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Barriers regarding information-exchange required for the performance management of canal lock maintenance by RWS Oost

GRADUATION THESIS

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Bachelor thesis Industrial Engineering and Management

"Barriers regarding information-exchange for the performance management of canal-lock maintenance by Rijkswaterstaat-Oost"

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Preface

Dear reader,

You are about to read the bachelor thesis “Barriers regarding information-exchange for the performance management of canal-lock maintenance by Rijkswaterstaat-Oost”. This graduation research has been conducted at Rijkswaterstaat-Oost. The aim of this bachelor thesis is to clarify the current situation and challenges of information-exchange.

During my time at Rijkswaterstaat-Oost I have learned a lot about the functioning of an organisation. Everyone I met at Rijkswaterstaat was eager to help me or cooperate in my research, for which I am very grateful. Especially because this thesis was conducted during the Covid-19 lockdown and employees were working from home. The open attitude of everyone really helped me in my research.

A special thanks to my company supervisor Dinant Schippers for guiding me through my research. Dinant was always open to meet or help me whenever necessary. Together we went to the different steps of this research, Dinant always respecting my opinion. Due to the Covid-19 virus I was not able to come to the office, however Dinant was the link who made me feel part of the organisation.

A next person I owe my thanks to is Guido van Capelleveen, who enormously helped me setting up and designing the graduation thesis. Even though my assignment was not as straightforward as I expected from the beginning, Guido was always an optimistic force pushing me towards the end. I would also like to thank Ipek Seyran Topan and Lucas Meertens. Ipek for her guidance during module 11, being a listening ear whenever necessary. Lucas for being my second supervisor and his attention points at the end of my thesis.

Next I want to express my gratitude towards Roy Koers and Ruben Klaas. With the three of us we formed a team, keeping each other up-to-date of our bachelor theses. We feedbacked on written pieces and motivated each other to keep going. Roy also provided me with 2 playlists and a new music genre on which I wrote my whole thesis: “Hardstyle”. Without this music I doubt I would have finished in time!

Lastly, probably the most important person for me during this thesis, the person I could always turn to when I had a setback or a question: Laurens Kok. From the very beginning till the very last letter of this bachelor thesis, Laurens was always willing to answer questions that were on my mind, be a listening ear to my problems or feedback on a piece I wrote. Without Laurens I would not have been able to deliver this thesis to you.

Thank you for reading my bachelor thesis and feel free to reach out to me if you have any questions,

Maarten van Oosterom

Juli 2021

Management Summary

This research has been conducted a Rijkswaterstaat-Oost, which is a regional department of Rijkswaterstaat. Rijkswaterstaat is the executive agency of the ministry of infrastructure and water management, which means the company is responsible for the maintenance and construction of infrastructure in the Netherlands. The last year a project group at Rijkswaterstaat-Oost is trying to integrate performance management in the asset management-chain of canal-locks. However, during the project the problem arose that it was unclear which information were required between the different planning levels to actually implement performance management in a correct way. To research this problem the following research question is formulated:

"Which information-exchange is required to successfully align strategic ambitions for maintenance planning of canal-locks to tactical key performance management."

To understand the situation at Rijkswaterstaat-Oost better initial interviews with the employees of the asset management-chain are conducted. These initial interviews clarified how the asset management-chain of Rijkswaterstaat-Oost is structured and how the reorganisation from a few years ago has influenced the chain. The ramifications of the reorganisation are still being felt as documents like the NWSP and P-IHP are still being implemented. Besides the chain itself the interviews also revealed important concepts for the asset management-chain like the PDCA-Cycle and the different planning levels (Strategical, Tactical and Operational).

After the initial context analysis, a literature study was conducted to research similar literature and information flow categorization methods. As similar literature the BIM and LITE methods were discovered. Furthermore, multiple differentiation methods for information flows were identified, like static or Dynamic, structured or unstructured, targeted or actual and push or pull.

After identifying the differentiation methods for information, flows the flow of processes and information flows in the asset management-chain had to be visualised. To do this the BPMN method was used to create a BPM. The one big BPM of the whole process of the asset management-chain that resulted from this visualization initiative was too big and complicated to understand and interpret. Therefore, the decision was made to divide the asset management-chain into four sub-processes: "Vision Formulation", "Programming Creation", "Contract Composition" and "Contract Execution".

