projects. The AI method Decision Making can realize a matching with the available employees. Data analytics can also be useful for optimal planning under time constraints of resources.	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Consulted

	Int. Project Team	Informed
	Ext. Service Supplier	Informed

Process:	**Describe processes**	**P.9.3**
Process Group:	Project structure	
Description:	Similar to the work package descriptions, the individual operations can be described and assigned to employees. However, the subdivision can become very elaborate and thus increase the complexity in the planning and later in control, not insignificantly. The level of detail will depend on the scope of the project and the number of people involved.	
Predecessor processes:	P.9.2 Describe work packages	
Succession processes:	P.1.1 Plan operations	
Input	• Project goals • Project contents • Milestone plan • Project structure plan • Work package descriptions	
Output	• Operation description	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction • Decision Making • Knowledge Refinement	

AI Application description	Similar to the previous process, the goal is a description at the activity level. Project contents, milestone planning, and the work breakdown structure can serve as a basis for extracting descriptions. So can the use of Knowledge Refinement. The distribution of the tasks to the responsibilities and coordination with the dates and budgets are tasks for the AI decision-making method based on rules fixed in advance.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Determine contract content with suppliers**	**P.10.1**
Process Group:	Contracts and claims	
Description:	The aim here is to prepare an initial draft of the contract with the supplier, which will serve as the basis for a decision on how to proceed and, if necessary, for further negotiations with potential suppliers.	
Predecessor processes:	P.1.3 Create project plan	
Succession processes:	P.3.2 Grant approval	
Input	• Project goals • Project environment and stakeholders • Project plan • Procedures for dealing with Contracts • Tasks, competencies, and responsibilities (AKV) in	

	• handling of contracts • Organization-specific regulations on contracts	
Output	• Draft supplier contract with scope of supply and services and interface agreement • Rough scope of Procurement	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Text Extraction • Knowledge Refinement	
AI Application description	The goal of the process is a draft supplier contract with rights and obligations to be agreed upon, as well as the scope of the procurement. The AI method, Text Extraction, can extract essential building blocks from the analyses of the project environment and the stakeholders as well as from documents on the procedure for handling contracts and the organization-specific regulations. A project and knowledge base can also contain master suppliers with master agreements that can be used as suggestions in drafting.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

6.4.5 Use Case: Controlling

Process:	**Trigger processes**	**S.1.1**
Process Group:	Procedure and dates	
Description:	After the preparatory phases of initialization, definition, and planning have been carried out, the actual implementation begins with processing the individual activities to achieve the project goals. The persons responsible for each activity have been named and instructed. Furthermore, each exercise's content, quality specifications, and duration have been defined. Subsequently, the individual actions are triggered according to the project plan, and the work on these activities is to be authorized.	
Predecessor processes:	S.5.1 Conduct kick-off	
Succession processes:	S.1.2 Control dates	
Input	• Project plan • Process descriptions	
Output	• Start of operations • Order for the implementation of the individual operations	
Knowledge Management	-	
AI Method:	• Knowledge Refinement • Control	
AI Application description	The project tasks and task packages defined in advance are stored in the definition phase and the planning phase in the project and knowledge database as part of Knowledge Refinement's AI method. These can now be retrieved and	

	automatically started in interaction with the AI method.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Control dates**	**S.1.2**
Process Group:	Procedure and dates	
Description:	According to the project plan, each task has a start and end date, and often dependencies on other tasks, which in turn may also be related. Therefore, timely completion of individual tasks is very important to ensure the end date of the entire project.	
Predecessor processes:	S.1.1 Trigger operations	
Succession processes:	S.3.2 Issue acceptance	
Input	• Project plan	
Output	• Status on the deadline situation • Control measures, if necessary	
Knowledge Management	• Knowledge utilization	
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving	

	• Decision Making • Relationship Learning • Knowledge Refinement	
AI Application description	The monitoring of project tasks and task packages includes a deadline check and a data-based forecast of when these are considered critical and potentially represent a project risk. The AI methods of data analytics and text extraction are suitable for this. The AI method of relationship learning can identify and analyze the dependencies and effects of delays on other tasks. If a risk is identified, the project plans must be adjusted. The changes are automatically documented in the project and knowledge database. If data is missing, the knowledge acquisition method comes into play. This applies to the actual processing of data but also to the representation of this data. The AI methods of planning and decision-making can be used for this.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Control changes**	**S.2.1**
Process Group:	Changes	
Description:	If changes are requested by the client or are necessary as a reaction to deviations from the plan, it must be ensured before implementation that the effects of these changes are analyzed and evaluated, a clear decision is made on how to proceed, and consistent implementation is begun. All interactions in	

	planning and implementation must be taken into account.
Predecessor processes:	S.5.1 Conduct kick-off
Succession processes:	-
Input	• Project goals • Project environment and stakeholders • Contract contents • Project plan • Procedures for dealing with Changes • Reporting channels/means
Output	• Documentation of the Changes • Implementation of the changes (usually • usually also change of the project plan) • Documentation of claims
Knowledge Management	• Knowledge development • Knowledge utilization
AI Method:	• Data Analytics • Text Extraction • Planning • Decision Making • Relationship Learning • Knowledge Refinement • Manipulation
AI Application description	The project progress is continuously monitored. In case of changes that may be desired by the client or as consequences of deviations from the plan, the AI methods Data Analytics and Text Extractions can be used to support them. Dependencies on other entities in the project can be captured with Relationship Learning, which serves as a basis for replanning with the help of Planning and Decision Making. The AI

	method Manipulation can also assist in rearranging the project plan. The changes should then be stored in the project and knowledge database as a basis for further processing.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Control information, communication, reporting and documentation**	**S.3.1**
Process Group:	Information / Communication / Documentation	
Description:	Project success and progress depend mainly on functioning information, communication, and reporting system. Important decisions are regularly made based on the available information and reports and are influenced by their quality. For this reason, it is essential to regularly monitor whether the exchange of information and communication is functioning correctly. Corrective action should be taken in the event of deviations.	
Predecessor processes:	S.5.1Conduct kick-off	
Succession processes:	-	

Input	• Plan on information, communication and reporting	
Output	• Status report on the situation in the information, communication and reporting system, if necessary, control measures project documentation	
Knowledge Management	• Knowledge development • Knowledge distribution • Knowledge utilization • Knowledge retention • Knowledge assessment	
AI Method:	• Text Extraction • Problem Solving • Decision Making	
AI Application description	Creating status reports on project reputation and documentation can be done using Text Extraction and Decision Making AI methods. For this purpose, the essential information can be extracted from the regular reports of the project teams or subproject managers. The decision Making clarifies the question of relevance and suggests the information's distribution circle. Problem Solving can be used when new challenges arise that are not in the original plan for information and reporting. For this, the AI method can suggest corrective actions.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	-

	Ext. Service Supplier	-

Process:	**Grant acceptance**	**S.3.2**
Process Group:	Information / Communication / Documentation	
Description:	Like the releases before, the acceptance also creates a decoupling of two successive phases. Acceptance initiates the final phase in which the project is completed after the services have been rendered. Acceptance can take on special significance in certain constellations since it is the legally effective acceptance of the result of the overall project. It should therefore be carried out with appropriate intensity.	
Predecessor processes:	S.1.2 Control dates S.6.1 Assure quality S.10.2 Control subsequent claims S.11.1 Control target achievement	
Succession processes:	A.4.1 Create post calculation A.10.1 End contracts	
Input	• Project goals • Project plan • Decision template	
Output	• Acceptance protocol	
Knowledge Management	• Knowledge acquisition	
AI Method:	• Text Extraction • Decision Making • Knowledge Refinement	

AI Application description	Text Extraction can determine from the reporting whether all previously defined tasks have been fully completed. If this is not the case or only partially the case, Decision Making can suggest how to deal with this. For this purpose, the project and knowledge database can be accessed to obtain information from completed and comparable projects. A proposal for an acceptance protocol can be generated from this interaction of AI methods.	
Stakeholder	Sponsor	Informed
	Steering Committee	Accountable
	Project Manager	Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Informed

Process:	**Control costs and financial resources**	**S.4.1**
Process Group:	Costs and finances	
Description:	The success of a project depends on the systematic control of costs and financial resources. The costs incurred and the necessary financial resources must be kept within the planned framework, and, if necessary, control measures must be taken to meet the business plan's requirements.	
Predecessor processes:	S.5.1 Conduct kick-off	
Succession processes:	-	
Input	• Cost and financial plan • Business plan	
Output	• Status on costs and financial resources	

	• control measure, if applicable Project documentation	
Knowledge Management	• Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Problem Solving • Decision Making • Relationship Learning • Knowledge Refinement	
AI Application description	Project controlling can monitor, analyze, and extrapolate the corresponding KPI using AI methods Data Analytics. The data can be extracted from the corresponding documents using Text Extraction. Suppose previously defined thresholds are exceeded or are in danger of being exceeded in the future. In that case, the AI methods of Problem Solving can suggest appropriate alternatives in collaboration with Decision Making. Relationship Learning also considers the impact on related parameters. Knowledge Refinement stores the new knowledge and makes it available for subsequent projects.	
Stakeholder	Sponsor	-
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Carry out kick-off**	**S.5.1**
Process Group:	Organization	
Description:	Through the kick-off, all project participants should once again develop a shared understanding regarding the project, its goals, the project planning, and the tasks of each employee and make a clear commitment. Then the actual realization can begin.	
Predecessor processes:	P.3.2 Grant approval	
Succession processes:	S.1.1 Trigger operations S.2.1 Control changes S.3.1 Information, communication, reporting and Documentation S.4.1 Costs and financial resources control S.5.2 Form project team S.6.1 Assure quality S.7.1 Control resources S.8.1 Managing risks S.10.1 Contracting with customers and suppliers S.11.1 Manage target achievement	
Input	• Project goals • Project plan • Project organization chart • Release	
Output	• Understanding and commitment of all project participants regarding the project goals, the project plan and the Distribution of roles	

Knowledge Management	• Knowledge utilization including all aspects of the phase socialization of the SECI Model	
AI Method:	• Knowledge Refinement • Communication	
AI Application description	After approval has been granted, the kick-off can be carried out. Important information collected up to this point can be taken from the project and knowledge database and made available to the project team. The AI method can also be fed with chat-based questions and answers to provide relevant information to the project members and stakeholders at any time.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Form project team**	**S.5.2**
Process Group:	Organization	
Description:	The project team will have to work together, sometimes under considerable strain and pressure. Typically, the project team members do not know each other before the start of a project, so that collective success depends on whether it is possible to establish resilient relationships in the shortest possible time. This is the goal of this process.	
Predecessor processes:	S.5.1 Conduct kick-off	

Succession processes:	S.5.3 Develop project team
Input	• Project goals • Project plan • Project organization chart • Organization-specific specifications for personnel deployment
Output	• Clear distribution of roles with mutual commitment • Rules for the cooperation in the project team
Knowledge Management	• Knowledge identification • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment
AI Method:	• Speech recognition • Face Recognition • Text Extraction • Decision Making • Knowledge Refinement
AI Application description	Since the cooperation of the individual team members is a large part of the project's success, it is essential to form the individuals into a team. Speech and Face Recognition can analyze voices and faces in virtual project teams for emotional states, indicating mood. This can be picked up by the project team members and proceeded accordingly. The composition of teams can be supported by AI methods Text Extraction and Decision Making, as roles are filled based on skills, and these can be assigned to available team members in a decision

	and selection process. A database in the form of Knowledge Refinement can also support this.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Develop project team**	**S.5.3**
Process Group:	Organization	
Description:	After team building, the goal is to form a high-performing team within the shortest possible time concerned with completing its tasks and not with interpersonal problems. For this purpose, a team development process should be initiated and run through.	
Predecessor processes:	S.5.2 Form project team	
Succession processes:	-	
Input	• Project goals • project plan • Project organization chart • Organization specifications	
Output	• Clear distribution of roles with mutual commitment • Rules for the cooperation in the project team	
Knowledge Management	• Knowledge identification • Knowledge acquisition • Knowledge development • Knowledge utilization	

	• Knowledge assessment	
AI Method:	• Speech recognition • Face Recognition • Knowledge Refinement	
AI Application description	The goal of this process is to create rules for collaboration in projects. As in the previous process, Speech and Face Recognition can also support analyzing the mood based on speech and facial expressions. A project and knowledge database can also draw on proven rules for collaboration here and thus support the project.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable
	Int. Project Team	Responsible
	Ext. Service Supplier	Consulted

Process:	**Ensure quality**	**S.6.1**
Process Group:	Quality	
Description:	Without the consistent implementation of quality assurance, the quality of the project results cannot be ensured. This can result in considerable disadvantages for the project or the company (loss of orders, liability, claims for compensation due to work not being carried out professionally). With the help of this process, quality must be continuously monitored and compared with specifications so that appropriate measures can be taken immediately in the event of deviations.	
Predecessor processes:	S.5.1 Conduct kick-off	

