

Dealing with complex project management

A multidimensional approach

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ABSTRACT

Project failure occurs due to several reasons, but complexity and underestimation of complexity can be the cause often. Because of the interdisciplinary character of projects, it seems that project management approaches are not sufficient to deal with the complexity of projects. Therefore the interdisciplinary aspect, has to be considered and managed appropriately, which brings us to the following research question is: "How can project managers combine tools and techniques from project management approaches and discipline oriented approaches, for managing multidimensional complex projects successfully?" First a number of management approaches are selected and classified, so that it becomes clear what the focus and methods are behind the approach. Expert interviews provided that the project management approach score weak in dealing with actors, support tools and involving the context elements of a project, while other management approaches score better. The techniques of these management approaches are presented to enhance the project management approach for dealing with complex projects.

Keywords: *Project Management, Complexity, Management Approaches, Frameworks, Expert Interviews*

1. INTRODUCTION

Project failures in terms of cost overrun and time delays occur frequently and are being investigated for a long time now (Flyvbjerg et al. 2003). The reasons that are given for project failure are the increasing complexity of projects (Williams 2005) and the underestimation of project complexity. Different factors can be the cause of complexity, e.g. the number of stakeholders, risks, uncertainties, dynamic conditions, new technologies or combinations of these factors. This means that project complexity can be influenced from different dimensions, which makes it difficult to assess projects adequately. Several specific project management approaches are available, but this might no longer be sufficient to deal with the complexity as projects become increasingly interdisciplinary. The influence of actors, support systems and different contexts play a greater role for

managing projects successfully. The problem that can occur is that a specific project management approach does not take all factors that can make a project complex into account. These factors have to be considered and managed adequately within projects, which means that project management approaches possibly should be combined with other management approaches, e.g. for quality improvement, process design, software development and systems engineering.

This can mean that if techniques from other management approaches are combined to enhance specific project management approaches for dealing with complexity factors, project failures can be reduced. Several management approaches are available, but their purpose and methodology is different. This research makes a distinction of a specific project management approach, where the term project means a planned

set of interrelated tasks that will be executed over a fixed period and within certain cost and other limitations (business dictionary 2011). On the other hand there are management approaches, also defined as discipline oriented approaches, for actor negotiations, software development or quality improvement.

The goal of this study is to present techniques about how specific project management approaches and other approaches can be combined for managing projects successfully. The underlying research is based on the following question: "How can project managers successfully combine tools and techniques from project management approaches and discipline oriented approaches for managing multidimensional complex projects?"

In order to gather the required information that is needed to answer the research question, several steps have to be conducted. First a framework is presented that is created to classify information systems development approaches, but is suitable to compare and classify the selected management approaches. The classification of the different management approaches is needed to understand and identify differences between them. Next, the term complexity needs to be elaborated and explored on frameworks that can help to assess complexity of projects.

Further information needs to be gathered on how the management approaches deals with complexity. Therefore expert interviews are conducted, where experts are asked to which extent the management approaches can deal with complexity elements. The insights provide possible starting points for enhancements for project management.

The general approach that is used for this research is the Grounded Theory method, which can be defined as theory that is derived from systematically collected and analyzed data during the research process (Strauss et al., 1998). This approach is particularly chosen because data is collected and synchronized through several steps and viewpoints.

The structure of the paper is derived from the steps that are taken to conduct the research. Section 2 contains a comparative analysis of the selected approaches and is based on a literature study. The selected approaches are presented, followed by a comparison model and the results that were achieved from the comparison. Section 3, elaborates on the term complexity and two frameworks that are created for assessing complexity are presented. In the following section, the expert interviews are presented. First a list of experts is presented, followed by the structure of the interview, which is based on a chosen framework of section 2.

The results are analyzed in section 5, where is discussed how the approaches score on the complexity elements of the chosen framework. This provides the basis for possible combinations of techniques to enhance project management and is presented in section 6. Conclusively, the paper ends with a discussion and suggestions for further research.

2. A COMPARATIVE ANALYSIS

This section includes a comparative analysis of different management approaches. First a list of approaches that are selected for this research are presented, followed by the five ways model, which is originally a framework for information systems development. In this research however, it is used for comparing and classifying the selected management approaches.

2.1 List of selected approaches

First a random selection is made out of available management approaches, consisting minimally of one explicit project management approach and other discipline oriented approaches. The selection is based on a sample of available approaches, where the time constraints of the research, the availability of experts during the research period and the aim for a balanced mix of approaches from different disciplines, have been taken into account. The selected approaches are listed in table 1.

