Tauw

Identifying measures to improve the issue management standard within Tauw, based on the Prince2- and BCF principles

Author

Colin Reit

JULY 1, 2020

BACHELOR OF CIVIL ENGINEERING, UNIVERSITY OF TWENTE
Tauw B.V.

Colophon

This document comprises the final report of the Bachelor Thesis for completion of the Bachelor Civil Engineering at the University of Twente.

Title	Identifying measures to improve the issue management standard within Tauw, based on the Prince2- and BCF principles
Version	Final
Report size	35 pages
Place	Deventer
Date	01/07/2020
Author	Colin Reit
Student number	s1865161
Email-adress	C.a.j.reit@student.utwente.nl
UT-supervisor	Dr. Ir. F. Vahdatikhaki University of Twente Department of Construction Management and Engineering
Company-supervisor	Ir. N. Vossebeld PDEng Tauw B.V. Adviseur en product manager BIM

Tauw B.V
Business Unit Leefomgeving
Department: Ontwerpbureau
Handelskade 37
7417 DE
Deventer
Nederland
https://www.tauw.nl/

University of Twente
Faculty of Engineering Technology (ET)
De Horst, building 20
7500 AE
Enschede
Nederland
https://www.utwente.nl/nl/et/

Preface

Before you lies the final product of my thesis report 'Identifying measures to improve the issue management standard within Tauw, based on the Prince2- and BCF principles'. In this research, five design projects with very different characteristics have been evaluated on their issue management approach and compared to theory of 'efficient issue management'. This report is written in context of my graduation research for the Bachelor of Civil Engineering at the University of Twente. This research is performed in association with Tauw B.V. and was executed between April 13th, 2020 and June 19th, 2020.

During my second year of the Bachelor I gained interest in the concept of BIM, and its promising future in the civil engineering field. After I followed a 3D-modelling course during my minor in Melbourne, I started looking for research projects related to BIM, and I found Tauw! In cooperation with my company supervisor Niels Vossebeld, the research question was formed to include my interest in both BIM and project management. This mix of subjects kept me interested and helped me in deciding what Master's degree I want to follow.

I specifically want to thank Niels Vossebeld for his enthusiastic dedication to help me during my research, as well as providing me with quality feedback with his expertise in the field. The outstanding support I received truly helped me enjoy this research project, despite the fact that I had to work from home due to the pandemic. I also want to thank my university supervisor Farid Vahdatikhaki for his support and expertise, by providing me with quality feedback as well. I thoroughly enjoyed working with my supervisors, who both showed me the importance of a good research proposal and helped me take my academic competences to the next level.

Hereby, I also want to express my gratitude for the Tauw employees I came in contact with throughout my research period. Even though all contact was through online meetings, everyone was very helpful, professional, and friendly. Without your help I would not have been able to finish this research in such a short period of time. Besides providing me with specific knowledge about the projects, I also learnt a lot from the practice perspective of working in project teams within a company.

I hope you will enjoy reading this report.

Colin Reit

Diepenveen, July 1st, 2020

Management summary

Tegenwoordig zijn 'reworks' de primaire aanleiding voor faalkosten en vertragingen binnen de bouwsector (Love & Irani, 2002). Redenen hiervoor zijn bijvoorbeeld: een gebrek aan goede communicatie binnen het project team of het niet effectief oplossen van issues gedurende het ontwerpproces. De afwezigheid van een goede issue management strategie ligt hieraan ten grondslag. Binnen Tauw is er geen standaard strategie voor issue management, dit heeft als gevolg dat projecten op veel verschillende manieren aangepakt worden. Hierdoor moeten medewerkers bij elk project een nieuwe aanpak adopteren, wat ten koste gaat van de issue management kwaliteit en efficiëntie.

In dit onderzoek is een raamwerk ontwikkeld dat staat voor efficiënt issue management, bestaande uit de combinatie van de methodologie van Prince2 en het gebruik van BIM (BCF-perspectief). Vervolgens is dit raamwerk gemodelleerd en uitgewerkt in tien kenmerken voor efficiënt issue management. Deze kenmerken zijn gebruikt voor de evaluatie van vijf Tauw ontwerpprojecten op basis van de geadopteerde issue management aanpak. Deze evaluatie bestond uit het herzien van projectdocumentatie en het afnemen van interviews met projectmedewerkers. Nadien zijn deze projecten vergeleken met elkaar en met het issue management raamwerk, om zo tot een gesubstantieerd advies te komen voor het verbeteren van de issue management strategie binnen Tauw. Dit advies is samen te vatten in de volgende vijf hoofdzaken:

1. Het centraal stellen van (maximaal) 1 of 2 issue management tools binnen een project (Relatics en een standaard Tauw BIM-tool), afhangend van project eigenschappen.
2. Het registreren van 1-op-1 communicatie in een centrale online omgeving, om zo betere traceerbaarheid van issues en besluiten te creëren binnen het ontwerpproces.
3. Het aanstellen van een rolhouder binnen het project team (bestaand of apart, afhangend van de grootte van het project), die zich actief bezig houdt met het managen van issuecommunicatie binnen het project.
4. Het prioriteren van issues op basis van een impact- en urgentie methodologie.
5. Het aanstellen van een 'Issue and Change Control Plan' dat standaard ingevuld moet worden tijdens de Project Start-Up.

Deze adviespunten zijn gebaseerd op de volgende observaties die voortkwamen uit de projectenanalyse:

- Er worden veel verschillende tools en documenten gebruikt voor dezelfde doeleinden binnen de projecten, dit leidt tot inconsistent gebruik binnen het project team.
- Veel communicatie verloopt nog 1-op-1 (verbaal of via mail) en wordt niet centraal geregistreerd, dit zorgt voor slechte traceerbaarheid van besluiten in het ontwerpproces.
- Het merendeel van de projecten heeft geen rolhouder aangewezen voor het actief overzien en registreren van issues en communicatie gedurende het ontwerpproces.
- Issues worden erg gevarieerd geregistreerd en worden niet consistent beoordeeld op prioriteit, impact, en urgentie. Dit leidt tot inefficiënte en inaccurate issuecommunicatie.
- Project afspraken met betrekking tot issue management worden niet consistent vastgelegd aan het begin van veel projecten, leidend tot misverstanden later in het ontwerpproces.

Door middel van dit advies kan Tauw haar issue management op de projecten verbeteren en standaardiseren. De implementatie van dit advies zal zorgen voor een efficiënter, traceerbaar ontwerp- en communicatie proces. Daarnaast is dit rapport voorzien van een korte implementatieaanpak. Tijdens dit onderzoek zijn restricties van opdrachtgevers en mede-aannemers buiten beschouwing gelaten, omdat Tauw hier geen invloed op heeft. Het advies is wel voorzien van enkele optionele methodes voor Tauw wanneer deze restricties zich voordoen, maar dit is niet het hoofddoel van het onderzoek geweest.

Table of Contents

Table of Figures

Table of Tables

List of abbreviations

Table 1: list of abbreviations

Abbreviation	Dutch translation	English translation
BIM	-	Building Information Modelling
CDE	Gedeelde data omgeving	Common Data Environment
IME	Issue management omgeving	Issue Management Environment
V&V	Verificatie en Validatie	Verification and Validation
PMP	Project Management Plan	Project Management Plan
BIM-IP	BIM Implementatie Plan	BIM implementation Plan
RFC	Verzoek tot Wijziging	Request for Change
VO	Voorlopig Ontwerp	Preliminary Design
DO	Definitief Ontwerp	Definitive Design
UO	Uitwerkings Ontwerp	Implementation Design
PM	Project Manager	Project Manager
OM	Omgevings Manager	Environment Manager
SE	-	Systems Engineering
PSU	Project start	Project Start-Up
PFU	Project evaluatie	Project Follow-Up
SMART	Specifiek, Meetbaar, Acceptabel, Realistisch, Tijdgebonden	Specific, Measurable, Acceptable, Realistic, Time-bound
ICC-Plan	-	Issue and Change Control plan

1. Introduction

This research is conducted in cooperation with Tauw B.V. and the University of Twente. Tauw is a European based engineering consultancy with a strong position in environmental advice and the development of a sustainable environment. The topic of this research is the assessment of Tauw design projects' issue management approaches based on issue management principles derived from literature, to develop measures for the improvement of issue management within Tauw.

1.1. Issues in construction projects

Love and Irani (2002) have concluded that rework is the primary factor of failure costs and time overruns in construction projects. Rework is the act of redoing or correcting work that was not done correctly the first time (Novotny, 2019). Rework in construction typically costs about 5% of the overall contract value (Hwang & Thomas, 2009), and roughly 7.1% of total working hours in time overruns (Chidiebere & Ebhohimen, 2018). According to a survey from PlanGrid and FMI (2018), almost half of all rework is due to poor communication among project stakeholders, across disciplines, or between team members (26%), and poor project information (22%). This shows the importance of efficient information exchange for the delivery of a profitable project.

The design process in construction projects often involves many people, teams, disciplines, and companies. When a change or decision is made by a project member, other stakeholders in the communication chain may need to be informed before the implementation. Unnecessary late-stage changes confuse stakeholders and often result in reworks. Reworks in the design process result from issues that either have not been managed properly or registered timely, therefore requiring extra work, time, or money. The use of project management technology can help reduce the number of reworks by managing issues more efficiently throughout the design process. Project management technology can improve the accuracy of information exchanges, communication, visibility of activity, productivity, and thereby also profitability. Technology can also provide more detailed record keeping and keeps documents in a centralized place. Failure to keep detailed documents is a major cause of scrap and rework that is ultimately avoidable (Novotny, 2019).

According to Litten (2016), there are three issue types that occur in the design process:

- **Request for Change (RFC)**, this project issue occurs when a project member wants to implement a change to a baselined product. A baselined product is a product that has been quality checked and signed off. This issue often involves extra costs.
- **Off-Specification (Off-Spec)**, this project issue occurs when the product fails to meet its quality criteria and is not expected to fulfil them in the future. An 'off specification' can also be raised before the product is tested on its quality criteria or when the product exceeds its specification.
- **Problem/concern/opportunity**, these issue types can be any comment regarding the project/design that the needs to be resolved, this could be either positive (opportunity) or negative (problem/concern). This type of issue occurs most frequently in the design process and is part of the day to day communication within the project team.

1.2. The implementation of BIM in the design process

One of the most promising solutions to the challenge of efficient communication in the design process, as stated in the section above, is the use of Building Information Modelling (BIM). Boukara and Naamane (2015) explained BIM as an intelligent model-based process that provides insight to help plan, design, construct, and manage buildings and infrastructure. Deckers (2019) argues that the BIM concept can reduce costs, reworks, loss of information and the number of last-minute design changes by improved communication and data exchange across the life cycle of projects. Furthermore, BIM is shown to be very efficient in streamlining the communication across the disciplines and stakeholders.

These benefits are generated by the following aspects:

- Centralising communication around the design model in a Common Data Environment (CDE)
- Using open standards to bridge different design software
- Automated clash detection tests to identify issues between disciplines
- Providing the possibility to add more detailed information to objects/issues in the model

Some companies have a more developed BIM maturity than others, as the implementation of BIM requires a serious change in the design approach of projects. Even with BIM fully implemented, errors, anomalies and inconsistencies cannot be completely eradicated in projects. These issues especially occur in the models and representations used during the design phase, due to the many abstract designs and assumptions/uncertainties. However, BIM does provide a centralised environment where all communication around the design model is stored. Issues can be reported in one software and opened in another with the use of viewpoints in issue reports. Communication is directly related to the model, reducing the probability of misunderstandings. Another benefit of BIM is the possibility to communicate the design with non-technical stakeholders more easily, with use of BIM-viewers (3D).

1.3. The importance of issue management strategies

Managing one issue is relatively easy; however, managing an accumulation of issues requires an issue management strategy to make sure issues do not get lost in the design process. Strategic issue management involves having a system in place to monitor potential issues that could impact your project, and having a strategy implemented to positively impact the outcome of priority issues (Nelson, 2014). It is crucial for design firms to develop robust BIM-based issue management strategies to address the various types of issues that may arise throughout the design phase of the project. This provides the opportunity for every issue to be assigned, addressed, and solved. An efficient issue management strategy should increase the quality of design, ensure a more traceable and complete resolution, and lower the lead time between issue identification and resolution.

In a study performed by Mossalam (2018), 124 engineers, managers and designers were questioned on the day to day issue management within their company. He found that over 90% of the respondents' organisations do not have a standard guideline for managing their project issues. Furthermore, he found that 25% of those consider issue management as a normal activity that does not need a guideline, 11% attributed this to the lack of awareness, while the majority (54%) referred the reason to the lack of a standard. Mossalam's research shows the need to increase awareness of project teams with the right definition of issues and make the required paradigm shift for those who consider issues as something that does not need planning or controlling. There is a noticeable need for having automated tools to manage issues which will enhance the implementation maturity level.

1.4. Research problem

In the infrastructure sector, most companies face challenges with issue management in their projects' design process (Mossalam, 2018). Often these companies have access to a wide variety of project management technology to achieve effective issue management in design projects. The problem in this regard is the absence of a standard issue management approach integrated in the company guidelines. As a result, project teams work very fragmented and ad hoc around the design model. This means that project teams adopt different issue management approaches and tools (by means of which the issues are managed) per project. Consequently, the chance of inefficient issue management in the design process increases, as project members need to adjust to a new methodology every project they are involved in. This is a challenge that many companies face in this industry, Tauw seeks to improve on this common problem. Leading to the following problem statement:

There is an absence of standard framework for issue management in the design process within Tauw, resulting in fragmented and inefficient issue management approaches.

1.5. Research questions

In this research, the following questions will be answered:

Main research question

Where can the issue management approach within project design processes be improved with the use of principles of efficient issue management?

Sub question 1

Can an assessment framework be developed based on principles of efficient issue management found in literature?

- Which existing methodologies are considered efficient issue management?
- What do the workflows of these issue management principles look like?
- How can these principles be used in assessing design projects' issue management?

Sub question 2

How does Tauw address their design issues at the moment?

- Which design projects are representable for Tauw's current issue management?
- What are the general project characteristics?
    - Scope, goal, contract structure, design approach, phasing, roles etc.
- How is the issue/change management approach described?
- Which agreements were made regarding issue management in the project team?
    - To what extent were they adhered?
- Which communication tools were used for registering and managing issues/changes?
    - How well are these tools implemented?
- What were important roles in the design process regarding issue management?
- What did the practice look like compared to the documentation?

Sub question 3

What do the workflow models of the issue management approaches used in the design process in Tauw look like?

- What are the characteristics of the project's issue management approach?
- How do the workflows of the project's issue life cycles look like?

Sub question 4

How do the different issue management approaches compare to each other, and to the baseline issue management framework discovered through answering sub question 1?

- How can an overview be developed that displays how the design projects perform in the issue management characteristics from the framework?
- What are the differences and similarities of the projects within this overview?
- What are the differences and similarities of the projects with the issue management framework?
- What conclusions can be drawn from this comparison?

Sub question 5

How can Tauw improve their issue management approach based on the issue management framework developed in sub question 1?

- What measures can be taken to get Tauw's issue management approach closer to the workflow of the issue management principles?
- Which steps should Tauw take to implement these measures?

1.6. Research scope

In this research, five historical and ongoing design projects are evaluated that Tauw is, or was, involved in. The design types in these projects include an inner-city road and subsurface, historical locks, a bridge, a road, and wastewater treatment plants. The issue management tools that were utilized in these projects are BIMCollab, BIM360 Docs, BIMTrack, Relatics, and Excel. In the design processes of these projects, different issue management tools and approaches have been adopted. These issue management tools and approaches are compared to efficient issue management principles. 'Efficient' issue management represents a streamlined communication process that keeps track of the issues and thereby reduces time lost on resolving issues. The issue management principles used in this research are derived from literature related to Prince2 and BIM (BCF-perspective). These principles are used to evaluate the issue management of the projects. In this process, qualitative research methods are applied to uncover trends in Tauw design projects. This study is limited to improving the standard from Tauw's perspective. Therefore, client requirements and restrictions are left out of the scope.

1.7. Research aim

The aim of this research is to develop a list of measures for the improvement of the issue management strategy within Tauw. To this end, the current issue management approaches within Tauw will be evaluated and compared. In this evaluation, the context in which each issue management strategy is adopted will be taken into account to draw a global map of current strategies in context for Tauw. In this research, the opportunity will be provided to develop an increased understanding of the importance of efficient issue management within Tauw. By doing so, it aims to ensure that the issues that might affect the project's performance targets (time, cost, quality, scope, risk, and benefits), can in the future be managed in a more standardized way that is appropriate for Tauw.

1.8. Report structure

This report will start with the research methodology, where an in-depth description of the research questions and methods will be presented. Thereafter, the theoretical framework is displayed that describes efficient issue management based on literature. From this framework, characteristics of efficient issue management are derived for the assessment framework of the projects. Then, a synopsis of the project evaluations is provided, as the main elements of the evaluation are displayed in the comparative study. The complete evaluations can be found in Appendix C. Following the project evaluation, the projects are compared to each other based on their performance on the criteria set in the assessment framework. This table is then extensively analysed on trends among projects and differences with the issue management principles. The observations of the analysis are then used to develop the list of recommended measures which Tauw can take to improve their issue management. The report is concluded with a discussion, conclusion, and future research.

2. Research methodology

In this Chapter, the research methodology is explained. At the start of each section, it is clearly stated which research sub question will be addressed. This provides an overview of the research and decisions behind it. Then, an overview of the research structure is displayed in Figure 1.

2.1. Developing the issue management assessment framework

The first step in this research, and thus relating to sub question 1, was performing desk research to identify issue management methodologies that met the criterion set in the project scope. The criterion was based on information extracted from KUBUS (2020), and implied that the issue management principle had to represent a streamlined communication process that keeps track of the issues and thereby reduces time lost on issues. After evaluating the alternatives, the company supervisor was consulted for the selection of issue management principles. The issue management principles selected for this research were the Prince2 approach to issues changes and the BCF-perspective on issue management (BIM). The two provide unique perspectives on issue management, as Prince2 originates from the project management perspective, whereas the BCF-perspective is a more technical approach. These methodologies are explained in Chapter 4.

Once the issue management principles were established, literature research was conducted to gain substantial knowledge on the two principles. All relevant information on the principles was gathered, and step-by-step workflow descriptions were derived, these workflows can be found in Appendix B. Subsequently, the workflows were modelled in flowcharts that provided an overview of the life cycle of the issue management principle. This flowchart structure was based on a structure developed by Pijnenburg (2018). In this flowchart, the different design parties/groups and tools involved in the methodology are used to represent the general life cycle of an issue.