Succession processes:	S.3.2 Issue acceptance	
Input	• Project goals • Project content • project plan	
Output	• If necessary, control measures • Status report on quality assurance	
Knowledge Management	• Knowledge acquisition • Knowledge development • Knowledge distribution • Knowledge utilization • Knowledge retention • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Problem Solving • Decision Making • Knowledge Refinement	
AI Application description	The quality assurance plan was created in the planning phase, and the quality parameters were defined. These KPIs can be extracted and calculated in the control phase using the AI methods Data Analytics and Text Extraction. Extrapolation and how to deal with emerging quality problems can be performed. For this purpose, the AI methods Problem Solving and Decision Making can suggest appropriate solutions. The results can be entered into the project and knowledge database for subsequent projects.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed

	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted
Process:	**Control resources**	**S.7.1**
Process Group:	Resource	
Description:	The consistent implementation of resource control is one of the essential success factors in project management especially in the case of scarce resources and complex supply relationships. This process must be used to ensure the best possible utilization of resources.	
Predecessor processes:	S.5.1 Conduct kick-off	
Succession processes:	-	
Input	• Project plan • Resource plan • Contracts with suppliers	
Output	• Status regarding • resources • Control measures, if necessary • Information for supplier/ • supply chain management	
Knowledge Management	• Knowledge identification • Knowledge acquisition • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving	

	• Decision Making • Predictive Inference • Relationship Learning • Knowledge Refinement	
AI Application description	The control of resources based on predefined parameters can be extracted from existing documents using Text Extraction and analyzed using Data Analytics. These can then be compared automatically with the planned values. In case of relevant deviations, which also consider dependencies on other entities with the help of Relationship Learning, possible countermeasures can be suggested with Problem Solving and Decision Making. These can then be used with AI Method Planning to adjust the corresponding project plans. Predictive Inference can then check whether the changes also lead to the desired result or whether contraindications are to be expected, from which new problems can arise.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Control risk**	**S.8.1**
Process Group:	Risk	
Description:	Monitoring and controlling the risk situation is necessary throughout the entire course of the project. This involves checking the extent to which new risks need to be taken into account for the project or whether the assessment of the risks in the planning	

	phase with their probability of occurrence and scope has changed. If the risk situation changes, the project team and the higher-level committee or the client must be informed accordingly, and suitable measures must be initiated.
Predecessor processes:	S.5.1 Conduct kick-off
Succession processes:	-
Input	• Action plan (if applicable emergency/crisis plan) • Procedure for dealing with risks • Risk portfolio with the respective • probability of occurrence and scope
Output	• Current risk assessment • Control measures, if necessary
Knowledge Management	• Knowledge acquisition • Knowledge utilization • Knowledge assessment
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving • Decision Making • Predictive Inference • Relationship Learning • Knowledge Refinement
AI Application description	Risk analysis evaluates the project at regular intervals. Text Extraction can identify the potential risks from the regular reports. Data Analytics can categorize them according to their probability of occurrence and their scope. Appropriate control

	measures can be suggested using the AI methods Problem Solving, Decision Making, and Predictive Inference. Relationship Learning also considers possible connections to other parameters in the project. Knowledge Refinement can provide helpful information through a project and knowledge database collected in completed projects.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Handle contracts with customers and suppliers**	**S.10.1**
Process Group:	Contracts and claims	
Description:	Contracts with customers and suppliers determine the project's success to a high degree of the project and usually account for a significant proportion of the risks. Therefore, the systematic and professional implementation of this topic is excellent is of great importance. This process, therefore, involves the professional handling of contracts with customers and suppliers and minimizing the associated risks.	
Predecessor processes:	S.5.1 Conduct kick-off	
Succession processes:	S.10.2 Control subsequent claims	
Input	• Project plan • Procedure for handling contracts • AKV in dealing with contracts • Draft contracts	

Output	• Status on contract execution • Control measures, if applicable • Information for legal • and supplier/ • supply chain management • project documentation	
Knowledge Management	• Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Knowledge Refinement	
AI Application description	The status of contract execution can be done with the help of Text Extraction. The relevant text components can be extracted from contracts, documents, and systems. Possible discrepancies can be highlighted with the help of Data Analytics. Knowledge Refinement can support project documentation.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Control additional receivables**	**S.10.2**
Process Group:	Contracts and claims	

Description:	There are often additional, reduced, or different services in projects compared to the initially planned scope. These services' consistent and systematic control is a decisive success factor in project management. On the one hand, the implementation of these services in the project must be guaranteed, and on the other hand, the implementation must not be at the expense of the financial result.
Predecessor processes:	S.10.1 Contracts with customers and suppliers
Succession processes:	S.3.2 Issue acceptance
Input	• Status for contract execution, if necessary, with Control measures • Procedures for handling contracts • AKV in dealing with contracts • Contracts with customers and suppliers
Output	• Identified and documented Subsequent requirements • Control measures, if applicable Information for legal • and supplier/ supply chain management • project documentation
Knowledge Management	• Knowledge acquisition • Knowledge development • Knowledge utilization
AI Method:	• Data Analytics • Text Extraction • Predictive Inference • Knowledge Refinement

AI Application description	Monitoring for under-performance can be supported by the AI methods Text Extraction and Data Analytics. Extracting text-based building blocks and comparing data analytics to what was contractually agreed before the start of the project can support this process. Predictive Inference can also provide insight into the extent to which the changed circumstances impact the project. This can be stored as new knowledge in the project and knowledge database.	
Stakeholder	Sponsor	-
	Steering Committee	-
	Project Manager	Accountable / Responsible
	Int. Project Team	Consulted
	Ext. Service Supplier	Consulted

Process:	**Control target achievement**	**S.11.1**
Process Group:	Target	
Description:	This process must ensure that the project objectives are achieved within the specified framework and that the current completion percentage corresponds to the planned completion percentage. In case of deviation, appropriate measures must be prepared and implemented after a decision has been made.	
Predecessor processes:	S.5.1 Conduct kick-off	
Succession processes:	S.3.2 Issue acceptance	
Input	• Project goals • Project plan • Contract contents	

Output	• Status on target achievement (with deviations, if applicable) • Control measures	
Knowledge Management	• Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Planning • Problem Solving • Decision Making • Predictive Inference • Knowledge Refinement	
AI Application description	The target achievement as the degree of completion is continuously monitored. The AI methods data analytics and text extraction can be helpful here. The extraction of the corresponding information from the status reports and the analytical evaluation with the help of data analytics can support here. Dependencies of entities within the project can be detected and evaluated by Predictive Inference. In case of necessary adjustments such as control measures Decision Making, Problem Solving, and holistically the AI method Planning can show appropriate suggestions. The project and knowledge database within the AI method Knowledge Management can refer to already completed projects and offer corrections approaches.	
Stakeholder	Sponsor	-
	Steering Committee	Consulted
	Project Manager	Accountable / Responsible

	Int. Project Team	Informed
	Ext. Service Supplier	-

6.4.6 Use Case: Closing

Process:	**Create project final report**	**A.3.1**
Process Group:	Information / Communication / Documentation	
Description:	The primary purpose of the project completion report is to create a "shared reality" among all stakeholders regarding the completed project. On this basis, future events (recourse claims, subsequent claims, follow-up projects) can be better handled. In addition, the project completion report also serves to secure experience and as a basis for the final meeting.	
Predecessor processes:	A.4.1 Create post calculation A.10.1 End contracts	
Succession processes:	A.5.1 Final meeting conduct	
Input	• Project goals • Project plan • Project documentation (e.g. also the list of open points) • Acceptance	
Output	• Final project report	

Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge retention • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction • Knowledge Refinement	
AI Application description	The project completion report must be approved and accepted by the client. With data analytics and text extraction, the relevant project KPIs and information can be extracted and analyzed from various documents such as the project plan and the project documentation. The results can then be stored in the project and knowledge database for future projects.	
Stakeholder	Sponsor	-
	Steering Committee	Consulted
	Project Manager	Accountable / Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	-

Process:	**Archive project documentation**	**A.3.2**
Process Group:	Information / Communication / Documentation	
Description:	The project documentation must still be available for follow-up work and research after the project has been completed. Therefore, the documentation must	

	be archived in a suitable form to be easily found and edited.	
Predecessor processes:	A.6.1 Save project experience	
Succession processes:	A.7.1 Returning resources	
Input	• Project documentation • Project final report • Organization-specific and legal requirements for archiving	
Output	• Project archive	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge distribution • Knowledge utilization • Knowledge retention • Knowledge assessment	
AI Method:	• Text Extraction • Knowledge Refinement	
AI Application description	The project documentation must be checked for completeness and consistency before archiving. For this purpose, the AI method text extraction can check whether all relevant information is available in the documents. A project and knowledge database can support this from historical projects. In order to do justice to the issue of data protection, analytical methods can also be used to check directories and file archives and delete them if necessary.	
Stakeholder	Sponsor	-
	Steering Committee	Consulted

	Project Manager	Accountable / Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	-

Process:	**Create post calculation**	**A.4.1**
Process Group:	Cost and finance	
Description:	Post-costing must be used to determine the project's commercial success and compare it with the specifications from the planning. On the one hand, this information is used to prepare the project completion report; on the other hand, this information is also used to safeguard experience because deviations provide valuable information for the planning of future projects.	
Predecessor processes:	S.3.2 Issue acceptance	
Succession processes:	A.3.1 Project completion report	
Input	• Project plan • Cost and budget plan • Business plan • Project documentation	
Output	• Post calculation, income statement • Variance analysis	
Knowledge Management	• Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Data Analytics • Text Extraction	

	• Knowledge Refinement	
AI Application description	Post-calculation is calculated based on the project plan, the financial plan, and the business plan. Deviations can be calculated and displayed using Data Analytics. AI method Text Extraction can extract relevant information from the previously mentioned documents. The results can be stored in a project and knowledge database for further projects to ensure knowledge.	
Stakeholder	Sponsor	-
	Steering Committee	Consulted
	Project Manager	Accountable / Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	-

Process:	**Conduct final meeting**	**A.5.1**
Process Group:	Organization	
Description:	After the final report has been prepared, the main findings and suitable measures are discussed and recorded by all those involved in the project. The focus is not only on the hard facts of the project but also on the soft facts, i.e., the cooperation within the project team and external stakeholders. The aim is to gather experience and learn for the following projects.	
Predecessor processes:	A.3.1 Project completion report	
Succession processes:	A.5.2 Recognize achievements	
Input	• Project goals • Project plan	

	• Final costing • Project completion report	
Output	• Minutes of the final meeting with further Measures	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge utilization • Knowledge assessment	
AI Method:	• Speech recognition • Face Recognition • Knowledge Refinement	
AI Application description	Speech recognition can recognize and record spoken language and mood. The recognition of facial expressions can also be recognized and interpreted by Face recognition, after which a mood picture can be reproduced. The goal of the final meeting is to create a protocol with further measures, if necessary. In the context of knowledge refinement, the most important findings can be stored in a project and knowledge database.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable / Responsible
	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Appreciate achievements**	**A.5.2**

Process Group:	Organization	
Description:	After the project work, which is usually very demanding, it is necessary for the long-term job satisfaction of the project participants that the achievements are adequately appreciated. If this does not happen, it will be difficult to find motivated team members again for the next project, and there may even be a risk of burnout and fluctuation.	
Predecessor processes:	A.5.1 Final meeting conduct	
Succession processes:	A.6.1 Project experience secure	
Input	• Project goals • Work package descriptions • Project final report	
Output	• Information to Human Resources about suitable measures	
Knowledge Management	• Knowledge utilization	
AI Method:	• Face Recognition • Speech Analytics	
AI Application description	Facial recognition makes it possible to recognize users' reactions, as does the possibility of voice recognition. Facial and speech characteristics can be used to draw conclusions about users' emotions. Data privacy and personal rights in particular must be observed in advance.	
Stakeholder	Sponsor	Informed
	Steering Committee	Informed
	Project Manager	Accountable / Responsible

	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Dissolve project organization**	**A.5.3**
Process Group:	Organization	
Description:	The project manager and, if applicable, the project team bear the responsibility for achieving the project goals. They are now released from their responsibility and can thus devote themselves to new tasks. This formally ends the project.	
Predecessor processes:	A.7.1 Returning resources	
Succession processes:	-	
Input	• Project goals • Project organization chart • Project final report	
Output	• Discharge of the project manager (and if necessary, the project team) • Final protocol	
Knowledge Management	• Securing experience and newly acquired knowledge (Best practice)	
AI Method:	No findings	
AI Application description	No findings	
Stakeholder	Sponsor	Consulted
	Steering Committee	Consulted
	Project Manager	Accountable / Responsible