Table 1. List of Selected Approaches

Quality Improvement	Actor Management	Software Development	Systems Modeling
PMBOK (PMI 2004)	Process Management (De Bruijn et al. 2010)	Waterfall Approach (Sommerville 2000)	Systems Engineering (NASA 2007)
Lean Six Sigma (SigmaPro 2011)	Collaboration Engineering (Kofschoten et al. 2006)	Agile Development (Agile alliance 2011)	System Dynamics (SD Society 2011)

The Project Management Body of Knowledge (PMBOK) is the only explicit approach here. The other approaches are focused on other areas, e.g. process improvements, actor negotiation processes, software development and systems modeling. Although the different purposes are known, it is necessary to find out what the deeper differences are in terms of the philosophies behind the approaches and what steps there are taken in every approach. This is needed to identify what the possible strengths of the approaches are and possible starting points for combinations. But to conduct this comparison, in the following paragraph a model is presented that was originally created for information systems development.

2.2 The Five Ways Model

When information systems are developed, the problem that developers come across is that the development is too complex to handle it straight forward. This complexity can be dealt with by using a model that can classify the different aspects of the development and focus to one certain aspect. The theory of Seligmann (1989) provides a structured way to look at information systems development processes. This theory contains a framework, where five important parts of a development approach are described, consisting of a way of thinking, a way of working, a way of modeling, a way of supporting and a way of controlling. The elaboration of the five

ways is presented in the next sections and is supported with some elaborations of another research (Wijers 1991).

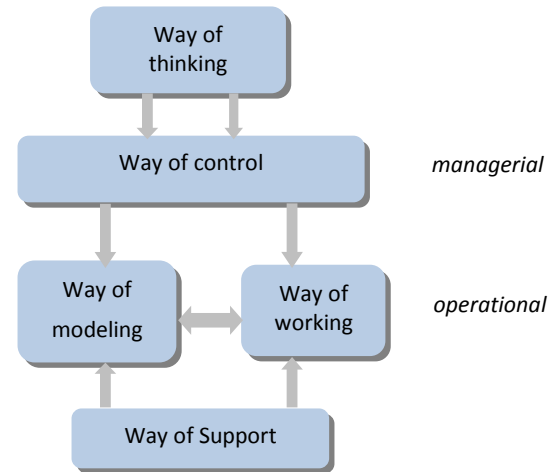


Figure 1 The Five Ways Model

Way of thinking

According to Sol (1983), for really understanding a development approach or methodology, it is important to look at the way of thinking or the philosophy behind the approach. The way of thinking forms the basis for the important features that are considered for the processes that take place and the methodologies that are used. The basic assumptions and viewpoints of the method are described, including their relationship with the environment and components.

Way of control

The way of control consists of the managerial point of view of the approach. The project management elements, such as the control of time, costs and quality within the scope stand central here. The way of control comprises means that an approach offers at managerial level. Controlling an information systems development consist of dividing the project in a logical sequence and parts, defining a project organization which includes the involvement of stakeholders and internal resources. Furthermore it is important to denote points were decisions and controls are necessary. The way of modeling and the way of working depend

on the way of control, because they are both driven from the way of control.

Way of modeling

The way of modeling encapsulates the model concepts that are used and a description of the relations that it consists of. For example, in the development of information systems, there are many different aspects and interrelated problem areas that have to be dealt with. Therefore a series of models are needed to represent all the aspects of the development process, which is defined by the way of modeling. The models that are used can represent parts of the reality, organization or business systems, information systems or stages of the process. Specifically mentioned the way of modeling describes (Wijers & Heijes 1990) the models and their relationships and the elements and their relationships. Some development methodologies present models with a clear elaboration on how to construct or verify a product, while other offers practical propositions for obtaining a model.

Way of working

This part describes the tasks that have to be carried out for developing an information system. Subtasks are distinguished, arranged and described how they should carried out. The ways products are developed or constructed are presented in the way of working. Further it presents guidelines for creating and working on the operational level. Besides this, it offers a means of describing the structure of the work that have to be carried out, including tasks and definitions at the operational level, procedures and informal indications.

Way of Support

The way of support describes the tools that are needed to support the way of working, the way of modeling and the way of controlling in the best possible way. It can consist of simple templates, charts, but also computer aided software engineering (CASE) tools (Hoffer et al. 2002). Here it must be taken into

account that the usefulness of the tools is related to the level in which the way of support is integrated with the other ways.

2.3 Comparison outcomes

The complete table with comparison outcomes can be found in appendix 1, but here important findings are stated. When we look at the way of thinking, or the philosophy of the approach, there is only one explicit project management approach, the PMBOK. Lean Six Sigma has the goal of improving quality and reducing waste from an organization, so it can be seen as a quality improvement approach rather than a project management approach. The way of control is both approaches are based on clearly defined roles and responsibilities. PMBOK thrives on process flow diagrams that have to be followed for completing the tasks within each knowledge box successfully, while Lean Six Sigma is based on design principles.

Process Management and Collaboration Engineering are clearly focused on the management of actors, their stakes and solving conflicts between them. Process Management specifies how a negotiation process between actors can be shaped on basis of 4 principles, while collaboration engineering focuses on reaching a joint group goal and is supported by electronic tools. This could mean that in situations where a group of actors play a role; these two approaches can be helpful to manage their involvement.

