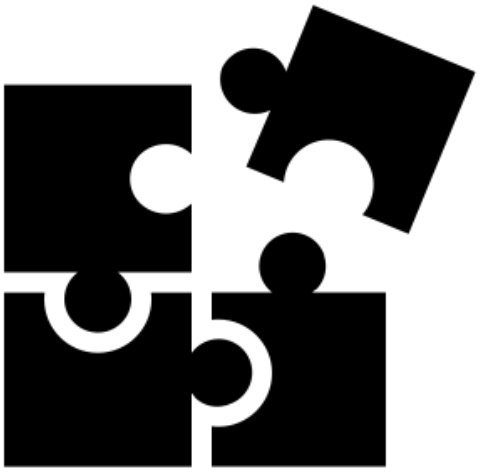
MASTER THESIS

TOWARDS THE IMPLEMENTATION OF A DOCUMENTATION STRATEGY FOR DESIGN DECISIONS IN CIVIL ENGINEERING PROJECTS: AN ASSESSMENT

PAMELA DACCACHE



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Towards the implementation of a documentation strategy for design decisions in civil engineering projects: An assessment

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Preface

This thesis marks the end of my master Construction Management & Engineering at the University of Twente. This research was commissioned by Witteveen+Bos and focuses on the implementation of a documentation strategy for design decisions in civil engineering projects.

I have enjoyed conducting this research greatly and I would have not been able to do so without the help of my four supervisors. First, I would like to thank my UT supervisors Robin de Graaf and Marc van Buiten. Robin, after guiding me through the final project of my bachelor and helping me write a paper for the Student Research Conference, I had no question in my mind of who I wanted to supervise my master thesis. Thank you for helping me accomplish my achievements during my studies. Your valuable feedback and enthusiasm helped me realize my full potentials. Marc, I want to thank you for your critical feedback and support during our meetings. Your questions and feedback always helped me to put things in another perspective, critically reflect on my work and to improve my thesis greatly.

Second, I want to thank Tim van Dijck and Tara Kinneging for guiding me on behalf of Witteveen+Bos. Tim, thank you for always believing in me and asking me the right questions. Your advice helped me improve my research and gain more confidence in my potentials. Tara, without you my internship would not have been nearly as fun as it was. I will cherish our weekly meetings that always took longer than planned because of our fun and random conversations. Even though you had a busy schedule, you always made time to provide me with valuable feedback and to help improve my thesis. You are the best supervisor I could have asked for and I cannot wait to implement our researches in practice!

Lastly, I want to thank all of my family and friends who have supported me during my thesis. You were always there for me to discuss my thesis and to provide support and laughter. A special thanks to my mother, who has always been my number one supporter.

I hope you enjoy reading this thesis.

Pamela Daccache
Enschede, October 2020

Towards the implementation of a documentation strategy for design decisions in civil engineering projects: An assessment

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ABSTRACT

Implementing a new strategy in civil engineering projects can be a tough challenge due to for example the traditional ways of working. Civil engineering literature characterizes strategy implementation at project level as difficult and there is yet more to learn on this topic. This study was conducted at an engineering consulting firm that experienced difficulties with implementing a documentation strategy for design decisions in infrastructure projects. The purpose of this research was to assess why there were difficulties with implementing this strategy and to provide recommendations to overcome these barriers. A theoretical framework was developed based on the implementation of different construction industry methodologies in the past decade, Change Management and Project Management. The theoretical framework was then confronted with three infrastructure projects conducted by the engineering consulting firm by means of pattern matching. Findings show that a specific approach for implementing a documentation strategy for design decisions at project level is missing in current practices. The results show that implementers experience several obstacles during implementation, such as resistance by employees, lack of management support and the inability of change agents to fulfill implementation tasks. This research proposes recommendations to enhance the implementation process in the form of an implementation guideline. The aim of the implementation guideline is to facilitate project members with a structured and practical approach for strategy implementation, with a specific focus on a documentation strategy for design decisions. The guideline addresses five processes and nine building blocks that consist of checklists to guide implementers through the implementation process from start to finish. The implementation guideline has been validated by experts working at the engineering consulting firm.

Keywords: strategy implementation; civil engineering; documentation strategy; design decision; implementation guideline; change management; project management

1. INTRODUCTION

The architectural, engineering and construction (AEC) industry is changing and adopting new ways of working to improve their project delivery process (Lines et al., 2017; Vass & Gustavsson, 2017). However, implementing a new idea or strategy in design teams can be a tough challenge due to for example the traditional ways of working. Formulating a consistent strategy is a difficult task for any management team, but making that strategy work, is even more difficult (Hrebiniak, 2006). Strategy implementation is defined as the translation of a strategy into an actual action plan (Mohamed et al., 2013, cited in Zaidi et al., 2019). However, the implementation of a strategic plan fails often (Kazmi, 2008). The inability of firms to carry out successful strategy implementation despite having a good strategy can be attributed to the fact that these firms lacked knowledge in strategy implementation as compared to strategy formulation (Zakaria et al., 2017). Furthermore, strategy implementation has a higher complexity in process than strategy formulation (Kazmi, 2008).

In this study, the implementation of a documentation strategy for design decisions as developed by Kinneging et al. (2020) is considered, as presented in fig. 1. Kinneging et al. (2020) developed this strategy to improve the traceability of design decisions in infrastructure projects. The concept strategy consists of the current practices for documenting design decisions, followed by three levels. The reason why the strategy is divided into levels, is that it is unlikely for an organization to implement the strategy all at once. Therefore, this strategy was developed with regard to applicability in the work practices of the engineering consulting firm, and thus the strategy has been tailor-made for the specific engineering consulting firm where the study by Kinneging et al. (2020) was conducted. The levels

should be implemented in the specific order as shown, as each level goes more into depth. The concept strategy begins with a base situation, which features the current practices that were derived from the case studies. This level focusses on good accessibility of documentation by all parties and responsibilities for documentation and monitoring the documentation. The project team should then move on to the first level of the concept strategy. In this level, design decisions should be documented in a specific location. This documentation should be done immediately after the design decision is made. The project team then moves forward to the second level. In this level, the interrelations for the design decisions should be discussed and documented, including the design rationale. The concept strategy then describes that the latter should be visualized by placing the design decisions for example in a web or in conceptual drawings and thus creating a network of design decisions. In the final level, which is level 3, the project team should evaluate all available documentation before moving on to the next phase.

Following the study by Kinneging et al. (2020), the strategy has been (partly) implemented in three projects of an engineering consulting firm. However, during implementation, several challenges have been experienced such as: (1) lack of commitment by management, (2) reluctancy by designers in documenting their decisions, (3) lack of priority for documenting design decisions due to time pressure and (4) an unclear understanding of what a design decision is and to what detailed extent design decisions should be documented. The strategy has functioned as a project tool for improving the documentation of design decisions, but there have been barriers experienced at project-based level. The latter raises two main questions: (1) why are there difficulties experienced during the implementation of the documentation strategy for design decisions at project level and (2) which recommendations can be formulated to overcome these barriers? Currently, there is no answer that can be derived directly from literature on implementing a strategy for the documentation of design decisions. This indicates that a study with regard to this topic is relevant for any company or organization that strives for improving the documentation of their design decisions. Another important factor that contributes

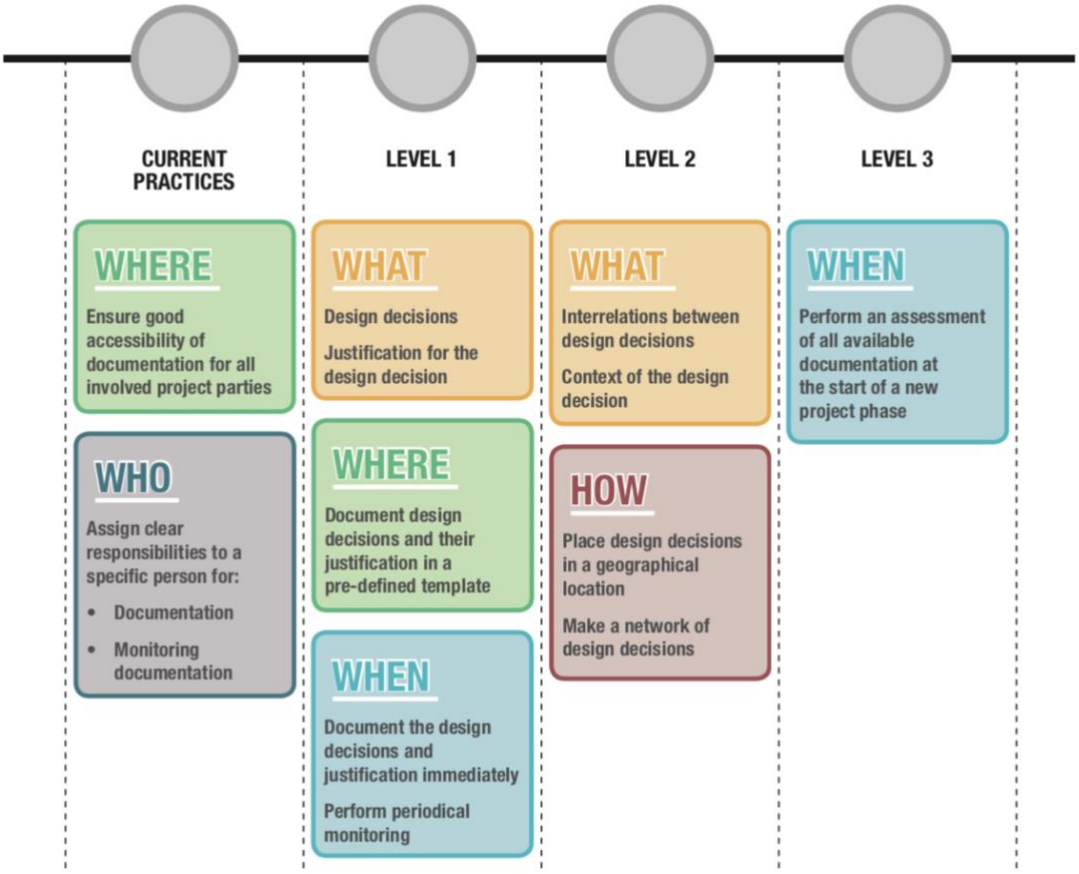

Figure 1. The concept strategy by Kinneging et al. (2020)

to the relevance of this study is that nowadays there is an increasing demand by the client for the documentation of design decisions to enhance the transparency and traceability of the design.

According to theory, guidelines are important for successful implementation. Not having a clear model or guideline to guide implementation efforts is a major obstacle when implementing a strategy (Hrebiniak, 2006). Clear decisions and guidelines are needed at the beginning of a project to guide the implementation process (Nuttens et al., 2018; Hochscheid & Halin, 2019). Therefore, the objective of this research is to assess why an engineering consulting firm had difficulty implementing a documentation strategy for design decisions and to provide recommendations in the form of an implementation guideline to overcome these barriers. This is achieved by conducting a literature study, investigating current practices and developing and validating an implementation guideline. The current practices will be investigated by evaluating the implementation of a documentation strategy for design decisions in three infrastructure projects conducted by an engineering consulting firm. In two of the three projects, the concept strategy of Kinneging et al. (2020) has been (partly) implemented. In the third project, a different approach to documenting design decisions has been used and therefore provides insights from another perspective regarding this topic.

In chapter 2, a theoretical framework is presented on strategy implementation within different construction industry methodologies, change management and project management. In chapter 3, the used methodology to answer the research question is described. Chapter 4 presents the results as derived from the case studies and chapter 5 will provide an analysis of the results. In chapter 6, the development of the implementation guideline is described and in chapter 7 the validation of the guideline is presented. Chapter 8 provides the discussion, limitations and future directions of this study. Lastly, chapter 9 presents the conclusions and final recommendations of this research.

2. THEORETICAL FRAMEWORK

2.1 Strategy implementation per construction management methodology

In this section, the implementation of several construction management methodologies of the past decade is discussed. Similarities and differences between the methodologies on implementation have been identified in literature. An important note is that only factors that have influenced the implementation process and are considered relevant for this study have been taken in consideration. Therefore, factors that were either too technical or context based have been excluded.

Building information modelling (BIM)

The implementation of BIM practices in firms has brought along several challenges as it obstructs the habits and practices of a company (Hochscheid & Halin, 2019). Many recent studies have focused on these challenges and have provided recommendations for improvements. One of the main challenges that has been determined is an unclear purpose of implementing BIM and thus changing the current approach of working (Eadie et al., 2013). This is supported by Dowsett and Harty (2019) who emphasize that by assessing the project benefits in parallel to the implementation approach, users challenged their awareness and understanding of BIM and set aside accumulated and rigid assumptions of BIM. Therefore, it is crucial to formulate operational and achievable goals while taking the purpose of and the perceived need for the new strategy in consideration (Cummings & Worley, 2014, cited in Bråthen & Moum, 2015). On top of that, the vision of BIM should be communicated with all parties as it is an important opportunity to get everyone on board with the strategy (Nuttens et al., 2018). This includes stakeholders and the client, as lack of interest by these parties in using BIM is considered a challenge (Almuntaser et al., 2018).

The next challenge that has been identified in literature for BIM implementation is lack of knowledge and skills on BIM (Eadie et al., 2013; Bråthen & Moum, 2015; Vass & Gustavsson, 2017; Siebelink et al., 2018). Without sufficient knowledge, the different BIM tasks cannot be fulfilled to the full extent and employees generate resistance to steering away from the old ways of working. Vass and Gustavsson (2017) suggest that managers should provide training and educational activities to assure that employees have the sufficient skill set and knowledge to fulfill their tasks. Siebelink et al. (2018) add that there should be tasks and responsibilities formulated and assigned to the project members as well.