	Int. Project Team	-
	Ext. Service Supplier	-

Process:	**Save project experience**	**A.6.1**
Process Group:	Quality	
Description:	Experience should be systematically collected and made available for future projects. be made usable for future projects. To this end, it is necessary to systematically process the experience gained by all participants systematically processed, documented with the help of appropriate systems and and to disseminate them through personal exchange. This ensures ensure that the same mistakes are not made over and over again and that project management project management can continue to develop.	
Predecessor processes:	A.5.2 Recognize achievements	
Succession processes:	A.3.2 Project documentation archive	
Input	• Project documentation • Project completion report • Organization-specific guidelines for handling knowledge	
Output	• Measures to secure the project experience gained ("lessons learned") • Information for knowledge management	
Knowledge Management	• Knowledge objectives • Knowledge acquisition • Knowledge development • Knowledge distribution • Knowledge utilization • Knowledge retention	

	• Knowledge assessment	
AI Method:	• Text Extraction • Knowledge Refinement	
AI Application description	Securing the accumulated experience is the core objective of this process. The predefined knowledge objectives can be compiled in the context of a lessons learned meeting. The project closing meeting can also be a suitable medium for this. Text Extraction can extract the relevant information from the documents and minutes, transfer it to the project and knowledge database, and make it available for future projects.	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	Informed
Process:	**Return resources**	**A.7.1**
Process Group:	Resource	
Description:	After their use, all resources must be returned, which means that employees are released and transferred to their new/old jobs, and materials are returned. Only when all resources have been returned, the project organization and thus the project can be terminated.	
Predecessor processes:	A.3.2 Project documentation archive	
Succession processes:	A.5.3 Project organization dissolve	
Input	• Resource plan • Acceptance	

	• Project completion report	
Output	• Protocol on the return of Resources • Information for human resources	
Knowledge Management	No findings	
AI Method:	No findings	
AI Application description	No findings	
Stakeholder	Sponsor	Accountable
	Steering Committee	Consulted
	Project Manager	Responsible
	Int. Project Team	Informed
	Ext. Service Supplier	Informed

Process:	**End contracts**	**A.10.1**
Process Group:	Contracts and claims	
Description:	At the end of the project, all contracts concluded in the context of the project must either be terminated or handed over to the organizational units that continue to manage the service created in the project. If this is neglected, costs may continue to be incurred from the project after its completion.	
Predecessor processes:	S.3.2 Issue acceptance	
Succession processes:	A.3.1 Project completion report	
Input	• Procedure for dealing with Contracts • AKV in dealing with contracts	

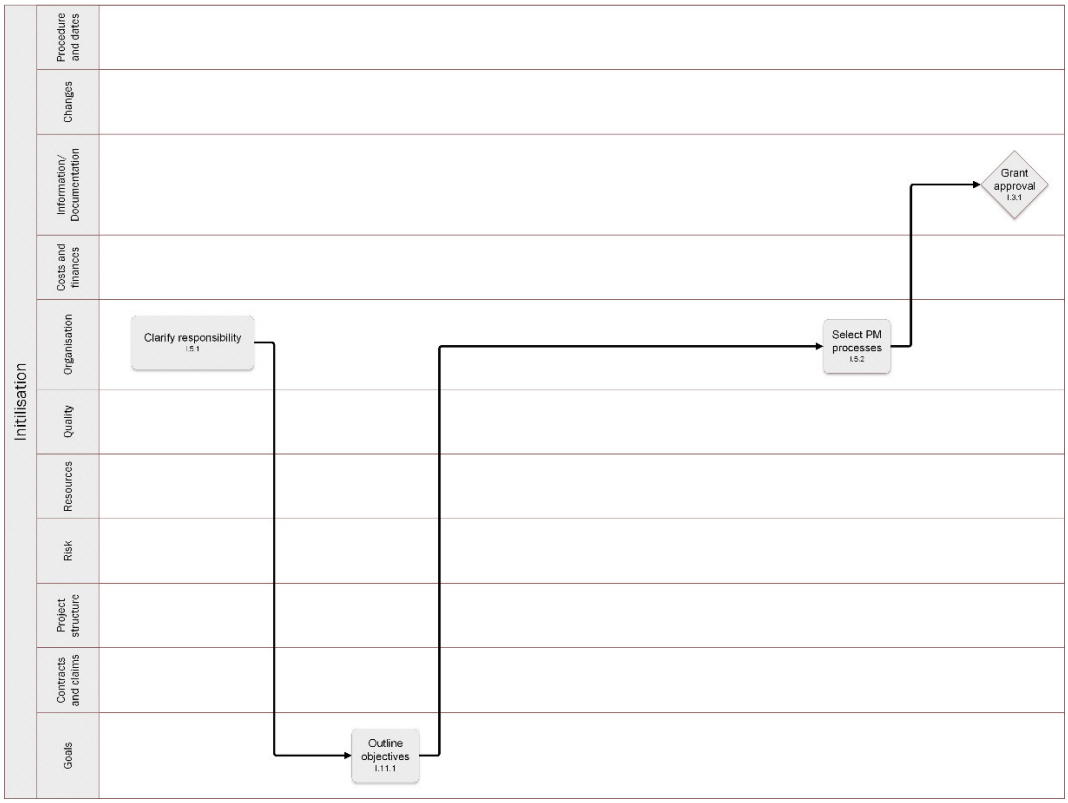
<table>
<tr><td></td><td colspan="2">Acceptances subsequent claims
Concluded contracts</td></tr>
<tr><td>Output</td><td colspan="2">Terminated contracts (including realized additional claims, if applicable)
Information for legal and supplier/supply chain
Chain Management</td></tr>
<tr><td>Knowledge Management</td><td colspan="2">-</td></tr>
<tr><td>AI Method:</td><td colspan="2">Decision Making
Knowledge Refinement
Text Extraction
Data Analytics</td></tr>
<tr><td>AI Application description</td><td colspan="2">All contracts that are no longer required after the end of the project must be terminated. The services that are to be transferred to regular operation after the project remain in place and may need to be adapted. The decision-making process can support this decision. The results and decisions can also be made available in a project and knowledge database as part of the AI method Knowledge Refinement. Knowledge refinement, text extraction and analytics can also be used to check the duration of contracts with third-party providers, for example, or which skills and requirements are needed.</td></tr>
<tr><td rowspan="5">Stakeholder</td><td>Sponsor</td><td>Informed</td></tr>
<tr><td>Steering Committee</td><td>Informed</td></tr>
<tr><td>Project Manager</td><td>Accountable / Responsible</td></tr>
<tr><td>Int. Project Team</td><td>Consulted</td></tr>
<tr><td>Ext. Service Supplier</td><td>Consulted</td></tr>
</table>

6.5 Process view Project Management

The visualizations presented below to introduce the process perspective of the different process phases in a project. Depending on the process phase, different process subgroups are addressed, with the transitions of the individual process phases, resulting in a holistic process for a project, according to DIN 69901.

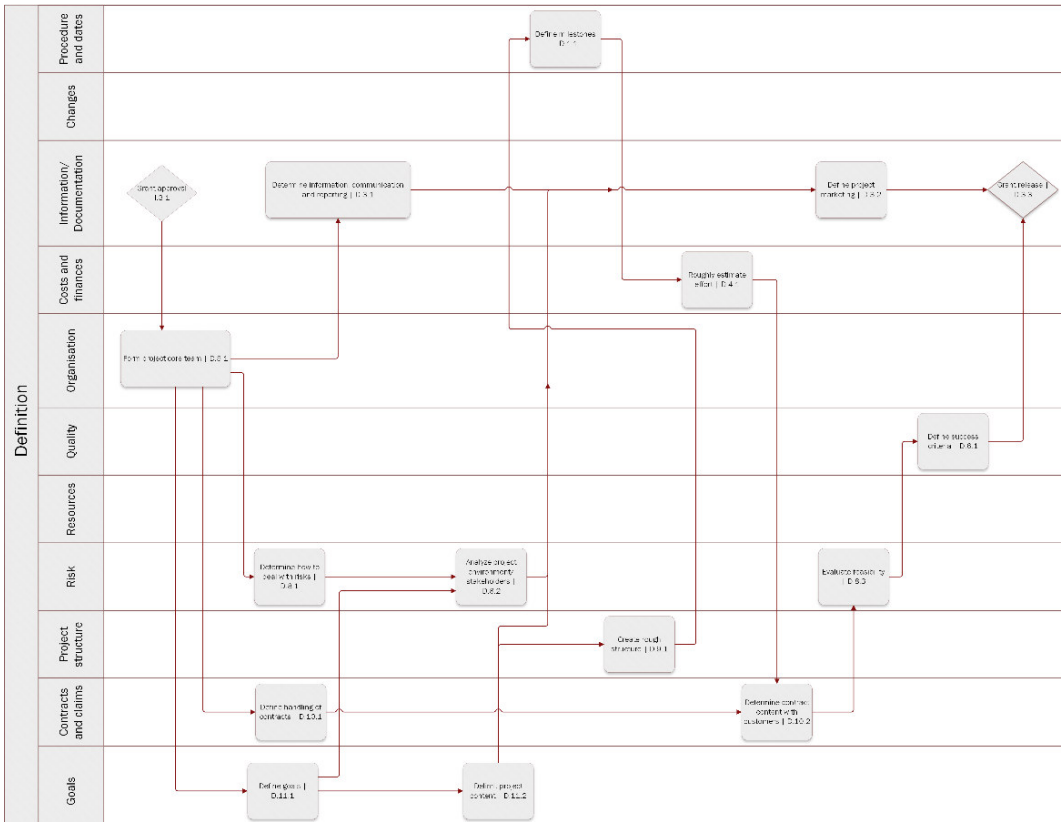
6.5.1 Process view Project Management: Initialization

The process perspective initialization shows four processes divided into three process subgroups. The conclusion of the initialization phase is process I.3.1 Grant approval to advance to the next process phase.



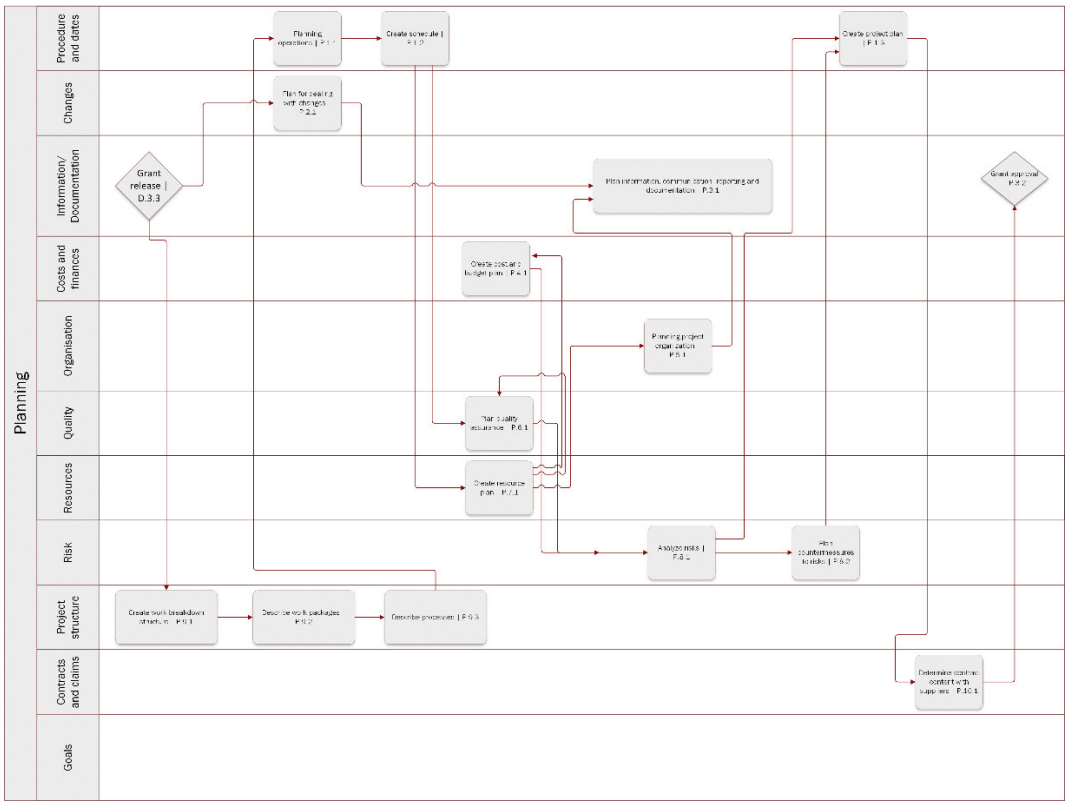
6.5.2 Process view Project Management: Definition

The process perspective definition shows 15 processes divided into nine process subgroups. The first process is the acceptance (I.3.1 Grant approval) from the previous perspective. After the process chain has been completed, permission must be granted again for the definition phase (D.3.3 Grant release) to move to the following process perspective.