The waterfall approach and Agile Development were developed for software engineering. They differ largely in the sense of way of working, because the waterfall approach is based on a linear way of working while Agile Development is based on an iterative way of working. Both methods can be useful, the waterfall approach in situations where all requirements are clear from the beginning and Agile Development when uncertainties exist and rapid changes and input of the team is required.

Systems engineering is based on balancing the requirements that are derived from the context, so that the design consist of all possible requirements. System dynamics is a modeling approach for understanding the behavior of systems. Both methods take the context into account.

Further it is remarkable that nearly every approach is supported by tools, mostly in terms of information systems or software. The most important conclusion of the comparison is that PMBOK is the only project management approach here and the enhancements will be focused on this approach.

3. PROJECT COMPLEXITY

First, the term complexity is discussed, because it is clear that different factors can make a project complex and project management approaches have to deal with this complexity. Next, two complexity assessment frameworks are presented as a result of research on this area. These frameworks are not linked with a management approach in this stage.

3.1 Complexity

Some interesting definitions and key aspects of project complexity that are found in project management literature give an indication of the way complexity could be treated. However, it was clear that no well-defined framework that could be used to analyze and systematically describe the key dimensions and characteristics of project complexity. The need for a complexity assessment was clear, as this could help managers to analyze and respond to the practical project complexities. The certain characteristics of different projects are needed to determine the specific actions that can be taken to manage them successfully. Baccarini (1996) states that organizational, technological and informational complexity are such project dimensions and proposed that project complexity can be measured in terms of differentiation and interdependencies. Some projects are complex because of many stakeholders involved, while others are complex because unproven technologies are experimented or dynamic conditions are taken into account. The definition of complexity by Mickulecky (2008) followed the idea that every complex thing is different from another viewpoint. He stated that "complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties". This definition makes it clear that

complex systems can be studied from multiple disciplinary perspectives and can be different for the purpose it serves. Therefore two totally different frameworks that can help to assess project complexity are presented in the next paragraph.

3.2 Complexity Assessment Frameworks

First the Actor, Support, Context framework (Van der Lei et al. 2010) is presented.

ASC Framework

The framework that is developed by Van der Lei et al. (2010) is the result of combining aggregate complexity (Manson 2001) and four dimensions (Xia and Lee 2005) to the actor and system dimension of multi actor systems. It consists of four aspects of complexity, namely, elements, relations, dynamics and uncertainty. These four aspects are applied on a multi-actor perspective and a system perspective, which are translated into an actor dimension and context dimension. In a multi-actor setting, the different actors can have different stakes and they interact with each other and the systems they are surrounded with (de Bruijn and ten Heuvelhof, 2010). The multi-actor perspective is applicable for every discipline where actors are involved. The context dimension is based on a system, which is defined as a set of entities, comprising a whole where each component is related to at least one other component and they all serve a common purpose. This framework is used to perform a meta-analysis to classify the complexity of multi-actor research. Initially the framework consisted of two axes, the actor dimension and the context dimension, but the support dimension was added on later. The support dimension seemed an important factor, as the query of the study consisted a wide range of articles where tools or social software were mentioned to facilitate actors or test context models. The study resulted in the actor, context and support framework as presented in figure 2 and an elaboration of all elements is presented in Appendix 2.

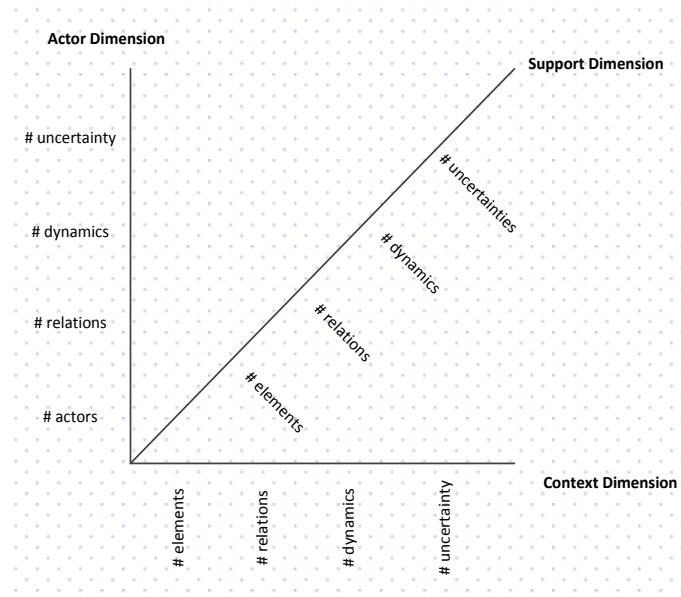


Figure 2 Actor, Support, Context Framework

TOE Framework

This framework is developed by Bosch-Rekvelde et al. (2010) for characterizing project complexity in large engineering projects. They state that the importance of complexity is made clear by a large number of project complexity related papers, but there was no framework that could provide support to characterize and analyze project complexity in large engineering projects. Consequently the TOE (Technical, Organizational, and Environmental) framework was developed based on a literature survey and a number of interviews in the process engineering industry.