Another challenge identified in literature is the lack of guidance when implementing BIM. Guiding and supporting the change that is caused by BIM

implementation is crucial and necessary for the success of implementation (Nuttens et al., 2018). Without proper guidance, the level of execution of different BIM activities can differ. Therefore, Nuttens et al. (2018) emphasize that project meetings should be organized to gain insight on the implementation process and whether there are difficulties experienced by team members.

Lastly, radical process changes can cause resistance for change by employees, and therefore Hartmann et al. (2012) recommend aligning strategy activities closely to work practices of construction teams.

Concluding, there have been several challenges and suggestions for improvement identified in BIM literature. The following actions have contributed positively to the successful implementation of BIM in construction firms: communicating the vision and benefits with project members, formulation of purpose and operational goals, assigning roles and responsibilities to the different project members, conducting project meetings, providing training and educational activities, assigning a team to guide the implementation efforts and aligning tools closely to work practices.

Systems Engineering (SE)

Literature on SE implementation has provided several insights in factors that have contributed to successful implementation of SE in construction projects. There have been several similarities identified between BIM and SE literature on implementing a new construction management methodology. First, SE literature also addresses the need for clear benefits and purpose of implementing SE (Van den Houdt & Vrancken, 2013; Beasley, 2017). Furthermore, responsibilities and roles should be assigned to the different project members for the different SE processes (De Graaf et al., 2017). By assigning certain roles and responsibilities to project managers that fully understand the strategy and its benefit for application, support from individual project members will increase (Van den Houdt & Vrancken, 2013). Additionally, as suggested when implementing BIM, SE literature addresses the need for training and educational activities on SE (Van den Houdt & Vrancken, 2013; De Graaf et al., 2016). Van den Houdt & Vrancken (2013) add that by training and educating the involved people, managers are able to assign the right people for specific tasks. Moreover, both BIM and SE literature refer to the alignment of tools with work practices. Van Den Houdt & Vrancken (2013) suggest that adopting SE activities in task descriptions of employees will slowly change the standard approach of working by designers, engineering, planners and executers. Implementing a strategy gradually as opposed to rapidly, while taking the current working practices in consideration decreases the amount of resistance for change by employees.

However, SE literature does stress a few other factors that influence the implementation process. First of all, there should be an understanding of a need for implementation (Beasley, 2017). To realize the value of a new strategy, the reason for why a new strategy is needed in the first place should be clear to all involved parties. Furthermore, literature on SE addresses that the client can play an important role during the implementation of SE. De Graaf et al. (2017) conclude in their study that a lack of client demand can cause SE activities to not be applied to the full extent.

Concluding, several factors have influenced the implementation of SE in the past years. Similar to BIM, SE literature also suggest communicating the benefits and purpose of SE to project members, assigning responsibilities and roles for the different SE tasks to project members, aligning tasks with current work practices and providing training and educational activities on SE to project members. However, the next actions have been identified in SE literature as well: there must be a sense of urgency created and the client requirements should be identified.

Lean Management (LM)

Within other literature, similar implications have been determined. Literature on LM support BIM and SE findings as the need for proper guidance when implementing a new strategy is elaborated (Shang & Pheng, 2014; Kobus et al., 2017). Furthermore, Shang & Pheng (2014) also concluded in their study on implementing Lean practices in the construction industry that sufficient knowledge on Lean is needed and that employees should be motivated to work with Lean.

2.2 Insights from Change Management (CM)

Resistance for change by employees has been repeated constantly in literature on strategy implementation. Managing this type of change requires a different approach to management as employees need to withdraw from traditional practices which often have been built up over years of activity. In this study, Change Management (CM) is

defined as the management of adopting new practices in the procurement, contracting and management of AEC projects while simultaneously disengaging from traditional practices (Lines et al., 2015).

Decades ago, Lewin (1947) mentioned inner resistance for change by individuals as a factor that negatively influences change. He developed a change model consisting of three steps: unfreeze, change and refreeze. During the unfreezing phase, awareness for change needs to be created as people initially tend to resist to change. Once people begin to realize the value of change, the next step, which is the implementation of change, takes place. Lewin (1947) emphasizes that this step is the most difficult as people need to learn new behaviors, rules and thinking. Lastly, the new reality is refreezed as the new rules, procedures and behaviors now are considered as the new status quo. The main challenge here is that people don't convert back to the traditional ways of working. However, even though Lewin's (1947) three-step procedure for chance is one of the most recognized change models, Galli (2018) points out that Lewin's theory does not deal with the human part of change. Instead, Galli (2018) emphasizes that Kotter's model provides more guidance in implementing change. Kotter (1995) developed an Eight-step model for change consisting of the next steps: establish a sense of urgency, form a guiding coalition, create a vision, enlist a volunteer army, enable action, generate short-term wins, sustain acceleration and institute change. Kotter's (1995) model is a step-by-step procedure for implementing change and it is emphasized that change is a process that takes time. Therefore, Lines and Vardireddy (2017) suggest following an implementation timescale plan. The latter would decrease the amount of resistance by employees (Lines et al., 2017).

Even though these models have been developed decades ago, the influence of these models on strategy implementation can be traced to recent studies. Lines et al. (2015) agree with Kotter (1995) and concluded in their study that change agents are needed when implementing a new strategy. A change agent is a person or group that facilitates the change process in an organization or project. Change agents are needed to guide the implementation activities and they should have a direct day-to day involvement at operational level. A group of change agents can serve as an implementation team as they guide the implementation efforts throughout the process. Kotter (1995) refers to such a team as a guiding coalition where senior managers form the core of the group, accompanied by non-seniors.

Furthermore, there must be a need for change among people to prevent resistance for change (Lewin, 1947; Kotter, 1995). Employees must understand change in order to support it (Galli, 2018) and therefore, implementers should communicate the reasons behind the need for change and how employees can benefit from it (Lines & Vardireddy, 2017). Moreover, forcing change also increases resistance by employees (Kotter, 1995; Lines et al. 2017), and therefore there should be consensus between the involved parties on the implementation of change (Lines & Vardireddy, 2017).

2.3 Insights from project management literature

As literature on strategy implementation on project level is scarce, literature on project management is gathered to gain insight on implementation on project management level. Parker et al. (2013) state that there is a lack of appreciation for formal processes and technical contributions as offered by project management in delivering change. Therefore, project management practices are considered for strategy implementation at project level. Almuntaser et al. (2018) used the five process groups of the PMBoK methodology to create a framework for the implementation of BIM practices. PMBoK was created by the Project Management Institute (PMI) to ensure a set of knowledge principles in project management (Matos & Lopes, 2013) and is considered as the standard for project management knowledge (Siegelaub, 2017). The PMBoK methodology consists of five process groups: (1) initiating, (2) planning, (3) executing, (4) monitoring and controlling and (5) closing (PMI, 2013). Each process involves detailing the inputs, outputs, tools and techniques to meet the objective of the process (Parker et al., 2013).

Next to the PMBoK, the PRINCE2 methodology is another widely used project management practice (Jamali & Oveisi, 2016). PRINCE2 stands for Projects IN Controlled Environments and is described as a structured method for effective project management (Wideman, 2002). It is a process-based, structured project management methodology that consists of seven processes: (1) starting up a project, (2) initiating a project, (3) directing a project, (4) controlling a stage, (5) managing product delivery (6) managing stage boundaries, and (7) closing a project (Siegelaub, 2017). Siegelaub (2004) describes that PRINCE2 is not meant to stand on its own and needs experience and the depth of PMBoK to fill it out.

Therefore, it is not a matter of which methodology is better as both complement each other. Parker et al. (2013) refer to both PMBoK and PRINCE2 to emphasize that project-based processes can be applied for implementing CM initiatives.

2.4 Additional findings

There have been additional findings regarding strategy implementation within other sectors. Within literature on the implementation of ICT systems, the alignment of work practices with the new system is stressed once again by Adriaanse et al. (2010). Furthermore, Boonstra and de Vries (2015) studied the implementation of information systems and emphasize that consensus on the implementation of the new system between managers and employees is needed to avoid a 'pushed down the throat' effect. Furthermore, assigning roles and responsibilities to the different project members increases user participation and involvement and should decrease frustration among the parties as they experience ownership of the positive outcomes.

Lastly, the presence of a requesting actor can positively influence the actors' willingness to change (Adriaanse et al., 2010). During validation, Kinneging et al. (2020) concluded that the perspective of the client is decisive for the successful implementation of the author's developed strategy. The latter was explained as follows: the more focus the client puts on documentation, the more extensive the documentation process will be according to the experts (Kinneging et al., 2020). Therefore, contractual arrangements can activate the extrinsic motivation of employees to use a new tool (Adriaanse et al., 2010).

2.5 Development of the theoretical framework

The theoretical framework is developed based on the insights of the different construction management methodologies obtained from the literature study. These were all somehow implemented at project level and addressed as analog of the problem in this research. CM literature has provided the understanding that strategy implementation is not an activity that is merely executed at the beginning of a new project. On the contrary, it is a process that takes time and needs to be executed and monitored within the different phases of a project and therefore a project management methodology as a framework is considered suitable. Furthermore, Parker et al. (2013) emphasize that combining project management and change management can enhance the success of project-based initiatives. On top of that, by aligning the theoretical patterns with project management processes, a theoretical framework for strategy implementation specifically at project level could be developed. As there are no specific criteria or literature on which project management methodology to use for change management initiatives, it is chosen to categorize the theoretical patterns by using the processes of PMBoK. The PMBoK framework is used as it presents a well thought-out strategy for the execution of a project (Almuntaser et al., 2018). Below, each process is explained with regard to strategy implementation. In table 1, the theoretical framework and the patterns are presented based on the findings of the literature study.

Initiating

In the first step of the implementation process, the new strategy and need for change is initiated. An implementation team should be established to guide, monitor and support the implementation process from start to finish. They must identify all stakeholders that will be either involved in or affected by the new strategy and take the client requirements in consideration. Moreover, the vision, goals and purpose of the strategy should be formulated and communicated to all involved parties. This includes creating an understanding among the project members on the benefits of the new strategy and how everyone involved can enhance their project work by applying the new strategy.

Planning

The implementation team then moves on to the next step which involves a detailed planning of the implementation activities. As change is a time-consuming process that consists of several steps, it needs to be carefully managed and planned. An implementation timescale should be developed that describes the duration of the implementation activities and when these activities should be executed in the project. This implementation timescale should be compared to the project activities of the employees, to ensure that the needed activities and change of tasks do not increase the work burden of the employees, but rather are aligned with their current work processes. Furthermore, the needed knowledge and skills for working with the new strategy should be assessed and if needed, educational activities should be planned.

Executing

In the third phase of the implementation process, the strategy is executed. This phase takes the longest and needs to be carefully managed and monitored by the implementation team. They should have a direct involvement with the project members that need to work with the strategy. There must be roles and responsibilities assigned to the project members for the different tasks of the strategy and meetings should take place to evaluate previous work and to discuss work progress.

Monitoring & Controlling

The implementation team is responsible for monitoring and controlling the different phases in the entire implementation process. If there are any hurdles or burdens experienced on operational level by project members, they must provide support and guidance. Furthermore, if agreements on project deliverables are made, they must ensure that these agreements are held in place. Therefore, the implementation team should hold meetings to review and evaluate the implementation process.

Closing

The last phase of the implementation process is the closing of a project. In this phase, the implementation team gathers once again to discuss and evaluate the entire process. Lessons learned should be captured, documented and distributed to the stakeholders for future projects.

Table 1. Theoretical framework

Framework	Theoretical patterns	Explanation	Field of discipline	Sources
Initiating	Form an implementation team *There should be at least one senior manager in this team	There should be change agents assigned to guide and support the implementation process at operational level.	BIM, CM*, LM, SE	(Kotter, 1995*; Van den Houdt & Vrancken, 2013; Shang & Pheng, 2014; Lines et al., 2015; Kobus et al., 2017; Lines & Vardireddy, 2017; Nuttens et al., 2018)
	Formulate and communicate the vision, goals and purpose of the strategy	There must be a need for change and understanding among employees to prevent resistance.	BIM, CM, IS, LM, SE	(Lewin, 1947; Kotter, 1995; Eadie et al., 2013; Van den Houdt & Vrancken, 2013; Shang & Pheng, 2014; Bråthen & Moum, 2015; Nuttens et al., 2018; Dowsett & Harty, 2019)
	Identify client requirements regarding the strategy	The presence of a requesting actor increases the external motivation of employees	ICT, IS, SE	(Adriaanse et al., 2010; De Graaf et al., 2017; Kinneging et al., 2020)
Planning	Create an implementation timescale	There should be sufficient time available for employees to cooperate the new activities alongside their workload.	CM	(Lewin, 1947; Kotter, 1995; Lines & Vardireddy, 2017)
	Align strategy tasks with work activities	The strategy implementation process should be aligned with the work processes to prevent radical process changes, resistance for change and additional workload.	BIM, SE, ICT	(Adriaanse et al., 2010; Hartmann et al., 2012; Van den Houdt & Vrancken, 2013)
	Plan trainings and educational activities	Employees should have sufficient knowledge and skills to work with the new strategy to prevent resistance and relapsing to the traditional ways of working.	BIM, CM, LM, SE	(Eadie et al., 2013; Van den Houdt & Vrancken, 2013; Bråthen & Moum, 2015; De Graaf et al., 2016; Kobus et al., 2017; Lines & Vardireddy, 2017;

Framework	Theoretical patterns	Explanation	Field of discipline	Sources
				Vass & Gustavsson, 2017; Siebelink et al., 2018)
Executing	Assign roles and responsibilities to each project member	There should be clear responsibility and roles assigned for each member during the implementation process to increase user participation and prevent frustration.	BIM, IS, SE	(Kotter, 1995; Van den Houdt & Vrancken, 2013; Boonstra & de Vries, 2015; De Graaf et al., 2017; Siebelink et al., 2018)
Monitoring & Controlling	Conduct progress meetings and evaluate phases	The different phases of the implementation process should be monitored and evaluated to distribute lessons learned and improve where needed.	BIM, CM	(Kotter, 1995; Almuntaser et al., 2018)
Closing	Evaluate the implementation process and document findings for future projects.	The implementation process should be evaluated at the end of a project to capture lessons learned for the next project.	BIM, CM, PM	(Kotter, 1995; Parker et al., 2013; Almuntaser et al., 2018)

BIM = Building Information Modelling, CM = Change Management, ICT = Information and Communications Technology, IS = Information Systems, LM = Lean Management, PM = Project Management, SE = Systems Engineering

The theoretical framework will serve as input for the case studies, to assess the current implementation of the documentation strategy for decisions by Kinneging et al. (2020).