Finally, the assessment framework was developed. Ten characteristics were drafted that represented- and summarised the literature research findings and workflow models of both principles. In this process, the subsequent project evaluation was taken into account to make sure the characteristics could be used as assessment criteria. These ten characteristics were clearly described, accompanied by the assessment criteria for the project evaluation. The assessment framework was then displayed in a table. This table is used in the comparative analysis of the projects. The first characteristic of this framework concerns general project characteristics, this aimed to provide project context in the table of the comparative study. This characteristic is not directly related to the issue management-framework or performance of the project.

2.2. Selecting representable design projects

This section addresses the first part of sub question 2. In order to be able to develop a robust advice on the improvement of issue management for Tauw as a company, design projects were selected that represented a wide spectrum of Tauw design projects. This way, the measures drawn up in the advice would be more generalisable for all types of design projects within Tauw. In the selection process, led by the company supervisor, projects were selected based on their diversity in design type, contract structure and size, issue management tools, level of collaboration with external parties, and Tauw's role within the design process. This resulted in the selection of five design projects, this number of projects was chosen in relation to the duration of the research (10 weeks). The design projects and their main selection criteria are displayed in Table 2. This table shows the diversity in the design projects used in this research, for a more detailed introduction to the projects, see Appendix B.

Table 2: Project selection criteria

Characteristic/ Project	Design type	Contract- structure and value (Tauw)	Issue management tool	Level of collaboration	Tauw's role in the design process
V7WK	Historic locks	Bouwteam, 2.5M Euro	Relatics/ BIM360	Medium	Design process, project mgmt.
Ceintuurbaan	Bridge	RAW contract 45k Euro	Excel	Low	Design process, tender support
Vestdijk	Inner city road redesign	Bouwteam, 700k Euro	Excel/ BIMCollab	Medium	Integrated- /technical design and specifications
Ring Groningen	Highway reconstruction	UAV-GC, N/A	Relatics/ BIMTrack	High	Various roles with-in overall design organisation
RWZI Panheel/Stein	Wastewater treatment plants	Bouwteam, 1.3M Euro	Relatics/ Excel	High	Civil technical designs for VO, DO & UO

2.3. Evaluating design projects

In the second step of sub question 2, desk research was conducted to find out more about the general characteristics of the five projects (characteristic 1 of the assessment framework). In order to assess projects, the context of the project needs to be known. This context can be derived from the project characteristics. The term 'project characteristics' concerns all information that defines the project. Defining the project characteristics ensures that the project boundaries are set, and less unexpected issues or changes will arise. Therefore, it is crucial to clearly document these characteristics.

The criteria for this characteristic include clear documentation of: the definition of project goals, project scope; specified as explicit requirements, contract structure, roles of the company in the project, specification of products of the company, duration of the design phase of the project, design approach, and use of phasing.

These characteristics were then summarised in short project introductions to provide background information of each project. The project introductions can be found in Appendix B. Then, qualitative research was conducted on the projects, consisting of documentation review and interviews with project members. Qualitative research was selected to gain understanding of the underlying reasons, motivation and opinions of the issue management approaches adopted in the various projects. This qualitative research was used in the projects' evaluations, development of workflow models and comparison with the theoretical framework of efficient issue management. During the study, no subjective arguments were involved in the assessment of the projects, as the goal was to compare the different projects based on their performance in the assessment criteria of Chapter 4.

Documentation review

First, requests were sent out to all project-contacts informing them about the research and suggesting an informal meeting. In this meeting, the research was further explained and project documentation regarding issue management was discussed. For 3 out of 5 projects, access was granted to the project's SharePoint, one resulted in separate project documents and for the last one no documentation was provided (only interviews). Then, all project documentation regarding issue management was extensively examined. This data consisted of documents ranging from project management plans and reports to design logs and BIM implementation plans. In this process, knowledge was gathered about internal agreements, meeting structures, project roles, use of issue management tools, issue registrations and more issue management related aspects. This resulted in basic project knowledge and provided the required input for structuring the interviews.

Conducting interviews

Following the documentation review, semi-structured interviews were conducted with Tauw employees who were involved in the issue management of the projects, more specifically the designers, BIM-coordinators, or project/technical managers. In these interviews, the goal was to gain knowledge about:

- The internal structures and processes within the project
- Their insight on the differences between documentation and practice
- Underlying reasoning for the issue management approach
- Their experience with the projects' issue management approach
- Uncertainties regarding assessment criteria that were not covered in the documentation

The interviewees were informed that the interviews were recorded for the purpose of documentation. The environment of choice was MS Teams, as this is the preferred platform within Tauw and provides the opportunity to record safely. The interview summaries were sent out to the interviewee(s) for confirmation on the use of answers and provided the opportunity to make changes. The interviewees were informed that information extracted from the interviews is processed in the project evaluations. Before the interviews, it was explicitly mentioned that no names would be used, as it is not the purpose of this research to point fingers. The interview summaries are not published to respect the privacy of the interviewees, a general setup of an interview can be found in Appendix A. The interviews were semi-structured because this allowed the interviewer to improvise follow-up questions based on a participants response. Additionally, it allows for participants to freely express their opinions and views without obstructing the interview (Kallio, Pietila, Johnson, & Kangasniemi, 2016).

The documentation review and interviews with project members resulted in a full understanding of the project's issue management approach and the required information on the criteria of the assessment framework. This process was repeated for each project. As the research progressed, these evaluation processes were conducted in parallel due to the delays of certain interviews and improved increased experience in evaluating design projects. The extensive project evaluations models can be found in Appendix B and are discussed in Chapter 5.

2.4. Developing issue management workflow models of the projects

This section comprises sub question 3. With the project knowledge gained in the qualitative research of the projects, workflow models of the issue management approaches used in the historical parts of the five projects were developed. The models show a representation of the issue management approach in practice, not how it was documented. These models have the same structure as the workflow models from the assessment framework in Chapter 3. The models provide a clear overview of the projects' issue management approaches and will be used in the comparative study.

2.5. Comparing and analysing projects to the issue management framework

This section addresses sub question 4. The final step in the qualitative research was the comparison of the five design projects' issue management approach. This step is a synthesis of all previous steps, as the assessment framework, project evaluations and workflow models were all used. The table setup developed in the assessment framework, with criteria per characteristic of efficient issue management, was filled in with processed project knowledge derived from the project evaluations and workflows. This provided an overview of the projects' performance on each individual criteria and characteristic of the issue management framework. Subsequently, the table was analysed to uncover differences and trends among projects. These observations were then briefly explained, substantiated with cross references to the comparison table and the extensive project evaluations. The observations derived in the analysis were then compared to the issue management principles' workflows to uncover the differences between practice and theory of efficient issue management.

2.6. Drawing up the list of measures

Finally, the advice (sub question 5) was drawn up on how Tauw can improve their issue management based on the analysis. This advice consists of a list of measurements that the company could introduce to improve its issue management within the design process. The development of these measurements was based on the comparison of the analysis findings with the issue management framework, to figure out where and how Tauw can improve its issue management. In this process, the context of Tauw was taken into account to make sure no unnecessary comparisons were made that were not relevant for Tauw as a company. This context was indirectly extracted from the documentation reviews and interviews in the project evaluations, while gaining insight on the practice. For example: average project size, willingness for certain measures among project members, possibilities, or limitations.

This advice is aimed to improve and standardize the issue management strategy within Tauw. Therefore, the client limitations are excluded in this advice, however some alternative approaches have been provided for when limitations block the recommended approach. As part of this advice, some steps for implementation were provided.

2.7. Schematic overview of research methods

This research methodology is summarised in a schematic overview, displayed in Figure 1. In this overview, the steps and methods are displayed according to the methodology described above. The sub questions have been indicated in blue squares, the results in green squares, and research methods are indicated with circles, the colour depends on the consulted research method. A legenda is provided to give an overview of the components of the methodology.

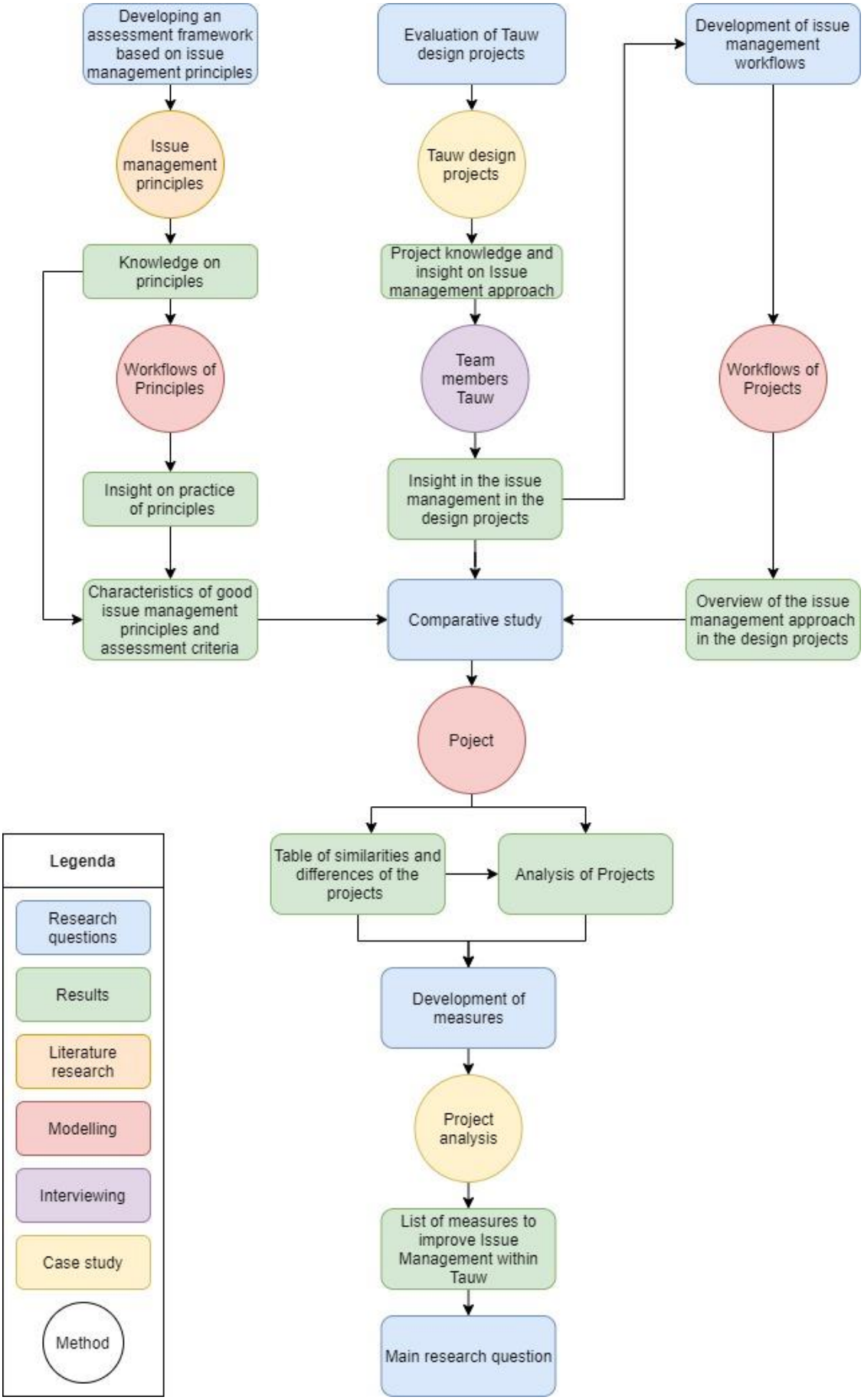

Figure 1: Schematic overview methods

3. Issue management principles

In this Chapter, the Prince2 approach to the matter of design issues, and the issue management approach from the BIM Collaboration Format (BCF) open standard perspective are explained. Through extensive literature research, the workflows of these approaches are studied, the extensive workflow descriptions can be found in Appendix B. This Chapter summarises the key points of the approaches. Each approach is then modelled in a workflow, developed based on the extensive workflow descriptions. These models provide an overview of the approaches. First, the selection of these principles is substantiated.

3.1. Selection of principles

Prince2 is a widely recognized and understood project management approach, and so provides a common vocabulary for all those involved in a project, which helps effective communication (Axelos, n.d.). The BCF-perspective is based on the implementation of BIM, Btoush and Harun (2017) identified BIM as a powerful tool to reduce delays in construction projects. Deckers (2019) argues that the BIM concept can reduce costs. These principles have been identified as efficient issue management based on the fact that they represent a streamlined communication process (clear workflows) and keep track of issues throughout the design process.

3.2. Prince2 workflow

The Prince 2 approach is characterised by the centralised position of the Project Manager (PM) in a project. The PM starts a project with developing an Issue and Change Control plan. This plan should define all the standards regarding issues throughout the period where a company is involved in the project. Figure 2 displays the general characteristics of this plan. Some examples have been included in the figure to provide insight on potential approaches to the characteristics of this plan. Note that the document is not limited nor bounded to these definitions (besides the “CEPDI” approach), this varies depending on the project characteristics and preferences of the project team.

After the development of this document, the approach for managing issues in the Prince2 approach, as suggested in the figure above, is the Capture – Examine – Propose – Decide – Implement (CEPDI) approach. This methodology is modelled in Figure 3 in the same structure as the flowchart developed by Pijnenburg (2018). Once a project member identifies an issue, an Issue Report must be submitted to the project manager, however there are exceptions to avoid overloading the PM. From then on, the issue is controlled by the PM, who will follow the CEPDI methodology as already indicated in Figure 2. This workflow model includes specialists/designers, the PM, and Project Board/Change Authority. The latter two play a crucial role in the issue and change management methodology of Prince2, as they have more authority regarding decision making. These roles are described in the more extensive description in Appendix B. Figure 3 displays the step-by-step process of the lifecycle of one issue in the design process.

The workflow model in Figure 3 shows the workflow of one issue life cycle, though, the PM can also periodically complete this process for multiple issues simultaneously to reduce the workload. The Issue Register and Daily Log are the locations where issues are kept, these registers can be any tool or document as suggested in Figure 2, or similar. The implementation of this methodology should result in a more uniform workflow because of the centralised role of the project manager. Though, this role does not necessarily have to be the project manager but can also be appointed to another individual, as long as the issues are actively managed.

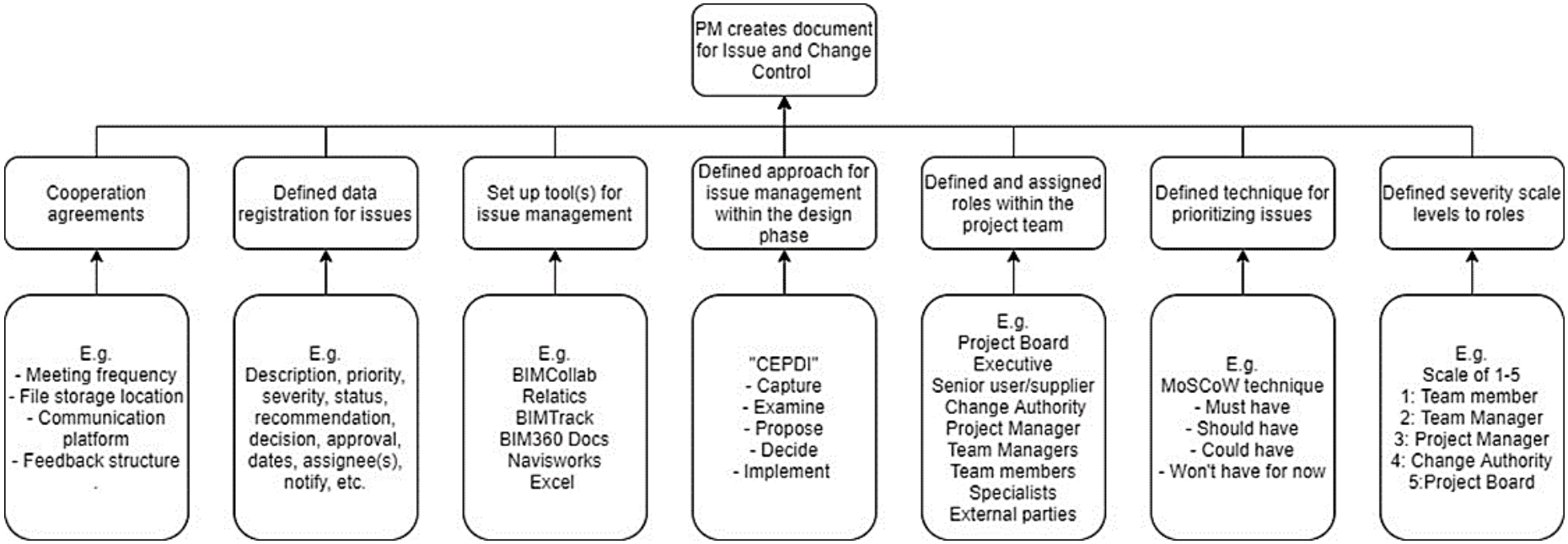

Figure 2: Issues and Change Control document characteristics

3.3 BCF open standard perspective workflow

The issue management from the BCF open standard perspective is a more technical approach that centralises an online BIM environment through which all communication regarding issues around the design model is managed. This environment is accessible for project members (mostly technical specialists/managers/designers), consultants, and the client through personal accounts. The use of personal accounts keeps the project data safe and the design alterations traceable. BCF allows model mark-ups, clash detection software, and general comments between all project members, requiring responsibility and accountability from everyone involved in the design process. The BIM environment notifies the designated users after an issue report is submitted and automatically generates analytics on the issues. The possibility to add information such as viewpoints and snapshots to the issue description helps the assignee to resolve the issue faster by providing a more accurate issue report.

BCF provides a smooth cooperation process between different disciplines by allowing users to work in their own respective software and connecting these platforms directly. BCF offers a more efficient methodology to structure the workflow for storing, sharing and managing issues in projects (Deckers, 2019). Besides the benefits for issue management, the BCF-perspective allows for better communication with stakeholders who are not BIM-specialists, through integrated model viewers.

This methodology is described in three simple steps: setting up the environment, detecting and uploading issues, and resolving issues. When the environment is set up by the BIM-specialist, issues can be uploaded by project members (more likely the design team). When an issue has been assigned to a team member, this member will receive a notification and can directly open the issue in their respective software with help of the viewpoint that is attached to the issue report. Once the issue has been resolved, the involved team members are notified (often including the design leader or PM) for approval of the change. This methodology simplifies the role of the PM/design leader as an overview of all issues is provided directly related to the model, making it easier to manage. The workflow model of this methodology is displayed in Figure 4, for a more detailed description see Appendix B.