This framework makes it possible to assess complexity and subsequently to manage the complexity of the project in an early stage. Bosch-Rekvelde et al. (2010) aimed to make a detailed description of project complexity, by using an inductive approach. They first performed a literature study to gather elements that are assumed to contribute to project complexity, followed by case studies where elements that contribute to project complexity were found by performing interviews in six different projects.

Table 1 Elements of the TOE framework

Technical	Organizational	Environment
Goals	Size	Stakeholders
Scope	Resources	Location
Tasks	Project team	Market Conditions
Experience	Trust	Risk
Risk	Risk	

Next, a choice is made between both frameworks for conducting interview research on the extent to which management approaches support complexity elements.

3.3 Framework Choice

Both frameworks have some similarities, because both take into account the involvement of actor and context elements. The TOE framework specifies this into internal and external actors and the technological aspect of the TOE framework can be linked to the context dimension of the ASC framework. The complexity elements, size and uncertainty are mentioned in both frameworks, but the generic form of the ASC framework provide a better starting point for mapping a broad scale of approaches. So, the framework that is chosen for further research in this thesis is the Actor, Support, Context framework of van der Lei et al. (2010). As described earlier in this research, the focus is on different dimensions of complexity levels and this framework provides a foundation for the multi-dimensional character of the research. The TOE framework of Bosch-Rekvelde et al. (2010) provides a detailed view of complexity in engineering projects, but does not provide starting points to measure the extent to which different management approaches support the management of complexity elements. Another important aspect is that the support dimension is stated explicitly in the ASC framework, as this is considered as important. The five ways model of Seligmann (1989), which is used to classify different approaches, also incorporates the support dimension in the model.

4. INTERVIEW RESEARCH

As presented earlier, interviews are part of this research. The interviews are based on the selected framework in the previous section. This section includes the purpose and setup of the interviews that were conducted during the research.

4.1 Purpose and Setup

The purpose of the interview was to get an overview of how different approaches support mapping and managing the complexity of projects. The interview starts with a short introduction, followed by a definition of projects and complexity and largely with questions on how a specific approach deals with the complexity elements of the ASC Framework, which is used as basis for the interviews.

4.2 Approach

The respondents are chosen from different backgrounds and are experienced with the management approaches. All experts are professors at the faculty of Technology, Policy and Management of Delft University of Technology. First they were selected on basis of the list of management approaches, next they were approached by email and when they agreed the interviews were conducted and recorded. Next the interviews were transcribed to useful data, reported and finally analyzed to aggregate information for answering the research question. The next section presents how the data was analyzed.

5. ANALYSES OF RESULTS

The results of the interviews are analyzed and described in this section. First a score framework is derived for analyzing to which extent the different approaches provide insight in describing and managing the various complexity elements of the different dimensions. This is adapted from CMMI, where maturity levels are described. Further the interviews are scored on basis of the analysis framework, providing a starting point for combinations of techniques from different approaches.

5.1 Maturity Levels

CMMI (Capability Maturity Model Integration) presents collections of best practices that help organizations to improve their processes. CMMI consist of a capability/maturity dimension which is used for benchmarking and appraisal activities, or guiding the improvement efforts (Software Engineering Institute 2010). Capability levels can be applied to achieve organization process improvements in individual process areas and are a means to improve processes incrementally, within a given process area. On the other hand, maturity levels are applied to gain an organization process improvement across multiple process areas. The levels can be used for improving the processes that correspond with a given set of process areas and are seen as foundation layers for ongoing process improvement.

Table 2 Maturity Levels (CMMI)

<i>Maturity Level</i>	<i>Definition</i>
Level 1	Initial
Level 2	Managed
Level 3	Defined
Level 4	Quantitatively Managed
Level 5	Optimized

Every level consists of related specific and generic practices for a predefined set of process areas that improve the performance of the organization. The maturity levels are measured by the achievement of specific and generic goals associated with each predefined set of process areas. An elaboration of each level is given in appendix 2, as the content is not important for this research, but the way of leveling the maturity of processes within organizations. This concept is adapted to formulate a score level for measuring the extent to which management approaches provide means for mapping and managing complexity elements of the actor dimension, support dimension and the context dimension.

5.2 Score Levels

The concept of levels is worked out for this research and can be defined as follows: Each level defines the extent to which an approach deals with describing and managing the complexity elements of the actor dimension, support dimension and the context dimension (Van der Lei et al. 2010). Consequently the following score levels are formulated.