3. METHODOLOGY

As this study is a follow-up study on the research conducted by Kinneging et al. (2020), an evaluation study is conducted as proposed by Verschuren & Doorewaard (2007) to determine whether the intervention has delivered the desirable results. To understand the dynamics of certain events, Yin (2014) proposes to use case studies for data collection. Furthermore, case studies give an in-depth perspective on the situation and allows the researcher to find explanations on certain situations (Verschuren & Doorewaard, 2007).

In the first phase of the research, a theoretical framework has been developed. This framework has served as an input for the case studies. In the second phase, the data from the case studies was confronted with the theoretical framework by means of pattern matching (Cao, 2007; Yin, 2014).

Afterwards, a guideline for the implementation of a documentation strategy for design decisions was developed, based on the results from the pattern matching. Due to the limited timespan of this study, the implementation guideline has not been validated by testing the guideline in practice. Instead, validation has taken place through a new series of interviews with experts, other than the already interviewed participants from the case studies.

3.1 Theoretical data collection and analysis

The development of the theoretical framework was a process consisting of several steps. As there was a gap in literature concerning the implementation of a documentation strategy for design decisions in civil engineering projects, insights from construction industry methodologies and sectors were gathered as examples to the research problem. Furthermore, the amount of studies on strategy implementation at project level are considerably few as previous research has mainly focused on strategy implementation at country, industry or single firm level (Bråthen & Moum, 2015). Therefore, a specific approach was used to develop the theoretical framework. At first, papers on the implementation of different methods within the construction management field (e.g. Building Information Modelling, Systems Engineering) have been selected to obtain insights on how these construction industry methodologies have been implemented in construction projects, including the factors that have influenced successful implementation. These papers have been selected by using Boolean operators and this process will be further elaborated in the next section. Following this step, literature on Change Management (CM) has been gathered as the implementation of new practices requires learning new approaches to working. On top of that, insights from project management literature were used to create an understanding of how a

strategy could be implemented at project level. In the final step, the theoretical framework was created by using the insights from literature obtained in the previous steps.

Selection of papers

The literature study has been performed using Google Scholar as the search engine. When entering the keywords "implementing", "documentation strategy", "design decisions" and "civil engineering projects" in Google Scholar, no hits were received. Removing the keywords "design decisions", and later "civil engineering projects" still provided no significant hits. This indicates that there are no scientific papers on implementation of the specific niche of documentation strategies and design decisions. Therefore, a specific approach was needed to locate and select relevant papers for this study. This approach consists of two aspects. The first aspect is the development of table 2 that represents an overview of the constructs and their related, broader and narrower terms. As the ideal keywords deliver insignificant hits, a broader search area is needed. Simultaneously, papers that provide relevant information might use different keywords or terms for similar topics. The second aspect is the use of the Boolean Operators (AND, OR, NOT) while searching for papers. By making use of the Boolean logic, keywords can be combined or excluded which results in more focused results and eliminates irrelevant hits. Lastly, the search field was set on 2010 to 2020 and the language settings to either English or Dutch.

To obtain a broad overview on recent implementation studies in the construction industry, the first two constructs are used. This has resulted in several hits on the implementation of Building Information Modeling (BIM). The latter indicates that implementation studies in the context of the construction industry have mainly focused on BIM implementations, and therefore papers on the implementation of BIM have been selected.

In the next step, the first two constructs are used again, however by using the NOT operator (in Google Scholar "-"), papers on BIM were excluded. This has resulted in papers in a variety of topics. However, one topic in particular appeared in several hits which was the implementation of Lean Management (LM). Therefore, next to BIM literature, papers on the implementation of LM were selected.

Within the following searches, keywords were either broadened, excluded or combined differently and this approach has resulted in a database of papers within different fields of construction management methodologies, For example, combining *application, documentation* and *Civil Engineering* while excluding literature on BIM and LM has resulted in papers on the implementation of Systems Engineering (SE).

Table 2. Keyword search

Constructs	**Related terms**	**Broader terms**	**Narrower terms**
Construction industry	AEC industry, building sector	Civil Engineering	Dutch Construction Industry, infrastructure projects
Implementation	Adoption, application, operation	Execution, effort	Doing, usage
Strategy	Plan, tactic, procedure, approach	System, direction	Tool
Documentation	Record, transcription, archive	Information	Explanation

3.2 Empirical data collection

The empirical patterns were collected through the case studies. A total of three projects concerning road infrastructure development in the Netherlands have been studied. The projects are selected based on the notion that the concept strategy by Kinneging et al. (2020) has been (partly) implemented in these projects. Furthermore, the role of the change agent in these case studies is allocated by project members who are assigned the task to implement and execute the documentation strategy for design decisions. That could be for example project members who were responsible for: developing a predefined template for documentation, developing an action plan for implementing the documentation strategy or providing educational activities on documenting design decisions. Moreover, in each case study design decisions were documented in a digital shared environment. The digital shared environment is an application where predefined templates can be used

for documentation. In these templates, design decisions and their rationale can be documented by project members. This environment will be further referred to as the IT-tool. Next, a short description of each case study is presented:

1. Case A: renovation of a sluice complex. This project is currently in the contract preparation phase. Within the tendering process of this project, the documentation of design decisions has been considered as highly important and the application of Systems Engineering has been requested by the client. The concept strategy by Kinneging et al. (2020) is partly implemented in this project. The different elements of the concept strategy have been implemented in the predefined template. The different levels have not been implemented explicitly or by order, which means that the specific steps as prescribed in fig. 1 were not explicitly followed.
2. Case B: enlargement of a highway. This project is currently in the contract preparation phase. The concept strategy by Kinneging et al. (2020) has been used as an input for documentating design decisions. However, the specific steps and elements of the strategy have not been explicitly implemented in the project. The design decisions were documented in a predefined template in an IT-tool requested by the client.
3. Case C: renewment of a road traffic control centre. This project is currently in the exploration phase. Within this project, the engineering consulting firm has been in charge of collecting the requirements among the stakeholders and preparing the design decisions. A predefined template was developed for documenting design decisions in a digital environment. This template was based on the concept strategy by Kinneging et al. (2020). However, not all levels or elements have been included as the project was not a standard infra project. Therefore, the concept strategy was formatted to optimally fit this type of project.

The case studies can differ in stages, with different parties involved and different clients. Furthermore, the extent to which the concept strategy by Kinneging et al. (2020) has been implemented varies among the cases, depending on the context of the projects and the people involved. However, every project had a documentation strategy for design decisions applied, therefore it was possible to form an assessment and conduct pattern matching.

A total of 17 participants have been interviewed; seven for case A, four for case B and six for case C. The roles of the participants varies from project and technical managers to designers and key staff members of SE. The selection of the participants was based on their involvement during the implementation of the documentation strategy or their role regarding the design decisions within the project. An interview list is developed and is outlined similar to the theoretical framework. The interview questions can be divided into two groups: result-oriented and process-oriented questions. The result-oriented questions focus on whether the specific action has taken place. For example: was there an implementation team to guide and monitor the implementation of the documentation strategy for design decisions? Depending on the interviewee's answer, follow-up questions with regard to process were asked. These type of questions were asked depending on the answers of the interviewee on the result-oriented questions. For example, process-oriented questions that could have been asked following the previous question could be: who were part of this team and how was this team established? The interviews have been recorded and intelligent verbatim transcripts were written for data analysis.

Furthermore, a document analysis has been conducted. Documents that should include design decisions, describe the policy for documenting design decisions or where project members expect to locate design decisions have been analyzed to determine whether there is still a lack in documenting design decisions after the concept strategy has been implemented. The IT-tool was investigated to determine whether there is coherence between formulation of the design decisions and whether design decisions were substantiated with a rationale. Furthermore, it is determined whether connections between design decisions in the IT-tool were made.

3.3 Empirical data analysis

The interviews transcripts were analyzed by making use of the software ATLAS.ti. Data analysis was performed based on an iterative process of open coding and axial coding. Open coding was performed by assigning relevant statements from interview transcript a certain code. The codes have been deducted from the theoretical framework. For example, if the interviewee mentioned a lack of consensus within the project team, the code *consensus* was attached to the statement. Thereafter, axial coding was performed by reorganizing all the codes into groups based on the elements of the theoretical

framework. For example, the code *implementation team* is arranged in the group *initiating*. Furthermore, additional codes were used for relevant statements that are not necessarily directly linked to the theoretical patterns. These are grouped under *additional findings*. The group *concept strategy* was used for all statements referring to the concept strategy by Kinneging et al. (2020).

After coding and grouping the statements in ATLAS.ti, the data of the case studies was analyzed by means of pattern matching (Cao, 2007; Yin, 2014). Pattern matching is a method for confronting theory with observations from practice (Cao, 2007). The theoretical framework serves as the *theoretical patterns* whereas the empirical data from the case studies serve as the *empirical patterns*. As the theoretical patterns describe how a strategy should be implemented ideally, the empirical patterns describe the current practices of how a documentation strategy for design decisions currently is implemented. The development of the theoretical framework prior to the case studies was crucial as the expected pattern needs to be specified before the matching takes place (Hak & Dul, 2009). Therefore, the theoretical framework as presented in chapter 2 was developed prior to the case studies.

The theoretical pattern is confronted with the empirical pattern, to analyse whether they are in line with each other (Cao, 2007). The data stored in ATLAS.ti was used to formulate empirical patterns. To analyze the data, a three-point scale has been used to assign values to the confrontation. As the patterns have been formulated in actions that need to performed, the indicators are assigned based on whether the action has been executed. Therefore, if the action has been performed, a + value is assigned whereas if the action was completely absent, a - value was assigned. If the action has been performed partially or only by or for a specific group of people, a partial match *o* was assigned. An explanation of each pattern confrontion is included to provide a justification of how the data has been interpreted. Lastly, a summarizing overview will be presented that gives a general overview of the results of pattern matching for each case study. Table 3 presents the structured outline of this table.

Table 3. Table used for summarizing the case study results

Framework		**Case A**	**Case B**	**Case C**
Element 1	Theoretical pattern	-/o/+	-/o/+	-/o/+
Element 2	Theoretical pattern	-/o/+	-/o/+	-/o/+
Element 3	Theoretical pattern	-/o/+	-/o/+	-/o/+

3.4 Validation

The implementation guideline has been validated by six experts through a new series of interviews. These experts were not part of the first round of interviews as conducted during the case studies. Experts are selected based on their roles and field of expertise. As the guideline is written for project members who aspire to organize and guide the process of implementing a documentation strategy for design decisions, project members with process-oriented responsibilities were chosen to participate in the validation sessions. Validition has taken place in a one-on-one setting with project members and consisted of two parts. In the first part, project members received background information on documenting design decisions and strategy implementation. In the second part, the guideline was discussed and assessed based on six criteria that were adapted from the study of Beecham et al. (2005).
Table 4 provides an overview of the criteria that were used for validation. The guideline was sent prior to the validation session to participants to give them the opportunity to prepare for the meeting and be aware of the content of the guideline. Furthermore, additional questions were asked with regard to the general overview of the guideline such as: what are the strengths and weaknesses of the guideline and what is your general impression of the guideline?

The data obtained from validation is analyzed similar to the case study data by making use of ATLAS.ti. Relevant statement are assigned codes such as *use of checklists* and *terminology*. The codes are then reorganized in groups that are based on either one of the six criteria as mentioned in table 4 or the group *general remarks* for the codes derived from the additional questions.

Table 4. Criteria used for validation, adapted from Beecham et al. (2005)

Criteria	Standard
Consistency	• There should be a consistent use of terms in the guideline
Understandability	• All terms should be clearly defined • Users should have a shared understanding of how to use the guideline
Usability	• The guideline is easy to use and to follow
Soundly	• The guideline should only contain information that contributes to the implementing the documentation strategy • The suggestions provided in the guideline should be correct
Tailorability	• The guideline should be tailorable and adaptable depending on the context of the project • The guideline should be tailorable for other implementations than a documentation strategy for design decisions
Verifiability	• It should be verifiable whether the use of the guideline has had a positive effect on the implementation process

4. RESULTS: CASE STUDIES

In this section, the pattern matching results are provided. Table 5 gives a general overview of the pattern matching results for each case study. The confrontation was scored by the following scale: + patterns match, o patterns match partly, - patterns do not match. In Appendix I, detailed pattern matching tables including the explanation for the assigned values are presented. The next section provides a within-case description of the results.