Prince2

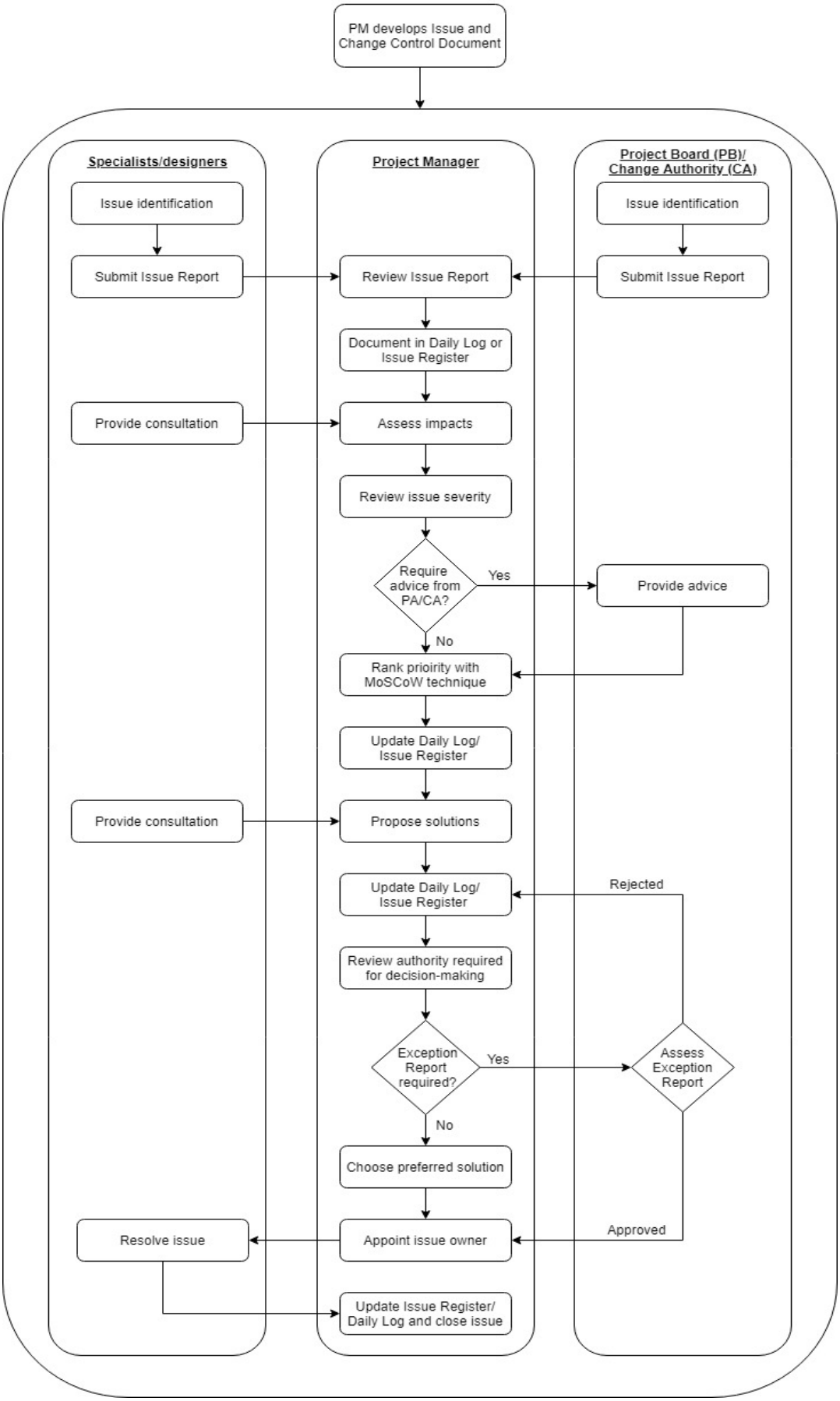
PM develops Issue and Change Control Document
Specialists/designers
Project Manager
Project Board (PB)/ Change Authority (CA)
Issue identification
Issue identification
Submit Issue Report
Review Issue Report
Submit Issue Report
Document in Daily Log or Issue Register
Provide consultation
Assess impacts
Review issue severity
Require advice from PA/CA?
Yes
Provide advice
No
Rank prioirity with MoSCoW technique
Update Daily Log/ Issue Register
Provide consultation
Propose solutions
Update Daily Log/ Issue Register
Rejected
Review authority required for decision-making
Exception Report required?
Yes
Assess Exception Report
No
Choose preferred solution
Resolve issue
Appoint issue owner
Approved
Update Issue Register/ Daily Log and close issue

Figure 3: Prince2 workflow

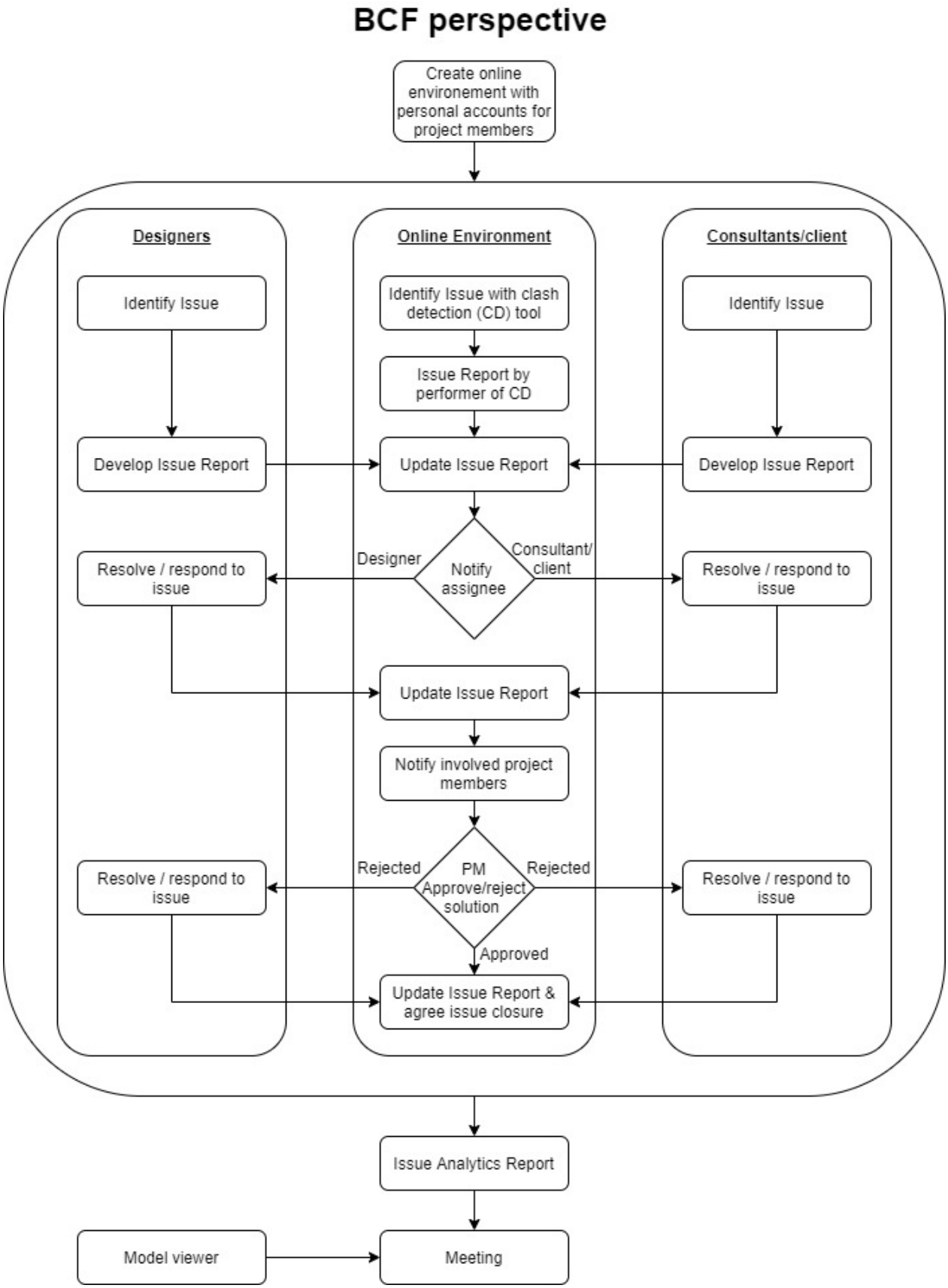

Figure 4: BCF-perspective workflow

4. Project assessment framework

Based on the literature review and workflows presented in Chapter 3, ten characteristics of efficient issue management have been derived that include the key aspects of the issue management framework. The first characteristic is included to provide project context for the comparative study in Chapter 6 and is not directly related to the framework in Chapter 3. The other characteristics will be used to evaluate and compare the design projects on their issue management. Each characteristic is refined to general criteria that will indicate how the projects perform compared on the issue management framework. For each characteristic, a description is provided that explains why this is important for efficient issue management and how the criteria will measure the projects' performance. Following the descriptions of the characteristics, the project assessment framework is displayed in Table 3, this table will be used in the comparative study in Chapter 6.

1. Definition of project characteristics

In order to assess projects, the context of the project needs to be known. This context can be derived from the project characteristics. The term 'project characteristics' concerns all information that defines the project. Defining the project characteristics ensures that the project boundaries are set, and less unexpected issues or changes will arise. Therefore, it is crucial to clearly document these characteristics.

The criteria for this characteristic include clear documentation of: the definition of project goals, project scope; specified as explicit requirements, contract structure, roles of each contractor in the project, specification of products of the company, duration of the design phase of the project, design approach, and use of phasing.

2. General agreements in the team

It is important to make agreements with the project team, agreements provide a clearer structure in the workflow during the project. It is beneficial to make agreements early in the project, to minimize confusion and avoid disagreements on the approach. An important aspect of this characteristic is the documentation of these agreements, this makes sure that the project team can fall back on the decisions. For this characteristic only general cooperation agreements are assessed, as more specific agreements are included in other characteristics.

The criteria for this characteristic include having defined a meeting structure, cooperation strategy, file storage tool and feedback structure. These (except the file storage tool, see below) will be assessed based on presence in the project, and if so, where they are documented. The criteria are shortly elaborated below:

- The meeting structure should include meeting frequency, list of attendees, agenda, and a set location for meeting notes.
- The cooperation strategy includes anything that describes the cooperation process between team members and contractors, for example rules, a set cooperation day, or PSU.
- The file storage tool represents the communication of documentation between team members, among contractors or with clients. This criterion will be assessed on whether the project implemented a project wide file storage tool for documentation sharing (central), only communicated documentation within a project team/discipline (decentral), or both.
- The feedback structure should include the processes that improved the internal project workflow or product during the project, for example audits, evaluations, or teambuilding.

3. Set up issue management environment (IME)

There are various tools and methods available for documenting and managing issues. These tools can be used for multiple purposes at the same time, either directly or indirectly related to issue management. It is therefore important to set up an issue management environment at the start of the project to collectively work in the same tool(s) throughout the project. This increases traceability and accountability of decisions and actions made during the design process. The way the issue management tools are set up impacts the efficiency of the issue management within the project.

The criteria for this characteristic include clear definitions on what tools are used and for what ends this tool is used. Tools can be BIM-tools, Excel documents, Relatics or other documentation tools.

4. Defined issue management methodology

An issue management methodology describes how issues should be managed once they have been identified. This methodology should be a consistent stepwise approach to issues, vague descriptions leave space for ambiguity and consequently, different approaches within the project team. It is possible that there are multiple methodologies within the project, for instance one for each issue management tool, or one for a specific team. For this characteristic, the two (could also be just one) most important issue management tools will be assessed on the use of issue management methodologies.

The criteria for this characteristic are whether a stepwise workflow was defined for the issue management tool, which team used the tool, and if it was used central (project wide) or decentral (specific team).

5. Content of Issue Reports

Communicating about issues is important to minimize reworks, and thereby also costs and delays. For good communication, issues should be documented in a structured manner with defined data that must be kept. The more data kept in an issue report, the more understandable the issue is for the assignee. This should result in a more efficient issue management process. As issues can be kept in multiple tools, the two most used tools in the design process will be assessed.

The criteria for this characteristic are whether the issue report include the following features: status, type, assignee, description, solution, priority, deadline, and viewpoint. Issue type will be assessed on the Prince2 methodology: RFC, Off-specification, or comment/concern/opportunity (Litten, 2016). In addition to that it is important to note how the issue report is related to the model and if all issue reports are consistent in their data. Options for the model related criteria are:
(A) Through description (unrelated)
(B) Manual, e.g. by including an object code in a report log, or in relation to 2D drawing
(C) As viewpoint in the 3D BIM model or unrelated
(D) Flexible: as viewpoint in the 3D BIM model, in relation to a 2D drawing, or not related.

6. Issue assessment methods

Not all issues should be handled the same; some are more serious than others and some might need more urgent solving. When the issue register or log of a certain tool does not get sufficient attention during the design process, issues could get lost in the design process. Therefore, it is necessary to treat issues with the attention they need, to avoid loss of quality or unnecessary delays.

The criteria for this characteristic are whether the issues were assessed on priority, impact, or urgency throughout the design process. Methods for these assessments could be using a scale for the assessing these criteria or providing a deadline for resolving an issue. This assessment can either be included in the issue report or performed manually by a project member that manages the issues.

7. Overlooking manager/coordinator in design process

Issues arise on a daily basis throughout the project, the more complex the project is, the more issues arise. Issue registers get filled with unresolved issues; in an ideal situation these issues all get solved. However, this is often not the case, issues get forgotten due to the ongoing nature of the design project. This causes potential delays or loss of quality, depending on the issue details. Therefore, it is important to assign a role to an individual who overlooks the issue register(s), to make sure all issues are resolved and on time. This role can be assigned to multiple people, depending on the tools that are used in the project. An important aspect of this job is being actively involved in the meetings, as key activities related to issue management take place there.

The criteria for this characteristic assess the project on whether a role was assigned to an individual that actively overlooks issues, and if so which tools.

8. Escalation model

When issues are reported in the issue register, it might just be an issue. However, as the project progresses, this issue might grow out to affect the management aspects of the project. This threat needs to be managed with structure. Therefore, it is important that a methodology is defined regarding issue escalation. Potential changes need to be communicated effectively, as they have a higher impact than regular issues. Changes need to be registered separately from issues, as they affect the project's performance targets.

The criteria for this characteristic are whether the project has a set methodology defined, authority is assigned to roles regarding issue escalation, and if a separate register is used for change registration.

9. Involvement of client in the design process

To improve issue management throughout the project, it should be clear what role the client will play. The involvement of the client can determine how issue management will be conducted in the project. Therefore, it is crucial to define this role beforehand so that the issue management strategy does not change during the project. Active involvement can help reduce the number of issues. However, actively involving the client does not necessarily imply they have access to the design environments, these aspects of involvement need to be defined.

The criteria for this characteristic are whether the client is actively or passively involved in the design process, what roles they have in the design process and if they have access to the issue management tools.

10. Issue and Change control plan

As the Prince2 methodology described, the project should start with a plan that describes how issue management is conducted during the project. It is important to describe all issue management related topics in a centralised location, so that project members all follow the same approach. This plan can then be included in other plans like the Project Management Plan or Plan of Action.

The criteria for this characteristic assess the project on how the issue management strategy was documented (centrally/scattered/not at all), if this documentation was complete (all other characteristics defined), and which documents concern issue management.

Table 3: Project assessment framework

Characteristic	**Criteria**
1. Definition of project characteristics	Project scope: Contract type: Tauw contract roles: Main Tauw products: Design period: Design appr.: Phasing:
2. General agreements in the team	Meeting structure: Cooperation strategy: File storage: Feedback structure:
3. Set up IME	Tool → used for what end?
4. Defined issue methodology	Tool: Workflow: Used by: Central (1)/ decentral (2):
5. Content of Issue Reports	Tool: Status: Type: Assignee: Description: Solution: Priority: Deadline: Viewpoint: Model related: Consistent use:
6. Issue assessment methods	Tool: Prioritisation: Impact: Urgency:
7. Issue manager in design process	Is the issue manager role implemented? If so, how?
8. Escalation strategy	Methodology: Authority linked to roles: Change log:
9. Client involvement in the design process	Active/passive involvement: Role in design process: Access to Issue Management Environment:
10. Issue and Change control plan (ICC-plan)	How is IM defined: Complete: Which document(s):

5. Data collection

In this chapter, the data is collected that will be used in the comparative study in Chapter 6. This Chapter summarises each project based on findings in the project evaluations. These evaluations were conducted in two stages: documentation review and semi-structured interviews. From this obtained knowledge, workflow models were developed to provide an overview of the issue management approach. The full evaluation reports can be found in Appendix C, including workflow models of each individual project. In this evaluation, the criteria from the assessment framework developed in Chapter 4 were used to be able to compare the projects on the same aspects in the comparative study in Chapter 6. This evaluation was not about assessing the efficiency and quality of each project's issue management individually. Therefore, no subjective arguments were involved, and the project evaluations were simply founded on observations generated through documentation review and interviews with project members.

5.1. Verbeteren 7 Waterkerende Kunstwerken

Hoogheemraadschap Hollands Noorderkwartier (client) found that 7 of their 9 sluice systems did not meet the requirements based on unreliable closing mechanisms. For this project, a bouwteam was founded, with Tauw being in the lead during the design and Friso-civiel in the realisation phase. Tauw's contract value is 2.5M Euros and the design phase took approximately 2.5 years. The documentation review for this project was performed through access to the bouwteam's SharePoint (MS Teams). This review showed that the project team had developed clear plans for project management, verification, BIM implementation, etc. In these documents the meeting structure included an agenda, required attendees, and frequency. In addition to that, cooperation agreements were documented, and roles were defined.

Multiple issue management tools were used in the design process, including BIM360, Relatics, Tweekly, and an RFC-register. BIM360 was implemented as a pilot for design issues, this environment was used inconsistently due to the limited design scope for Tauw and low number of interfaces between disciplines. This complex, centralised, issue management setup resulted in scattered issue registration with very limited issue assessment. The escalation model provided a set methodology for changes. Throughout the project, the client was actively involved but did not have a design role. In this evaluation, 3 project members were interviewed: contract manager, designer, and BIM-coordinator.

5.2. Ceintuurbaan

The municipality of Meppel (client) found that a 90-year-old bridge nears the end of its life cycle. Tauw was hired for the development of the implementation specifications for a new bridge. Tauw's contract value was approximately 45k Euros and the design phase took 1 year, including a 6-month delay due to the discovery of a pipeline underneath the bridge. This delay caused a complete change in project members after resumption. The documentation review for this project performed through access to Tauw's MS Teams environment. This review resulted in minimal insight on the project's issue management approach. The project team started ambitiously with the setup of a Relatics environment for all issue management related documentation. Due to the shift in team members, this ambition was not continued after resumption. This, and the lack of documentation regarding issue management was caused by the tight budget and time pressure that characterised the project.