Table 3 Score Levels of Management Approaches

Score Level	Definition
Level 1	Complexity element is important, but approach contains no means for mapping and managing a specific complexity element
Level 2	The approach contains techniques for mapping a specific complexity element
Level 3	The approach contains techniques for mapping and managing a specific complexity element
Level 4	The approach is focused on managing a specific complexity element

A complete presentation of the scores and their meanings is given in appendix 3. The score is build up incrementally, because every level provides a basis for the next level. This means that when a management approach has a score of level 3, level 2 is automatically included. In the following paragraph the scores of the approaches, which are based on interview results are presented.

5.2 Score on the Actor Dimension

First the overview of the scores of the management approaches on the actor dimension is presented.

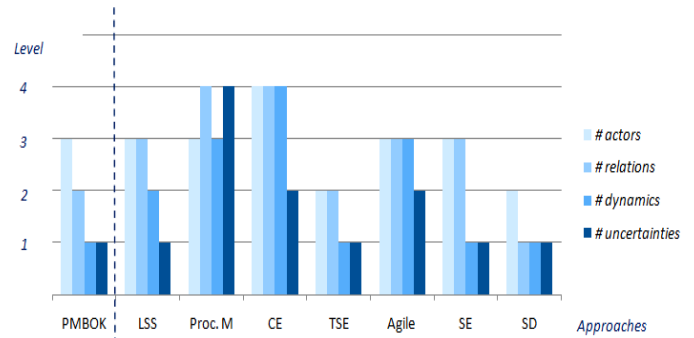


Figure 3 Scores of approaches on actor dimension

Every approach presents a mean for describing the actors that are involved in a project, but not every approach present a technique how the actors should be managed. The relations between actors can be described in every approach, except Systems Dynamics. Describing relations between actors is only dealt in Lean Six Sigma, Process Management, Collaboration Engineering and Agile Development.

The Project management body of knowledge scores low on management of relations between actors, dynamics of actors is not described and uncertainty of actors is also overlooked. Possible techniques that can be used to enhance these specific points can be derived from process management, collaboration engineering and Agile development methods.

5.3 Scores on Support Dimension

Here the scores of the management approaches on the support dimension are discussed.

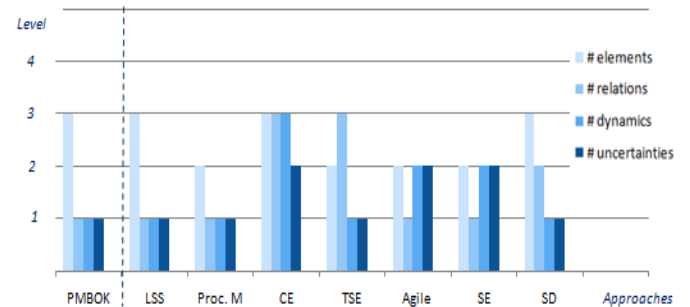


Figure 4 Scores of approaches on the support dimension

The Project management body of knowledge contains no means of managing the elements of the support system. Here it can be concluded that the support system is described in a very inflexible manner, as it is only described which tools can be used for each section. In general, all the other approaches score very low in describing and managing the complexity elements of the support dimension. This could mean that not much effort is spent in developing tools for the different approaches or the mentioned tools are static.

All approaches describe the necessary tools, but mostly the elements and relation between the components that the tools are build up with, are not mentioned. This could cause that most tools are not modular and flexible. Therefore they are also less capable of coping with dynamics and uncertainties.

5.4 Context Dimension

The scores of the management approaches on the context dimension are discussed below.

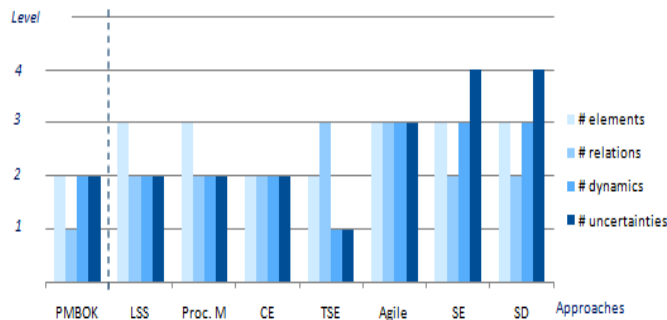


Figure 5 Scores of approaches on context dimension

The scores on the context dimension shows that the Project management body of knowledge scores low on the context dimension. The score means that the approach does provide techniques for describing the elements of the context dimension, but the management is overlooked.

However, there are some approaches that are strong in management of the complexity elements of the context dimension, like Agile development, Systems Engineering and System Dynamics.

The graphs provides clear directions to look for approaches that deal better with complexity elements of each dimension, which can be used to enhance project management approach, where necessary.

5. ENHANCEMENTS FOR PROJECT MANAGEMENT

In this section some possible suggestions for enhancing the Project management body of knowledge are presented. First verification is conducted in the literature to find out were possible issues can occur. Consequently suggestions for enhancements on each dimension are presented.