With the BPM model drawn the next step was to identify and analyse the important information flows. The information flows were identified and analysed on two levels. The first level was between the different sub-processes and the second level was between the departments within a sub-process. The analysis was done by drawing all possible information flows and using the conducted interviews to fill two tables, one with the current and one with the ideal information flows. By comparing the two the information flow problems of the asset management-chain were found.

Lots of improvement points were found in the asset management-chain of Rijkswaterstaat-Oost. In general, the information flows of Rijkswaterstaat are too infrequent and static. The next general barrier for the information flows is that they are often sender driven, instead of the receiver asking for them.

Besides these general remarks, more specific improvement points were found. These specific improvement points are the feedback information flow for the NOV department and the information flow from the OD to the Operational departments.

To conclude we can say that as required information-exchange all departments should receive feedback on their outgoing information flows, by at least one information flow. Furthermore, to align strategic ambitions to key performance management, frequent and dynamic information flows should be integrated into the asset management-chain. To make the chain as a whole dynamic and fluent. Next to all this the responsibility of the information flows should lie with the receiver, as in this way the information transferred is more likely to be correct and necessary.

The following recommendations were made towards Rijkswaterstaat-Oost:

- Create a structured information flow from the A-Am to the NOV department, to feedback on the goals set by the NOV department.
- Use the KPI information from the dashboard as a feedback loop for each department in the chain.
- Create a new information flow from the tactical to the operational layer to convey the strategical and tactical goals better to the operational layer.
- As a last recommendation a process of continuous improvement of the information flows should be set up. In this way the frequency and dynamicity of the information flow can be improved.

Table of Contents

Abbreviations

- A-AM = Adviseur-Assetmanagement. The A-AM is the person responsible for the tactical planning level of an object.
- Canal-lock = an infrastructure asset in the canals and rivers. A canal-lock is used to maintain water levels and transfer boats between these different water levels.
- Contractor: The contractor is responsible for doing the day-to-day preventive and corrective maintenance of a canal-lock.
- GPO = “Grote Projecten en Onderhoud” Big Project and Mainenance. This department is reponsible for the bigger mainenance, like renovations.
- KPI = Key Performance Indicator. An indicator, used on a dashboard, to show what the current state of the asset is.
- NOV = “Netwerkontwikkeling en Visie”. NOV as a department is responsible for the long-term, strategic, vision of Rijkswaterstaat.
- NWSP = Network Change plan. Document introduced to improve the cooperation between the strategic and tactical level of Rijkswaterstaat.
- OD = “Objectdeskundige”. The OD is the person within the asset management-chain with all the knowledge about the canal-lock. His or her job is to know everything about the current state, future maintenance and risks of an object.
- PDCA-Cycle = Plan,Do,Check,Act-Cycle. Part of the ISO 55001 which is a global standard for asset management. This theory is further explained in section 2.1)
- P-IHP = “Prestatie-InstandHoudingsPlan” Performance Conservation Plan. Document introduced to improve the cooperation between the tactical and operational level of Rijkswaterstaat.
- POF = “Project Opdracht Formulier” Project Order Form. A document made by the asset management-chain to request a contract to be made by PPO.
- PPO = “Programma’s, Projecten en Onderhoud”. PPO is the responsible department for outsourcing the necessary maintenance of locks. Outsourcing is done by constructing contracts when a POF came in.
- Prog: the programming department is responsible for the decision whether or not to plan maintenance requested by the A-AM.
- RAM = Regisseur Asset Manager. The RAM, who works in the SLU department, is responsible for constructing and gathering the information for the POF which is necessary for PPO to start working on a contract.
- Rijkswaterstaat-Oost = The Eastern regional department of Rijkswaterstaat.
- RUPS = Model with the actual Programming of the maintenance
- SAP = Model for the monetary side of the asset management-chain.
- SLU = “Samenwerking Landelijke Uitvoering. Link between PPO, GPO and Assetmanagement.
- Ultimo = Database for the executed maintenance, filled in by the contractor.
- VTW = “Verzoek tot Wijziging” Request for Change. A document to request a change in the current PC.