The issue management approach after resumption consisted of weekly team meetings and the use of a design log. No formal agreements were made regarding the registration, or assessment, of issues in the design log. This design log was not consistently used among designers as progression had priority over documentation. The escalation model regarding changes was managed by the project manager in weekly meetings with the client's project manager and were documented in an RFC-register. For this project 2 project members were interviewed: the project manager and a designer.

5.3. Vestdijk

The municipality of Eindhoven learned that parts of the inner-city road 'the Vestdijk' did not meet the air quality requirements. The bouwteam, consisting of the municipality, Strabag, and three (design) sub-contractors, was set up for the redesign of the Vestdijk. As a sub-contractor, Tauw was responsible for the technical- and integrated designs. Tauw's contract value was approximately 700k Euro and the design process took 2.5 years. The documentation review for this project performed through access to Tauw's (decentral) project server. The Plan of Action provided some insight on the issue management approach, though a lot of agreements and methodologies were left undocumented, including the meeting structure. Progression had priority over documentation at the start of the project, ultimately resulting in a Tauw product not meeting requirements. This was followed by an internal evaluation.

The decentralised design log was actively kept by Tauw designers for documentation of design related issues. In addition to that, a BIMCollab test replaced the design log for a month for improved issue registration. The issue reports for both tools were consistent and included urgency assessment. Numerous decentralised action registers were kept for meeting notes. This structure of issue management left some project members confused on issue registration. Changes were managed via Email and RFC-templates with Strabag. The client was actively involved in the design process, taking account of design disciplines. For this project, the project manager and a designer were interviewed.

5.4. Ring Groningen Zuid

Congestions on the southern ring-highway are causing delays on other roads in the city. ARZ (client) appointed team of 6 contractors (CHP), supported by sub-contractors, for the redesign of 12km of highway. Tauw has multiple employees with different roles involved in various disciplines of this project. The design phase of this project will take approximately 3.5 years. The documentation sent by the (Tauw) design coordinator quickly revealed the comprehensive structure of the project. Processes, procedures, manuals, and standards were all defined in clear documents. Despite the absence of a central document specifically for issue management, everything regarding issue management was defined in a centralised SharePoint. The project organisation is currently working on an issue manager.

Relatics is being used for information registration regarding issue management, while BIMTrack is currently being implemented on a project wide scale for improved communication around the model. Issue reports in both tools are complete, outside of the impact assessment. The escalation model for issues is clearly depicted in the organisational chart and a contract management plan is defined for contract changes, documented in Relatics. The clients role is passive in the design process. One interview with the design coordinator provided enough information for this research.

5.5. RWZI Panheel/Stein

Two wastewater treatment plants (WTP) did not meet the effluent-requirements set by KRW. The waterboard of Limburg (client) appointed a bouwteam consisting of 6 companies for the construction of new WTP's. Tauw, a sub-contractor, is responsible for the civil department of the VO, DO, and UO. Tauw's contract value for this project was 1.3M at the time of research and the design phase was 1 year. No documentation review was conducted for this project as there were no official documents regarding issue management. The issue management approach rested on the verbally agreed meeting structure, which included an agenda, frequency, and attendees. In addition to that, Tauw actively used an action register within the design team, managed by the design leader and discussed weekly with the team. Progression had the priority over documentation, resulting in a dynamic approach. This approach can be derived from the fact that the client did not provide SMART requirements, causing frequent changes. Contract changes and shifts were actively managed by sending 2-weekly invoices to the contractor (Mobilis). The client had an active role, taking account for various design aspects. For this project, one interview was conducted with both the project manager and design leader civil.

6. Comparison of Projects

This Chapter comprises the comparative study on the design projects based on the assessment framework developed in Chapter 4. Table 4 provides an overview of the performances of all 5 projects in the criteria set in the assessment framework. The data shown in the table is directly extracted from the project evaluations in Appendix C. Although, some data are not explicitly discussed in the text, such as the exact content of the issue reports as shown in characteristic 5. This was still part of the documentation review and interviews. Each project is projected in a column, this way the differences in approaches can be directly discerned. The goal of this table is not to display how well each project organised their issue management, but to compare projects and discover trends in Tauw design projects' approach to issue management.

6.1 Data Analysis

This section aims to uncover trends among the evaluated projects by reviewing the characteristics and criteria displayed in Table 4. Findings are supported by the more extensive evaluations and the workflow models of the separate projects; these can be found in Appendix C. The most significant observations regarding the improvement of issue management within Tauw are briefly discussed and supported by cross references to Table 4. The observations found in this analysis are used as foundation for the development of the measures for improvement of issue management for Tauw. The 7 observations that followed from this analysis are displayed below.

1. There is no standard set of issue management tools adopted in Tauw design projects

Characteristic 3 shows that each project adopted a different set of issue management tools for issue- and change registration. In these 5 projects, 7 different tools have been used for issue registration and 3 different methods for change registration (characteristic 8). This absence of a standard issue management approach is supported by the differences in issue life cycle workflows of the projects, displayed in Appendix C. This observation confirms the problem description.

2. The majority of the projects either had multiple sources of issue registration or had no clear guidelines regarding issue registration at all

Characteristic 3 shows that 2 out of 5 projects used 3 or more locations for issue registration (V7WK and Vestdijk). The workflow criterion in characteristic 4 shows that 4 out of the 8 main issue management tools between the projects, had no clear guidelines defined regarding issue registration.

3. The issue management tools are mainly used for registering design related issues, thereby decentralising/excluding documentation of communication regarding other issues

Characteristic 3 shows that the majority of the issue management tools are used for documenting design related issues. Communication concerning other issues is either not documented at all or documented in a separate tool. This decentralised and ambiguous (observation 2) approach to documenting communication and issues caused confusion among team members, resulting in distributed (and sometimes lack of) issue management in projects.

Table 4: Project assessment framework

Characteristic	Project / Criteria	V7WK		Ceintuurbaan	Vestdijk		Ring Groningen Zuid		RWZI Panheel/ Stein
1.Definition of project characteristics	Project scope:	Relatics		PvA	Relatics		Relatics		Relatics
	Contract type:	Bouwteam		RAW contract	Bouwteam		UAV-GC		Bouwteam
	Tauw contract roles:	Design process, PM		Design process, tender support	PM, design integration		Support in design phase		Design process, technical scope
	Main Tauw products:	VKA, DO, PvA		UO, design- specifications	TDO, UO, specifications		N/A		VO, DO, UO (civil aspect)
	Design period:	~2.5 years		1 year (0.5 year)	~2.5 years		~3-4 years		~1 year
	Design appr.:	BIM-UP		PA	PvA		PR-Ontwerp		Dynamic
	Phasing:	Explore, plan, realise		Not used	Designing, Engineering		50%, 75%, 95%, 100%		PvE, VO, DO, UO
2. General agreements in the team	Meeting structure:	Yes, in PMP		Yes, not documented	Yes, not documented		Yes, in Think Projects		Yes, not documented
	Cooperation strategy:	Yes, in PMP		Yes, not documented	Yes, in PvA		Yes, in Think Projects		Yes, not documented
	File storage:	Central		Decentral	Decentral		Central		Central and Decentral
	Feedback structure:	Yes, in PMP		No, not documented	Yes, not documented		Yes, in Think Projects		Yes, not documented
3. Set up IME	Tool → used for what end?	**BIM360** → model sharing, design issues, action list **Tweekly** → issues, deviations **Relatics** → V&V, risks, client issues, requirements		**Design log** → design issues, actions	**Design log** → design issues **BIMCollab** → model sharing, design issues **Action register**→ meeting notes		**Relatics** → V&V, issues, interfaces, risks requirements, actions, objects **BIMTrack** → model sharing, design issues, actions		**Action register** → design issues/ actions
4. Defined issue methodology	**Tool:**	**BIM 360**	**Tweekly**	**Design Log**	**BIM Collab**	**Design Log**	**BIM-Track**	**Relatics**	**Internal action register**
	Workflow:	No	Yes	No	Yes	No	Yes	Yes	No
	Used by:	Design team	Project team	Design team	Design team	Design team	Design team	Project team	Design team
	Central (1) / decentral (2):	1	1	2	2	2	1	1	2

5. Content of Issue Reports	**Tool:**	**BIM 360**	**Tweekly**	**Design Log**	**BIM Collab**	**Design Log**	**BIM-Track**	**Relatics**	**Internal action register**
	Status:	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
	Type:	No	No	No	Yes	No	Yes	Yes	No
	Assignee:	Yes	Yes	No	Yes	No	Yes	Yes	Yes
	Description:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Solution:	Yes	yes	Yes	Yes	Yes	Yes	Yes	Yes
	Priority:	No	No	No	No	No	Yes	Yes	No
	Deadline:	Varies	No	Rarely	Yes	Yes	Yes	Yes	No
	Viewpoint:	No	No	No	Yes	No	Yes	No	No
	Model related:	A	A	A	C	B	D	B	A
	Consistent use:	No	Yes	No	Yes	Yes	Yes	Yes	Yes
6. Issue assessment methods	**Tool:**	**BIM 360**	**Tweekly**	**Design Log**	**BIM Collab**	**Design Log**	**BIM-Track**	**Relatics**	**Internal action register**
	Prioritisation:	No	No	No	No	No	Yes	Yes	No
	Impact:	No	No	No	No	No	No	No	No
	Urgency:	Varies	No	Rarely	Yes	Yes	Yes	Yes	No
7. Issue manager in design process	Is the issue manager role implemented? If so, how?	One BIM360 coordinator, registering meeting notes		Not defined	Not necessary, only one active designer		Not defined, will be implemented in future		Action register coordinator (managing log)
8.Escalation strategy	Methodology: Authority linked to roles: Change log:	Yes → PMP Yes RFC-register		Yes → not documented Yes RFC-register	Yes → not documented Yes RFC-register		Yes → PR contract mgmt. Yes Relatics		Yes → not documented Yes 2-weekly invoice
9. Client involve-ment in the design process	Active/passive involvement: Role in design process: Access to IME:	Active Input, audits, meetings No, export to client's Relatics		Passive Input, audits, meetings N/A	Active Input, audits, meetings, design Yes→Relatics No→ BIMCollab		Passive Input, audits, meetings Yes→Relatics (restricted)		Active Input, audits, meetings, design Yes → Relatics
10. Issue and Change control plan (ICC-plan)	How is IM defined: Complete: Which document(s):	Scattered over documents No PMP, BIM-IP, PSU		Not defined No N/A	Scattered over documents No PvA, BIM-IP, PSU		Scattered over documents Yes BIM-IP, manuals processes		Not defined No N/A

4. The majority of the projects do not have a role assigned to a person that manages issues on a day-to-day basis

Characteristic 7 shows that 3 out of 5 projects do not have an active issue manager role assigned to a project member. V7WK has a BIM-coordinator role assigned, however the BIM-tool was not actively used for issues. The issue manager role in RWZI Panheel/Stein only applied to the action register and was very informal. Therefore, it can be concluded that this role (as derived from the assessment framework) is not part of the issue management approach within Tauw.

5. Changes are generally handled according to a project specific structure, but not related to the issue management methodology

Characteristic 8 shows that changes in projects are all following a specific methodology. In the project evaluations in Appendix C, this approach is described for each project. Though, most approaches are not officially documented or directly related to the issue management methodology.

6. Data in issue reports vary significantly between tools and are not consistently assessed on priority/impact/urgency in the majority of the projects

Characteristic 5 shows the variation in data that is kept in issue reports in the different issue management tools. This especially shows in the 'model related' criteria, where it shows that only 2 projects properly linked issues to the models. In addition to that, characteristic 6 shows that 4 out of 5 projects did not assess issues on impact throughout the design process and only rarely assigned urgency or priority to issue reports.

These observations combined, show the trend of inaccurate issue communication within Tauw projects. The primary reasons for this were the small scales of the projects (meaning less issues that need prioritising), and lack of possibility for documentation within the used tools or documents.

7. Agreements regarding issue management are not (consistently) documented in the majority of the projects

Characteristic 2 shows that 3 out of 5 projects did not have a meeting structure, cooperation strategy, or feedback structure documented. Though, each project did seem to have periodic meetings followed by meeting notes/action points, cooperation agreements to some extent, and feedback in the form of audits and internal evaluation sessions. In addition to this, as already explained in observation 2, the majority of the tools are not accompanied by documented methodologies. Based on these observations, it can be concluded that issue management documentation is currently not one of the top priorities when starting up a project.

As characteristic 10 shows, not one project has defined its issue management approach in a central document. Though, some projects defined various aspects of issue management in different documents, but only one has defined all aspects.

The observations explained above indicate a lack of awareness for the importance of explicit issue management in a project within Tauw.

7. Recommendations

Following the analysis of the five different Tauw design projects in Chapter 6, a list of measures for the improvement of issue management within Tauw is derived. These measures were developed by comparing the analysis observations to the issue management framework and identifying opportunities for improvement. In this process, the context of Tauw projects was taken into account. By including a wide variety of project types in this research, the measures are more generalisable for companywide design projects. This advice is aimed to improve the issue management standard within Tauw, limitations caused by the client are therefore excluded.

1. Centralising 1 or 2 online issue management tools (maximum) within a project

The analysis showed that the majority of the projects either had multiple sources of issue registration or had no clear guidelines regarding issue registration at all. In some projects, this caused the professionals to adopt a personal approach instead of a common approach within the design process. To reduce this ambiguity on the locations of data registration, each project should be limited to either 1 or 2 centralised communication storage tools, depending on the project characteristics. This approach ensures that the entire project team works in the same environment(s), and thereby streamlining the communication process throughout the project. The Prince2 approach advises to have a methodology implemented for managing the issues. It is therefore important to centrally define for what end each tool will be used, how to use it, and who uses it. These agreements must be documented at the start of the project, see recommendation 5.

The recommended approach to the centralised communication storage tools is the standardisation of the combination of Relatics and a BIM-tool. Relatics is essential for all project related documentation such as requirements, plans, V&V, issues, etc. and should therefore be implemented in all projects. The BIM-tool greatly improves the communication process around models, as derived from the BCF-perspective in the issue management framework in Chapter 3. However, not all project characteristics allow for this, for example due to budget limitations. When this is the case, an alternative approach can be found in the Issue and Change Control template in recommendation 5. The advice for Tauw is to implement the following 'standard' approach to using tools:

Relatics
At the start of the project, set up a Relatics (TRASE) environment where the organisational structure, requirement specifications, objects, interfaces, risks, V&V, meeting notes/action points, RFC's and project related issues are documented. This tool should be accessible for all project members, alongside a centralised definition on how to use the tool. When Relatics is the only communication tool in the project, design issues should also be included in the issue register within Relatics.

BIM-tool
Before the design process starts, set up the company-preferred BIM-tool (e.g. BIMTrack, BIM360, or BIMCollab) for communication around the design model. It is important for the selection of this tool that it supports flexible model related issue registration methods (e.g. viewpoint, 2D drawings, object codes, unrelated), as projects in Tauw vary in design processes. This communication should include all design related issues, comments, questions, and notes. The tool should be accessible for the technical-/design team. To involve the rest of the project team regarding design issues, multiple alternatives are possible. One example is creating exports of the BIM-tool issue register and import these periodically into Relatics. Another example could be monthly Email reporting via PDF, which includes high quality dashboard statistics and a list of data per issue including the screenshot. This communication method between the BIM-tool and the project team is included in the 'Future research' Chapter.

2. Registering all communication in a central (online) environment for better traceability in the design process

The implementation of tools such as Relatics or BIM does not automatically guarantee consistent and traceable communication within the design process. Concrete agreements are necessary for a uniform issue registration approach. The project analysis showed that the issue management tools are primarily used for registering design issues, thereby decentralising, or excluding documentation of communication regarding other issues. Additionally, information documented in Emails often remains between the involved people. In order to improve the traceability of information exchange in the design process, such as decisions, two approaches have been identified.

Recommended approach
This approach is in accordance with the implementation of recommendation 1. Communication within the project (excluding design issues when a BIM-tools is implemented) should be documented in the issue register in Relatics. This register should be used to also ask questions, make notes, state concerns/opportunities, reply, or send documents. This centralises all project related information and creates a personal overview for each project member when they open the project environment, instead of the mailbox. The interviews supported this personal project 'dashboard', as this might improve communication efficiency and traceability. This measure must be agreed upon and documented in the Project Start-Up meeting as explained in measure 5. The implementation requires a change in habits of all project members and will therefore need monitoring during implementation on a project scale, see measure 3.

Alternative approach
When project characteristics do not allow for the above, an easier option is capturing all Emails related to the project based on a naming convention in the title and adding the project-email in the CC. This way, all project related communication that is not documented in the issue management tools, is stored in a central location. This process is less efficient but still ensures traceability of information.

3. Assign a role to a team member that actively manages issues in the project

The issue management framework, more specifically Prince2, shows the importance of an individual that manages issues on a day to day basis and is actively involved in the design process. This role includes escalating issues, reviewing and managing issues on priority, allocating issues to the correct project members, ensuring involvement of the team members (see measure 2), leading regular team meetings and registering meeting notes/action points in the issue management tool(s). The analysis showed that this role is missing in most Tauw projects. This role should be defined to streamline the issue management process. The importance of this role is amplified in big and complex projects like Ring Groningen, where clash detection tests in the integrated model result in too many clashes to manage and assign effectively. In small scale projects this role can be appointed in combination with another role as this role is only necessary for instance once a week. When projects get bigger and more complex, like Ring Groningen, a separate individual should be considered as it will be a full-time job to manage the issue- and change related communication. At the start of the project, this role should be assigned alongside the frequency of executing this process.

4. Prioritize issues based on impact and urgency

The analysis showed that issues are rarely assessed on impact and urgency once they have been identified. Prince2 shows the importance of issue assessment, without it, issues might not receive the attention or urgency they require, potentially affecting the management aspects. The current reality, with the majority of Tauw design projects being relatively small, i.e., issue-wise, shows that issue assessment on impact is not indispensable. However, with the full implementation of recommendation 1, 2 and 3, this will prove to become a valuable asset to issue management, as the issue count will rise.

Impact
The advice for Tauw is to implement the MoSCoW technique as a standard for assessing impact. This method can be applied when submitting an issue report in a tool or document, by assigning a score of 1 to 4 to the issue. Turley (n.d.) explained the MoSCoW impact scale as following:

- **Must have (1):** The change is essential for the viability of the project and its absence would affect the project objectives.
- **Should have (2):** The change is important, and its absence would weaken the Business Case. However, the project would still meet its objectives.
- **Could have (3)**: The change is useful, but its absence does not weaken the Business Case.
- **Will not have for now (4)**: The change is not essential or important, so it can wait.