Case A

The documentation of design decisions was requested in the tender documents by the client. In the start-up of the project, the purpose of the documentation strategy was formulated and communicated to all project members. Responsibilities for pursuing it were assigned and the discipline leaders held the responsibility of documenting design decisions in the IT-tool. The change agent responsible for guiding and supporting the documentation strategy of the project, was a junior engineer operating solo during the implementation process. The interview findings reveal that there was a lack of management support for the documentation strategy and that there was no implementation timescale created and used during the implementation process. Furthermore, activities regarding documentation were moved up the timeline of the project and were not executed parallel to the design process. Within the environment in which design decisions were documented, there was a lack of coherence between design decisions of different disciplines. Educational activities were provided to project members on documenting design decisions, however, there was no guidance on operational level. Furthermore, the documentation strategy was not evaluated throughout the project, however there was little monitoring and controlling of the environment where design decisions should be documented. Lastly, a final evaluation on the implementation of the documentation strategy for design decisions was not conducted as the evaluation session was planned but canceled due to circumstances.

Case B

There was no documentation strategy initiated during the start-up of the project. The documentation of design decisions was requested by the client in the process description of Systems Engineering, however; not all interviewees were aware of this request. Two project members, none a senior manager, entered the project at a later stage and took on the responsibilities of a change agent. The design decisions were documented by the technical manager with retrospect. The interviewees revealed that it was unclear who was bearing the responsibilities for design decisions and that specific roles and responsibilities for the documentation strategy were not assigned. Also, not all project members have made use of the digital environment for documenting design decisions. Furthermore, there were no educational activities for documenting design decisions provided and there was no communication of benefits and purpose of a strategy. The interview findings also reveal that an implementation timescale was absent in this project. However, there were

Table 5. Pattern matching results of each case

Framework		Case A	Case B	Case C
Initiating	Form an implementation team *There should be at least one senior manager in this team	o	o	+
	Formulate and communicate the vision, goals and purpose of the strategy	+	-	+
	Identify client requirements regarding the strategy	+	+	-
Planning	Create an implementation timescale	-	-	-
	Align strategy tasks with work activities	o	-	+
	Plan trainings and educational activities	+	-	+
Executing	Assign roles and responsibilities to each project member	+	-	+
Monitoring & Controlling	Conduct progress meetings and evaluate phases	o	+	o
Closing	Evaluate the implementation process and document findings for future projects.	-	-	-

+ indicates a match, o indicates a partial match and – indicated no match

occasional evaluations between the change agents on the progress of documenting design decisions. During these meetings, lessons learned were discussed and used in further phases of the project. However, these findings were not shared with other project members, Furthermore, technical managers on both the contractor and client side did check the documentation of design decisions on completeness. Lastly, interviewees have stated that a process evaluation will be planned at the end of the project and that there is a need for evaluating the process of documenting design decisions, however it is unknown whether this will become an item on the agenda.

Case C

In this project, the documentation of design decisions was not requested by the client. However, the client did request for a decent substantiation of the choices made during the project. During the project start-up, the project team gathered and decided to implement a documentation strategy for design decisions. Two change agents took on the role for guiding and executing the strategy; one was a junior engineer and one a senior manager. The project team decided to conduct joint work sessions and the purpose and benefits of the strategy was communicated to the team in one of those sessions. Furthermore, during these sessions, agreements on documentation and formulation of design decisions were established. Also, a role division with regard to documentation was made and educational activities were provided to project members when needed. However, there was no implementation timescale created and used during the project. Furthermore, the change agents frequently monitored and controlled the design decisions in the digital shared environment. However, lessons learned were not captured and used during the course of the project. At the end of the project, a final evaluation was conducted. However, the documentation strategy was not considered during this evaluation.

5. ANALYSIS OF THE RESULTS

In this section, a cross-case analysis based on the results of the cases is provided. The findings of all three cases were compared to identify similarities and differences. The pattern matching results in table 5 indicate that the implementation processes for case A, B and C are not in line with theory. At the utmost it is case C that scores the most matches (+). As observed, the cases score fairly differently on the patterns, which could be explained by their different contexts. Both case A and B were large design projects whereas case C was a small project conducted in the exploration phase and deliberately decided to

apply a different method for documentation. Different project teams have performed in these cases and the team stratification varied as well. The cases show that the road to obtain documented design decisions can be diverse. In this section, case study observations are analyzed and explained.

5.1 Cross-case analysis

Initiating

As observed in practice, at least one person partly performing the responsibilities of a change agent could be found. However, the change agents were often not able to fully commit to the implementation tasks. An explanation to this is the experience among the change agents. In case A, the change agent was a junior engineer operating solo and without the support of management, which made it difficult for the change agent to put pressure on the team to cooperate with the strategy. Furthermore, it was difficult for the change agent to overlook the entire strategy and execute all tasks without the support of an additional change agent. Contrarily, in case C the junior engineer was accompanied by a senior manager who did put pressure on the project team to cooperate. In case B, the change agents both joined the project at a later stage and once they did, there already was a specific approach to working in place. The already established approach made it difficult to implement the documentation strategy. Concluding, there is at least one change agent found in practice, however there is a lack of seniority in the implementation team and change agents experience a high workload and difficulty with fulfilling the needed implementation tasks.

As observed in the cases, the vision, goals and purposes of the strategy are often communicated to project members. However, there is still resistance by project members towards the strategy. An explanation to this is the lack of consensus and lack of urgency by project members on the documentation strategy. In case A, the use of a digital shared environment combined with documenting in the integral design note was perceived as double work. In case B, there was a lack of urgency for documenting design decisions at the start-up of the project and design decisions were not prioritized. In case C, there was consensus on the strategy as project members felt the need for this documentation. Summarized, the vision goals and purposes of the strategy are often communicated to project members, but there is resistance against the strategy because of lack of consensus and urgency among project members.

As observed in practice, the client often requests for the documentation of design decisions. Yet, project members are not always aware of this request. In case A, this request was written in the tender whereas in case B, the request was written in a separate document. Project members do not always read these specific documents, and if such information is not communicated, then they are not aware of the expectations of the client. In case C it was deliberately decided to document design decisions as a means of providing a substantiation of choices to the client. Management was aware of this request and communicated this to the project team. Concluding, the client requirements are identified in current practices, however not all project members are always aware of this request.

Planning

As observed in practice, none of the three cases has developed and used an implementation timescale. The reason for this is that an implementation timescale was not considered. In case B and C, the documentation of design decisions was considered in the process planning. However, a specific implementation timescale taking in consideration the time needed for the implementation activities is missing in current practices.

An essential finding from the three cases is that strategy tasks are often not aligned with work activities. There are different explanations to this for the studied cases. In case A, the initial proposal to have designers document design decisions parallel to the design process generated resistance among project members. In addition to that, time pressure caused the documentation of design decisions to be moved up the timeline of the project. In case B, design decisions were not a focal point from the start of the project. Design decisions were documented with retrospect at a later stage in the project, which took additional time and effort. Contrarily to the other two cases, documentation activities were integrated with work activities in case C through joint work sessions. Documentation activities were considered during these sessions and as the change agents were available, other project members could quickly receive assistance when needed. To conclude, currently there is a lack of alignment of strategy tasks with work activities.

As observed in practice, educational activities on the documentation strategy are often provided to project members. Yet, project members still have difficulties with adjusting to the new ways of working.

The reason for this is the lack of operational guidance. In case A the educational activity was perceived positively by the project members. Yet, they nonetheless converted back to the traditional ways of working due to lack of operational guidance. Project members were not able to apply the newly gained knowledge into practice as most knowledge was forgotten at the time of application. Contrarily, in case C, explanation on working in the IT-tool was provided combined with operational guidance during the joint work sessions. The small size of the team and the joint work sessions made it possible for the change agents to provide direct feedback and assistance. In case B, educational activities were not provided as only the project members that already were familiar with the application used it. Summarized, educational activities are often provided in current practices, however these are often not complemented with operational guidance.

Executing

As observed in practice, specific roles and responsibilities for documentation are not structurally assigned. Furthermore, project members do not always know who to turn to for questions with regard to the strategy and there is a lack of coherence between design decisions of different disciplines. Currently, there is a difference in perception of who should bear the responsibility of documenting design decisions. The reason for this is that documentation activities are not included in the task description of employees. In case B, project members who were not familiar with working in the IT-tool, were not assigned roles and responsibilities for documentation in the digital shared environment. Further, the case study results disclose that project members entering at a later stage were unaware of whom to turn to for questions as a general overview of all roles and responsibilities were lacking. The lack of coherence between design decisions of different disciplines in case A can be explained by the absence of a project member responsible for this aspect. For case C, the small size of the project team made it easier to enhance user participation by discussing the strategy in joint work sessions. In this case, documentation was considered a shared responsibility. Concluding, roles and responsibilities for the documentation strategy are not structurally assigned in current practices.

Monitoring & Controlling

As observed in practice, frequent evaluations regarding the documentation of design decisions are considered in case C, but less in the other two projects. One potential reason is that the size of the project team of case C was relatively small and progress was easily discussed during the work sessions, meanwhile planning was altered if needed. Other potential reasons could be the experience and knowledge level of one the change agents and that there were two change agents who could support the project team members. In both cases A and B there were no specific rules set or agreements made on monitoring and controlling the documentation strategy. In case B, the change agents discussed progress sporadically. Therefore, evaluations to discuss progress during the lead time of the project happened mostly occasionally. Summarized, monitoring and controlling during implementation happens sporadically in current practices, but there are no clear rules or agreements set for this.

Closing

As observed in practice, there is no evidence of a final evaluation conducted regarding the implementation of the documentation strategy for design decisions in none of the cases. The absence of a final evaluation including the implementation of a documentation strategy for design decisions was clear in both cases A and C. According to an interviewee of case C, the implementation of a documentation strategy was not part of the final evaluation of the project because there were no obstacles to be discussed. This suggests that positive lessons learned are not always considered and shared. Project members of case A have expressed the desire to evaluate the documentation strategy for design decisions, however due to circumstances, the final evaluation was canceled. Project B is still ongoing and project members have also expressed a desire for a final evaluation of the documentation strategy, however it is unknown whether this will be done. Another reason why a final evaluation is often not conducted, is that project members prefer sharing lessons learned through dialogues instead of documenting lessons learned for future projects. Concluding, lessons learned with regard to implementation of the documentation strategy are not captured and distributed for future projects.

5.2 Summary

The case study results and analysis show that the implementation of a documentation strategy for design decisions often does not perform up to the

theoretical standard. For many patterns there are differences found between theory and practice. Change agents sometimes operate solo or without management support and have difficulties with fullfilling their obligations regarding the strategy. Furthermore, the vision goals and purposes of the strategy are often communicated to project members, but there is resistance against the strategy because of lack of consensus and urgency among project members. The client requirements are currently identified in practice, however project members are not always aware of the request. There is a lack of alignment of strategy tasks with work activities as documentation activities often happen afterwards instead of during the design process. The analysis indicates that educational activities are currently provided to project members, however because of lack of operational guidance, project members experience difficulties with applying the newly gained knowledge in practice. The division of roles and responsibilities is partly covered in current practices. However, project members are not always aware of who bears certain responsibilities. Monitoring and controlling often happens sporadically in current practices as there are no specific rules set for this. The pattern matching indicates that the two patterns that are least in correspondance with literature are the development of an implementation timescale and the performance of a final evaluation. The time needed for different implementation activities is currently not considered prior to implementation. Furthermore, the evaluation of the documentation strategy for design decisions was either canceled due to circumstances or not considered.

6. DEVELOPMENT OF THE IMPLEMENTATION GUIDELINE

The pattern matching results reveal that there is a gap between theory and practice with regard to strategy implementation. This does not necessarily indicate that implementation has failed. In all three case studies, the design decisions were eventually documented and stored in a digital shared environment. Therefore, even though there are many semi- and mismatches assigned during the pattern matching analysis, the absence of certain patterns does not nesessarily affect whether the main goal for implementation is met. Specific results are not consequently a causal effect of the framework. There might be other factors in play. Therefore, it is possible to have positive results without semi- and mismatches. The case study results do provide insight in the process that project members went through to have these design decisions documented. Especially cases A and B show the difficulties that were experienced with achieving this final level of documentation. The difference between the cases can be partly explained by the fact that there is no uniform method for documenting design decisions in the studied engineering consulting firm. It is therefore up to each project team to decide how to organize this documentation. Literature currently provides elements that are needed when implementing a new strategy, however, there are limited studies on how these steps should be achieved. Therefore, the theoretical framework is translated into a guideline that prescribes the needed steps to perform the theoretical patterns. Even though the absence of certain patterns has not necessarily resulted in implementation failure, these patterns are considered important in enhancing the implementation process and thus providing project members with a structured approach during implementation.

The analysis has shown that some patterns are consequently executed whereas other patterns are completely absent in current practices. A process connecting all these patterns is missing and therefore the guideline is outlined by the five processes corresponding to the theoretical framework: *initiating, planning, executing, monitoring & controlling* and *closing*. These processes are meant to guide implementers step-by-step from start to finish. The building blocks are arranged in one of these five processes similar to the theoretical framework. Next, the development of the nine building blocks of the guideline is elaborated for each process.