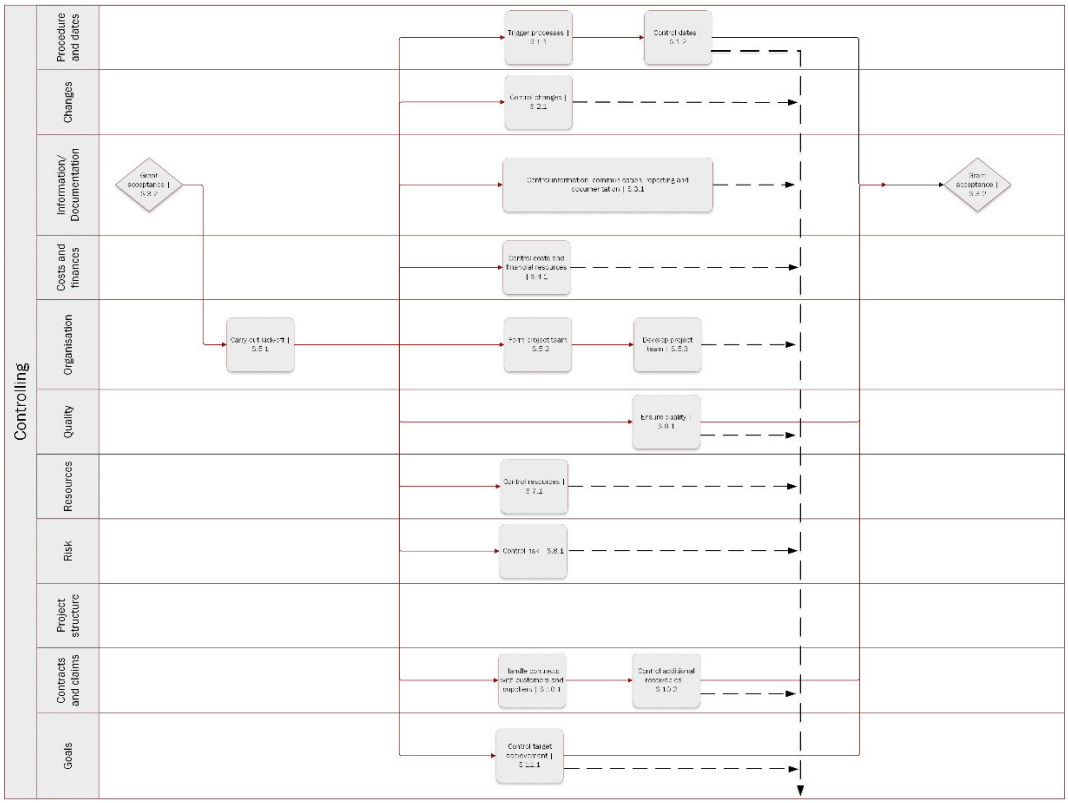
6.5.3 Process view Project Management: Planning

The Planning process perspective shows 16 processes, divided into ten process subgroups. The first process is the approval (D.3.3 Grant approval) from the previous perspective. After the process chain has been completed, permission for the planning phase must be granted again (P.3.2 Grant release) to move to the following process perspective. The planning phase has the most individual processes and uses almost every one of the process subgroups. Therefore, this process perspective is also considered the busiest.



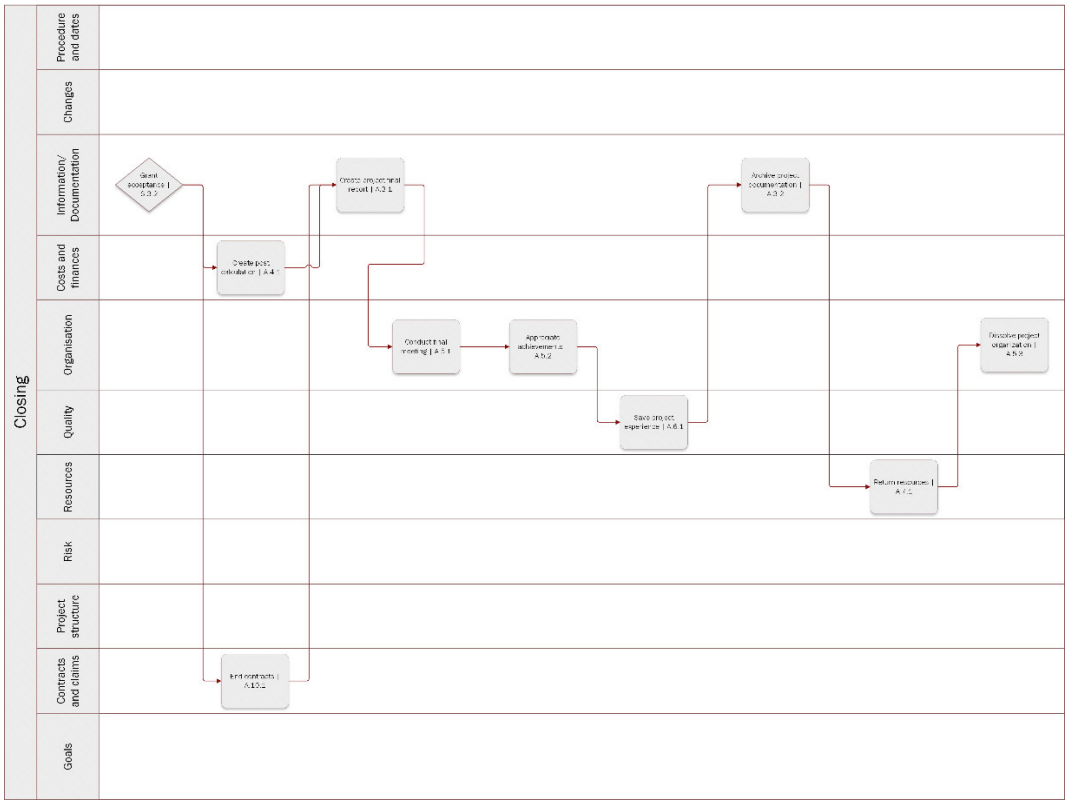
6.5.4 Process view Project Management: Controlling

The process perspective Controlling shows 15 processes divided into ten process subgroups. The first process is the approval (S.3.2 Grant approval) from the previous Planning perspective. After the process chain has been completed, another permission must be granted for the Planning phase (S.3.2 Grant acceptance) in order to move to the following process perspective.



6.5.5 Process view Project Management: Closing

The process perspective Closing shows nine processes, which are divided into six process subgroups. The first process is the acceptance (S.3.2 Grant acceptance) from the previous Controlling perspective. The last process (A.5.3) is the dissolution of the project organization and the return of resources. After the process chain has been completed, the project is considered finished.



6.6 Process view Stakeholder

6.6.1 Process view Stakeholder: Initialization

Process Group	Process	Project Sponsor	Steering Board	Project Manager	Project Team	ext. Service Supplier
Information/ Documentation	Grant approval | I.3.1	Accountable	Consulted	Responsible	Informed	Informed
Organization	Clarify responsibility | I.5.1	Informed	Informed	Accountable & Responsible	Consulted	Consulted
Organization	Select PM processes | I.5.2	Informed	Informed	Accountable & Responsible	Consulted	Consulted
Goals	Outline objectives | I.11.1	Consulted	Consulted	Accountable & Responsible	Informed	Informed

The overview shows that the project manager has the most tasks in this initialization phase. The remaining stakeholders are mainly in an advisory role or informed about the individual processes' results.

6.6.2 Process view Stakeholder: Definition

Process Group	Process	Project Sponsor	Steering Board	Project Manager	Project Team	ext. Service Supplier
Procedure and dates	Define milestones | D.1.1	-	Informed	Accountable	Responsible	Consulted
Information/ Documentation	Determine information, communication, and reporting | D.3.1	Informed	Informed	Accountable	Responsible	Informed
Information/ Documentation	Define project marketing | D.3.2	-	Informed	Accountable	Responsible	-
Information/ Documentation	Grant release | D.3.3	Accountable	Consulted	Responsible	Informed	Informed
Costs and finances	Roughly estimate effort | D.4.1	-	-	Accountable	Responsible	Responsible
Organization	Form project core team | D.5.1	-	-	Accountable & Responsible	Consulted	Informed
Quality	Define success criteria | D.6.1	Accountable	Consulted	Consulted	Informed	Informed

Risk	Determine how to deal with risks | D.8.1	Informed	Accountable	Responsible	Consulted	Informed
Risk	Analyze project environment/stakeholders | D.8.2	-	Informed	Accountable	Responsible	Consulted
Risk	Evaluate feasibility | D.8.3	Informed	Informed	Accountable	Responsible	Consulted
Project structure	Create rough structure | D.9.1	-	-	Accountable & Responsible	Consulted	Consulted
Contracts and claims	Define handling of contracts | D.10.1	-	Consulted	Accountable & Responsible	Informed	-
Contracts and claims	Determine contract content with customers | D.10.2	-	Consulted	Accountable & Responsible	Informed	-
Goals	Define goals | D.11.1	Accountable	Consulted	Responsible	Informed	Informed
Goals	Delimit project content | D.11.2	Accountable	Consulted	Responsible	Informed	Informed

Also, in the definition phase, the responsibilities often lie with the project manager and are decided jointly with the project sponsor and the steering board, depending on the process. On the other hand, the internal project team and the external service providers are often required for effort and resource estimates, and it is their responsibility to carry these out.

6.6.3 Process view Stakeholder: Planning

Process Group	Process	Project Sponsor	Steering Board	Project Manager	Project Team	ext. Service Supplier
Procedure and dates	Planning operations | P.1.1	-	-	Accountable	Responsible	Consulted
Procedure and dates	Create schedule | P.1.2	-	-	Accountable	Responsible	Consulted
Procedure and dates	Create project plan | P.1.3	-	Informed	Accountable	Responsible	Consulted
Changes	Plan for dealing with changes | P.2.1	-	Informed	Accountable	Responsible	Consulted
Information/ Documentation	Plan information, communication, reporting and documentation | P.3.1	-	Informed	Accountable & Responsible	Consulted	-
Information/ Documentation	Grant approval | P.3.2	Accountable	Consulted	Responsible	Informed	Informed
Costs and finances	Create cost and budget plan | P.4.1	Informed	Informed	Accountable & Responsible	Consulted	Consulted

Organization	Planning project organization | P.5.1	-	-	Accountable & Responsible	Consulted	Informed
Quality	Plan quality assurance | P.6.1	-	-	Accountable	Responsible	Consulted
Resources	Create resource plan | P.7.1	-	-	Accountable & Responsible	-	-
Risk	Analyze risks | P.8.1	Informed	Informed	Accountable	Responsible	Consulted
Risk	Plan countermeasures to risks | P.8.2	Informed	Informed	Accountable	Responsible	Consulted
Project structure	Create work breakdown structure | P.9.1	-	-	Accountable & Responsible	Consulted	Consulted
Project structure	Describe work packages | P.9.2	-	-	Accountable & Responsible	Consulted	Consulted
Project structure	Describe processes | P.9.3	-	-	Accountable & Responsible	Consulted	Consulted

Contracts and claims	Determine contract content with suppliers ǀ P.10.1	-	Consulted	Accountable & Responsible	Informed	-

In the planning phase, the project team and external service providers are involved more often than in the previous stages to carry out various planning activities or provide advice. Nevertheless, the responsibility for this often lies with the project manager, who justifies the results to the project sponsor and the steering board.

6.6.4 Process view Stakeholder: Controlling

Process Group	Process	Project Sponsor	Steering Board	Project Manager	Project Team	ext. Service Supplier
Procedure and dates	Trigger processes | S.1.1	-	-	Accountable & Responsible	-	-
Procedure and dates	Control dates | S.1.2	-	-	Accountable & Responsible	-	-
Changes	Control changes | S.2.1	-	-	Accountable & Responsible	-	-
Information/ Documentation	Control information, communication, reporting and documentation | S.3.1	-	Informed	Accountable & Responsible	Consulted	-
Information/ Documentation	Grant acceptance | S.3.2	Accountable	Consulted	Responsible	Informed	Informed

Costs and finances	Control costs and financial resources | S.4.1	-	-	Accountable & Responsible	Consulted	-
Organization	Carry out kick-off | S.5.1	Consulted	Consulted	Accountable & Responsible	Consulted	Consulted
Organization	Form project team | S.5.2	-	-	Accountable & Responsible	Consulted	Informed
Organization	Develop project team | S.5.3	-	-	Accountable & Responsible	-	-
Quality	Ensure quality | S.6.1	-	-	Accountable	Responsible	Consulted
Resources	Control resources | S.7.1	-	-	Accountable & Responsible	-	-
Risk	Control risk | S.8.1	Informed	Informed	Accountable & Responsible	Consulted	Consulted
Contracts and claims	Handle contracts with customers and suppliers | S.10.1	-	Consulted	Accountable & Responsible	Informed	-

Contracts and claims	Control additional receivables | S.10.2	Informed	Informed	Accountable & Responsible	-	-
Goals	Control target achievement | S.11.1	Informed	Informed	Accountable & Responsible	Consulted	Consulted

The project manager is often responsible for the various processes in the control phase. In some processes, he is also the one who carries out the tasks. However, the project team and, in a consultative manner, often the external suppliers are also involved. The Project Manager is responsible for informing the Steering Board and the Project Sponsor about the project's progress.