5.1 Identified issues in actor dimension

The possible issues that can occur when a project is managed according to the Project Management Body of Knowledge are mapped first, before techniques from other approaches are proposed to help assessing the identified issues. The issues are can be listed as follows:

- Complex projects are carried out within a network of actors.
- Difficult negotiation processes between stakeholders.
- Some stakeholders have hidden agendas and informal power of influencing projects.
- Conflicts between stakeholders or resources.
- Unresolved issues that continue during the project.
- Overlapping activities during the project can cause conflicts.
- Stakeholders are limited in their input by the project planning.
- Resources have to operate on remote locations.
- Uncertainties about competencies, motivation and performance of resources.

Based on these identified issues some techniques that are used in other management approaches are presented in the following paragraph.

5.2 Enhancements in actor dimension

In this section some suggestions for using techniques from approaches that are strong in actor management are presented.

Process Management techniques

In most projects a network of actors are involved, who are mostly dependent of each other. Project Management approaches have a limited meaning in a network of dependencies. So, a process approach is more appropriate for dealing with a network of dependencies between actors. Process designs can be made for negotiation rounds between stakeholders, but the four principles, speed, content, transparency and protection of core values have to be taken into account. Further some soft skills are required to negotiate with stakeholders and to get them in the right direction.

Collaboration Engineering techniques

Collaboration techniques can help to create consensus between stakeholders, meaning that a state is reached where all stakeholders are willing to commit to a proposal or solution. Commitment building can be used for letting a group of mission-critical stakeholders arrive at mutually acceptable agreements. Another issue occurs when team members are not in a face to face setting, but collaboration is needed. Therefore web collaboration techniques are proposed, creating a virtual work setting where team members can collaborate and cooperate from distance.

Agile Development Techniques

A sprint planning meeting can be used to prioritize tasks for the team. During this meeting the team can ask questions and afterwards prioritize tasks. One of the problems of PMBOK was that the feedback of the stakeholders was limited till the project planning session. After all the stakeholders value have to be maximized, thus Agile methods propose that the stakeholders should be available frequently and closely consulted for feedback

and understanding requirements. Uncertainties about team performance can be addressed by creating good working conditions, rotating personal to various positions and communicating project standards clearly to the team.

5.3 Identified issues in support dimension

The support tools that are mentioned in PMBOK form the elements of the total support system that is necessary for managing projects. Each support tool has a specific purpose, but is interrelated in some way to each other. Some of the tools provide the input for another tool or system, e.g. forecasting systems could be used as input for estimation software. It is likely that the Project Management Information System, which is in general intended to direct and manage project execution, should be linked with the other support tools. Verification in the PMBOK guide (PMI Institute, 2004) points out that the tools are mentioned for each knowledge area, but not specified how they are connected with each other.

Another issue is that the tools in PMBOK poorly support to deal with the complexity elements of the actor and context dimension. The following examples clarify this:

- Communication tools and methodologies are proposed for the distribution of information and managing stakeholder expectation, but the way the tool have to cope with changes is not taken into account.
- Group decision making techniques are proposed to collect requirements, but it is not described how the tool supports commitment or consensus building.
- Information gathering tools is required for identifying risks, but as risk management is of great importance more detailed execution of this part is required. So some risk analysis and management tools should be presented.
- It is not stated how stakeholders (actor dimension) can have insight in project information and progress, which should enable feedback from them.

- Small projects could be completed with MS Project, but for larger projects tools as Primavera are necessary.

5.4 Enhancements in support dimension

The support system as described in the PMBOK guide is limited in two ways. First, the relations between the elements are not elaborated and dynamics and uncertainties regarding situations where innovative tools are needed are not considered. This could mean that the tools that are mentioned are designed and used statically. In this sense a simple diagram of how the tools are related to each other would be helpful. This would make it easier to identify bad performance of tools and replacing them or to adjust and select the needed support tools according to the project configurations.

The second aspect is that it is not described how the tools have to cope with the complexity elements of the other dimensions. This is an important issue that has to be addressed, because the support dimension is seen as the link or the dimension that enables communication between the actor and the context dimension. Further the experts denote the importance of the support tools, but more in the sense of how they could facilitate or support the activities of the actor dimension and the context dimension.

Tools have to be developed in such a way that functionalities can be added or connections with other tools are possible in a later stage. An example of a support system that is built up in a modular way is Blackboard, in which functionalities can be added, e.g. for enabling communication between users.

Another example of a tool that deals with dynamics is SharePoint, developed by Microsoft. The idea behind this tool is that nowadays highly collaborative, mobile and virtualized work styles are expected by people and the business. In this way people can work simultaneously by sharing documents, data and information with colleagues, partners and suppliers. Further they can respond accurately and quickly with information that is acquired from experts across the organization.