An alternative is assigning risk scores to certain performance targets (time, costs, quality). This does provide a more accurate description of the issue impact but requires more time and knowledge. A comprehensive approach to assessing impact will not significantly improve the issue management, as the issues count is often relatively low, the MoSCoW technique is therefore advised.

Urgency
Urgency assessment was already present in most issue management tools as a 'due date' could be assigned, though this was not used consistently. When implemented consistently, this feature urges team members to resolve issues on time and thereby avoid endangering the project planning.

Implementation
The implementation of this recommendation requires the addition of an impact option/column within the issue reporting tools, as well as company-wide agreements on consistently assessing the impact and urgency in issue reports.

5. Creating an issue and change control plan at the start of each design project

The analysis has confirmed that the issue management approach within Tauw is very fragmented, variegated and lacks a standard structure. The majority of the projects in this research did not have concrete, documented, agreements regarding issue management strategy at the start of the project.

This recommendation is derived from the Prince2 issue and change control template, as already introduced in the issue management framework in Chapter 3. This template contains all issue management related aspects that are important based on the research findings and Prince2. The process of filling in this template at the start of each project should be standardised within the project team/bouwteam during the PSU. This filled in template functions as an issue and change control plan that can be included in other project plans. By implementing this template in projects on a companywide scale, a more standardized issue management approach within Tauw should follow.

The template is divided into four main aspects, derived from this study: cooperation strategy, issue management tools, issue reporting and methodologies. Each aspect is divided into sub-aspects that need to be agreed on at the start of the project. The recommended approach per sub-aspect is provided in the second column, and the optional approaches are indicated in the third column. With the implementation of this template, each project will have an issue and change control plan at the start of the project. With the recommendations provided in the template, a more standardised approach within Tauw should follow. The template is displayed in Table 5 below.

Table 5: Issue and Change Control template

Aspects / Approach	Recommended	Optional
Cooperation strategy		
Team roles	*Define:* - *Team roles* - *Authority per role* - *Assign issue manager*	*Define:* - *Client roles* - *Organisational structure* - *Communication lines*
Escalation strategy	*Assign Prince2 roles:* - *Project Board* - *Change Authority* - *Project Manager*	*Develop and document custom approach, including authority links to roles*
Cooperation agreements	- *Document Breakdown Structure* - *Cooperation rules* - *Issue log management* - *Audit structure*	- *Evaluation sessions* - *Teambuilding sessions*
Meeting structure	*Define per meeting:* - *Required. attendees* - *Frequency* - *Agenda points* - *Notes location*	*Define:* - *Action points* - *Meeting roles*
Documentation storage tool	*MS Teams or Relatics for project documents, BIM-tool for model sharing*	*Online SharePoint with contractor team and client*
Issue management tools		
Relatics	*Requirements, objects, V&V, interfaces, meeting notes, project issues, risks, changes*	*Separate (Excel) documents for:* - *Meeting notes* - *Risks* - *Changes*
BIM-tool	*Design issues, model sharing, BIM-viewer in design meetings*	*Separate (Excel) document for design log*
Issue reporting		
Project issues	*Status, type, description, assignee(s), impact, deadline, response,*	*Approval, area, phase*
Design issues	*Status, type, description, assignee(s), impact, deadline, response, viewpoint*	*Approval, area, phase*
Methodologies		
Issue and Change methodology	*Prince2 "CEPDI" approach integrated with BIM-tool*	*Develop custom stepwise approach from issue identification to closure (issue life cycle workflow model)*
Impact assessment	- *MoSCoW technique for impact* - *Deadline for urgency*	*Risk score per performance target (time/costs/quality/etc.)*

8. Discussion

The given problem for this research was the absence of a standardized issue management strategy within Tauw. This resulted in project teams working in a very fragmented manner. In addition to that, the project evaluations showed the inconsistency in data registration and lack of documented agreements. The analysis indicated that Tauw can improve their issue management by registering all project related communication into 1 or 2 issue management tools, applying assessment methods, assigning an issue manager, and implementing a standard issue and change control template in the PSU.

Interpretation of results

This research did not aim to assess the quality of the issue management approaches adopted in the chosen design projects, but rather to uncover trends in Tauw as a company. The assessment table in the comparative study reveals the differences between the projects' approaches based on the criteria of the assessment framework. These findings were directly derived from observations in the project evaluations and did not include any subjective arguments regarding the adopted issue management approach. Therefore, this table might indicate the complexity and completeness of the projects' issue management approaches, but not the quality and efficiency. A simple issue management approach might be as efficient as a more comprehensive approach, depending on the project characteristics and team preferences. Though the goal was to standardise and improve the issue management approach within Tauw, therefore, the individual quality of the projects' issue management was not assessed.

The main results of this study are captured in the Issue and Change Control template. The implementation of this measure should be followed by the improvement of the issue management standard within Tauw. Despite the fact that in the development of the measures the context of Tauw was taken into account, the improvement depends on the willingness of Tauw employees to actively apply the template/plan throughout the project. This implementation requires change in habits of the employees and therefore needs active monitoring to achieve better results. The question in this regard remains whether the measures are too ambitious for the context of Tauw or not.

In the evaluation of the project 'Ring Groningen Zuid', it was discovered that Tauw was not part of the main contractor team and only aided by taking on various roles in the design process. Therefore, Tauw had no contribution to the comprehensive issue management strategy that was adopted for this project, contrary to the other projects. The project was still included in the study as Tauw often works on projects where they are not part of the main contractor team. However, the issue management approaches of these large-scale projects are not always as developed as the case was for Ring Groningen. When this is not the case, Tauw employees could introduce the Issue and Change Control template from this study to the contractor team to improve the issue management within the project. Ring Groningen exemplifies that a good documentation structure regarding issue management processes is crucial for efficient project wide issue management in large scale projects.

Implications

As an implicit part of the advice, Tauw is urged to identify a standard BIM-tool that will be used in design projects on a company scale. As discussed in the recommendations, this tool should be able to allow for flexible model related issue registration methods, given the current practice at Tauw. Selecting a standard BIM-tool is crucial for an efficient implementation process, as tools require time to get adjusted to. Frequent changes in tools (as is the current reality) will likely diminish the willingness to adapt to the new standard. Therefore, the Chapter 'Future research' includes the recommendation for a companywide survey among technical specialists to identify the preferred BIM-tool for Tauw.

In addition to this, the interviews unexpectedly revealed that designers frequently work in their own distinctive ways. Continuing work from another designer could potentially cause confusion regarding their working method or result in backtracking of the applied design approach. Consequently, information frequently gets lost in a transition between designers, for instance information in Emails or a details of a certain personal design approach. This problem is indirectly related to issue management, as confusion regarding working methods potentially results in issues. The implementation of a companywide guideline regarding the use of design software should result in a more uniform workflow among designers. This advice is also included in the implementation strategy of this research in the 'Future research'.

This research is valuable for Tauw as they can derive an advice including specific steps to improve the communication within design processes on a company-wide level. This will improve the information exchange within projects and around models, increasing efficiency in the design process and improving traceability of information. The implementation of the measures should provide a decrease in reworks and delays in the design process, ultimately resulting in less costs for Tauw. The recent pandemic has accelerated the digitalised communication process in design projects. This new way of working provides optimal circumstances for the implementation of the measures found in this study. In addition to that, the interviews revealed the enthusiasm for this new approach and deemed it necessary.

Not only is this study valuable Tauw, but it can also be used by other engineering- or architecture firms in the industry who want to improve their issue management approach. This research provides an example of how to identify company specific measures for the improvement of issue management, using an assessment framework developed based on issue management principles. This assessment framework can be used by other companies to uncover trends in their projects and to identify points of improvement based on their circumstances.

Limitations

This study is based on the evaluation of five Tauw design projects that represent the issue management standard within Tauw. Despite the choice of different types of design projects, the generalisability of this advice for all types of design projects within Tauw remains uncertain. It might be the case that some recommendations are not valid for certain design types or projects. This needs to be tested during the implementation phase, as suggested in the 'Future research' Chapter. Though, the measures resulting from this study can still be implemented on a company scale as it is certain that there is no defined standard approach to issue management.

It was beyond the scope of this study to include the limitations caused by clients or other contractors in the development of measures for improvement of issue management. In reality, Tauw is often limited by clients as they might prefer more traditional approaches, or by other contractors who, for example, do not have the required BIM-maturity. These limitations force Tauw to work outside of their preferred working methods, which partly justifies the distributed approach to issue management in Tauw. In those cases, still, the Issue and Change Control template can be completed and a pragmatic approach to issue management is possible whereby the client or contractor is not involved within the approach chosen by the Tauw project team.

9. Conclusion

The absence of a standard issue management strategy within Tauw caused very fragmented approaches among design projects. By comparing and analysing the issue management strategies of various design projects, this thesis aimed to identify points for improvement in the issue management strategy within Tauw.

Through literature review, two principles of efficient issue management were identified, being the Prince2- and BCF-perspective approach to issues and changes. These principles were used as foundation for the development of an assessment framework, consisting of 10 characteristics. The developed framework of issue management principles and the derived assessment framework can potentially also be valuable to many other engineering firms who want to improve their issue management.

Five representable design projects with different design characteristics were then evaluated based on the developed assessment framework. This evaluation was performed based on qualitative research methods such a documentation review and semi-structured interviews with project members. The assessment framework's criteria were then used to draft a table that provided an overview of the projects' issue management approaches. The analysis of the comparative table uncovered trends among the design projects by reviewing the characteristics and criteria. Key observations following this analysis included: the lack of awareness regarding the importance of explicit issue management, low priority for documentation of issue management related agreements/methodologies, inconsistent and incomplete issue registration, and distributed use of issue management tools.

These observations were then used as input for the development of measures for the improvement of the issue management standard within Tauw. In this process, the observations were compared to the developed issue management framework to identify effective approaches for improvement. In addition to that, the reality of Tauw was taken into account to avoid unrealistic advice. This resulted in the following measures for improvement for Tauw:

1. Centralising 1 or 2 (maximum) online issue management tools within a project, Relatics & BIM-tool, depending on project characteristics
2. Registering all 1-on-1 communication in central (online) environments for better traceability in the design process
3. In each project, assign a role to a team member that is actively involved in the design process and leads the process of managing, registering, escalating, and distributing issues
4. Prioritizing issues based on impact and urgency assessment methods
5. Creating an issue and change control plan at the start each design project

These measurements are specifically valuable to Tauw, as they are based on Tauw design projects. The key point for the improvement of issue management is the implementation of a standard Issue and Change Control plan at the start of each project. The implementation of this plan should help standardize the issue management approach within Tauw design projects, as it includes all recommendations for the improvement of issue management.

This study was aimed at the standardisation within Tauw, therefore, limitations caused by either clients or associated contractors are left out of the advice. In those cases, still, the Issue and Change Control template can be completed and a pragmatic approach to issue management is possible whereby the client or contractor is not involved within the approach chosen by the Tauw project team.

Future Research

The research revealed that Tauw's issue management strategy can be improved with the implementation of 5 measures. The implementation of these measures will take time as it requires changing people's habits. Therefore, it is important to plan ahead and progressively introduce the measures in the company. The suggested implementation strategy is divided into three quarters, followed by an evaluation process later in 2021. Each quarter includes action points that need to be executed or researched in that period. The strategy is advised as follows:

2020 Q3: Introducing

- Presentation of research results within Tauw
- Conduct internal survey on preferred BIM-tool for design process
- Define Issue and Change Control Template
- Define internal guidelines for using design software
- Write basic Issue and Change Control plan

2020 Q4: Validating

- Assess suitability of all project types for implementation of measures
- Define Tauw wide issue management tools and preferred method for linking BIM issues to the rest of the project team
- Pilot projects with implemented measures from research
- Management "ontwerpbureau" to validate plan, template and tools
- Include target in annual plan 2021 to from now on apply the Issue and Change Control template at each PSU

2021 Q1: Implementing

- Mandatory online training on the importance of issue management and implementation of the Issue and Change Control plan for everyone actively involved in the technical communication related to the design
- Instruct Relatics- and BIM360 (can also become another BIM-tool) support teams on the new 'standard' implementation of these tools

2021 Q3: Evaluating

- Conduct internal survey on implementation results of recommended measures
- Evaluate long term implementation results with project managers
- Process internal feedback within Issue and Change Control plan and issue management tools

10. Reference List

Arayici, Y., Egbu, C., & Coates, P. (2012). UILDING INFORMATION MODELLING (BIM) IMPLEMENTATION AND REMOTE CONSTRUCTION PROJECTS: ISSUES, CHALLENGES, AND CRITIQUES. *Journal of Information Technology in Construction* , 75-91.

Axelos. (n.d.). *Key benefits of Prince2*. Retrieved June 18, 2020, from Axelos: https://www.axelos.com/best-practice-solutions/prince2/key-benefits-of-prince2

Baoping, C. (2011). BIM and its effect on the project managers. *Proceedings of the 8th International Conference on Innovation & Management*, 825-827.

BibLus. (2019). *BIM maturity Levels: from stage 0 to stage 3*. Retrieved from BibLus: http://biblus.accasoftware.com/en/bim-maturity-levels-from-stage-0-to-stage-3/

BIMCollab. (2016, August 16). *werken met BCF manager en BIMCollab*. Retrieved from youtube: https://www.youtube.com/watch?v=b-wOnnXogrg

Boukara, A., & Naamane, A. (2015). A Brief Introduction to Building Information Modeling. *Journal of Renewable Energy and Sustainable Development* , 126-130.

Btoush, M., & Harun, A. (2017). Minimizing delays in the Jordanian construction industry by adopting BIM technology. *IOP Conf. Series: Materials Science and Engineering*.

BuildingSMART. (2020). *BCF open standard*. Retrieved from BuildingSMART: https://technical.buildingsmart.org/standards/bcf/

Chidiebere, E., & Ebhohimen, i. (2018). Impact of Rework on Building Project and Organisation Performance: A View of Construction Professionals in Nigeria. *International Journal of Sustainable Construction Engineering & Technology* , 29-44.

Deckers, P. (2019). *What is good issue management?* Retrieved from BIMcollab: https://www.bimcollab.com/en/Resources/Blog/Blog/what-is-good-bim-issue-management

Eck, E. v. (2019, March 1). *BIM level 2*. Retrieved from BIMAdvies: https://www.bimadvies.com/bim-level-2/

Eindhoven, G. (2020). *stapsgewijs naar een nieuwe vestdijk*. Retrieved from beleef de vestdijk: https://www.eindhoven.nl/projecten/beleef-de-vestdijk/stapsgewijs-naar-een-nieuwe-vestdijk

Hinde, D. (2012). Prince2 study guide. John Wiley & Sons.

Hogan, M. (2002). *Issue management.* Riga: Forest Communicators Network .

Hwang, B.-G., & Thomas, S. R. (2009). Measuring the Impact of Rework on Construction Cost Performance. *Journal of Construction Engineering and Management*, 187-198.

Invenis. (2018, November 19). *Six Aspects of Project Performance that PRINCE2 can Control*. Retrieved from Invenislearning: https://www.invensislearning.com/resources/prince2/six-aspects-of-project-performance-that-prince2-can-control

Kallio, H., Pietila, A., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review :. *Journal of Advanced Nursing*.

KUBUS. (2020). *What is good issue management*. Retrieved 2020, from BIMCOLLAB: https://www.bimcollab.com/en/Support/Support/Get-started/Start-your-first-project/What-is-good-issue-management

Litten, D. (2016, December 10). *prince2 issue management demystified*. Retrieved from prince2primer: https://www.prince2primer.com/wp-content/uploads/PRINCE2-Issue-Management-Demystified.pdf

Love, P. E., & Irani, Z. (2002). A project management quality cost information system. *Information & management*, 649-661.

Love, P. E., Morrison, J., & Teo, P. (2018). Revisiting Quality Failure Costs in Construction. *Journal of Construction Engineering and Management*, 2.

Management Plaza. (2018). *Change control approach.* Retrieved from mplaza.training: https://mplaza.training/templates/prince2/change-control-approach/

Mossalam, A. (2018). project's issue management. *Housing and Building National Research Center*, 400-407.

Nelson, R. (2014, July 15). *issues management*. Retrieved from nscstrategies: https://www.nscstrategies.com/issues_management/when-is-an-issues-management-strategy-needed/

Novotny, R. (2019, January 21). *The cost of rework in contruction and how to prevent it*. Retrieved from Esub: https://esub.com/the-costs-of-rework-and-how-to-prevent-them/#:~:text=Rework%20is%20the%20act%20of,prevalent%20on%20construction%20job%20sites.

Pijnenburg, E. (2018, June 8). *bim-integrated-issue-management*. Retrieved from bimcommunity: https://www.bimcommunity.com/news/load/855/bim-integrated-issue-management

PlanGrid, & FMI. (2018). *Construction Disconnected.* San Francisco: PlanGrid.

Treldal, N., Parsianfar, H., & Karlshoj, J. (2016). Using BCF as a mediator for task management in building design. *Proceedings of the International RILEM Conference Materials, Systems and Structures in Civil Engineering*, 48-59.

Turley, F. (n.d.). *Prince2.Wiki*. Retrieved March 24, 2020, from Change: https://prince2.wiki/theme/change/

van Berlo, L., & Krijnen, T. (2014). Using the BIM Collaboration Format in a server based workflow . *Procedia Environmental Sciences*, 325-332.

Willis, R. (2017, January 14). *Roles prince2 projects*. Retrieved from Yourprojectmanager: https://yourprojectmanager.com.au/roles-prince2-projects/

Appendix A: General interview setup

Average duration:1h 15min
Number of interviewees: 9
Location: MS teams
Language: Dutch
Interview setup: semi structured
Functions of interviewees: BIM-coordinator, contract manager, project manager, design leader, design coordinator, designer

Statements before interview:

- This interview will be recorded for documentation purposes only
- Summaries of the answers will be checked with the interviewee for confirmation
- The data that is extracted from the interview will be processed in the project evaluations
- No names will be used in the report
- Interview summaries will not be published

General questions occurring in interviews:

To what extent have the issue management tools been used?

How was the client involved in the design process?

How was documentation shared among team members and between contractors?

Was there a meeting structure set up? If so, why was this not documented?

How did the team manage setbacks?

Did issues often get lost during the design process?

What did the communication look like outside of issue management tools?

What agreements have been made concerning the cooperation strategy with other contractors?

How have these agreements been adhered throughout the project?

Could you keep up to date with the issues that were assigned to you?

Have issues been documented consistently by all project members throughout the design phase?

What caused the inconsistency in issue registration?

Can the Prince2 approach to issues and changes be identified within this project?

How have issues been assessed based on priority, impact, and urgency?

What did the process around changes look like?

Was there a role assigned that actively overlooked the issues?