6.6.5 Process view Stakeholder: Closing

Process Group	Process	Project Sponsor	Steering Board	Project Manager	Project Team	ext. Service Supplier
Information/ Documentation	Create project final report | A.3.1	Informed	Informed	Accountable & Responsible	Consulted	Consulted
Information/ Documentation	Archive project documentation | A.3.2	-	-	Accountable & Responsible	Consulted	-
Costs and finances	Create post calculation | A.4.1	Informed	Informed	Accountable & Responsible	-	-
Organization	Conduct final meeting | A.5.1	Consulted	Consulted	Accountable & Responsible	Consulted	Consulted
Organization	Appreciate achievements | A.5.2	Accountable	Consulted	Consulted	Informed	Informed

Organization	Dissolve project organization | A.5.3	-	-	Accountable & Responsible	-	-
Quality	Save project experience | A.6.1	-	-	Accountable	Responsible	Consulted
Resources	Return resources | A.7.1	-	-	Accountable & Responsible	-	-
Contracts and claims	End contracts | A.10.1	Informed	Informed	Accountable & Responsible	-	-

In the last phase, the project manager is often in the responsible and executing role. On the other hand, the remaining stakeholders are in the advisory role or are informed about the events and results.

6.7 Process view Knowledge Management

6.7.1 Process view Knowledge Management: Initialization

Process	K. objectives	K. identification	K. acquisition	K. Development	K. distribution	K. utilization	K. retention	K. assessment
Grant approval | I.3.1	no	no	no	no	no	no	no	no
Clarify responsibility | I.5.1	yes	yes	yes	yes	yes	yes	no	yes
Select PM processes | I.5.2	yes	no	yes	yes	no	yes	no	yes
Outline objectives | I.11.1	yes	no	yes	yes	no	yes	no	yes

6.7.2 Process view Knowledge Management: Definition

Process	K. objectives	K. identification	K. acquisition	K. Development	K. distribution	K. utilization	K. retention	K. assessment
Define milestones | D.1.1	yes	no	yes	yes	no	yes	no	yes
Determine information, communication, and reporting | D.3.1	yes	no	yes	yes	yes	yes	yes	yes
Define project marketing | D.3.2	yes	no	yes	yes	no	yes	no	yes
Grant release | D.3.3	no	no	no	no	no	yes	no	no
Roughly estimate effort | D.4.1	yes	no	yes	no	no	yes	no	yes
Form project core team | D.5.1	no	yes	yes	yes	no	yes	no	yes
Define success criteria | D.6.1	yes	no	yes	yes	no	yes	no	yes

Determine how to deal with risks | D.8.1	yes	no	yes	yes	no	yes	no	yes
Analyze project environment/stakeholder | D.8.2	yes	no	yes	yes	yes	yes	no	yes
Evaluate feasibility | D.8.3	yes	no	yes	yes	no	yes	no	yes
Create rough structure | D.9.1	no	no	yes	yes	no	yes	no	yes
Define handling of contracts | D.10.1	yes	no	yes	yes	no	yes	no	yes
Determine contract content with customers | D.10.2	no	no	yes	yes	no	yes	no	yes
Define goals | D.11.1	yes	no	yes	yes	no	yes	no	yes
Delimit project content | D.11.2	yes	no	yes	yes	no	yes	no	yes

6.7.3 Process view Knowledge Management: Planning

Process	K. objectives	K. identification	K. acquisition	K. Development	K. distribution	K. utilization	K. retention	K. assessment
Planning operations | P.1.1	yes	no	yes	yes	no	yes	no	yes
Create schedule | P.1.2	yes	no	yes	yes	no	yes	no	yes
Create project plan | P.1.3	yes	no	yes	yes	no	yes	no	yes
Plan for dealing with changes | P.2.1	yes	no	yes	no	no	yes	no	yes
Plan information, communication, reporting and documentation | P.3.1	yes	no	yes	no	yes	yes	yes	yes
Grant approval | P.3.2	no	no	no	no	no	no	no	no

Create cost and budget plan | P.4.1	yes	no	yes	yes	no	yes	no	yes
Planning project organization | P.5.1	yes	yes	yes	yes	no	yes	no	yes
Plan quality assurance | P.6.1	yes	no	yes	yes	no	yes	yes	yes
Create resource plan | P.7.1	no	yes	no	yes	no	yes	no	yes
Analyze risks | P.8.1	yes	no	yes	yes	no	yes	no	yes
Plan countermeasures to risks | P.8.2	yes	no	yes	yes	no	yes	no	yes
Create work breakdown structure | P.9.1	no	no	yes	yes	no	yes	no	yes
Describe work packages | P.9.2	yes	no	yes	yes	no	yes	no	yes

Describe processes | P.9.3	yes	no	yes	yes	no	yes	no	yes
Determine contract content with suppliers | P.10.1	yes	no	yes	yes	no	yes	no	yes

6.7.4 Process view Knowledge Management: Controlling

Process	K. objectives	K. identification	K. acquisition	K. Development	K. distribution	K. utilization	K. retention	K. assessment
Trigger processes | S.1.1	no	no	no	no	no	no	no	no
Control dates | S.1.2	no	no	no	no	no	yes	no	no
Control changes | S.2.1	no	no	no	yes	no	yes	no	no
Control information, communication, reporting and documentation | S.3.1	no	no	no	yes	yes	yes	yes	yes
Grant acceptance | S.3.2	no	no	yes	no	no	no	no	no
Control costs and financial resources | S.4.1	no	no	no	no	no	yes	no	yes
Carry out kick-off | S.5.1	no	no	no	no	no	yes	no	no
Form project team | S.5.2	no	yes	yes	yes	no	yes	no	yes

Develop project team | S.5.3	no	yes	yes	yes	no	yes	no	yes
Ensure quality | S.6.1	no	no	yes	yes	yes	yes	yes	yes
Control resources | S.7.1	no	yes	yes	no	no	yes	no	yes
Control risk | S.8.1	no	no	yes	no	no	yes	no	yes
Handle contracts with customers and suppliers | S.10.1	no	no	no	no	no	yes	no	yes
Control additional receivables | S.10.2	no	no	yes	yes	no	yes	no	no
Control target achievement | S.11.1	no	no	yes	yes	no	yes	no	yes

6.7.5 Process view Knowledge Management: Closing

Process	K. objectives	K. identification	K. acquisition	K. Development	K. distribution	K. utilization	K. retention	K. assessment
Create project final report | A.3.1	yes	no	yes	yes	no	yes	yes	yes
Archive project documentation | A.3.2	yes	no	yes	no	yes	yes	yes	yes
Create post calculation | A.4.1	no	no	yes	yes	no	yes	no	yes
Conduct final meeting | A.5.1	yes	no	yes	yes	no	yes	no	yes
Appreciate achievements | A.5.2	no	no	no	no	no	yes	no	no
Dissolve project organization | A.5.3	no	no	no	no	no	no	no	no

Save project experience | A.6.1	yes	no	yes	yes	yes	yes	yes	yes
Return resources | A.7.1	no	no	no	no	no	no	no	no
End contracts | A.10.1	no	no	no	no	no	no	no	no

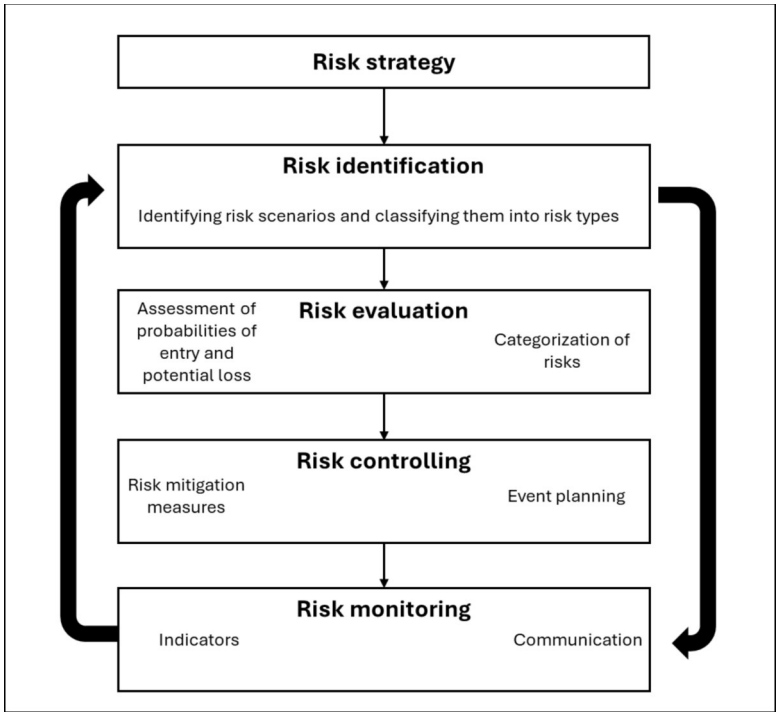
6.8 Risk management process view with AI methods

As projects are, by definition of DIN 69 901-5:2009-01, risky over the entire project duration, successful implementation also depends on how risk management is installed and used. In addition, new risks can be added, or existing risks can be eliminated. These must, therefore, be constantly identified, analyzed, and evaluated. The established project management software programs support the corresponding processes within projects, but AI methods can also support them. The focus is, therefore, on the comparison of classic process steps in risk management and the assignment of AI methods.

6.8.1 Classic risk management process with AI

Figure 6-4 below shows the main initial steps of the risk management process, which are then explained. The five-stage architecture is based on the individual phases and runs through a loop to guarantee permanent monitoring of activities.

Figure 6-4: Classic risk management process



Note: Adapted from Lächelt et al (2024)

The risk strategy forms the basis of risk management. This is based on risk preference on the one hand and the organizational and legal framework conditions on the other (Franz Xaver Bea, Scheurer, & Hesselmann, 2011). In order to set up a risk strategy, the organization must determine its stance on risk preference. These can be seen as risk-averse, risk-neutral, or risk-taking. The decision-makers are usually the project manager and the project sponsor or client. At best, an AI can make suggestions which risk strategy approach make sense under the project conditions. However, AI can play a greater role in continuation and implementation. The connection with established early warning or early detection systems. AI is also useful in the development of measures.

Once the strategy for dealing with risks has been decided, all relevant project risks must be recorded and documented. This step is of particular importance, as it lays the foundations for the subsequent implementation of a functioning risk management system (Seidel, 2011). Risks can also be divided into external risks, such as legal regulations or forces of nature, and company-specific risks, such as those emanating from the organization. This also includes communication with stakeholders. Closely related to corporate risks are financial risks, such as cost structure or the organization's liquidity. The use of AI methods is obvious here in that risk identification also draws on empirical values, knowledge gained from completed projects, and analogies. AI can take a holistic view of these and generate corresponding suggestions for risk identification.

The risk analysis and subsequent evaluation identify the potential risks and categorize them into meaningful parameters. The probability of occurrence or the frequency of occurrence can be used here. An assessment can be carried out qualitatively, quantitatively, or in a mixed form (Seidel, 2011).

Seidel further explains that AI can also support this step, as it can present and categorize a holistic picture of the risks. The project manager is supported in this because, ideally, the AI reminds them of all possible project risks and enables them to react.

Actual risk management is divided into risk mitigation and contingency planning. As the costs of the measures should be lower than the costs of the risk, the measures must be designed accordingly. The minimization principles can be differentiated according to Bea et al. These are discussed in detail in Chapter 3.2.6. In this area, AI applications are useful, for example, in the area of risk transfer, to check legal circumstances before legal advice becomes necessary.

The final step is risk monitoring and communication, divided into two sub-areas. The first is the observation of the risks themselves and the associated monitoring and control of measures. Secondly, the risk process must be communicated to the relevant stakeholders. In order to always have up-to-date data available during the project, the critical risk figures must be recalculated at the time of reporting. The correct information must be prepared for the communication concept as part of risk management so that the information can be communicated transparently and to the proper addresses at all times. In this phase, an AI can summarize defragmented information and output it in report form.