Initiating

The case study results show that in each case, there were people assigned to guide and support the documentation strategy. However, the data also indicates that one change agent is not enough to take on this responsibility due to a high workload. Especially when the change agent was not a senior project member, difficulties were experienced with putting pressure on the team to cooperate with the strategy, Furthermore, current practices show that there is a lack of coherence experienced in formulating design decisions in the shared environment for documention. Therefore, an additional role is added to the implementation team, called the *coordinator*. All these elements result in the development of the first building block of the guideline: *implementation team.*

The case study results indicate that there is a lack of consensus between project members on the documentation strategy. The benefit of the strategy is communicated to the project team, however, even on management level, disagreements have been observed. Management support is required to deal with possible resistance by project members as much as possible when proposing the strategy to the project team. Therefore, special attention is given to establishing consensus and management support in the second building block: *vision, goals and purposes.*

The client requirements are identified in current practices, however project members are not always aware of this request. The case study results show that the client plays an important role in decision making. Besides, involving the client during the implementation process helps project members to decide on the format in which design decisions should be documented. Therefore, a third building block is added to the guideline which is: *client requirements*.

Planning
An implementation timescale is currently not considered during the implementation process. However, implementers do experience time pressure when executing the strategy tasks. An implementation timescale helps to set a direction and manage time efficiently. Furthermore, the creation of an implementation timescale should give implementers an overview of the activities that need to be executed and the availability of the implementation team to provide operational guidance to project members. Therefore, the fourth building block of the guideline is: *implementation timescale.*

Documentation activities often happen at a later stage in a project which results in a lack of alignment of strategy tasks with work activities. Ideally, design decisions should be documented parallel to the design process, this to avoid documenting in a later stage which could then more likely be experienced as an administrative burden. One of the case studies showed the benefit of organizing work sessions with the entire project team, which makes it possible for change agents to provide operational guidance. The latter is considered as a valuable opportunity for project members for learning, documenting and conducting work at the same time. Therefore, the fifth building block of the guideline is: *align strategy tasks.*

Lack of experience and knowledge is identified in current practices with regard to documenting design decisions. Educational activities are currently provided to project members and these are considered positive. However, lack of operational guidance following the educational activities is observed as an obstacle for the learning process. Educational activities are crucial to enhance the knowledge of project members, but enhancing skill needs practice and therefore a sixth building block is created that deals with this aspect: *knowledge and skills.*

Executing
The case study results show that project members experience an unclear task division. Certain roles and responsibilities are often not assigned to project members because they are not familiar with for example working with the IT-tool. Also, project members are not always aware of who bears certain responsibilities. The assignment of roles and responsibilities should enhance user participation. Therefore, the seventh building block of the guideline is: *roles and responsibilities.*

Monitoring & Controlling
In current practices, progress meetings and evaluations happen either occassionally or do not happen at all. Every project is different which means that the implementation process will also vary. It is important for the implementation team to carefully monitor this process and to adjust where needed. Furthermore, regular check-ups on the progress of documentation help keeping the design decisions up to date. Therefore, an eighth building block is created to deal with his aspect: *progress meetings and evaluations.*

Closing
There is no evidence of a final evaluation conducted at the end of a project. The lack of a final evaluation results in lessons learned to not be captured and distributed for future projects. The distribution of lessons learned can prevent reinvention of the wheel and repeating mistakes. Therefore, the ninth building block is: *evaluation and lessons learned.*

6.2 Underpinnings of the guideline
An extended overview of the content of each building block and corresponding process is visualized in fig. 2. In appendix III, the guideline is presented which provides the detailed checklists for each building block. For each building block, a checklist is created. Each checklist consists of detailed actions to carry out for the specific building block. Certain checklists are divided into two sections: *crucial* and *noncrucial*. The crucial checklist items are actions that are critical for

implementation. These items should be carried out at any time. The noncrucial items are not critical for succesful implementation, but are nonetheless highly recommended to execute. Underneath certain actions, directions are provided to assist implementers during implementation. Factors such as project size, team stratification and lead time might influence certain directions. Implementers should take these factors in consideration when following the directions. The guideline includes a fill-in form that can be used for documenting agreements, deadlines and other relevant information. Both the fill-in form as the guideline itself can be printed or used digitally. Next, a summary of the content of the processes and building blocks of the guideline is presented. Afterwards, a summary is provided on the key issues and proposed measures according to their corresponding building blocks and processes in table 6.

Initiating

The implementation process starts with one implementer seeking to implement a documentation strategy for design decisions. Within the initiation phase, the implementation of the documentation strategy of design decisions should be initiated by the implementer. This phase contains the first three buildings blocks: *implementation team, vision, goals and purpose* and *client requirements.*

- Implementation team: the formation of the implementation team should consist of at least two members for small projects and three members for large projects and there should be a senior manager in the team. The guideline also prescribes the profile characteristics of an implementation team member and the tasks to be executed during the implementation process. The coordinator is an additional role added to the implementation team and is responsible for controlling the shared environment and to check all design decisions on coherence, completeness and formulation. Depending on the project size, the implementation team should decide whether an independent coordinator is needed in a project or whether the projectmanager, technical manager or another implementation team member takes on this role as an additional responsibility.
- Vision goals and purposes: the guideline prescribes that the vision, goals and purpose of the documentation strategy should be determined by the implementation and included when developing an action plan. It is suggested to set milestones divided in short-term wins and long-

Figure 2. The building blocks of the guideline

term achievements to motivate project members and to show intermediate results. Furthermore, the strategy itself and its benefits should be discussed during a management meeting to establish consensus among the managers and thus achieve management support.

- Client requirements: the client requirements with regard to documenting design decisions should be determined beforehand and communicated to the project team. The guideline prescribes to check in documents or during meetings whether this has been requested by the client. That could be in tenders or prescribed process descriptions. If the latter is not the case, the documentation strategy should nonetheless be discussed with the client to make arrangements on the format in which the design decisions should be delivered to the client.

Planning

In the second step of the implementation process, the implementation should plan the needed activities for implementation. As change is a time-consuming process that consists of several steps, it needs to be carefully managed and planned. This phase contains the following buildings blocks: *implementation timescale, align strategy tasks* and *knowledge and skills.*

- Implementation timescale: an implementation timescale should be created that includes the implementation activities, e.g. educational activities, work sessions and meetings, to set a direction and manage time efficiently. The creation of this timescale will give the implementation an overview of the activities to be executed and the availability of the implementation team to provide operational guidance to project members. The implementation timescale should be discussed with the management team in order to organize work sessions and educational activities.
- Align strategy tasks: agreements should be made on when to document design decisions. The guideline prescribes to organize work sessions with the project team in which designing as well as documentation takes place.
- Knowledge and skills: educational activities should be planned and executed by the implementation team at the start of the project which should be followed up by guidance at operational level. The guideline prescribes different forms of educational activities such as trainings, workshops or work sessions. It should at least provide explanation on the benefits of working in the predefined template, how to work in the predefined template and how to formulate design decisions. Educational material could be provided in the form of e.g. checklists, handouts and guidelines for project members to use and fall back to when there is no immediate operational guidance available.

Executing

In the third step of the implementation process, the documentation strategy is executed. This phase takes the longest and needs to be carefully managed and monitored by the implementation team. This phase contains the building block: *roles and responsibilities.*

- Roles and responsibilities: roles and responsibilities should be assigned to project members. The guideline provides a suggestion of a possible role division that includes who should document design decisions, who should monitor and control the overall completeness of the documentation and who should control and monitor the shared environment. However, the division of roles is among other things dependent on the project type, project size, stratification of the projet team and lead time of the project. Consequently, the division of roles should be discussed with the project team at the start of the project and documentation activities should be adopted in the task description of the project members. Lastly, an overview of the roles and responsibilities of each project member regarding the documentation strategy should be created and made available to all project members.

Monitoring & controlling

Within this phase, the implementation team is responsible for monitoring and controlling the different phases in the entire implementation process. The corresponding building block is: *progress meetings and evaluations.*

- Progress meetings and evaluations: the implementation team should conduct progress meetings to discuss progress, obstacles and short-term wins. Furthermore, the checklists can be updated if needed during these meetings. The amount of progress meetings to conduct depends on the preference and schedule of the implementation team. However, the guidelines does provide suggestions for the amount of meetings and their volume. Lastly, progress

evaluations should be conducted to determine whether improvements or alterations need to be made throughout the project.

Closing

The final phase of the implementation process is the closing of a project. This phase contains the final building block: *evaluation and lessons learned.*

- Evaluation and lessons learned: the implementation team should gather once more towards the end of the project to evaluate the entire implementation process. The guideline prescribes what to evaluate during this meeting. Questions such as - what went well? what could have gone better? have the goals been met? - should be discussed and documented for future use.

Table 6. Summary of the key issues and the proposed measures for the building blocks

Process	**Key issues**	**Proposed measures**	**Corresponding building block(s)**
Initiating	High workload on change agents	Assign at least two change agents to the implementation team	Implementation team
	Lack of management support	Add a senior manager to the implementation team	Implementation team
	Lack of coherence between design decisions	Assign an additional role and to check all design decisions on coherence, completeness and formulation.	Implementation team
	Resistance towards the strategy	Communicate the benefits to the project members. Set milestones to provide project members with intermediate results.	Vision, goals & purpose
	Lack of awareness on the client requirements	Identify client requirements and communicate this to the entire team	Client requirements
Planning	Absence of an implementation timescale	Create a planning for the implementation activities	Implementation timescale
	Strategy tasks are often not aligned with work activities	Organize work sessions to integrate work activities and documentation tasks	Align strategy tasks
	Lack of knowledge and experience among project members	Organize educational activities regarding the strategy	Knowledge and skills
	Lack of operational guidance	Provide operational guidance to project members during the course of the implementation process	Implementation timescale and Knowledge and skills
Executing	Unclear task division with regard to the documentation strategy	Create an overview of all roles and responsibilities and add documentation activities in task descriptions	Roles and responsibilities
Monitoring & Controlling	Lack of frequent evaluations on the implementation process	Plan and conduct progress meetings for evaluation and distribution of lessons learned	Progress meetings and evaluation
Closing	No distribution of lessons learned	Conduct final evaluations for future projects	Final evaluation and lessons learned

7. VALIDATION: IMPLEMENTATION GUIDELINE

In this section the validation of the implementation guideline is discussed. The validation has been conducted with experts using the criteria as described in §3.4. In appendix II, a more extensive version of the results is provided in table II.1.

Overall impression

The use of the five processes *initiating, planning, executing, monitoring & controlling* and *closing* is perceived positively by the participants. The use of project management processes as an outline summons recognition among the project members and is close to current work practices. The building blocks are considered logical and the guideline is described as a good combination of theory and practice. One participant points out that all building blocks should be reconsidered by the implementation team at the start of a new project phase. Furthermore, participants consider the use of checklists positively as it provides a structured, step-by-step approach. Some participants acknowledge that the use of the guideline depends on the type of people in the project team and one participant notes that the effectivity of the guideline depends on the commitment of the project team members.

Perceived bottlenecks

Participants mention that convincing people to use the guideline is a bottleneck and that the focus on implementing a documentation strategy for design decisions depends on the type of people that are involved in the project. Besides that, the number of employees that would fit the characteristics of a change agent for this specific topic is limited in the studied engineering consulting firm. One participant suggests that it would be interesting for future research to study implementation on firm level as the top down approach would force people to do it. Furthermore, two participants note that the use of structured checklists fits a certain type of thinking and might not appeal to everyone.

Consistency

Participants agree that the guideline is consistent in structure and the definitions are clear. One participant suggests adding the coordinator in the terminology.

Understandability

Participants agree that the guideline is understandable and clear. Several participants suggest addressing the possibility of combining roles such as change agent and coordinator more clearly. Furthermore, the experts suggest some additions with regard to quantifying certain checklist items such as project size and adding roles for the suggested role division. Furthermore, one participant argues that the guideline checklists could be shortened and more compact by, for example, combining the first four checklists items into one. However, another participant disagrees and notes that having specific checklist items for the different roles of the implementation team is useful and provides insight in how such a role can be allocated.

Usability

The guideline is perceived as easy to use and to follow by participants. Especially the suggestions provided in italics below specific actions are considered valuable as they set a direction and give readers an idea of the content. The fill-in form is considered useful. One participant notes that it would be useful to add a column with discussed actions in the fill-in form as well. Another participant states that the fill-in form is convenient, but that it would be more useful to document the discussed actions in the IT-tool that is used for documenting design decisions.

Soundly

Participants agree that the suggestions provided in the guideline are valuable and needed as they provide implementers with a perception of the checklist item. Two participants provide suggestions for enhancing the flow chart and corresponding table; clarify what a design team is and clarify the difference between change agent and coordinator. One participant argues that it is not feasible to have discipline leaders responsible for documenting design decisions due to the increase in workload.

Tailorability

Participants agree that the implementation guideline is fitted for different types of projects. One participant argues that it would be better to not adapt the guideline and keep it as general as possible. Another participant notes that several guidelines could be made: one for small projects, one for middle projects and one for large projects. Furthermore, participants agree that the buildings blocks of the guideline could be used for other implementation initiatives than a documentation strategy for design decisions.