Reader's Guide

Chapter 1 consists of a general introduction to this bachelor thesis and the company at which it is conducted: Rijkswaterstaat-Oost.

Chapter 2 illustrates the relevant context of the thesis. The current situation at Rijkswaterstaat is further clarified and relevant concepts are explained. Both are necessary in later chapters to fully understand this graduation assignment.

Chapter 3 explains the relevant literature for this graduation research. Similar research projects and relevant methods for identifying information flows are described. The conclusion of this chapter gives a summary of the literature that is used within this bachelor thesis.

Chapter 4 shows the results of conducted interviews with the employees in the asset management-chain of Rijkswaterstaat. The interviews are used to create an overview of the processes and information flows present at Rijkswaterstaat-Oost.

Chapter 5 analyses the information flows present in the asset management-chain process. The method of analysis and the process of visualization are explained. The visualizations are then analysed and problems indicated.

Chapter 6 describes solutions for the problems found in Chapter 5. Next to the general solutions found, the performance management dashboard is covered together with the possibilities to solve some of the problems.

Chapter 7 evaluates the conducted research in this graduation thesis and determines its' value. Remarkable observations are outlined, limitations are identified and the generalization of this thesis is pointed out.

Chapter 8 consists of the conclusion of this graduation thesis. a small summary is given and the research questions answered. Recommendations and advice for Rijkswaterstaat are explained.

1 Introduction

In this first chapter a general introduction is given to this bachelor thesis, conducted at Rijkswaterstaat-Oost. In Section 1.1 a general description is given of Rijkswaterstaat and the regional department Rijkswaterstaat-Oost. In Section 1.2 the problem identification is described.

1.1 Company Description

In this first section of this bachelor thesis Rijkswaterstaat, the company at which the graduation assignment is located, is described and explained.

Rijkswaterstaat

Rijkswaterstaat is the executive agency of the ministry of infrastructure and water management and was officially established in 1798 (Rijkswaterstaat, n.d.-b). Rijkswaterstaat is responsible for the public infrastructure of the Netherlands, for example the maintenance and construction of roads, bridges, dikes and waterways. Being under the government means Rijkswaterstaat is funded through taxes and has a yearly budget of almost 2 billion euros. This results in a lot of responsibility towards and critic from the general public and media. To summarize the task, Rijkswaterstaat formulated a mission:

"Cooperating to promote safety, mobility and the quality of life in the Netherlands."
(Rijkswaterstaat, n.d.-a)

To fulfil this mission Rijkswaterstaat has lots of employees and different departments all with their own task. Figure 1 shows the departmental structure at Rijkswaterstaat.