As the risk management process does not end at this point, but rather represents a cycle, the last step of risk monitoring is followed by a new start with new findings in risk identification. This creates a continuous risk cycle throughout the entire duration of the project.

6.8.2 Classification of AI methods to risk management processes

The assignability of AI methods or even AI tools is challenging because the number is constantly growing, and their half-life is usually short (Lächelt, Portillo, & Braun, 2024). The following overview classifies AI methods into the individual risk management process steps described above.

The assignment results from an analytical process in which the description of the AI methods is viewed and placed in a context with the risk management phases through argumentative rationalization. This overview cannot claim to be exhaustive, as the development of such methods is very dynamic. Dependent factors such as the size of the organization or the strategic orientation can influence the use of AI methods and, therefore, cannot be universally valid.

Thus, it is advisable to examine the specific individual case before using it in practice. Nevertheless, the overview provides an initial impression of the existing possibilities.

The various AI methods are outlined below, starting with the risk strategy as the basis for the other sub-processes.

Sub process risk strategy	**AI Methods**	**Tools**
Risk strategy	LLM / Chatbot	ChatGPT
	Text analytics incls. extracting text, data, and images from various documents, including IDs, passports, invoices	Base64.ai Document AI
	LLM / Chatbot	CustomGPT AI
	LLM / Chatbot incl. text analytics	Copilot

Individual process steps can be mapped using large language models (LLM), for example. Thanks to no-code or low-code services, various LLMs can not only be managed by experts but are also generally understandable and easy to set up. This makes it easy to generate AI workflows adapted to the organization and the project and, thus, do not change the applicable framework conditions.

Sub process risk identification.	**AI Methods**	**Tools**
Risk identification	LLM / Chatbot incl. text analytics (PDFs)	AskYourPDF
	Text analytics incls. extracting text, data, and images from various documents, including IDs, passports, invoices	Base64.ai Document AI
	Product Data Management & content distribution	Copysmith

The anticipation of risks, early identification, and rapid intervention are the main advantages in this phase of the risk management process. Risk management is often carried out when uncertainty arises, but risk identification should be carried out continuously and systematically (Lächelt, Portillo, & Braun, 2024).

In this phase of the risk process, LLMs can complete and summarize texts and information or provide voice output so the user can have a natural conversation with the chatbot. If historical data can be accessed and used as the basis for the training data, AI can significantly contribute to time savings. Therefore, A high-quality LLM can carry out risk identification in the individual organization-specific context and identify possible risks in the project holistically.

Sub process risk evaluation.	**AI Methods**	**Tools**
Risk evaluation	LLM / Chatbot incl. text analytics (PDFs)	AskYourPDF
	Text analytics incls. extracting text, data, and images from various documents, including IDs, passports, invoices	Base64.ai Document AI
	Product Data Management & content distribution	Copysmith

Risk assessment in projects is generally time-consuming. AI methods can reduce this, relieving the project manager. They are able to identify and analyze risks based on historical data using deep learning or machine learning algorithms.

For example, log files from different systems can be cumulated and analyzed to give the end user a better understanding of changes, trends, and anomalies. These can be indications of future problems or risks. The customizability of machines or deep learning methods means that they can be trained for specific problems and are highly adaptable to the organization.

Sub process risk controlling	**AI Methods**	**Tools**
Risk controlling	LLM / Chatbot incl. examinations in law and economics	Claude
	AI-powered search engin for organizations	Coveo
	Interpreting AI system for application, web server, and database logs.	Log Analyzer Pro GPT

The creation of measures and emergency planning, for example, can use large language models to generate a better understanding of documents that are difficult to understand, thus also saving time. Depending on the LMM, this can be done by summarizing the text, or the user can ask detailed questions about the text and get information from the LMM.

The transfer of risks is often contractually regulated. In order to obtain an initial legal assessment, a specialized AI can also provide valuable legal advice before expensive third-party legal services are used. Documents of any kind can be examined for critical points. Lawyers and legal departments also benefit from this AI method in processing routine activities in this area.

Sub process risk monitoring	**AI Methods**	**Tools**
Risk monitoring	Realistic AI voices in any voice, style and language	ElevenLabs
	Immediate personality and social and emotional skills (SES) assessments	Human AI Tech
	AI Workflow with all-in-one Platform	Leap

Communicating risks and associated information to the relevant stakeholders is essential to risk monitoring. Various AI models offer the option of creating data in images or graphics and distributing it in a way that is appropriate for the target group. Key process steps can thus be visualized quickly and easily. For example, meeting recordings can be automatically transcribed into different languages for the documentation process. This allows details of meetings to be recorded directly, reducing the project team's workload.

Most of the applications shown are based on large language models, which can develop their full potential. However, there are also some hurdles to overcome. According to Hadi et al. these are the following barriers (Hadi et al., 2023):

Hallucination

If there is a lack of knowledge or data, the AI can try to fill these gaps by making assumptions. The results are falsified, therefore, and can lead to misleading conclusions. Hannigan et al. refer to these results as 'botshit' (Hannigan, McCarthy, & Spicer, 2024).

Reasoning errors

Ambiguous inputs to the AI system can lead to errors in logical reasoning and incorrect conclusions (White et al., 2023).

Bias

If data is already biased, this often leads to a distorted perception. This can include inaccurate or discriminatory aspects in the result. Therefore, It is important to view AI-generated results more as suggestions and question them with common sense.

Lack of transparency of AI results

One disadvantage of LLM is the large number of parameters. This can lead to models delivering results without these being explainable and comprehensible. As the number of parameters increases, the process that leads to the delivered results becomes opaque and difficult or impossible for the user to explain.

As the training process usually works with data from different sources, this can lead to these data having different patterns and correlations, leading to distortions in interpreting the results.

The software solutions for AI presented here only represent a snapshot, as the development of these models is very fast-moving and, therefore, has a short half-life. Other issues, such as ethical challenges, still need to be investigated. It is easier for organizations with the financial resources to set up appropriate learning models than for SMEs.

However, this includes not only the individualization of the learning model but also raising awareness of AI and training for users and developers. In addition, large organizations can connect their AI to their ERP system to have even more extensive and more individualized data.

7 Evaluation of NICEL reference architecture

This chapter explains the method of evaluation. The design science research approach is explained in more detail further on.

7.1 Introduction

Evaluation is referred to by March and Smith as the second element of design-science research. This is used for the systematic assessment after developing the artifact under investigation (March and Smith, 1995, p. 254). Furthermore, it is pointed out that the model can only be completed through evaluation, and based on this, new design cycles can be created (vom Brocke and Buddendick, 2004, p. 157). In the following subsections, the reference model is examined using two types of evaluations. These evaluations aim to assess whether they can address the problems (Riege, Saat, & Bucher, 2009, pp. 69–85).

7.2 Objectives and Procedure of the Evaluation

In the context of this reference model, the aim is to investigate whether the corresponding views using methods of artificial intelligence and knowledge management and IT projects can be carried out more efficiently. Chapter 6.3 uses analytical evaluation. Requirements defined in advance, primarily from the expert interviews in chapter 5.3.1, are used here as criteria. These criteria form the basis for the analytical evaluation to examine the usefulness of the reference model. In chapter 6.4, the second evaluation method is used. Here, the reference model is discussed and evaluated by a focus group of experts. In this process, the reference model is assessed by experts concerning its usefulness in IT projects.

In addition to the evaluations, further requirements are necessary. In addition to the functionalities, ISO9126 also mentions reliability, usability, maintainability, portability and efficiency (International Organization for Standardization).

7.3 Analytical evaluation

Hevner and Chatterjee point out that according to design-oriented research, the artifact must be evaluated in terms of quality, efficiency, and usefulness using comprehensible evaluation methods (Hevner et al., 2010, p. 12). Defining the requirements that the artifact should fulfill is the first step (L. J. Heinrich and Häntschel, 1999, p. 40). Therefore, according to Fettke and Loos, in the following, there is a need to define the criteria of the reference architecture based on the natural language, analytical and feature-based evaluation (Fettke and Loos, 2003, p. 7).

Therefore, according to Fettke and Loos, in the following, there is a need to define the criteria of the reference architecture based on the natural language, analytical and feature-based evaluation (Fettke and Loos, 2003, p. 7).

7.3.1 Requirements for the reference architecture NICEL

Evaluation Requirements 1 (E-RQ1): Project requirements and versioning

The research shows that unclear project goals or lack of documentation of project goals and the inadequately described requirements are the most common causes of project failure (Rietiker, Scheurer, & Wald, 2013, pp. 33–39).

The experts also confirmed this in the interviews. In addition, it was noted that when requirements were changed, there was often insufficient versioning of the new requirements, resulting in poor handling within change management.

Evaluation Requirements 2 (E-RQ2): Communication within the project and with stakeholders

The experts also frequently called for more efficient communication among the project participants and stakeholders who are not directly involved in the project operations. Missing documentation on processes in the project or project KPIs, which are necessary for project reporting, are also included in this point.

Evaluation Requirements 3 (E-RQ3): Store, categorize and distribute project knowledge

Because knowledge management methods are often lacking or inadequate, employees' experience is often relied upon. The risk is that their experience can no longer be drawn upon due to dismissal or retirement. Therefore, there is a requirement to design a socio-technical system to eliminate or minimize these risks.

Evaluation Requirements 4 (E-RQ4): Increase project quality

Quality assurance proves and documents the defined quality requirements for the delivery object of a project. Although many test strategies exist, error conditions must be eliminated at great expense. Continuous monitoring in the phases before testing would help minimize the error rate.

Evaluation Requirements 5 (E-RQ5): Cost management and project financing

Another requirement mentioned by the experts was the adequate estimation and management of project costs and financing. Along with often unclear goals, as already described in the first requirement, these can impact the ongoing project costs. The financing of many external service providers can also become a challenge for the project.

Evaluation Requirements 6 (E-RQ6): Recipient-oriented reporting

The experts criticized the fact that reporting to different groups of recipients was not always appropriate. Since many stakeholders in the projects may have other interests, different types of reports should be prepared to address the information with the respective focal points in a way that is appropriate for the recipient. In practice, however, this is considered costly and time-consuming, so there are only one or two types of reports for all stakeholder groups.

Evaluation Requirements 7 (E-RQ7): Simplify project planning and project control

Especially in complex and unclear projects, project planning and control play a unique role. Thereby dependencies within the project and other projects can arise, which must be considered. Also, to be identified are projects which serve as prerequisites to be able to start the own project. Another requirement of the experts is establishing a system to support the project manager.

Evaluation Requirements 8 (E-RQ8): Simplified management of risks and risk mitigation

This requirement stems from the need in a project to appropriately identify and address the risks and the subsequent risk treatment. Identifying and analyzing risks are the first two steps in the process, followed by assessing the risk. This often relies purely on empirical data from employees. This applies to the quantifiable approach to the impact of the risk and its probability of occurrence. Also, the experience validation of the risk and the risk treatment is often neglected.

Evaluation Requirements 9 (E-RQ9): More effective use of external service providers

The experts also named requirements for efficient commissioning, management, and coordination during the ongoing project with one or more external service providers. More efficient handling of external service providers is necessary for successful project completion. Frequently, the scope of services leads to misunderstandings or misinterpreted project requirements and, thus, to incorrect project results.

Evaluation Requirements 10 (E-RQ10): Better estimations in terms of effort and resources

Depending on the size and complexity of the project, it is increasingly difficult to estimate the effort and time required to create the corresponding project plans. This would be supported by a system that, based on a large number of similar projects from the past, makes it possible to propose appropriate values and adapt them to the project to ensure a more accurate estimate of the effort and duration of the project.

7.3.2 Results of the analytical evaluation

In this chapter, the requirements from chapter 5 are taken up and evaluated based on the reference model. The aim is to determine whether the reference model can provide efficient support for the requirements specified by the experts. The evaluation of the degree of fulfillment of the requirements is made argumentatively.

Evaluation Requirements 1 (E-RQ1): Project requirements and versioning

In the DIN 69901-2 project management process, evaluation requirement 1 (E-RQ1) relates to the processes Outline objectives I.11.1, Define objectives D.11.1, and Delimit objectives and project content D.11.2, which are now being examined concerning the use of AI methods, the knowledge management process and from the perspective of the stakeholders. All in all, these processes are supported by a total of five AI methods. Data An alytics, Text Extraction, Decision Making, Relationship Learning, and Knowledge Refinement can make the process more efficient. These processes are flanked by the knowledge management components of knowledge objectives, acquisition, development, utilization, and assessment. The project manager, the project team, and possible external service suppliers are primarily operationally familiar with this process from the stakeholder perspective. This combination of the three views and the use of socio-technical systems makes it possible to efficiently support requirement one by the experts' statements.