Verifiability

Participants agree that it is possible to verify throughout the implementation process whether the guideline has had a positive effect. They suggest various forms for verification: (1) whether design decisions of different disciplines have been documented in a similar way, (2) whether project members were aware of the documentation strategy, (3) by discussing during progress meetings whether certain checklist items took additional effort to implement or (4) by verifying whether documentation was up to date and monitored. However, one participant argues that it would be possible to verify the use of the guideline, but it would be difficult to proof whether the use of the guideline was the determining factor.

8. DISCUSSION, LIMITATIONS AND FUTURE RESEARCH

This section provides a discussion on the research results in comparison with literature. Furthermore, the limitations of this study and future directions are presented.

First, this study has mainly focused on internal processes. However, it is reasonable to assume that other factors, such as context factors (e.g. project complexity) also may have influenced the results. It was assumed that external effects would manifest themselves during the internal processes, but this was not explicitly studied.

Second, the case study data has revealed that there is a difference in level of urgency among project members towards the documentation strategy. The level of urgency is among others an important factor that contributes to people's will to change. This type of change is addressed in CM literature in the form of organizational behavior. However, this study did not seek to investigate how behavior can be influenced. Therefore, future research is suggested with a specific focus on CM. Another aspect with regard to behavioral management is the different opinions of the experts regarding the implementation guideline. It is difficult to create a tool or a model that suits all project members as everyone works differently and has other preferences. The implementation guideline stimulates a formal approach to working. Project members already work with many formal processes and might prefer a more flexible approach. The aim of the implementation guideline is to improve the design process and create a more transparent process. However, that means that additional effort is needed, which might not be preferrable for some project members.

Third, the theoretical framework and empirical data point out important factors that contribute to successful implementation of a strategy. Yet, the influence of the type of people involved in the projects should not be underestimated. This study supports Kotter (1995), Lines et al. (2015) and Lines and Vardireddy (2017) in the importance of having change agents during the implementation process. However, the findings of the validation do show that the number of employees that fit the characteristics of a change agent for this specific topic is limited in the studied engineering consulting firm. The limited availability of change agents is considered an obstacle for future implementations and therefore it is suggested when assembling project teams, to consider recruiting the right people to assist during implementation.

Fourth, the case study projects are all infrastructure projects of the same engineering consulting firm. These cases were selected as these were the only projects in which aspects of the concept strategy by Kinneging et al. (2020) were used. This reduces the generalizability of the findings for different types of projects. Furthermore, the acquired data is limited, and future research is suggested with additional cases to increase the external validity. Also, additional research is suggested that takes different documentation strategies for design decisions into consideration.

Fifth, 'organizational' strategy implementation is not taken into consideration as this research specifically focusses on strategy implementation at 'project' level. The implementation of a documentation strategy for design decisions provides value to the client as it enhances the transparency and traceability of the design. Therefore, adopting an approach to documenting design decisions is beneficial to firms regarding client satisfaction. However, strategy implementation on organizational level requires a different approach and involves other factors that should be taken into account. Therefore, it is suggested to perform an additional study that takes upscaling to organizational level into consideration.

Sixth, due to the limited timespan of the research the implementation guideline has not been used in a project. Validation has taken place with only six experts from the same engineering consulting firm as the interview participants. Additional research is suggested on using the implementation guideline in a project as a testcase. It is also recommended to

validate the implementation guideline with a larger panel of experts.

Last, the empirical data obtained from the case studies are more detailed than what the theoretical patterns prescribe. An explanation to this is that the theoretical patterns are generic. A different research method than pattern matching could have been more suitable for this specific research and therefore the use of pattern matching is considered as a constraint of the research method.

9. CONCLUSION

This research has been carried out on behalf of an engineering consulting firm that experienced difficulties with implementing a documentation strategy for design decisions in infrastructure projects. The objective of this study was to assess why an engineering consulting firm experienced difficulty with implementing this strategy and to provide recommendations in the form of a guideline to overcome these barriers.

This study shows that currently there is no specific approach to implement a documentation strategy for design decisions in the studied engineering consulting firm. It is up to project teams to decide how documentation is organized. In all three case studies, design decisions were eventually documented in a digital shared environment. However, the case studies have provided insight in the obstacles project members experienced to have these design decisions documented. The findings of the pattern matching show that currently there is a gap between theory and practice when implementing a strategy at project level. Project members who are assigned the task to guide and execute the implementation of the documentation strategy are often junior engineers who experience lack of management support. Identification of the client requirements regarding the strategy should enhance the extrinsic motivation of project members to cooperate with the strategy, however project members are often not aware of this request. Furthermore, there is resistance by project members against the documentation strategy due to lack of consensus and lack of urgency. Even though educational activities are provided to project members, the lack of operational guidance has been an obstacle for the learning process of project members. Furthermore, project members, especially those who have entered the project in a later stage, are often not aware of who to turn to for specific matters with regard to the strategy. Lastly, this study identifies a lack in frequent progress meetings and final evaluations and therefore lessons learned are not captured and distributed throughout the implementation process as well as for future projects.

In conclusion, it is the lack of a structured implementation approach that has contributed to the several obstacles that implementers have experienced during the implementation of a documentation strategy for design decisions and this study aims to provide assistance to implementers for future implementations.

9.1 Recommendations

This study provides a practical guideline for implementing a documentation strategy for design decisions in projects. The guideline consists of five processes and nine building blocks. For each building block, checklists are created that describe actions that need to be carried out by implementers during implementation. The use of the implementation guideline provides project members with a step-by-step approach through implementation from start to finish. It is highly recommended to start using the guideline from the moment a project is initiated to ensure a smooth implementation process. The implementation guideline is written specifically for civil engineering projects that deal with design decisions, therefore any company or organization striving for implementing a documentation strategy for design decisions can use the guideline. Furthermore, the validation findings indicate that the generic nature of the building blocks is considered useful for implementations other than a documentation strategy for design decisions. These building blocks could provide organizations and firms directives when implementing new initiatives for enhancing internal processes. Future research is required to show that this is possible. On a final note, it is the change agent who is able to achieve change during implementation and they should be given the resources, time and space needed in projects to fullfill their obligations.

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APPENDIX I – PATTERN MATCHING PER CASE STUDY

Table I.1. Pattern matching for Case A

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
Initiating	Form an implementation team *There should be at least one senior manager in this team	There was an implementation team to guide and support the documentation strategy.	o	There was one change agent assigned to guide and support the documentation of design decisions in Relatics[1]. The change agent was not a senior manager.
	Formulate and communicate the vision, goals and purpose of the strategy	The vision, goals and purpose of the strategy have been communicated to the project members.	+	There were meetings organized at the start of the project on the documentation strategy and the purpose behind it.
	Identify client requirements regarding the strategy	The client had requested for the documentation of design decisions.	+	The client had requested in the tender that design decisions should be documented and traceable.
Planning	Create an implementation timescale	There was not an implementation timescale created for the documentation strategy.	-	The different activities and time needed for each activity were not planned or discussed prior to the project.
	Align strategy tasks with work activities	The strategy tasks were partly aligned with the work processes.	o	It was initially suggested to document immediately in Relatics parallel to the design process. However, due to time pressure documenting design decisions was not a priority and therefore moved up the timeline of the project.
	Plan trainings and educational activities	There were several educational activities in the form of explanation sessions planned and executed.	+	The change agent has provided explanation on working in Relatics through several meetings throughout the project to the project members.
Executing	Assign roles and responsibilities to each project member	Roles and responsibilities were assigned to project members concerning the documentation strategy.	+	For each discipline, roles and responsibilities were assigned to cover the documentation of design decisions within that discipline.
Monitoring & Controlling	Conduct progress meetings and evaluate phases	The documentation strategy has not been evaluated or monitored throughout the project. However, the environment where	o	Due to time pressure there were no progress meetings or evaluation meetings conducted during the project. The change agent did control

[1] Relatics is a cloud platform used by large projects in the construction, infrastructure and civil engineering industry to control all information within a project.

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
		design decisions should be documented was controlled.		the documentation within the Relatics environment.
Closing	Evaluate the implementation process and document findings for future projects.	The implementation process has not been evaluated for future projects.	-	There has not been an evaluation planned on specifically the implementation process of the documentation strategy.

Table I.2. Pattern matching Case B

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
Initiating	Form an implementation team *There should be at least one senior manager in this team	There was an implementation team to guide and support the documentation strategy.	o	There were two project members responsible for guiding and supporting the documentation strategy. Both were not a senior manager.
	Formulate and communicate the vision, goals and purpose of the strategy	The vision, goals and purpose of the strategy were not formulated and communicated at the start of the project.	-	There was not a documentation strategy for design decisions initiated from the start of the project. There was a lack of urgency for this at the start of the project.
	Identify client requirements regarding the strategy	The client has requested for the documentation of design decisions.	+	The client has requested in the tender to work according to the process description of Systems Engineering. The importance for documenting design decisions are addressed in this process description.
Planning	Create an implementation timescale	There was not an implementation timescale created for the documentation strategy.	-	As there was not a documentation strategy for design decisions from the start of the project, there was not an implementation timescale made. The different activities and time needed for each activity were not planned or discussed prior to the project.
	Align strategy tasks with work activities	The documentation strategy tasks were not aligned with the work activities.	-	The documentation of design decisions in GRIP[2] did not happen from the start of the project as this activity was not considered. Eventually the design decisions were documented with retroactivity effect.
	Plan trainings and educational activities	There were no trainings or educational activities for working in GRIP.	-	The people that were involved with working in GRIP were already aware with GRIP. Designers have not used GRIP.
Executing	Assign roles and responsibilities to each project member	There were not specific roles and responsibilities assigned for documenting design decisions in the GRIP.	-	There was a lack of urgency at the start of the project for documenting design decisions. No clear responsibilities were assigned for documenting design decisions.
Monitoring & Controlling	Conduct progress meetings and evaluate phases	The different phases of the documentation strategy were evaluated throughout the project. The documentation of design decisions has been monitored.	+	The change agents have evaluated the progress of the documentation of design decisions throughout the process. The documentation of design decisions has been monitored by technical managers from both client and contractor side.

[2] GRIP is an application based on the Relatics database to secure, manage and retrieve project information.

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
Closing	Evaluate the implementation process and document findings for future projects.	The implementation process has not been evaluated for future projects yet.	-	The project is still ongoing. There will be a process evaluation, but it is unknown whether the documentation of design decisions will be a part of this.

Table I.3. Pattern matching Case C

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
Initiating	Form an implementation team *There should be at least one senior manager in this team	There was an implementation team to guide and support the documentation strategy.	+	There were two project members responsible for maintaining the Relatics environment and guiding the other project members. One of the two was a project manager.
	Formulate and communicate the vision, goals and purpose of the strategy	The vision, goals and purpose of the documentation strategy were formulated and communicated with the project team.	+	The action plan that includes the documentation strategy for design decisions was created in accordance with the project team.
	Identify client requirements regarding the strategy	The client did not request for the documentation of design decisions.	-	The need for documenting the design decision came from the project team and not from the client. The client did request for a decent substantiation of choices.
Planning	Create an implementation timescale	There was not an implementation timescale created for the documentation strategy.	-	There was a process planning created by the project manager. Agreements on where and when to document design decisions were made during meetings with the project team.
	Align strategy tasks with work activities	The strategy tasks were aligned with the work processes.	+	Documentation was considered as part of the project and therefore agreements on documenting in Relatics and in the final reports were made during work sessions.
	Plan trainings and educational activities	There were educational activities in the form of explanations provided to project members when needed.	+	During work sessions, explanation on documenting design decisions in Relatics were provided by a member of the implementation team.
Executing	Assign roles and responsibilities to each project member	Project members were assigned a certain role or responsibility concerning the documentation strategy.	+	Everyone had a role regarding a certain theme within the project. Agreements on this were made during work sessions.
Monitoring & Controlling	Conduct progress meetings and evaluate phases	The different phases of the documentation strategy were not evaluated throughout the project. There was frequent monitoring of	o	The Relatics environment was controlled and monitored by the implementation team. The compliance of the documentation strategy was controlled by the project manager. However, these actions have been performed rather

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
		the documentation of design decisions.		implicitly as opposed to explicitly.
Closing	Evaluate the implementation process and document findings for future projects.	The implementation process has not been evaluated for future projects.	-	The documentation strategy was not part of the evaluation that was conducted.