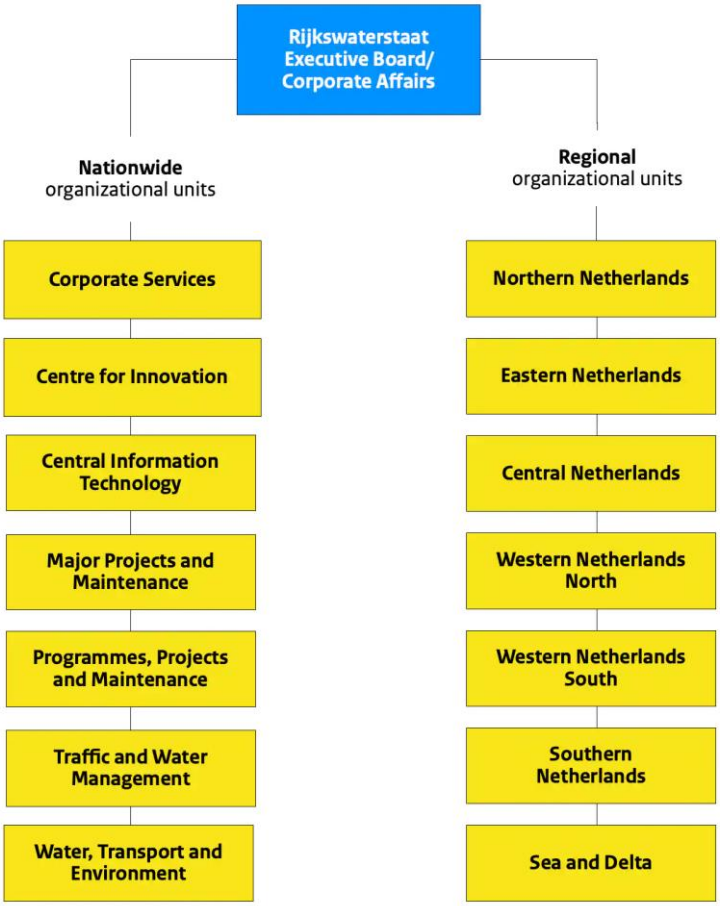

Figure 1: Department structure at Rijkswaterstaat (Rijkswaterstaat, n.d.-c)

Rijkswaterstaat-Oost

Rijkswaterstaat-Oost is a regional department of Rijkswaterstaat in the East of the Netherlands. It is responsible for the maintenance and construction of infrastructure in the East. The working atmosphere and structure of the organisation is quite different between regional departments, which makes Rijkswaterstaat-Oost almost its own organisation. To illustrate what Rijkswaterstsaat-Oost does some examples of projects:

- The expansion of the A1 between Deventer and Almelo
- The management of the Salland-Twente tunnel
- The maintenance of the Twentekanaal and the canal-locks in it, for example the ones at Hengelo and Delden

1.2 The Problem

In this Section the problem and problem identification approach are described. In Section 1.2.1 the action problem at the company is explained. In Section 1.2.2 the problems related to the action problem are described. Section 1.2.3 explains the core problem and motivation for choosing it as a core problem.

1.2.1 The Action Problem

For the identification of the action problem, core problem and problem cluster a substantial number of interviews have been conducted with employees in the asset management-chain of Rijkswaterstaat. Besides the identification part, these interviews also provided a better understanding and overview of the asset management process at Rijkswaterstaat.

Rijkswaterstaat is still experiencing some results of an internal reorganisation in 2015. These mainly include inefficiencies and ambiguities in the asset management chain. The main result, lack of overview over the asset management-chain and Rijkswaterstaat mainly busy putting out fires that continuously pop up. Rijkswaterstaat is therefore stuck fixing unexpected problems in the short-term and lacks the ability to focus and prepare for the long-term. A movement to create more long-term vision and therefore being able to predict problems is already being created, but is running into a lot of difficulties which will be discussed later on in this project proposal. The action problem of this bachelor assignment sums up this situation:

“The Asset Management Chain of Rijkswaterstaat-Oost functions short-term without an overview, the goal is to function long-term with a performance dashboard as steer on the chain.”

The current situation is one with short-term vision and no clear overview. This means that problems are popping up unexpectedly for Rijkswaterstaat and the maintenance process is corrective, which leads to unexpected unavailability of the canal-locks. This is a problem because corrective maintenance costs more money than when maintenance is preventive, both for Rijkswaterstaat and the users of the Twentekanaal.

The desired situation is the one with long-term vision and a performance dashboard as a steer on the chain. In this situation most of the maintenance is preventive, before the actual problems come up. The problems that do occur are taken into account in a risk analysis and therefore expected. In this situation the unavailability of canal-locks is planned, which means maintenance can be planned to minimize hindrance for ships.

1.2.2 Problem Identification

Figure 2 shows the problem cluster, which contains the identified reasons for the action problem. This problem cluster has been created to show in a clear and structured fashion how different problems present at Rijkswaterstaat-Oost relate to one another. The problems that cause the action problem have again been found and linked in interviews with employees throughout the asset management-chain.