5.5 Identified issues in context dimension

Each of the nine knowledge areas support to get insight in the context in which the project takes place, but do not provide a means for describing and handling the elements of the context. When elements are effected through interfaces, no means are provided to cope with the dynamics that occur.

Further, in innovative settings where is worked with unproven technology and potential risks exist, where there is a high level of uncertainty, the PMBOK do not describe how to deal with this. The critical success factors or drivers of a project could be derived from the context dimension, but it is not mentioned how this is covered. Risks can be covered via risk management, but when changes have to be made during the project, feedback loops are missing.

5.6 Enhancements in context dimension

Agile Development methods assume a largely emergent, rapid change context, while plan driven methods such as the PMBOK assume a stable context where the context requirements can be defined in advance. However, in a project there is likely that dynamics will occur and requirements will change during the project, meaning that an Agile approach is preferred. In this way dynamics in requirements or uncertainties could be discussed frequently and rapid adjustments can take place on time. Another technique that is used in software development, including Agile Development is the use of modeling languages, in particular UML. This exist largely of drawing class and object diagrams and relating them to each other. Further a decomposition of classes can be made, so that it becomes clear of what (sub) elements a system should exist. In projects this is a helpful tool to get insight in the elements of the context dimension and their relations.

Systems engineering score high on the management of dynamics of the context dimension, and is focused on managing uncertainties in this dimension. This is achieved by change management and bringing all the requirements together from the viewpoint of different actors. Risk sessions are organized, and

actors are in touch with each other about the requirements of the project. In this way all requirements are taken into account and dynamics are not overlooked, because the input of every actor during different phases of the project is processed.

System dynamics is aimed at providing insight in the dynamics of a system. Relations between the elements of the components are modeled in diagrams and uncertainties are tried to manage by conceptualization, simulation and sensitivity analysis. This way of working could be used to gather insight in dynamics of the context in a project, where elements could be modeled in terms of levels and flows and relations described via diagrams. By this the behavior of context elements or (sub) systems that can influence the project can be analyzed and addressed properly.

6. DISUSSION AND FURTHER RESEARCH

This paper provides an overview of the research problem, the research question and the steps that have been taken to achieve the research goal. First the results that are achieved are discussed followed by some suggestions for further research.

6.1 Discussion

The research was based on the following central question: "How can project managers combine tools and techniques from project management approaches and discipline oriented approaches, for managing multidimensional complex projects successfully?"

The first step that was taken, was making a selection of management approaches. This was based on a random selection of approaches, that involved at least one explicit project management approach and other discipline oriented approaches. The choice was limited by some constraints, as time and availability of experts. However a good balance of approaches was presented to conduct the research further. Next a comparative analysis was made on the different management approaches based on the five ways model. This provided insight in how the approaches differed in terms of the way of thinking, the way of control, the way of modeling, the way of working and the way of support. This pointed out that the PMBOK was the

only approach with a project management structure and the goal to manage a project, while the other management approaches were focused on actor management, software development or systems conceptualization.

Further, it was necessary to find out how complexity plays a role in projects. The framework that was chosen to analyze how different management approaches deal with complexity elements consisted of an actor dimension, a support dimension and a context dimension. To gather data on how the different management approaches scored on the complexity elements, an interview research was conducted with 8 experts of the Faculty of Technology, Policy and Management.

The results that were gathered provided insight in the scores of how the different approaches scored on the different dimensions. It was clear that the project management approach scored low on every dimension, meaning that enhancements were necessary. Therefore it was necessary to look at how other approaches scored on the complexity elements of the different dimensions. This provided a starting point for combining different approaches. The combination in this sense means combining techniques from approaches that score high to enhance the project management approach.

Section 5 of this paper present specific technique that can be used to enhance the project management approach for dealing with complexity elements. Consequently this could help to manage multidimensional complex projects properly and reduce project failures. However some further research is needed in some way to come up with more specific solutions.

6.2 Further research

The research that was conducted was limited in some ways. First only a selection of management approaches is taken into account, where there was only one explicit project management approach included. The next limitation was that only one expert was interviewed for every management approach. Finally the interviews were based on the ASC framework. The suggestions for future research are to take the following points into account:

- Another set of management approaches.
- Include more explicit project management approaches.
- Conduct interviews with experts who practice the management approaches in the field.
- Try to gather quantitative data, which can support your findings
- Conduct a specific study for e.g. the construction sector and base the interviews on another framework, e.g. TOE framework.