Why was the issue management approach not described more explicitly?

Where could the issue management approach in this project be improved according to your experience?

Appendix B: Issue management principle workflows

The Prince2 approach to issues

The Prince2 approach to change within the projects' design process can best be explained by describing the 5 steps to issue and change management: Capture, Examine, Propose, Decide and Implement (CEPDI). An overview of this process is displayed in Figure 5.

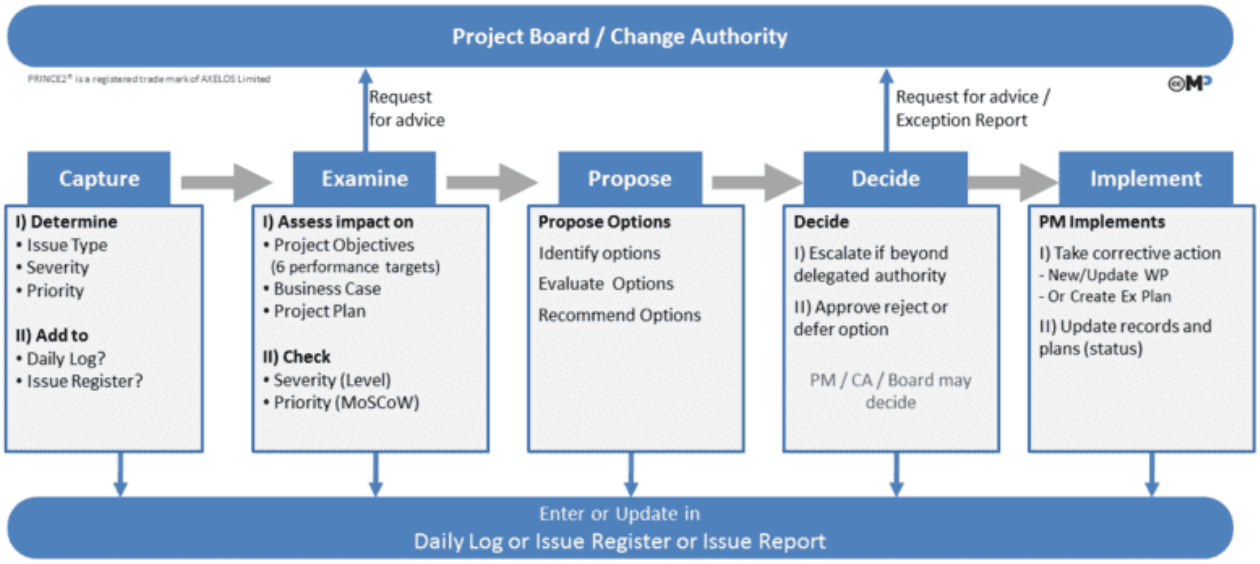

Figure 5: Overview of Prince2 Approach to Change (Turley, n.d.)

Step 1: Capture

There are three issue types that occur in the design process according to Litten (2016):
A **Request for Change (RFC)** project issue is when a project member wants to implement a change to a baselined product. A baselined product is a product that has been quality checked and signed off. Once a product is baselined, any change to it must go through the formal change control.
An **Off-Specification (Off-Spec)** project issue is when the product fails to meet its quality criteria and is not expected to fulfil them in the future. An 'off specification' can also be raised before the product is tested on the quality criteria and when the product exceeds its specification.
A **Problem/concern/opportunity** can be any comment regarding the project that the Project Manager needs to resolve, this could be either positive (opportunity) or negative (problem/concern).

Ideally, all project related issues are to be submitted in an **Issue Report** to the **Project manager (PM).** However, team members must be cautious when writing Issue Reports, submitting too many reports could overload the PM. One approach for this is having team members first consult a Senior Member before submitting an Issue Report. An Issue Report records the issue in full detail in a structured system, Figure 6 displays three examples of issues within an **Issue Register**.

Document: Issue Register | Project: Pen Project | Author: Project Manager | Date:

Data Date: Jul 19, 2013

ID	Description	Type	Date Raised	Raised By	Report Author	Priority	Severity	Status	Closure Date
01	Selected supplier sent the catalog three days later than expected	Problem/ concern	Jun 29, 2013	Rose Carr	Rose Carr	High	Level 2	Closed	Jul 1, 2013
02	Five evaluators did not return the forms in time	Problem/ concern	Jul 18, 2013	Rose Carr	Rose Carr	High	Level 2	Open (last updated Jun 30, 2013)	
03	Evaluation forms of four evaluators do not seem precise	Off-specification	Jul 18, 2013	Rose Carr	Rose Carr	High	Level 0	Open (last updated Jun 30, 2013)	

Figure 6: Issue Report examples (Turley, n.d.)

This example shows the concept of the Issue Report; however, some remarks must be made:

- The Report Author is normally the PM but can also be a Team Manager
- The Priority is determined by the MoSCoW technique, explained below
- The Severity is determined by a scale (e.g. 1-5), possibly linked to Project Roles, the higher the level, the higher the authority that will be involved in solving the issue
- The Priority and Severity ratings are not always certain in the initial Issue Report, the team members raising the issue often overrate them, this will be examined in step 2
- The Issue Report within the Issue Register can include information on the decision on the issue (e.g. recommendation, decision, approved by, decision date), this is not part of the initial Issue Report

Turley (n.d.) stated that the **MoSCoW technique** prioritises the issue based on four criteria:
Must have: The change is essential for the viability of the project and its absence would affect the project objectives.
Should have: The change is important, and its absence would weaken the Business Case. However, the project would still meet its objectives.
Could have: The change is useful, but its absence does not weaken the Business Case.
Won't have for now: The change is not essential or important, so it can wait.

The **Business Case** contains information about the reasoning behind the project, cost estimations, time scale, benefits and an overview of the risks. Based on the Issue Report, the PM will decide whether to handle to issue formally in the **Issue Register** or informally in the **Daily Log**. The Issue register is a control document, providing an overview of all the current issues shown. The Daily Log is used by the PM as a diary for all informal information.

Step 2: Examine

In this step, the PM seeks involvement where needed from team managers, team members, specialist contributors and possibly external parties such as suppliers. Litten (2016) warns for involving the **Project Assurance**, as this could potentially result in detracting from the impartiality. The PM then assesses the impact of the issue on:

- The 6 performance targets; costs, timescale, quality, scope, risks and benefits (Invenis, 2018)
- The wider environment
- The business-, user- or supplier's perspective on the project

Based on this examination, the Priority and Severity of the issue is checked and updated in the Issue Report and Issue Register if needed.

In this process, the **Project Board** can be requested for advice on RFC's or Off-Specifications. The Project Board consists of the **Executive**, **Senior User(s)** and **Senior Supplier(s**). However, the Executive owns the **Business Case** and has the final word on decisions. Therefore, the Project Board is not a democracy. If the Project board cannot handle the anticipated issues, they delegate them to a **Change Authority**. The Change authority can be a part of the board, a Project Manager, newly recruited people or a combination of these three. The Senior User is the representative that will be using the product. The Senior Supplier is the organisation or person that supplies the expertise required for the project to be successful (Willis, 2017).

Step 3: Propose

In this step, the PM proposes different approaches to deal with the issue. When necessary, the PM will consult the involved project members from step 2. First, the potential solutions will be identified with the knowledge of the various people involved. Then the PM will evaluate these options. After this, the Issue Report and Issue Register will be updated with the description of the **Recommendations** that followed from the evaluation. If one of these breaches the PM's authority, an **Exception Report** could be considered. An Exception Report describes the issue, specifies the options, and recommends one of the options.

Step 4: Decide

In this step a decision will be made regarding the approach that will be adopted to tackle the issue. If the PM has enough authority to deal with the issue, he/she chooses the preferred option from the Issue Report. Hinde (2012), describes that this authority includes the following circumstances:

- The PM has been allocated enough cost or time tolerance to tackle the problem or concern
- The PM has been allocated enough cost or time tolerance to correct the Off-Specification
- The PM has the Change Authority to authorize a particular request for change and the budget to fund it

If this is not the case, the PM will escalate the issue to the Project Board or relevant Change Authority by using an Exception Report. Figure 7 shows an overview of potential issue decisions. Once a decision has been made, the Issue Report and Issue Register are updated.

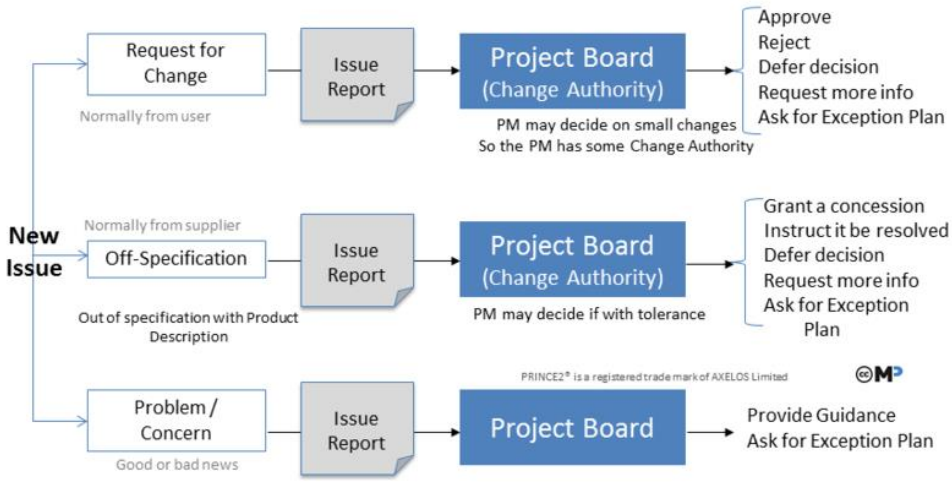

Figure 7: Issue overview (Turley, n.d.)

Step 5: Implement

The final step in the Issue and Change Control procedure is implementation. If the PM has the authority to implement the decision made in step 4, they can deal with the issue. The other option is creating an **Exception Plan** that needs to be approved by the Project Board before implementation. The PM then updates the Issue Report and Issue Register with details of the decision and informs any interested parties. Once the issue has been closed, both need to be updated one last time.

Change Control Approach Template

At the start of a project, the project manager should develop a document where the standards for the Issue and Change Control are defined, usually with a **Change Control Approach Template**. Turley (n.d.) argues that this document should provide clarity about the following questions:

- How are the products identified and controlled?
- How are Issues and Changes managed?
- What tools will be used to help track Issues and Product Information?
- What data is kept for each product?
- How often will the Project Manager consider Issue & Change Control?
- What will be the roles & responsibilities within the project?
- How are issues and changes prioritized? What scale will be used to prioritize issues?
- What scale will be used for severity of issues? Which authority will deal with what scale level?

However, this document is not limited to these definitions. Once the project manager defined the Issue and Control standards, the Project Board needs to approve it.

Issues Management from the BCF open standard perspective

This chapter explains a more technical approach to issue management in the design process. This approach centralises a communication hub where issues are added and stored by all the qualified project members.

BCF definition

The BIM Collaboration Format (BCF) standard is an open file format that introduces communication tracking. BCF allows different BIM applications to communicate issues related to the model. This communication is facilitated by a dedicated 3rd-party BCF server acting as the hub for such communications (BuildingSMART, 2020). BCF contains information about an issue (also called a topic in BCF) including status, type, assignee, any comments related to the task, and references to related objects. Van Berlo and Krijnen (2014), found that with growing BIM Maturity, designers and experts feel an increasing need to exchange more detailed information in context of the objects in the BIM. The addition of information like viewpoints and snapshots to the issue description helps the assignee to resolve the issue faster. The viewpoint- and snapshot features are implemented in the BCF file format.

BCF cloud-based

Cloud-Based BCF offers a more efficient methodology to structure the workflow for storing, sharing and managing issues in projects (Deckers, 2019). This is achieved through the implementation of an online centralized environment, where the issues are stored. This facilitates better collaboration, allowing multiple people to work on the design simultaneously. The BCF Cloud-Based method is now explained in three steps.

Step 1: Creating the centralized environment

The first step is creating an environment that will serve as an online hub for issues and communication around the design model. Nowadays, there multiple platforms available that provide this environment. For example: BIMCollab, BCFier, BIMTrack, BIMBox and BIM360. The BIMCollab Manager tab shown in Figure 8, illustrates the practical working of these types of environments. Once the project environment has been created, everyone who may be involved in the design process, must be provided access with their personal accounts. Once their name is in the system, they are allowed to add comments and issues on the model and receive assignments from other users.

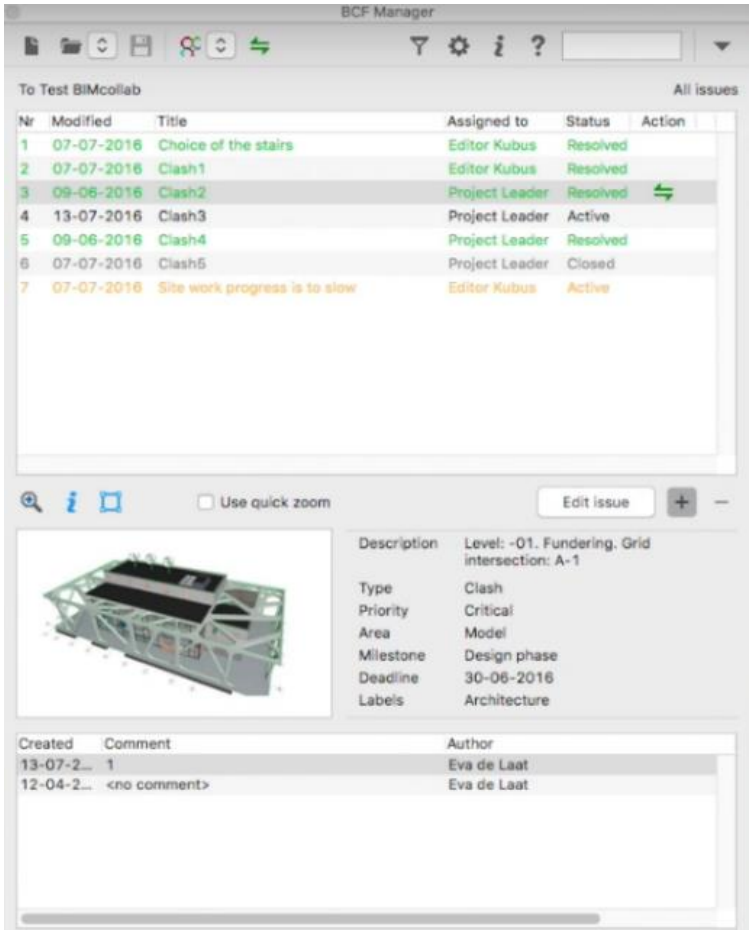

Figure 8: BCF Manager withing the software (BIMCollab, 2016)

Step 2: Detecting and uploading issues

Once the environment is set up, the users can start working on the model in their respective software, update it in the cloud, or add comments. Issues are easily detected with the clash software tool and added to the environment by creating comments regarding changes, concerns or opportunities. A word of warning here is that everyone who has access to the environment can add comments, potentially causing an overload of comments making it confusing for all project members. Agreements must be made regarding this potential problem. Once a project member encounters an issue, they can add it to the hub by filling in as many fields as possible in Figure 9 and upload it to the online environment. Then, a notification will be sent to the involved project members.

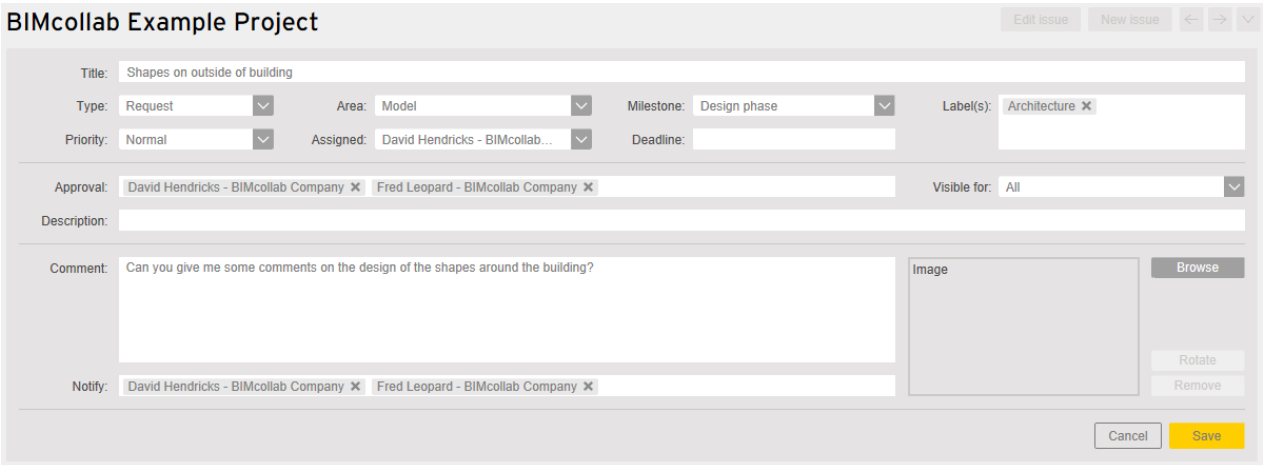

Figure 9: Issue in a BCF Manager (BIMCollab, 2016)

Step 3: Issue resolving

In the previous step, a project member or the client added an issue. In this step this issue is to be resolved by the person assigned in the issue report. This increases responsibility for everyone adding issues, to assign the right person for the job. When the assignee opens the BCF issue in their respective modelling software, which can vary depending on the discipline, they are directed to the exact same view in their model. When the issue is solved in the modelling software, the BCF Manager needs to be updated and this is communicated back to the project manager, who keeps track of the BIM Manager.

Benefits of Cloud-Based BCF

Deckers (2019) listed some of the major benefits that the BCF Cloud-Based methodology brings:

- All the communication about issues or requests for information is stored, making it possible to track all changes and comments and provide a full audit trail
- Accessible from anywhere and by multiple users at the same time
- Connects different software platforms of different disciplines for smoother communication
- Allows possibility to notify users when changes are made, and fixes are easily approved by project members, following the team's responsibility structure
- Creates legal trail, with single source of truth for individual accountability
- Every member can create issues and add comments, even non-BIM specialists
- BCF allows model mark-ups, clash detection software, and general comments between all project members. It also provides analytics on how many issues are generated each week and how long they are taking to be resolved
- The system allows the possibility of an integrated model viewer which optimises the design process by involving stakeholders who otherwise would not be able to access the data or the BIM model (Pijnenburg, 2018)

BCF Cloud-Based is an issue management approach that uses an environment where issues can be uploaded, assigned and resolved by all project members. Various tools exist for this and the BIM Manager illustrates how these environments can help the Project Manager keep track of the issues and provide analytics. The communication around issues is improved with viewpoints and snapshots that can be included in the Issue Report.