Evaluation Requirements 2 (E-RQ2): Communication within the project and with stakeholders

All knowledge management modules can be used for these project management processes and thus support the project. Requirement two is related to the DIN 69901-2 processes Determine information, communication, and reporting D.3.1, Plan information, communication, reporting and documentation P.3.1, Control information, communication, reporting and documentation S.3.1, Create project final report A.3.1 and Planning project organization P.5.1. Ten artificial intelligence methods can support these. In particular, Text Extraction and Knowledge Refinement can support these processes to a considerable extent. In conjunction with knowledge management, these two methods also provide additional support. This also impacts the possible applications of the knowledge building blocks.

Evaluation Requirements 3 (E-RQ3): Store, categorize and distribute project knowledge

Securing categorization, as well as the processing of knowledge within a project, extends across all project management phases. Therefore, a consistent application of the building blocks of knowledge management can lead to more efficient project processes. Considering the eight knowledge building blocks, the Knowledge objectives building block can support 31 processes (53% of all DIN 69901-2 processes), the Knowledge identification building block can support seven processes (12% of all DIN 69901-2 processes), the Knowledge acquisition building block can support 44 processes (75% of all DIN 69901-2 processes), the Knowledge development building block can support 40 processes (68% of all DIN 69901-2 processes), the module Knowledge distribution eight processes (14% of all DIN 69901-2 processes), the module Knowledge utilization 52 processes (88% of all DIN 69901-2 processes), the module Knowledge retention eight processes (14% of all DIN 69901-2 processes) and the module Knowledge assessment 46 processes (78% of all DIN 69901-2 processes).

The top three artificial intelligence methods can support these knowledge management building blocks. These are Knowledge Refinement, Text Extraction, and Data Analytics.

Evaluation Requirements 4 (E-RQ4): Increase project quality

Evaluation Requirement 4 (E-RQ4) relates to the project management processes define success criteria D.6.1, plan quality assurance P.6.1, and ensure quality S.6.1. These are located in the area of project phase quality and can be supported by seven artificial intelligence methods. Decision Making and Problem Solving are the preferred methods in this context, along with Text Extraction and Knowledge Refinement.

Combined with the seven building blocks of knowledge management and the clear responsibility of the project manager in connection with the operational implementation by the internal and external team members, these measures and technologies can contribute to the quality of the projects at a high level.

Evaluation Requirements 5 (E-RQ5): Cost management and project financing

Requirement 5 is related to the processes Roughly estimate effort D.4.1, Create cost and budget plan P.4.1, Control costs and financial resources S.4.1, and Create post calculation A.4.1 are the project manager's responsibilities from a stakeholder perspective. The Sponsor and Steering Board are informed, and the Project Team is consulted for effort estimates. On the AI side, the processes can be supported with seven methods. Data Analytics, Relationship Learning, and Decision Making are some of them and can suggest decision paths considering dependencies.

Evaluation Requirements 6 (E-RQ6): Recipient-oriented reporting

This evaluation requirement is similar to requirement two but with the distinction that this is pure reporting and not face-to-face meetings. When reporting to the respective stakeholders and stakeholder groups, the relevant key figures and information should be coordinated for the recipients. In this regard, superfluous and unhelpful information only burdens recipient-oriented reporting. Ten artificial intelligence methods can support this requirement.

With the methods of Speech recognition, Communication, and Control, it is also possible to communicate via chatbots and share, store and retrieve information when needed. From a knowledge management perspective, all the building blocks can be used for this requirement, as it fills the entire spectrum of information provision. From a stakeholder perspective, all the stakeholder roles already presented can also be considered here, as this describes the purpose of recipient-oriented reporting.

Evaluation Requirements 7 (E-RQ7): Simplify project planning and project control

Evaluation requirement seven (E-RQ7) relates to the two project management phases of planning and controlling and the requirement for an easier way to plan and execute a project. In principle, various factors such as the size of the project, its complexity, or interdisciplinary approaches depend on how and with what effort project plans can be generated.

However, this also offers the possibility of using methods of artificial intelligence to a particular extent for this purpose. There are 15 methods of AI to

support the 31 processes in the phases. Data Analytics, Text Extraction, Problem Solving, Relationship Learning, and Knowledge Refinement are among the most common support methods. Also, with a view to the stakeholder structures, all stakeholder roles are used here. Transparent distribution of responsibilities can help to structure planning and control options more clearly and ultimately reduce complexities.

Evaluation Requirements 8 (E-RQ8): Simplified management of risks and risk mitigation

This evaluation requirement affects the following processes in DIN 69901-2: In the definition phase, determine how to deal with risks D.8.1, Analyze project environment/stakeholders D.8.2 and Evaluate feasibility D.8.3. In the planning phase, the two processes Analyze risks P.8.1 and Plan countermeasures to risks P.8.2, and in the control phase, the process Control risk S.8.1. These processes can be supported by eight artificial intelligence methods. Data Analytics, Problem Solving, Relationship Learning, and Predictive Inference are some supporting methods. In addition, the stakeholder matrix helps distribute the risk management responsibility. The project manager is responsible for risk planning, with operational support from the project team. The steering board and the project sponsor are only informed but must also make decisions in the final instance in the event of escalation.

From a knowledge management perspective, the building blocks of knowledge objectives, knowledge acquisition, knowledge development, knowledge distribution, knowledge utilization, and knowledge assessment can be used. Risk planning can be carried out more efficiently and clearly from the combinations of the methods presented.

Evaluation Requirements 9 (E-RQ9): More effective use of external service providers

The evaluation requirements nine (E-RQ9) concern the project management phase Contracts and Subsequent Receivables and contain the processes Define handling of contracts D.10.1, Determine contract content with customers D.10.2, Determine contract content with suppliers P.10.1, Handle contracts with customers and suppliers S.10.1, Control additional receivables S.10.2 and End contracts A.10.1. These processes can be supported by eight methods from an AI perspective. Knowledge Refinement and Text Extraction methods play a predominant role since these can be used with most processes.In this respect, the distribution of roles and the question of who bears operational responsibility for these processes are evident. The project manager is responsible for planning and operations and informs the remaining project members. Depending on the situation, the Steering Board or the Project Team can also assist the Project Manager in a consultative capacity.

Evaluation Requirements 10 (E-RQ10): Better estimations in terms of effort and resources

The following six processes can be assigned to evaluation requirement ten (E-RQ10). In the definition phase, this is the process Roughly estimate effort D.4.1; in the planning phase, it is the processes Create schedule P.1.2 and Create cost and budget plan P.4.1; in the controlling phase, it is the process Control costs and financial resources S.4.1, and in the project completion phase it is the process Create post calculation A.4.1. From the perspective of artificial intelligence, these processes can be supported by eight methods. In order to identify any dependencies, the Relationship Learning method, in combination with the Data Analytics, Text Extraction, and Planning methods, is a good choice.

From a stakeholder perspective, it is the task of the project manager to estimate the effort and resource usage as best as possible. However, depending on the project's complexity, this can only be done with the support of the project team, the external service supplier, and the steering board, with the involvement of the project sponsor. Valuable parameters can also be derived here from a knowledge management perspective if historically comparable projects are made retrievable with the help of knowledge databases. For this purpose, the entire spectrum of knowledge management is used to create a process-based closed loop with the help of knowledge-building blocks. These methods, processes, and systems perform more valid estimates.

7.4 Focus group discussion on evaluation

Three experts assess the reference model as a second form of evaluation. These three experts were not previously interviewed in the expert panel in chapter 5.3 and are independent and can be considered unencumbered by the previous results and investigations. According to Wengraf, expert interviews can be used on the one hand, exploratively for deriving own research hypotheses (model-building) and on the other hand, for testing theories (model-testing) (Wengraf, 2011, p. 51). In this dissertation, the interviews are used for testing theories. In this case, for the application of the reference architecture.

The experts' goal is to review the reference architecture as a theory combined with the critical question of whether the reference architecture can efficiently support IT project management. The experts will, therefore, not disclose any information about themselves in the following, but rather the assessment of the reference architecture in this case (Lauth, Pickel, & Pickel, 2015, p. 178). The reference model was presented to the experts in person, and detailed questions were answered. Subsequently, the actual evaluation was carried out with all three experts simultaneously. This differs from the classic expert interviews in that they are conducted individually and are therefore not subject to any influence from other experts.

7.4.1 Procedure Focus group discussion

To answer the task explained in the previous chapter, the three experts need a deeper understanding and practical experience in the areas of knowledge management and IT project management, including dealing with stakeholders up to C-level and artificial intelligence methods. The experts are introduced below.

Expert A (KM): Currently responsible department manager of a consulting company with many years of experience developing company knowledge management. Also, technological expertise, especially in automation and artificial intelligence.

Expert B (PM): Currently co-managing director of one of the largest grocery retailers in Europe with project management experience from several decades in various roles. Due to their IT-heavy experience, he is also very experienced in

business process automation. Projects span across SAP, digitalization, and restructuring projects at the group level and the local companies within the group structure.

Expert C (AI): Currently division manager of an audit service provider for technical innovations. Years of experience in providing solutions using Artificial Intelligence. In addition, head of test laboratories to develop new solution approaches in the field of AI for own company as well as for customers.

The reference architecture can be evaluated from different perspectives due to the different focuses of the experts. Unification on the one hand and different views of the same architecture on the other.

The experts' statements refer to the exact requirements as in chapter 6.3.1. In addition, the artifacts of chapter 5.8 are assessed. The analysis technique of scaling structuring is used. In this form, scale points, presented below, are defined, and the material is assessed on this basis (Mayring, 2015, p. 99).

The experts evaluate using one of these assessment dimensions as an answer. Only these answers are used in this work. The agreement expressions are now defined and described as follows.

Table 7-1: Agreement expressions of the expert´s statements

Code	Expression of agreement	Definition
A1	Full agreement	The requirement was completely fulfilled
A2	Consent with reservation	The requirement is fulfilled under certain conditions or not completely fulfilled in certain subareas.
A3	Rejection	The requirement was not completely fulfilled
A4	No evaluation possible	No statement possible from the expert

The agreement expressions result from iterative processes, whereby the analyses were run several times, and adjustments were made.

7.4.2 Results of the focus group discussion

In this chapter, the responses of the three experts are presented in a visualized form. The two diagrams show the degree of agreement achieved by each expert and the overall degree of agreement achieved by all experts. Each requirement from Section 6.3.1has been adopted for standardization and is listed. The color coding is explained below.

- A1 Full agreement
- A2 Consent with reservation
- A3 Rejection
- A4 No evaluation possible

Table 7-2: Results of the focus group discussion

Expert	**E-RQ1**	**E-RQ2**	**E-RQ3**	**E-RQ4**	**E-RQ5**	**E-RQ6**	**E-RQ7**	**E-RQ8**	**E-RQ9**	**E-RQ10**
A KM)	A1	A1	A1	A1	A2	A2	A1	A1	A1	A1
B (PM)	A1	A1	A1	A1	A1	A2	A1	A1	A1	A1
C (AI)	A1	A1	A1	A1	A2	A1	A1	A1	A2	A1

The analysis clearly shows that most requirements are met completely (A1) or at least with restrictions (A2). The limitations A2 for expert A (KM) in E-RQ5 refer to the fact that knowledge management can support this, but other factors are more decisive for managing costs in a project. The limited agreement of the same expert for E-RQ6 refers to the same reasoning as E-RQ5. Although the basis for recipient-oriented reporting can be building blocks of knowledge management, the technical implementation also plays at least as important a role here.

The limited agreement of expert B (PM) with requirement E-RQ6 refers to the fact that there are concepts in the area of project management regarding recipient-oriented reporting, but similar to the limitation of expert A (KM), the technical

implementation is perceived as more important because otherwise, the manual effort is too great. Expert C's (AI) limitations for E-RQ5 are because cost and project financing can already be monitored so well today that the use of artificial intelligence methods should be decided on a project-by-project basis. The more complex the cost structures in the form of profit centers or cost centers used, the more suitable such forms of AI are for support. However, statistical analysis methods such as time series analysis would often suffice to control and manage costs. The second limitation of Expert C (AI) for requirement E-RQ9 is that the effectiveness of external service providers tends to be one of the classic management tasks of the project manager. It is difficult for an AI to control external resources because the tasks and problems can be too different from establishing this as a routine task by an AI.

The analysis confirms that 83% of the responses are without qualification (A1) on the usefulness of the reference model concerning the ten requirements. Only 17% gave their consent with reservations. All experts could evaluate the questions so that there was no answer option A4. Likewise, no expert completely doubted the improvement (A3).

In this chapter, the evaluation of the reference model was carried out. The first step evaluated the ten requirements analytically and in natural language. As an additional supplement, three experts were asked how they assessed the reference architecture in the second step. For this purpose, a category system was created, and the three experts also evaluated the ten requirements for the reference model. The results of the experts' evaluation show that the reference model can support IT projects efficiently. This means that a high level of usefulness and confirmation of the recommendation character can be assumed.