APPENDIX II – VALIDATION OF THE IMPLEMENTATION GUIDELINE

Table II.1. Validation of the implementation guideline

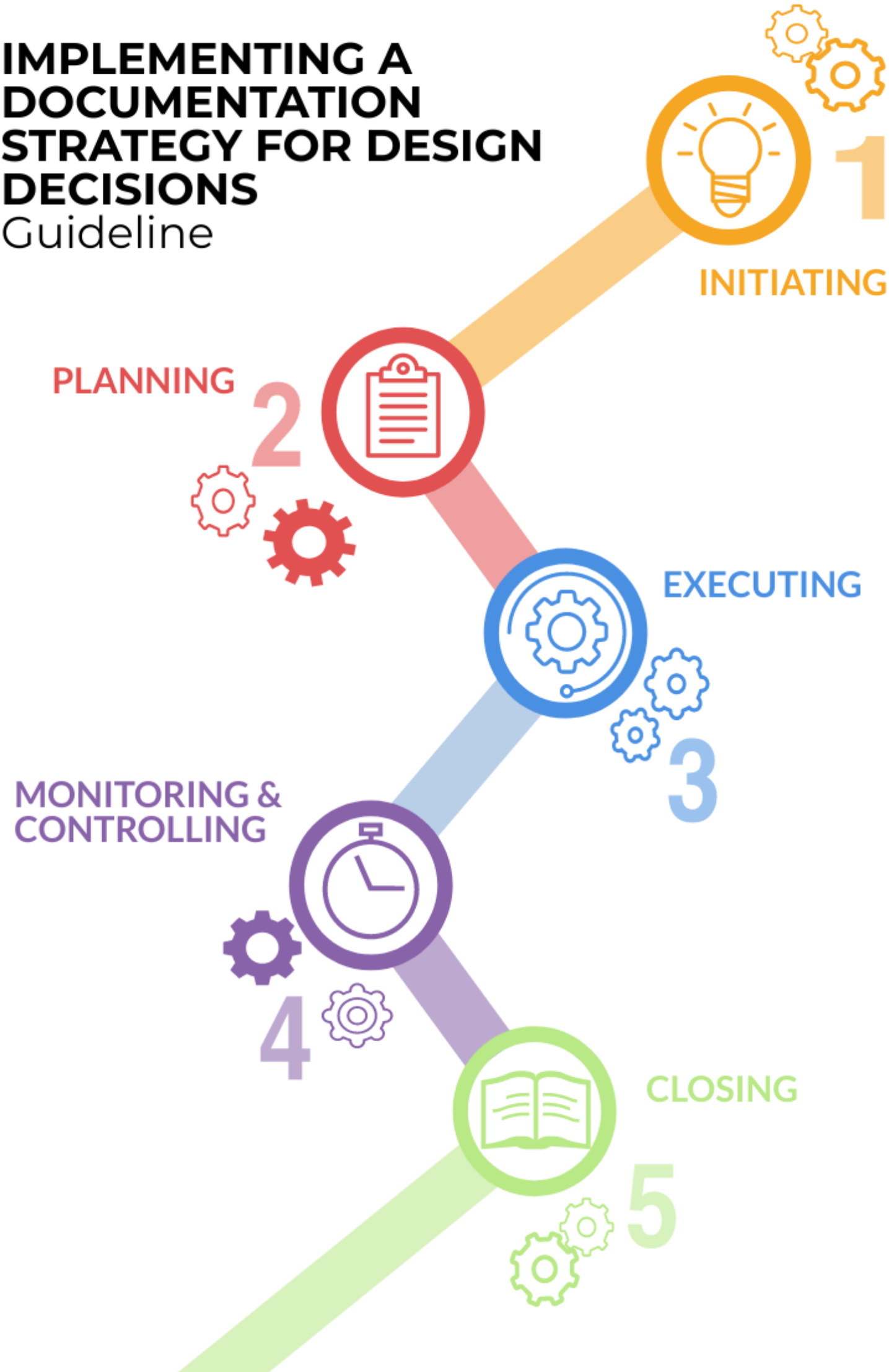
Validation	Result	Quotes
Overall impression	Participants find the use of the five processes for project management fitting as it is recognizable. Participants also mention as a strong point that the guideline forces you to think about the documentation process.	"The building blocks are logical." "The use of the five processes of project management is clear and makes it accessible." "The guideline is a good combination of theory and practice." "There is overlap with project management. That's why it is recognizable, and everyone should be able to follow this." "The systematics are clear. There is no question whether this should be done." "The step-by-step plan is very good. It says exactly was needs to be done." "The guideline forces people to think about how to approach documentation." "The structured approach and the fact it is part of the project and not a separate process."
Perceived bottlenecks	Participants mention that a major bottleneck is convincing people to do this. One participant note that the use of the guideline is dependent on the type of people involved in the project and that a top-down approach would force people to do it.	"The use of checklists might not appeal to everyone." "The bottom-up approach is dependent on the type of people in the project. The number of people who could serve as a change agent are limited." "The amount of work that needs to be done at the start of the project." "It is not verifiable whether it will work." "The guideline is for the team; however, you need somebody that pulls through with this." "Whether this works depends on the commitment of the project members and that is difficult to measure." "I think this helps, but it goes beyond the guideline. How can we convince people to do this?" "Convincing people to do this is a bottleneck."
Consistency	Participants agree that the guideline is consistent in structure and the definitions are clear. One participant suggests adding the coordinator in the terminology.	"Maybe you can add an overview of all definitions." "The structure is clear and consistent." "The difference between change agent and coordinator might not be clear for everyone. I would add the coordinator in the terminology."
Understandability	The guideline is perceived as understandable and clear. Three participants suggest that the possibility to combine roles could be addressed more specifically. One participant suggests quantifying small and large projects.	"Maybe it could be more compact. For example, the first four checklist items can be combined into one." "I would add the role of the coordinator in the terminology." "I would clarify that the coordinator and change agent for example could be the same person, and thus that combining roles is possible" "Can you combine roles?" "What is considered a large project? It would be good to quantify this."
Usability	Participants agree that the guideline is easy to use and to follow. The suggestions are considered valuable as they provide examples and sets a	"It is clear and consistent, and it is easy to add names and to check item lists off" "The use of checklists was a good choice. It provides a framework and guidance for people who like that."

Validation	Result	Quotes
	direction for the proposed checklist items. The fill-in form is considered useful. One participant mentions that the fill-in form could be extended by adding an option to document actions.	"The fill-in form is handy, but I would prefer documenting this in Relatics." "I would add the actions that are discussed in the fill-in form." "My suggestion would be to document in Relatics." "The suggestions are good. You have the freedom to follow them or not. They also help with perception."
Soundly	Participants agree that the suggestions provided in the guideline are valuable and needed. Two participants provide suggestions for enhancing the flow chart and corresponding table. One participant argues that it is not feasible to have discipline leaders responsible for documenting design decisions.	"I like the examples. If you provide only the action than people can misunderstand or misinterpret the purpose of the action." "I believe the suggestions are realistic." "The suggestions are valuable." "The flow chart is handy." "You can give discipline leaders the responsibility for documentation and then he can delegate the task." "The choice to have discipline leaders document is good for the integrality, but the question is whether they are sufficiently supplied by designers?" "When do you consider a design team?"
Tailorability	Participants agree that the implementation guideline can be used for different types of projects. One participant argues that it would be better to keep the guideline as generalizable as possible. Participants also agree that the implementation guideline can be used for other implementation processes as the building blocks are generic of nature.	"The question is whether you should want to adapt the guideline for different project types. I would keep it as generalizable as possible" "We could make guidelines for small, middle and large projects." "Yes, I believe so. I think you could use this for every project transition." "I believe you can use this for every project that deals with documenting information and design decisions." "Yes, it is relatively generic. We are currently dealing with another implementation process and these steps could be used for it."
Verifiability	Participants agree that it is possible to verify throughout the implementation process whether the guideline has had positive effect. However, one participant argues that even though verification is possible, it is difficult to proof whether the use of the guideline was the determining factor.	"You can verify whether documentation is better tracked." "I think it would be good to discuss in the progress meetings how much effort was needed to realize certain checklist items." "I believe you can verify the use of the guideline. However, I think it is difficult to proof whether the use of the guideline was the determining factor." "You can check whether all disciplines have documented their design decisions in a similar way." "You can check through an inventory whether all people were aware of the strategy."

APPENDIX III – THE IMPLEMENTATION GUIDELINE

IMPLEMENTING A DOCUMENTATION STRATEGY FOR DESIGN DECISIONS

Guideline



Introduction

This guideline is written for project members who seek to implement a documentation strategy for design decisions in civil engineering projects. This guideline provides a step-by-step approach in the form of checklists to guide implementers in executing the necessary steps towards implementation success. In this document, an implementer is defined as a person who wants to implement a documentation strategy for design decisions in a civil engineering project. That could be a project manager, technical manager or any other project member striving for a similar goal.

The documentation of design decisions can benefit a project for numerous reasons, for example:

- To enhance the traceability of the design
- To provide a substantiation of the choices made in the design to the client
- To prevent reoccurring discussions in a later stage of the project
- To have an overview on design decisions that are made or still need to be made

Therefore, the aim of this guideline is to assist implementers in implementing a documentation strategy for design decisions in civil engineering projects. Before getting started, it is advised to already have at least one project member who has taken on the responsibility of arranging the process of documenting design decisions or wants to assign a team to guide and implement this process. Once there is a project member assigned to one of the aforementioned tasks, or anything similar, the guideline can be used moving forward.

Getting started

This guideline can be used from the moment a documentation strategy is to be initiated. The guideline is built up out of five processes (1) initiating, (2) planning, (3) executing, (4) monitoring & controlling and (5) closing. Each process consists of building blocks. Figure 1 presents an overview of the processes and the corresponding building blocks.

Each building block consists of a checklist to use during implementation. The checklists items are actions that need to be performed during implementation. The checklist items do not have to be carried out in the specific order as presented. For each checklist item, additional columns are provided to write down who is responsible and to check off a certain action. A few checklists are divided into two sections: *crucial checklist items* and *noncrucial checklist items*. The crucial checklist items are actions that are critical for succesful implementation. These items should be carried out at any time. The noncrucial items are not critical for succesful implementation, but are nonetheless highly recommended to execute. Furthermore, there are factors that might influence particular checklist items, for example project size, team stratification and lead time of the project. These elements affect certain checklist items such as the amount of progress meetings to organize or the amount of members in the implementation team. Underneath specific items, suggestions for these elements are provided in *italics*. However, implementers should always take the context of their own project in consideration when following the suggestions.

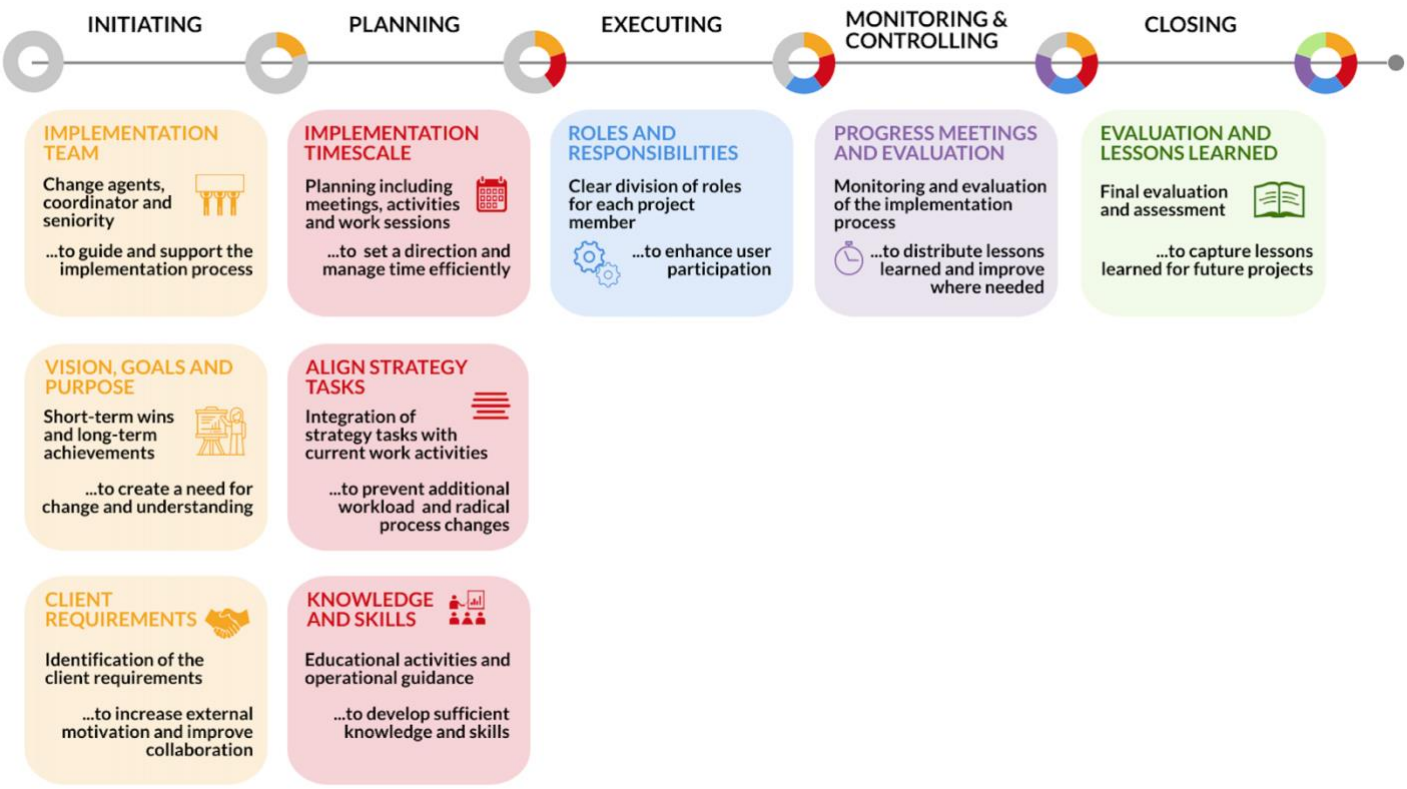


Figure 1. Summarized overview of the guideline building blocks

The guideline can be used by implementers during meetings as a directive to make sure the different elements are covered. During follow-up meetings, the guideline can be updated using the fill-in form as provided in the appendix. The fill-in form can be used for documenting agreements, deadlines and other relevant information. The guideline as well as the fill-in form can be printed or used digitally.

Terminology

A few phrasings that are used in the guideline and may need further elaboration are briefly explained.