Appendix C: Project evaluations

Project 'Verbeteren 7 waterkerende kunstwerken'

Project introduction

The Dutch Water Act prescribes that flood defences must be tested and evaluated periodically, to check whether they meet the legal norms for water safety in the Netherlands. In the province of Noord-Holland, the *Hoogheemraadschap Hollands Noorderkwartier (HHNK)* found that from the 9 sluices (kunstwerken), 7 did not meet the requirements. After analysing, it was concluded that all 7 were not reliable on their closing mechanism. This project aims for obtaining safety and reliability of the sluices for the next 100 years. The total construction costs for this project amount to ~5M Euro. Tauw's contract value is approximately 2.5M Euro.

HHNK opted for one contractor for the whole project to include constructors' knowledge in the design phase, which became the combination Tauw-Friso civiel (TFC). TFC started this project in 2018 and are on schedule to finish in May 2022. The project is divided into 3 phases, 'Verkenningsfase', 'Plan-uitwerkfase' and the 'Realisatiefase'. In the first phase, Tauw developed alternatives for each lock an choose the preferred option (VKA). In the 'Plan-uitwerkfase', the goal was to model the chosen VKA's in such a way that they are permitted, executable and cost-effective project designs. In this phase, Lutjeboer aided Tauw on mechanical engineering, and another company for electrical engineering. During the 'Realisatiefase' these plans will be executed by Friso-Civiel. Tauw is in the lead in the first two phases and is responsible for the entire design process.

Documentation

For this project, access was granted to the SharePoint of the project (MS Teams) and the Relatics environment of Tauw. There was a clear structure for the storage and characterisation (name) of the documentation following the project work breakdown structure, as explained in the Project Management Plan (PMP). The issue management approach itself was scattered over various documents. The main documents in this evaluation were the PMP and BIM-uitvoeringsplan (BIM-UP). The PMP provided a clear description, scope and contract structure, meeting structures, cooperation strategies, rules, teambuilding, and expectations. It also introduced the tools that were going to be used in the project with brief descriptions of what they were used for. However, this left room for speculation on how to operate within the tools, for instance what happens after submitting an issue to BIM360. A result of this was the use of multiple tools for the same goal, for instance the Tweekly (later Monthly) and BIM360 for documenting issues. The project with a Project Start-Up (PSU) meeting and held two Project Follow-Up (PFU) meetings to discuss the cooperation within the project team.

Issue management approach and tools

The design process followed the Systems Engineering (SE) approach, including frequent verbal communication and cooperation days with the project team. In this process, Relatics was used for the specification of requirements, risks, *environment* issues, verification & validation and as input for design & engineering. Additionally, the Plan-Do-Check-Act (PDCA) methodology was implicitly used in the project workflow to effectively tackle problems in the project, this process was not explicitly documented.

The two main tools that were used regarding issue management were the Tweekly and BIM360. Tweekly is used for keeping track of project issues and potential deviations in the project, and as input for meetings with HHNK. This register is kept in Excel and issues are frequently updated, new Tweekly entries are marked in red. BIM360 is the environment used to keep track of issues and communication

around the design models. This tool was used by the technical team only and was a pilot for issue management. Most of the functions of the tool were used where possible, but due to the limited design scope and low number of interfaces between disciplines resulted in sporadic use of some functions. Because of this, the issue count remained low and no further assessment was necessary for ranking the issues throughout the second phase. Issues discussed in meetings were often submitted in BIM360 by the BIM-coordinator, other project members were less invested in the issues tab. As this was a pilot, it was not used consistently by everyone and was often replaced by traditional methods like Emails.

Project organisation, roles, changes

The project organisation was clear, with definitions of the roles within the projects, back-ups, and an escalation model. An important role in the issue management process was the BIM-coordinator, who was responsible for the process and quality regarding the 3D-models, and active use of BIM360 issue management in the meetings of the technical team. When issues were promoted to deviations in the Tweekly/monthly, an RFC was submitted by Tauw. This RFC is evaluated by HHNK and documented in Tauw's RFC register when honoured. A key point in this project was the frequent communication with the client, who were actively involved in the design process and provided feedback through quality tests.

Issue management workflow

For a more specific insight on how the project team managed issues in the project, the general issue life cycle model in Figure 10 is developed. The main tools for issue management are the Tweekly/Monthly and BIM360. The design log was left out as the intention was to use BIM360 for managing model related issues in this project. The figure shows a simplified version of the theory presented in Chapter 3. This is mainly due to the low number of issues as discussed in the evaluation, which resulted in less managing/coordinating work in the issue life cycle.

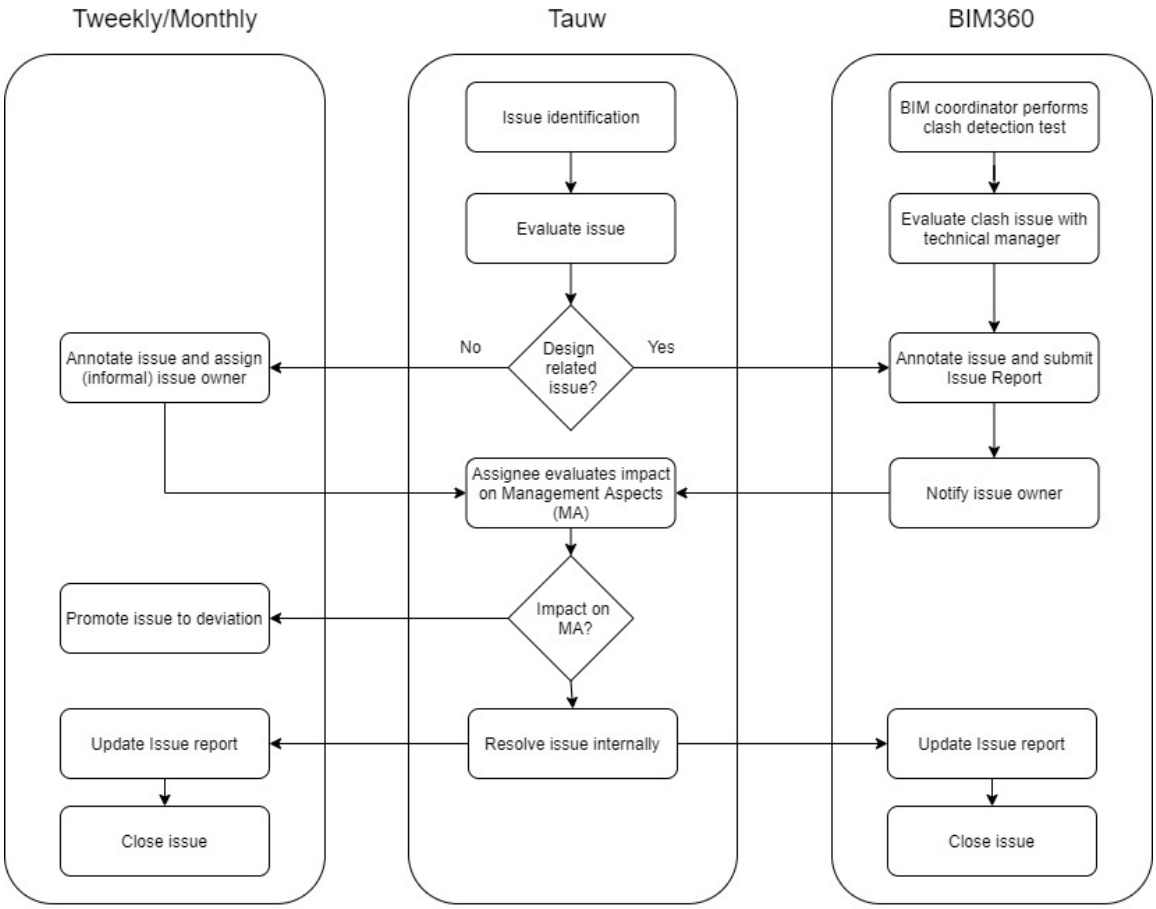

Figure 10: Issue life cycle V7WK

Project 'Ceintuurbaan'

Project introduction

A 90-year-old bridge on the Ceintuurbaan, Meppel, is at the end of its lifespan. The municipality of Meppel decided that a replacement of this bridge is necessary. The new design includes a vehicle bridge and a separate pedestrian bridge. The pedestrian bridge uses the old tram bridge abutments as foundation elements. The design must contribute to the 'blue' and 'green' future of the nearby 'Wandelbos' and 'Noorderpark' with environmentally friendly water banks and improved walking routes. The construction costs for this project are set on 800k Euro. Tauw's contract value was 45k Euro, though this project did not turn out profitable.

Tauw was won the tender to provide the preparation services for this project, the project started February 27th, 2019 and ended on March 12th, 2020. Due to discovery of an old pipeline underneath the bridge, an unexpected delay of 6 months occurred. This project was characterised by a tight budget and a huge shift in project members. The task for Tauw was to develop the implementation specifications for the new bridge and provide support throughout the tender phase. 3D-models were designed using Revit and Civil3D for the bridges and multiple alternatives for phasing in the construction process were developed. The municipality of Meppel is satisfied with the work Tauw delivered in this period.

Documentation

For this project, access was provided to the MS Teams environment of Tauw. It was agreed at the start of the project that this environment would be used throughout the project for project documentation. In interviews, it became apparent that this environment was not conventional when working with multiple designers in one folder. Therefore, designers shared their models in the traditional 'folder structure' method. There is no formal documentation that concerns issue management in this project besides the Plan of Action used in the tender. Though, MS Teams is frequently used for other project related files. Making official plans for issue management did not fit in the already tight budget of this project. As Tauw was the only contractor, all communication took place internally except for communication with the client. To communicate issues with the client, weekly meetings were planned followed by team meeting to update the team members.

Issue management approach and tools

The project started ambitiously by following the Proces Aanpak Ontwerp (PAO) workflow, defined in a ten-step-flowchart. This workflow is based on the SE-approach, starting with documenting requirements in Relatics and setting it up for various other functions like issues, V&V, risks etc. However, due to the project being on hold for 6 months, these ambitions did not continue after resumption. This was caused by time pressure, a shift in project members and a tight budget, resulting in a more practical approach where documenting did not have the priority. The main elements of the PAO workflow were followed but without the use of Relatics, affecting the traceability and the cooperative process. The requirements were never validated with the client, despite numerous tries.

Designers collectively kept a design log during the project, this included keeping track of design issues and their respective solutions. However, these issues were not saved related to the model, not categorised, and not ranked on priority, impact, or urgency. The team did not make any formal agreements regarding the use of the design log outside, of company guidelines. This caused inconsistency among designers in the use of this document. The design log was not the only source for issues and actions for designers, as personal action lists were made during meetings for convenience. Additionally, some actions and changes were also saved/stored in the Navisworks model. Practice showed that the issues were not actively kept and updated in a centralised location. This was caused

by the various issue management methods that were used in this project without formal agreements regarding how to use them. This made communication around the model confusing for designers and issue management less effective.

Project organisation, roles, changes

The organisation of this project changed due to the discovery of the pipeline. An important role in the issue management process was the role of the project manager. As this was a small project, the project manager took on the role of contract manager and technical manager as well. The project manager was the centrepiece in the communication with the client and team members. Issues from the client were discussed with the team via the project leader and vice versa. Therefore, RFC's were also communicated in meetings with the client's project manager and were documented in the RFC-register in Excel. The municipality of Meppel was passively involved in the design process. This involvement included providing input for the project, performing audits on the quality of the deliverables, and meeting weekly.

Issue management workflow

The evaluation above describes the issue management approach that was taken in this project. Due to some unforeseen circumstances, the ambitious start was not continued. This shows in the issue life cycle model displayed in Figure 11. The only issue management tool used in this process was the design log. The lack of formal agreements regarding this document resulted in a simple flowchart. Not all design issues were registered in the design log, as this was not consistently used by all the designers. Design issues were also frequently solved in 1-on-1 meetings with team members.

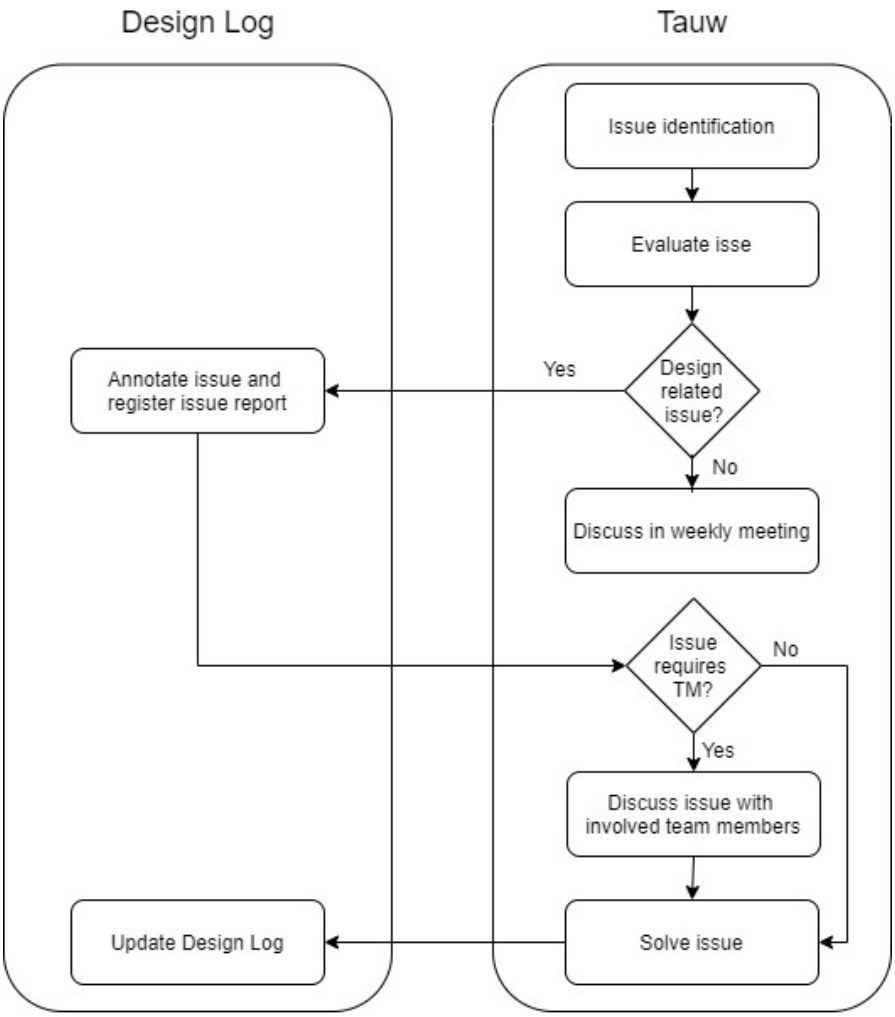

Figure 11: Issue life cycle Ceintuurbaan

Project 'Vestdijk'

Project introduction

Parts of the Vestdijk and adjacent streets do not meet the air quality requirements set by the European guidelines (Eindhoven, 2020). Additionally, an initiative from the municipality of Eindhoven includes the ambition to make the inner city more appealing, accessible, climate *resistant* for the future, and improve the quality of life in the city. This led to the project to reconstruct the Vestdijk. This reconstruction includes: more space for pedestrians, a two-way cycling lane, more green, climate proof materials, innovative lighting plan, single vehicle lane with separate bus lane, reduction to 30km/h, and water storing foundations for slower water discharge. These changes will be implemented in 6 phases, divided into smaller segments starting September 2018 and ending June 2020. The total project costs are ~17M Euro. Tauw's contract value is approximately 700k Euro.

For this project, the client (Municipality of Eindhoven) works alongside the contractor (Strabag) and the sub-contractors (Tauw, wUrck and Goudappel Coffeng) in a 'bouwteam' structure. As landscape architects, wUrck had the lead early in the project for the development of the 2 alternatives. After the board of directors of the municipality approved the definitive design, Tauw took the lead for the integrated design. Tauw focused on the project management, development of the technical definitive design (TDO), implementation design (UO), construction specifications, and advice on the sustainability and drainage aspects. Goudappel Coffeng advised on mobility, spatial and safety aspects.

Documentation

The bouwteam started ambitiously with an actively managed (offline) SharePoint. This SharePoint was left unused after the first design phase due to contractors working in their own 'quality-systems' and servers. Therefore, Tauw's project team shared files via the Tauw server. The plan van Aanpak (PvA) provided the most insight on the issue management approach, including visions on the assignment, cooperation, and design process. This document contained plans for a Project Start-Up (PSU), where agreements, responsibilities, information sharing, and the communication strategy for the project were discussed. Practice showed that the documentation of this meeting did not include agreements nor a meeting structure, however these were made verbally and adjusted when necessary. The bouwteam also implemented a Project Follow-Up (PFU) to evaluate the cooperation in phase 1 (design) and to make agreements for phase 2 (engineering). Due to a lack of concrete agreements on some aspects, a Tauw deliverable did not meet the requirements. An internal evaluation session was held resulting in clearer deadlines, a more streamlined escalation model, expansion of the design log, and more. This implementation improved the issue management and overall project workflow.

Issue management approach and tools

The design process followed the Systems-Engineering (SE) approach where possible, managed by the projects' SE-manager. However, some external factors hindered the full implementation, for instance the political interference or wUrck being in the lead in phase 1. In this approach, a broad participation plan was set up to increase community support. This caused more issues due to additional changes in the first phase but improved the overall project quality. The SE approach also included a significant amount of verbal communication, including a weekly cooperation day with the bouwteam. Action registers were kept for action points resulting from meetings, this resulted in various sources for actions. The Relatics environment used in this project was accessible to key members of the project team but was only actively used in the first design phase for requirements, risks, and V&V.

During the engineering (design) phase, Tauw designers actively kept a design log, documented in the Tauw drive. This log was kept in Excel and was consistently updated throughout the design phase. The issue report included owners, issue descriptions, solutions, urgency (3 levels), and status. Drawings

were periodically sent out to the bouwteam for validation/feedback, this communication went through PDF formats. In the drawing log, the comments on the PDF's were documented manually. Additionally, the BIMCollab tool was tested for 1 month within Tauw for better cooperation and issue reporting, replacing the design log. Here, the issues were directly related to the model and viewpoints were used in the issue reports. The only issue assessment method used in this test was issue categorisation, others were left out due to the small project size. The designer actively managed the issue register, while also using it as a personal action list. Though, this is not equal to the 'issue manager role' defined in the assessment framework, as there is only one active designer at time of use.