8 Conclusion

In this final chapter, the results of this dissertation are recapitulated. The results that emerge from chapter 5.3 and the creation of a reference architecture in chapter 5.4 are intended to answer the research questions from chapter 5. Subsequently, the implications of the results for practice and research are presented in chapter 7.2. A limitation is given in chapter 7.3. Finally, chapter 7.4 presents an outlook on further research possibilities based on these results.

8.1 Summary

This research work's goal was to conceive and generate a reference model that efficiently supports IT project planning and control. The target groups for the reference model are primarily the stakeholder groups that classically occur in IT projects. The development work was intended to promote the cooperation of all stakeholders involved using a simple representation, easy comprehensibility, and usefulness. From this objective, the research hypotheses and the extended research questions were derived and are answered as follows.

Research hypothesis 1 (H_1): Artificial intelligence, combined with knowledge management, can significantly improve planning and control for IT project management.

As already discussed in the similarly formulated Research Questions 1 (RQ1), Research Question 8 (RQ8), and Research Question 9 (RQ9), the experts from the interviews in Section 7.1.4.2.1 definitely see a monetary added value in using AI in combination with knowledge management in IT projects. The only restriction was that the companies would also have to use these methods. Many companies are not yet that far advanced in their development.

Concerning these research hypotheses 1 (H1), the reference model was also rated by the evaluation experts as applicable without any restrictions in the evaluation with Evaluation Requirements 4 (E-RQ4: Increase project quality), Evaluation Requirements 7 (E-RQ7: Simplify project planning and project control) and Evaluation Requirements 10 (E-RQ10: Better estimations in terms of effort and resources). The agreements with limitations made by the evaluation experts on the usefulness of the reference model were related to the effective use of external

service providers (E-RQ9), the simplification of cost management and project financing (E-RQ6), and beneficiary-oriented reporting (E-RQ5). The fact that the research question (RQ1) and the evaluation of the reference model, which aims to significantly improve IT projects with the help of AI and knowledge management, were evaluated positively leads to the conclusion that research hypothesis 1 (H1) can also be evaluated positively and does not need to be rejected.

Research hypothesis 2 (H_2): The methods are mature enough to produce high-quality results so that the role of the human will be only that of a decision maker who receives the alternative suggestions from the artificial intelligence and the knowledge management system in the manner of a decision support system.

The answer to this research hypothesis 2 (H_2) cannot be directly answered positively since the interview experts and the evaluation experts did not clearly answer this. However, derived from the answers to research question 4 (RQ4), AI should suggest corrections in ongoing projects. The evaluation experts, especially expert C (AI), who specializes in AI methods, also did not indicate the evaluation questions (E-RQ1 to E-RQ10) that technical implementation would not be possible. Evaluation Expert A (KM) answered eight out of ten evaluation questions without any restrictions.

Only two positive answers had rather organizational restrictions, but none impacted the overall result. An additional indication that AI methods are mature enough to make suggestions in certain situations is that in the reference model, the AI method Decision Making was mentioned 36 times, and the AI method Problem Solving was mentioned 13 times. Accordingly, it can be concluded from the answers that the current AI and knowledge management methods are mature enough to increase efficiency in IT projects, even if the experts did not explicitly state this.

Research hypothesis 3 (H_3): The artificial intelligence and knowledge management solutions are able to improve the communication between the relevant stakeholders due to using the knowledge management-based methods.

The AI method of Communication was mentioned five times in the reference model. In addition, research question 10 (RQ10) explicitly asked whether AI

methods can cause an improvement in projects. Here, the interviewed experts agreed that this was the case. Although the focus was seen differently in some cases, e.g., in the form that collaborative work is simplified or the quality of communication is improved, all experts rated the question positively.

Likewise, evaluation requirement 2 (RQ2) Communication within the project and with stakeholders) was positively evaluated by all evaluation experts without any restrictions. The corresponding view of the stakeholders on the project management processes in the reference model also leads to improved communication in an IT project. Therefore, research hypothesis 3 (H_3) can be answered positively and does not have to be rejected.

Research hypothesis 4 (H_4): Using artificial intelligence and knowledge management solutions will support decisions in IT Project Portfolio Management, which are based on data driven proposals.

Research question 7 (RQ7) asks whether AI methods can also recognize and display dependencies between different projects. This was answered positively across the board by the interview experts. The only restriction was that this depended on the information provided to the AI system. Research question 5 (RQ5) asked whether AI methods can propose projects in a portfolio that supports the business strategy and the company vision. This was also answered positively by the experts. Limitations were also found here concerning the data basis and corresponding criteria, which would have to be completely available.

Accordingly, this research hypothesis (H4) can also be confirmed and must not be rejected. This dissertation aimed to develop a reference model that uses artificial intelligence and knowledge management methods to efficiently improve IT project planning and control. For this purpose, different methods were used to investigate the research questions. In addition to the expert interviews, other experts were interviewed to evaluate the reference model to answer the research hypotheses. For research hypotheses H_1, H_3, and H_4, these can be answered positively and do not need to be rejected. The research hypothesis H_2 can also be answered positively, provided that the answers of the interview and evaluation experts are derived and applied to the research hypothesis H_2.

8.2 Implication for practice and research

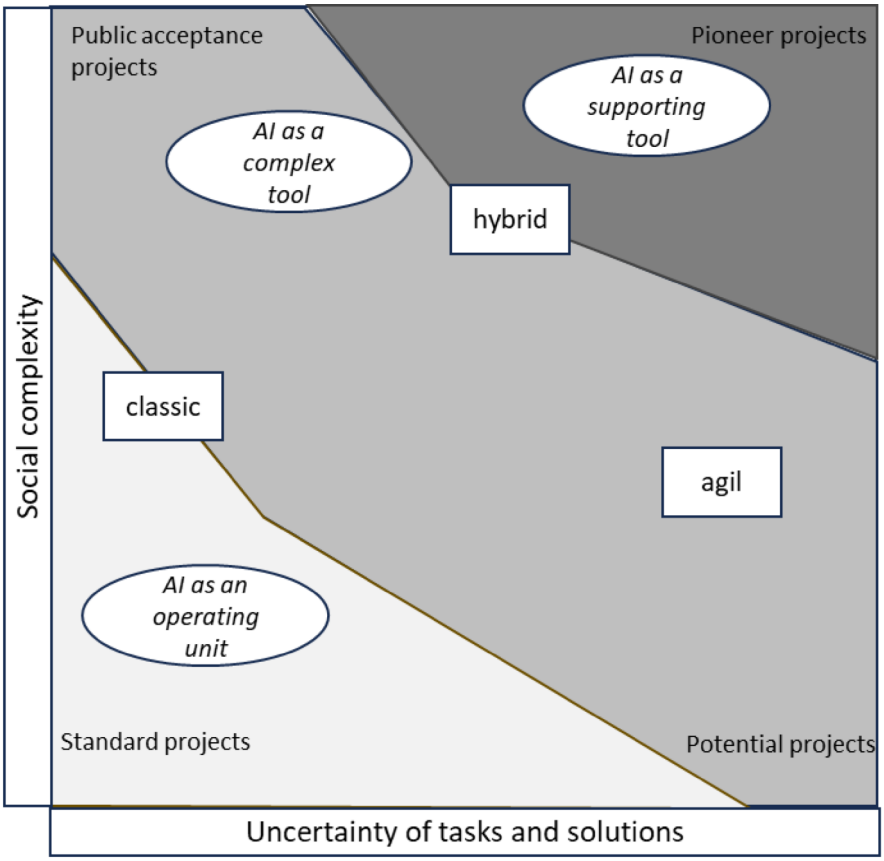
The theoretical contribution essentially comprises creating a reference model with different views on the DIN 69901-2 to use artificial intelligence methods and knowledge management to improve IT projects efficiently. For clarification, the individual phases of the project management process for artificial intelligence and knowledge management methods were presented transparently. This ensures that the flow processes are appropriately presented for the recipient. Each process in project management is assigned to one or more artificial intelligence methods that support this process. From the knowledge management point of view, the building blocks were also assigned to each process of DIN 69901-2 according to their usefulness. This has also been created clearly for each phase of project management. Since projects often have many stakeholders, a representation of each phase has also been generated for each stakeholder or stakeholder group. This also serves the clear and transparent form from the stakeholder's point of view for each individual project management process.

From the point of view of practical benefits, it can be added again that the success of IT projects in companies has a competitive factor. In addition, there is also agreement in companies that knowledge management is a critical factor in project management. However, due to various factors, handling knowledge in IT departments and, thus, in IT projects is complex. This work enables experienced project managers to manage projects more efficiently using the different views of the reference model and prospective project managers. However, the reference model also forms the basis for the decision to combine methods of artificial intelligence with knowledge management methods and introduce them into an organization. The respective functional managers can easily read and interpret the different transparent views.

In addition, it allows scalable and modular implementation, which has the advantage that not every method has to be implemented directly. Furthermore, data-based project planning and project control can be used to better evaluate and explore project progress and identify improvements (Le Rode, Svejvig, & Martinsuo, 2022). Nevertheless, the use of AI in IT projects is not always identical as far as the use of AI is concerned. According to Barth and Sarstedt, various parameters can be used to show the extent to which AI can provide support (Barth and Sarstedt, 2024). The Stacey Matrix serves as the basis for this categorization, with the axis designations relating to the ambiguity of tasks and solutions and social complexity (Stacey, Griffin, & Shaw, 2000). Based on this, the parameters can

be sorted according to their dependency. AI solutions can be viewed as an operating unit as long as it is more a matter of classic project management. Figure 8-1 illustrates the categorization of AI.

Figure 8-1: Categorization of AI in PM context



Note: Adapted from Barth and Sarstedt (2024)

With a relatively clear objective and solution path and high social complexity, AI can be used as a complex tool, as AI cannot take over the proportion of social exchange between people. This is where human protagonists are needed.

However, as soon as the tasks and the solution path are not transparent, it is advisable to use AI as a supporting tool. This can make perfect sense for pioneering projects. Consequently, the extent to which AI methods can be used without

jeopardizing the project goals depends on the requirements of a specific project. Ultimately, AI also relieves the project manager of work but must be aware of its possibilities and limitations.

8.3 Limitation

This dissertation developed a reference model for more efficient planning and control using methods of artificial intelligence and knowledge management for IT projects. DIN 69901-2 was used as a basis, and the corresponding views on it were developed. The reference model was created and evaluated with the help of requirements formulated by experts. The developed reference model is only one possible way of development. No statement can be made about whether it is the best possible reference model since other solutions are also conceivable. Another limitation is efficiency.

This work has consciously renounced a monetary complete cost calculation since this would show no generic values. This is because every organization is at a different technical level. Basically, there are also limitations to be mentioned, which also apply to this result in the run-up to project management. Why traditional techniques of project management continue to be presented in the prescriptive literature when they are so rarely used in practice (Green and Dikmen, 2022).

The potential applications of AR technologies have not been explored in this dissertation, as they do not fall into the category of artificial intelligence. However, this technology should not be forgotten, as future mobile and wearable computing technologies with an augmented reality (AR) interface will provide a ubiquitous, environmentally appropriate, and everyday reality augmentation. This new ubiquitous AR technology will lead to a continuous moderation of experienced reality that has the potential to support better and faster decision making, exploration of new information, and new ways of communicating, interacting, and collaborating (Regenbrecht, Zwanenburg, & Langlotz, 2022).

Furthermore, it depends very much on the nature of the projects and whether a purely monetary advantage would arise. The fundamental obstacles have already been discussed in detail in the expert interviews. A practical application has not yet been tested in ongoing project operations.

8.4 Outlook

The modular structure of the views within the reference model makes it a suitable basis for a variety of possibilities for further research. The rapid change in the various forms of project management will continue. The pressure on companies to complete IT projects in the required time while maintaining costs and quality will also increase. According to a published analysis by the Statista research department, the market for artificial intelligence is expected to grow to a turnover of 31.2 million US dollars by 2025. This corresponds to an increase of 1,014% compared to the 2.8 million dollars in 2019. With the rapid development of increasingly powerful and cost-effective IT components, there are more AI automation opportunities in this area.

On the other hand, it is becoming increasingly difficult to capture, appropriately use and process information and knowledge in such large and up-to-date quantities. The management of information and knowledge in organizations and IT projects will therefore become increasingly important. Here, too, there will be further developments that need to be researched. Particularly in the development of AI process chains on this topic or the operationalization of the reference architecture and the resulting change management approaches. Organizational influences and changes must also be considered, and their effects researched. In addition to the technical factors in dealing with AI, knowledge management and IT projects, questions in the area of applied law, in particular data protection and data security as well as ethics, also need to be investigated.

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