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Appendix 1. Comparison Table of Management Approaches

	<i>Way of Thinking</i>	<i>Way of Control</i>	<i>Way of modeling</i>	<i>Way of Working</i>	<i>Way of Support</i>
<i>Project Management (PMBOK)</i>	Organizational or managerial approach to the management of projects	Clear defined role and responsibility of project manager and project team	Process Flow diagrams	Activities based on knowledge areas	PMIS, CMS, CCS, templates, estimation tools
<i>Lean Six Sigma</i>	Reduce waste and improve quality	Defined roles with tasks	Design principles	Focus, Improve, Sustain, Honor	Excel Power Tools
<i>Process Management</i>	Change in complex issues, in network of multiple actors	A process design is based on four design principles	Activity diagram	Tasks of the process manager	No information systems
<i>Collaboration Engineering</i>	Create sustained collaboration support	Reusable and predictable collaboration process	Facilitation Process Model	Perform a sequence of selected thinkLet patterns	Group Support Systems and Software
<i>Software Development (Waterfall approach)</i>	Development proceeds sequentially through a series of phases	Software development lifecycle is divided into five distinct and linear stages	Requirements Specifications and Coding	Linear process: deployment activities of each phase	Software for compiling, interpreting, debugging and testing
<i>Agile Development</i>	Apply iterative evolutionary development	Collaboration, communication	Nine principles of Agile Development	Empirical, Iterative process	Software for designing, coding.
<i>Systems Engineering</i>	Developing a system that meets requirements	Seeks a Safe and Balanced design	Requirements, specifications, certification packages	Iterative process evaluation	Software: Drawing, SE software, UML
<i>System Dynamics</i>	Understanding the dynamic behavior of complex systems	Viewpoint of the modeler	Causal Loop diagrams, Flow diagrams	Predefined Steps, linear	Software: Powersim, Vissim

Appendix 2. Complexity Elements of the Actor Support Context Framework

<i>Complexity elements of the actor dimension</i>	<i>Definition</i>
# actors	The number of actors involved. If more stakes or perspectives are involved, the complexity level increases
# relations	When actors depend on each other, have long term relations, are bound by contracts, the complexity level can increase.
# dynamics	Amount of change or dynamics in the multi-actor dimension. This is caused by interaction, changing positions or collaboration between actors
# uncertainty	Uncertainty with respect to actor behavior; problems of trust, cultural differences and hidden agendas.

<i>Complexity element of the support dimension</i>	<i>Definition</i>
# elements	Amount of software components and other components the support system consists of.
# relations	When the support systems exists of several components, their interoperability and interdependency is an important determinant of complexity
# dynamics	Dynamics increase when support systems are subject to change, design, development or improvement.
# uncertainty	Plays an important factor when functioning of the system depends on third parties, or new innovative tools

<i>Complexity element of the context dimension</i>	<i>Definition</i>
# elements	The number of elements or components the context system exist of.
# relations	The way the components of a system are related or depend on each other.
# dynamics	Increases if a components or relations change and affects other components and relations trough interfaces.
# uncertainty	Plays a role in innovative settings, where the technology is still unproven or potential risks exist.

Appendix 3. Maturity Levels CMMI (Software Engineering Institute 2010)

Level	Definition
<i>Level 1. Initial</i>	Processes are usually ad hoc and chaotic. The organization usually does not provide a stable environment to support processes. Success in these organizations depends on the competence and heroics of the people in the organization and not on the use of proven processes
<i>Level 2. Managed</i>	Processes are planned and executed in accordance with policy; the projects employ skilled people who have adequate resources to produce controlled outputs; involve relevant stakeholders; are monitored, controlled, and reviewed; and are evaluated for adherence to their process descriptions.
<i>Level 3. Defined</i>	Processes are well characterized and understood, and are described in standards, procedures, tools, and methods. The organization's set of standard processes, which is the basis for maturity level 3, is established and improved over time. These standard processes are used to establish consistency across the organization.
<i>Level 4. Quantitatively Managed</i>	The organization and projects establish quantitative objectives for quality and process performance and use them as criteria in managing projects. Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers
<i>Level 5. Optimizing</i>	<p>An organization continually improves its processes based on a quantitative understanding of its business objectives and performance needs. The organization uses a quantitative approach to understand the variation inherent in the process and the causes of process outcomes.</p> <p>Maturity level 5 focuses on continually improving process performance through incremental and innovative process and technological improvements</p>

Appendix 4. Score Levels For Complexity Elements

	<i>Level 1</i>	<i>Level 2</i>	<i>Level 3</i>	<i>Level 4</i>
Actors or Elements	Actor or elements are considered important	Contains techniques for mapping actors or elements	Contains also techniques for managing actors or elements	The approach is focused on managing actors or elements
Relations	Important, but contains no means for describing the relations between actors or elements	Contains techniques for mapping relations between actors or elements	Contains also techniques for managing relations between actors or elements	The approach is focused on managing relations between actors or elements
Dynamics	Important, but contains no means for describing the dynamics between actors or elements	Contains techniques for mapping dynamics of actors or elements	Contains also techniques for managing dynamics of actors or elements	The approach is focused on managing dynamics of actors or elements
Uncertainty	Important, but contains no means for describing the uncertainties between actors or elements	Contains techniques for mapping the uncertainties of actors or elements	Contains also techniques for managing uncertainties of actors or elements	The approach is focused on managing uncertainties of actors or elements