Project organisation, roles, changes

The organisational structure was set up clearly, as key members and roles were assigned for all project members. The most important role regarding issue management was the lead designer, who actively managed design issues. RFC's were communicated between Tauw and Strabag, after which Strabag communicated with the municipality of Eindhoven. Tauw only proceeded after approval. This communication went via Email and was documented in Excel RFC-forms. The client played an active role in the design process. This role included account of various disciplines in the design process, presence on the weekly cooperation day, validation meetings, decision-making and providing input.

Issue management workflow

Based on the evaluation of the project documentation and interviews with Tauw project members, the issue life cycle model in Figure 12 is developed. This model includes the design log and BIMCollab tools because these were the only tools actively used for logging design issues. Other issues were solved via Emails and meetings. The model shows a simplified version of the theory in Chapter 4 due to there being one (main) designer managing the issues and design documents, resulting in fewer issues.

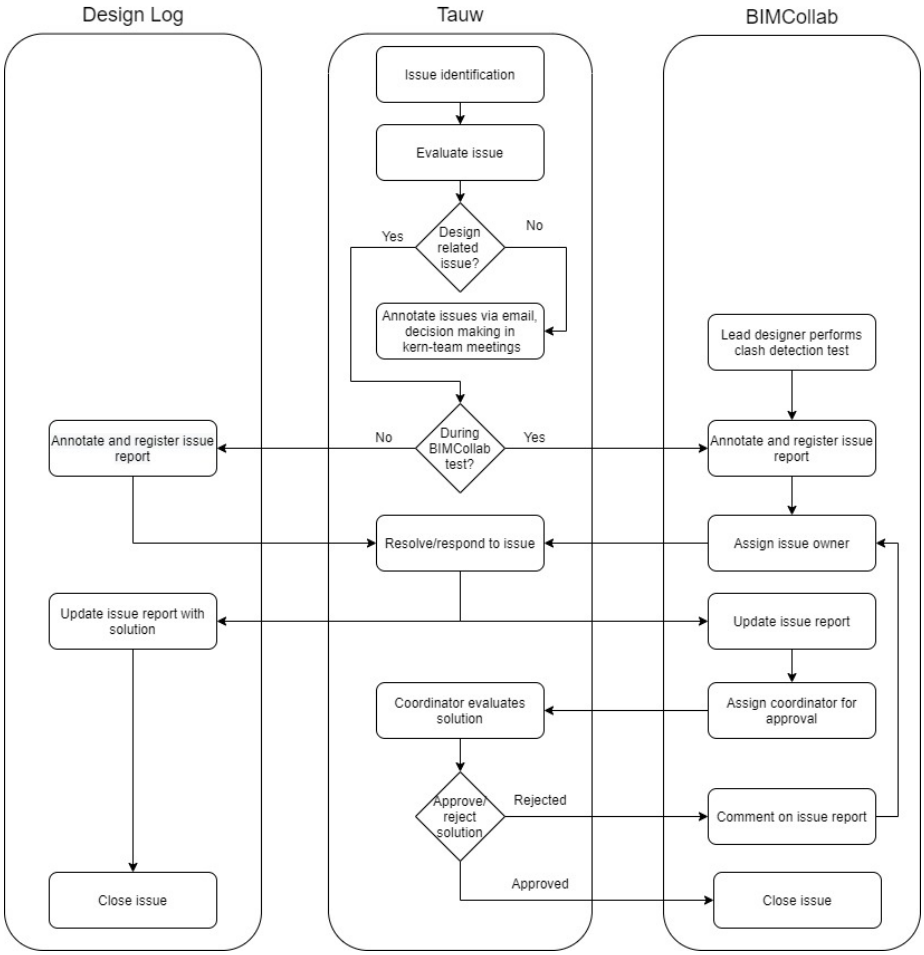

Figure 12: Issue life cycle Vestdijk

Project 'Ring Groningen'

Project introduction

Due to the growth of the city of Groningen, an increasing number of vehicles use the 'Zuidelijke Ringweg'. This causes congestions on the highway and even delays on other roads in the city. Consequently, the accessibility of offices, industrial areas and even certain neighbourhoods decreases. That is why the client organisation 'Aanpak Ring Zuid' (ARZ) wants to redesign 12km of this highway with the goals to make the city more accessible, improve the quality of life around the highway, and provide more safety on the highway. With these goals, the city aims to be future proof as they predict the traffic will only increase in the upcoming years. This plan consists of 9 major adjustments to the highway and the environment around it, including extra lanes, junction redesigns, more green, and more. The total project costs amount to approximately 600M Euro.

The client of this project is ARZ, a project organisation consisting of Rijkswaterstaat, the municipality-, and province of Groningen. In May 2016, Combinatie Herepoort (CHP) won the tender for this project. This team consists of 6 companies and has a complex contract structure with numerous sub-contractors involved. Tauw has multiple employees with different roles involved in various disciplines of this project. The project started in 2018 and is projected to be finished in 2024, the design must be ready in 2021. The project is divided into 8 phases, each representing a location on the highway.

Documentation

To make sure that the high number of companies involved in this project work uniformly, this project used a clear structure documented in processes, procedures, work instructions and standards. This 'project-wide' approach is divided into contract-, project-, technical- and support processes. These processes are described in clear workflows, divided into sub-processes. Each process refers to the procedures, work instructions and standards that are used in the workflow of that process. The project documents are centrally stored in the online environment 'ThinkProjects', where a clearly described document breakdown structure is followed to maintain a good overview of the documents. This environment is not accessible to sub-contractors, as they communicate files via email or WeTransfer. An important aspect of this project is the communication strategy that includes an extensive meeting structure, centrally defined with attendees, agenda, frequency, and roles within the meeting. Some meetings utilised the BIM-viewer in Navisworks to detect issues. The main documents defining issue management are the BIM-manual, modelling software manual and the contract management process. Practice showed that this documentation strategy results in a uniform workflow among contractors.

Issue management approach & tools

The design approach made use of phasing with rising level of detail in 4 deliverables/phases: 50%, 75%, 95%, 100%. The project is divided into 10 different design groups, each delivering a verification plan, design notes, object specifications and verification report. In the design process, iterations within the design teams are performed to improve the quality of the model and audits to check the quality before releases. This procedure is described in a 12-step system with 4 different levels of audits (internal, CHP, external and as-built). Audits are sent by email and include drawings in PDF formats. This method results in a high workload for the recipient, who registers all the comments manually in Relatics.

In this project, Relatics is used for registering objects, requirements, verification and validation, discipline interfaces, issues, and action lists from meetings. These functions are actively used within the whole project team and are set up in a structured manner with priority and urgency assessments. At the moment, the issues tab is manually updated with notes and comments from PDF-drawing audits. However, with the increasing implementation of BIMTrack, this time-consuming working method is slowly being replaced with performing audits within the BIM-model and adding comments

to the issue register. The issue register can then be exported to Relatics to assign issues to people without BIMTrack. Issues are registered in extensive issue reports that include all the main aspects with respect to the assessment framework in chapter 4. With this tool, communication within teams and between disciplines is structured and directly related to the modelling software that one uses, making use of viewpoints. Due to the complexity of the project, an interface management plan was implemented to make sure that all interfaces are registered in Relatics. Consequently, clash detection tests with the integrated model resulted in too many clashes to effectively manage because there is no formal BIM-coordinator who actively reviews the clashes. Smaller clash detection tests between 2 disciplines is now being tested.

Project organisation, roles, changes

Due to the size of the project and many different (sub-) contractors, a comprehensive organisation chart was made that showed the division of roles. Important roles regarding issue management are the design-coordinators who overlook the design process and make decisions, and discipline leaders who tackle issues within their discipline. In the future, a BIM-coordinator/issue manager role will be assigned, as this is still missing. The contract structure is very complex; therefore, a contract management plan was implemented that included registers for changes and costs. ARZ's role in the design process is passive and involves providing input, meetings, and auditing the DO and UO.

Issue management workflow

The issue management approach in this project is well developed, this shows in the issue life cycle model in Figure 13. In this project only 2 issue management tools are used for registering issues. In this process, priority and urgency issue assessment methods are used. The nature of the issue determines in which tool the issue is managed, unless exported to another platform. The situation displayed below is not the current situation project-wide, as BIMTrack is still being implemented. Once the audits will be performed in BIM consistently, the Relatics issue log will be parallel with BIMTrack issue log exports.

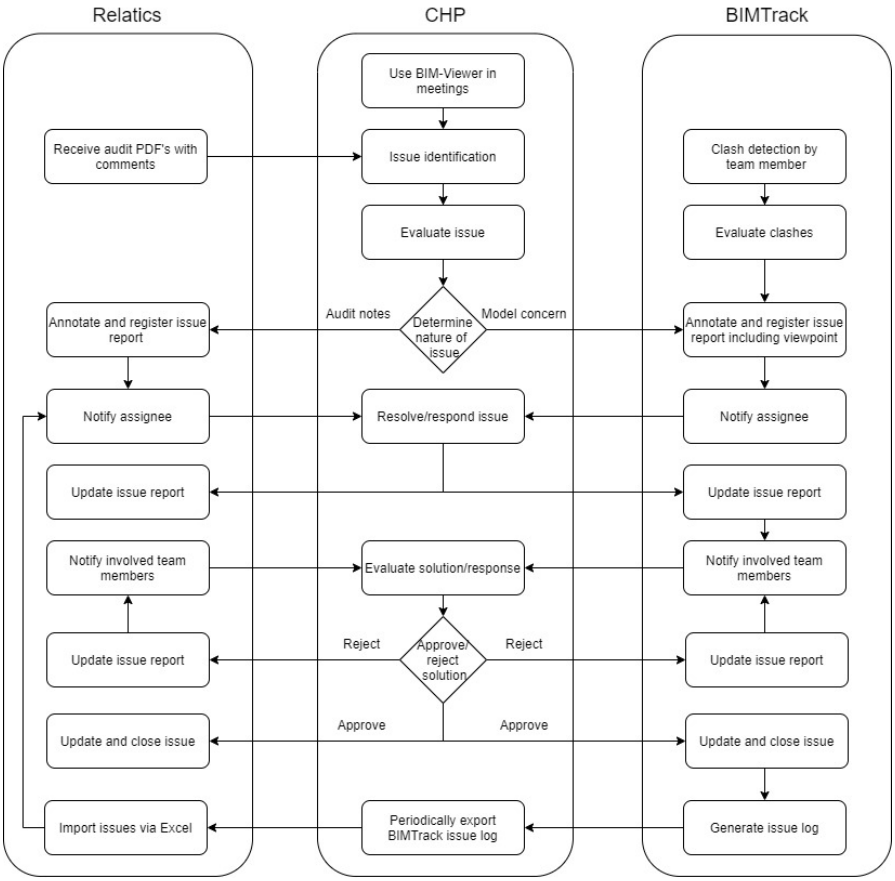

Figure 13: Issue life cycle Ring Groningen Zuid

Project 'RWZI Panheel/Stein'

Project introduction

Two Wastewater Treatment Plants (WTP) Panheel and Stein do not meet the current effluent-requirements and standards of the European Kaderrichtlijn Water (KRW). Therefore, the waterboard of Limburg (WBL) wants these WTP's renovated. In this project the two plants will be renovated according to the Verdygo-concept innovation. This concept is a revolutionary- and sustainable design that makes use of modular construction- and design techniques for WTP's. Compared to the traditional construction methods, where basins are entrenched in the ground, the Verdygo concept has tanks on the surface. These tanks consist of separate modules that are connected via the plug-and-play concept. Benefits of this innovation are easy replacements of modules, re-use of modules, scaling possibilities and low construction time compared to traditional methods. This project started in 2019 and finished in 2020, the construction is projected to ready by mid-2021. The total project is worth approximately 40M Euros, Tauw's contract value is about 1.3 million at the time of this research.

The project is divided into three parts, Panheel, Stein, and the Verdygo Modular development (PSM). The bouwteam consists of the client (WBL), Mobilis TBI, CWD (electrotechnical installations and automisation), RWB (mechanical design scope), Royal HaskoningDHV (Nereda technology) and Engie. Tauw is subcontractor of Mobilis (responsible for design and realisation Panheel) and is responsible for the civil technical parts of the VO's, DO's and UO's. Engie is responsible for the Engineering part of the UO and realisation of WTP Stein.

Documentation

This project utilises various structures for project documentation. The Tauw server is used for internal documentation and a SharePoint is used for bouwteam documentation, with access only for design- and project leaders. There are no official documents regarding issue management for this project or within Tauw. An internal PMP within Tauw was set up but never finalised due to the ongoing nature of the project and Tauw only being a part of the bouwteam. This preliminary PMP was consulted occasionally by members of the design team. Other plans originating from the bouwteam have never been implemented on project scale, as the design direction changed frequently. The lack of documentation was compensated with frequent internal and external meetings. This structure was not documented but verbally agreed upon; meeting notes, action lists and agendas were kept in the SharePoint or on the Tauw server (for internal design meetings). Besides the PSU, a cooperation seminar was held for setting working agreements, these were not documented. An intermediate evaluation session in the bouwteam was implemented to address process issues.

Issue management approach & tools

There is one central tool that is used within the bouwteam, this is the Relatics environment of Mobilis. In this tool, requirements, objects, interfaces, and V&V are managed. The already low number of requirements documented in this environment were also not SMART, this is because the client wanted to leave room for changes during the design process. This dynamic approach caused certain frustration among designers, as the design direction changed frequently. The client also deliberately chose not to use BIM in the design process, despite initiative from Tauw and Mobilis through a presentation.

Design issues were kept in an internal action register used only within the design team of Tauw. This action register was actively used for issues, actions, and choices throughout the design phase for both WTP Panheel and Stein. Each issue/action was clearly described, assigned to a team member, included a response where necessary, and showed the status. The status feature helped the team keep track of unsolved issues, using this register as a to-do list. This document was overlooked by the design leader, who also led the weekly design meeting. In the weekly design meetings, the issue register is discussed

and updated with the meeting notes. Tauw designed a 3D model, though audits were always on 2D drawings. Following audits, a lot of changes were still required, resulting in a complete re-do of the DO-delivery. This was discussed in the intermediate evaluation session.

Project organisation, roles, changes

The organisational structure of this project was rather complex, which made issue management more difficult to centralise. Important roles in the issue management process within Tauw are the project manager, who communicates issues with the bouwteam, and the design leader, who manages issues and actions within Tauw's design team. The dynamic approach, as explained in the segment above, can also be derived from the approach to changes. Between bouwteam companies, work is shifted frequently, without official contract changes (RFC's). Changes are discussed within Tauw with discipline- and design leaders and the project manager. The project manager then discusses these issues with the other project managers in the bouwteam. Every 2 weeks, Tauw sends an invoice with out to Mobilis, Mobilis sorts these changes out and forwards this to WBL. The client is actively involved in the bouwteam, as they have an integrated role in the design process and frequently change direction in the design.

Issue management workflow

The issue management workflow in this project can be characterised by a very simplistic and dynamic approach, as can be derived from Figure 14. Within Tauw, the only issue management tool that was used is the action register, this was used actively and functioned as a to-do list later in the project. This method worked well in combination with weekly team meetings. Even though the issue reports were very simplistic, the active issue management made sure this process went smoothly. Project issues were communicated with the Project Manager, who periodically discussed these with the bouwteam's project managers.

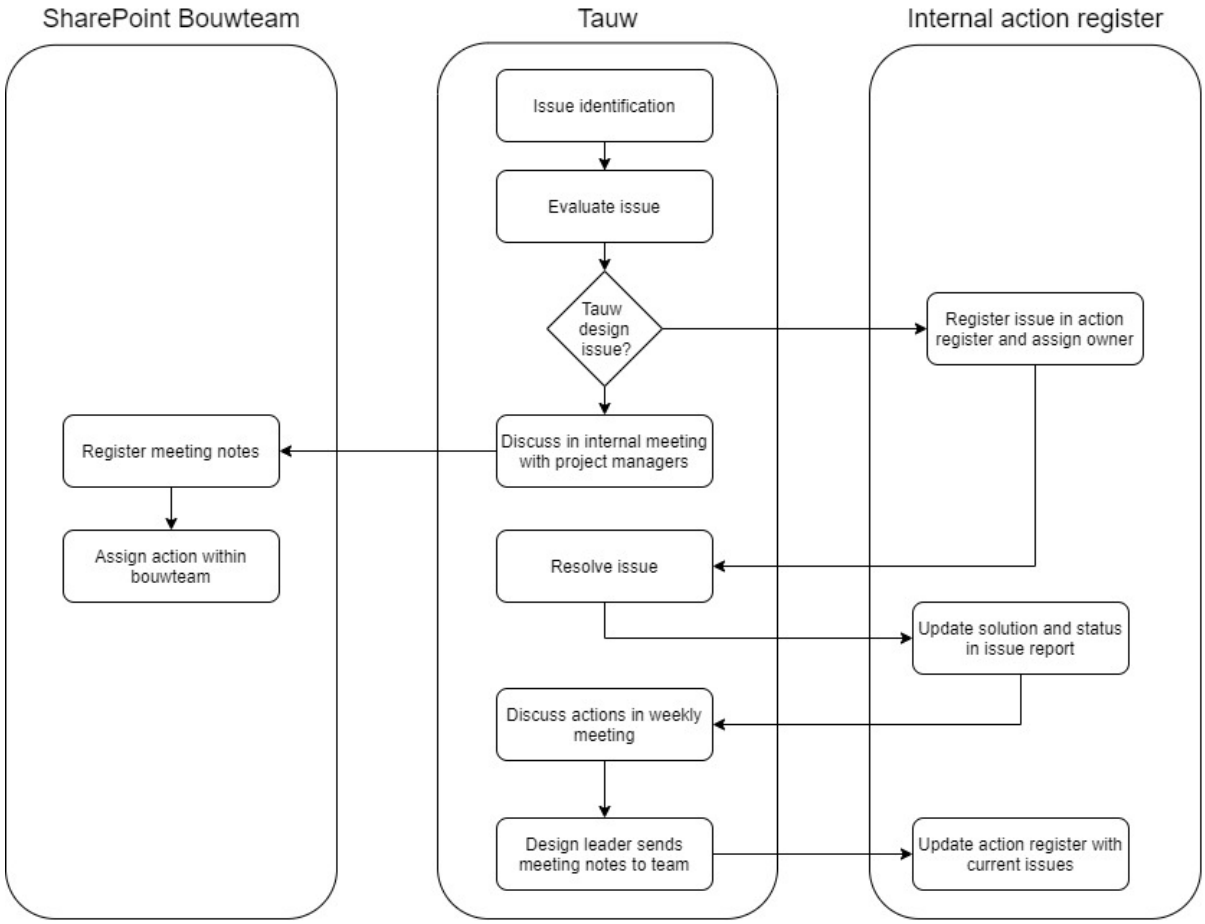

Figure 14: Issue life cycle Panheel/Stein