Change agent: a change agent is a person or group that facilitates the change process in an organization or project. Change agents are needed to guide the implementation activities and they should have a direct day-to-day involvement at operational level. In this guideline, the role of a change agent is seized as a project member who understands the purposes of implementing a documentation strategy for design decisions and is willing to support, guide and monitor the change needed for implementation.

Implementation team: the implementation team consists of a group of change agents who form a guiding coalition during the implementation process. It is the task of the implementation team to prepare all needed activities for successful implementation of the documentation strategy. There should be at least one senior manager (e.g. project manager, technical manager) in the implementation team to provide management support.

1 INITIATING

The first step towards the implementation of a documentation strategy for design decisions is initiating the strategy. Within this step, an implementation team is established who will form a guiding coalition throughout the implementation process. Furthermore, the vision, goals and purpose of the strategy should be formulated and communicated to the project members to establish consensus on the proposed documentation strategy. Lastly, the client's request with regard to documenting design decisions should be identified.

1. Form an implementation team to guide, monitor and support the documentation strategy for design decisions

ID	Item	Responsible	Check
1.1	Form an implementation team that consists of at least two to three project members, depending on the project size. *Suggested implementation team size:* *≧2 for small projects* *≧3 for middle to large projects*		
1.2	The implementation team consists of at least one to two change agents, depending on the project size. *Suggested profile for the change agent:* *- Sufficient knowledge on documenting design decisions* *- Skills in developing and working in a predefined template for design decisions e.g. Relatics* *- Able to provide educational activities on documenting design decisions* *- Able to guide and monitor project members on documenting design decisions*		
1.3	Connect at least one senior manager to the implementation team. The main task of the senior manager is to provide management support so that change agents can full fill their tasks.		
1.4	There is one coordinator in the implementation team who is responsible for controlling the shared environment for documenting design decisions on completeness, coherence and formulation of design decisions. *Suggested profile for the coordinator:* *- Process-oriented* *- Sufficient knowledge on documenting design decisions*		

	- Skills in developing and working in a predefined template for design decisions e.g. Relatics		
1.5	The implementation team provides educational activities to project members in the form of work sessions, trainings, workshops or meetings with regard to documenting design decisions and working in the predefined template.		
1.6	The implementation team provides operational guidance to project members who experience difficulties with the documentation strategy during execution. *Suggested form of operational guidance:* *Organize work sessions with the design team and provide guidance with working for example in Relatics.*		
1.7	The implementation team monitors the documentation activities throughout the implementation process. *Suggested form for monitoring:* *- Check in on project members during the execution of the strategy. This can be done through e.g. calls, meetings or e-mail.* *- Verify agreements and arrangements with the management team* *- Through progress meetings (will be further elaborated in step monitoring & controlling).*		

2. Formulate and communicate the vision, goals and purpose of the strategy

ID	Item	Responsible	Check
	Crucial checklist items		
2.1	The implementation team has developed an action plan describing the documentation strategy for design decisions. *The action plan should include at least the following elements:* *- Goals and purpose* *- Roles and responsibilities including task descriptions* *- A format of the predefined template for documenting design decisions* *- What design decisions are expected to be documented and when*		

2.2	Discuss the action plan with the management team until there is consensus among the managers with regard to the proposed documentation strategy. *Suggested activity:* *Organize a meeting between the managers and implementation team and make specific agreements with regard to the environment that will be used for documenting design decisions and the division of responsibilities.* *Document these agreements in minutes.*		
2.3	Discuss the action plan with all project members and managers. *Suggestion: perform this step after step 2.2*		
Noncrucial checklist items			
2.4	Set milestones and divide goals in short-term wins and long-term achievements. The goals are preferably formulated SMART.		

3. Identify the client requirements regarding the documentation of design decisions

ID	item	Responsible	Check
3.1	Check whether the client has requested the documentation of design decisions in documents e.g. tender and process descriptions.		
3.2	Include the client request in the action plan as one of the goals.		
3.3	Coordinate the proposed action plan with the client and discuss the level of detail of the design decisions and the format in which the design decisions will be handed over.		

2 PLANNING

In this step of the implementation process, the different activities are planned. As change is a time-consuming process that consists of several steps, it needs to be carefully managed and planned. An implementation timescale should be developed that describes the duration of the implementation activities and when these activities should be executed in the project. This implementation timescale should be compared to the project activities of the employees, to ensure that the needed activities and change of tasks do not increase the work burden of the employees, but rather are aligned with their current work processes. Furthermore, the needed knowledge and skills for working with the new strategy should be assessed and if needed, educational activities should be planned ahead.

4. Create an implementation timescale

ID	Item	Responsible	Check
4.1	Create an implementation timescale for the implementation activities. *Suggested elements to include:* *- Progress meetings with the implementation team* *- Educational activities* *- Work sessions* *- Meetings with the design team*		
4.2	Include the availability of the implementation team members in the timescale to gain an overview on when project members can receive operational guidance.		
4.3	The implementation timescale is monitored and if needed updated during progress meetings by the implementation team.		
4.4	The implementation timescale is discussed with the management team and made available to all project members.		

5. Align strategy tasks with work activities

ID	Item	Responsible	Check

5.1	Make agreements with the project team during project meetings on when to document design decisions. *Suggested activity:* *If a design decision is made, document immediately in the shared environment e.g. Relatics.*		
5.2	Organize work sessions with the design team to provide operational guidance while performing regular task activities (e.g. designing).		

6. Provide training and/or educational activities

ID	Item	Responsible	Check
6.1	The implementation team provides educational activities to project members on working in the predefined template. *Suggested format:* *- Present the benefits of working in the predefined template* *- Provide explanation on how to work in the predefined. template* *- Provide explanation and examples on how and when to document design decisions* *- Create educational material e.g. handouts for project members to use afterwards.*		
6.2	Educational activities are provided from the start of the project. *Provide at least one session to project members that will work with the predefined template. If needed, organize another session during the course of the project.*		
6.3	The educational activities are planned close to work sessions and design activities. *To have project members apply their new knowledge as soon as possible.*		
6.4	The implementation team performs regular checks on project members after the educational activities. *Suggestion: plan operational guidance closely after educational activities*		

3 EXECUTING

In the third step of the implementation process, the documentation strategy is executed. This phase takes the longest and needs to be carefully managed and monitored by the implementation team. They should have a direct involvement with the project members that need to work with the strategy. The prior planned educational activities and work sessions are executed in this phase. Furthermore, there must be roles and responsibilities assigned to the project members for the different tasks of the strategy to increase user participation. The previous planned meetings and educational activities are to be executed in this phase.

7. Assign roles and responsibilities

ID	Item	Responsible	Check
	Crucial checklist items		
7.1	There is one person in charge of monitoring and controlling the shared environment for documenting design decisions. *Suggestion: assign this role to the coordinator (see id 1.4)*		
7.2	There are responsibilities assigned to project members for documenting design decisions.		
7.3	There are responsibilities assigned for monitoring and controlling the overall documentation and completeness of the design decisions.		
	Noncrucial checklist items		
7.4	Include documentation activities in the task description of project members.		
7.5	Create an overview of all roles and responsibilities and make this document available to all project members. *Attach the overview to the predefined template e.g. Relatics.*		

Suggested role division

The role division on documenting design decisions depends on the project size, the lead time of the project, the stratification of the project team and whether the project includes design activities. During initiation, the implementation should discuss the proper division of roles and include this in the action plan. The division of roles should be decided in accordance with the management team.

On the next page, a flow chart is presented with a corresponding table. Use the flowchart to determine which situation is applicable (A/B/C).

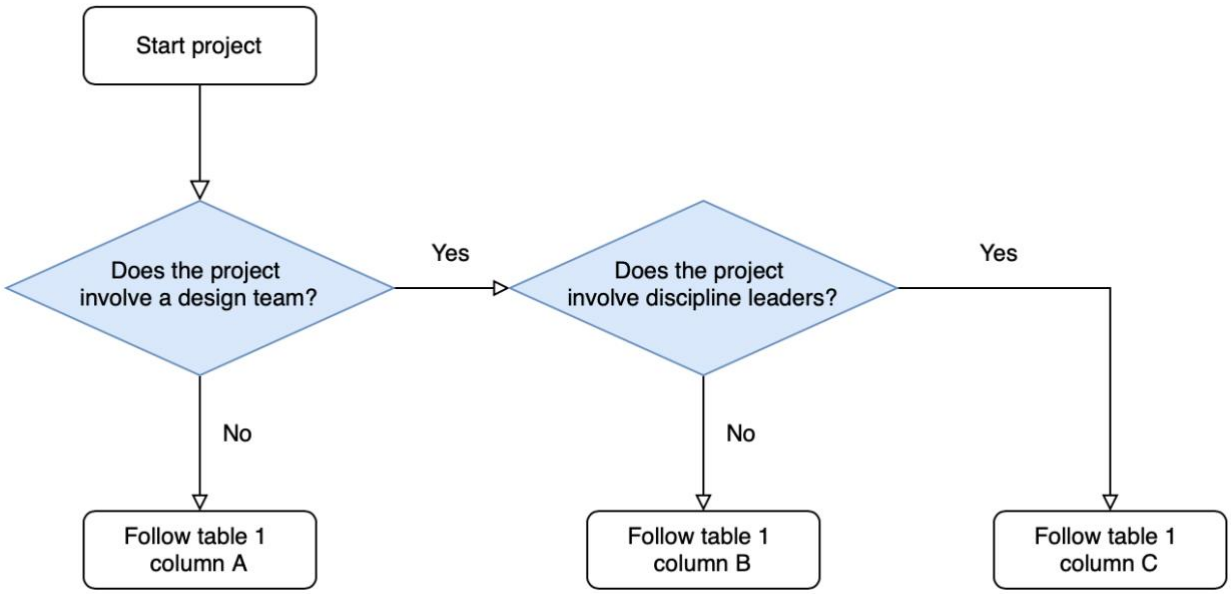


Figure 3. Flow chart for role divisions. Use this flow chart with corresponding table 1.

Table 1. Suggested division of responsibilities for documentation

Responsibility	**A**	**B**	**C**
Documenting design decisions in a predefined template	Project member	Designers	Discipline leaders
Monitoring and controlling overall documentation and completeness of the design decisions for each discipline	-	-	Discipline leaders
Monitoring and controlling overall documentation and completeness of the design decisions	Project manager	Technical manager	Technical manager
Controlling the shared environment for documenting design decisions on completeness, coherence and formulation of design decisions.	Coordinator/ change agent	Coordinator	Coordinator

4 MONITORING & CONTROLLING

The implementation team is responsible for monitoring and controlling the different phases in the entire implementation process. If there are any hurdles or burdens experienced on operational level by project members, they must provide support and guidance. Furthermore, if agreements on project deliverables are made, they must ensure that these agreements are held in place. Therefore, the implementation team should hold meetings to review and evaluate the implementation process.

8. Conduct progress meetings and evaluate the different phases

ID	Item	Responsible	Check
	Crucial checklist items		
8.1	Conduct progress meetings throughout the implementation process with the implementation team to discuss progress, obstacles, wins and lessons learned. *Suggested format:* *- At least at the start and end of each project phase.* *- Every four weeks a progress meeting. Frequency depends on the project lead time.* *- The checklists can be used as a directive for the meetings.* *- Make minutes during the meetings.*		
8.2	The coordinator monitors the progress in the shared environment at least every two weeks. *This step should be done in accordance with the technical manager and/or discipline leaders.*		
	Noncrucial checklist items		
8.3	Update the checklist items during the progress meetings		
8.4	Provide feedback that have resulted from the progress meetings to managers and/or discipline leaders. *That could be current obstacles and issues, but also positive feedback and short-term achievements.*		

5 CLOSING

The last phase of the implementation process is the closing of a project. In this phase, the implementation team gathers once again to discuss and evaluate the entire process. Lessons learned should be captured, documented and distributed to the stakeholders for future projects.

9. Evaluate the implementation process and capture lessons learned

ID	Item	Responsible	Check
	Crucial checklist items		
9.1	At the end of the project, the implementation team should conduct a final evaluation on the entire implementation process.		
9.2	Lessons learned are discussed and documented for future implementation. - *What went well?* - *What could have gone better?* - *Have the predefined goals been met?*		
	Noncrucial checklist items		
9.3	Conduct an inventory among the project members on how the documentation strategy was perceived and experienced by project members.		
9.4	In case Relatics or a comparable digital program that needs a license has been used, create a print-out of all design decisions at the end of the project so that all project members can still access these in a later stage.		

Appendix – Checklist fill-in form

ID	Date	Deadline (optional)	Responsible	Additional comments
1. Form an implementation team to guide, monitor and support the documentation strategy for design decisions				
1.1				
1.2				
1.3				
1.4				
1.5				
1.6				
1.7				
2. Formulate and communicate the vision, goals and purpose of the strategy				
2.1				
2.2				
2.3				

2.4				
3. Identify the client requirements regarding the documentation of design decisions				
3.1				
3.2				
3.3				
4. Create an implementation timescale				
4.1				
4.2				
4.3				
4.4				
5. Align strategy tasks with work activities				
5.1				
5.2				
6. Provide training and/or educational activities				
6.1				

6.2				
6.3				
6.4				
7. Assign roles and responsibilities				
7.1				
7.2				
7.3				
7.4				
7.5				
8. Conduct progress meetings and evaluate the different phases				
8.1				
8.2				
8.3				
8.4				
9. Evaluate the implementation process and capture lessons learned				

9.1				
9.2				
9.3				
9.4				