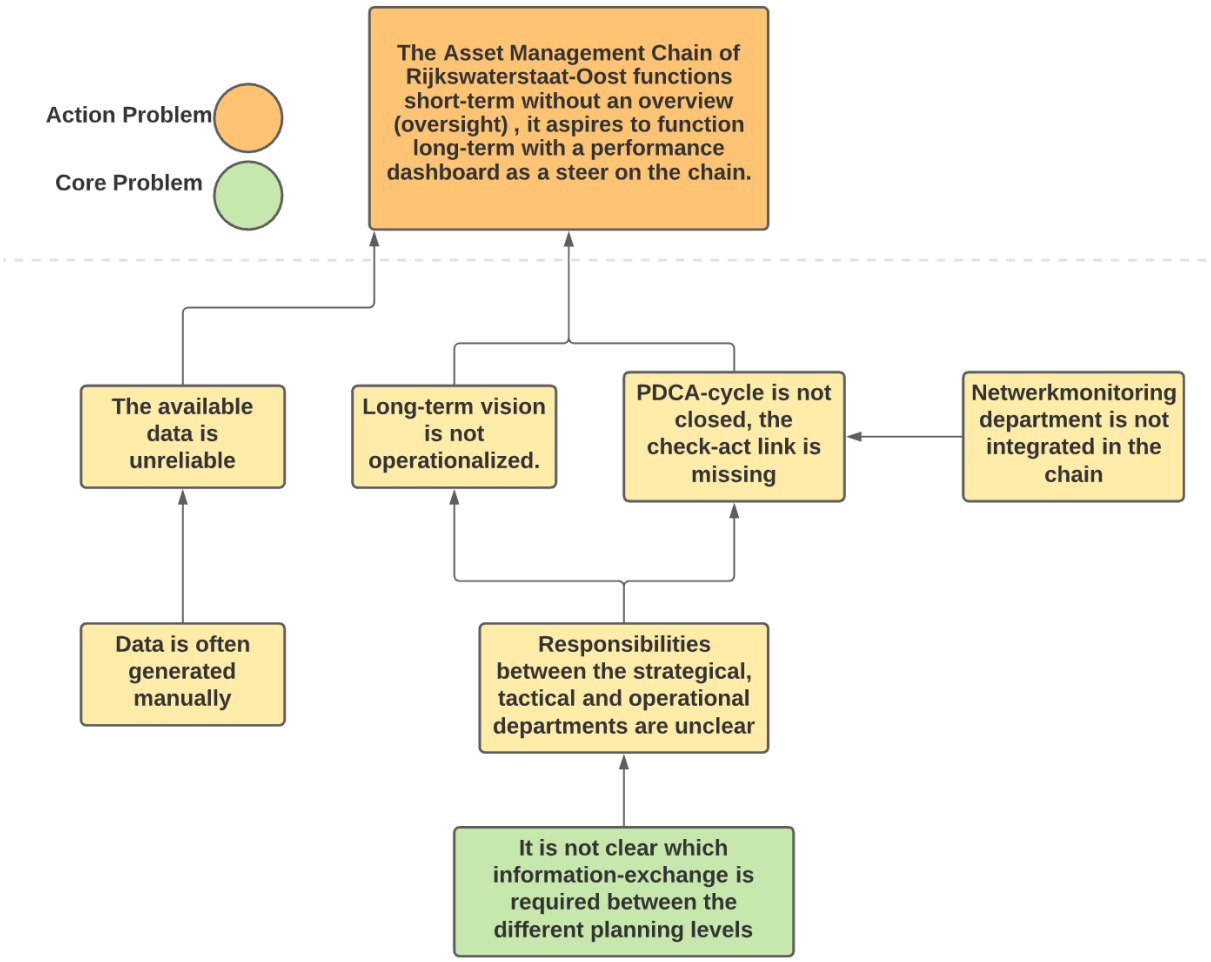

Figure 2: Problem Cluster

The first problem many of the employees came up with, was the fact that the available data was unreliable. There was data to base decisions upon, but the data was not trustworthy or incomplete. The main reason for the unreliable data is the fact that a lot of the data is still generated by hand, which leads to inconsistencies because operators see things differently or the mood of the operator can be different day to day. To solve this problem Rijkswaterstaat already has some initiatives in place. For example, there is an initiative to make sure the maintenance data is more up-to-date.

A second problem that came up is the fact that the long-term vision is not operationalized. NOV (the strategic department) sets new goals for the asset management chain, but for the other departments these goals in itself are useless. The translation between the chain-wide goals and what these goals mean for the reality of the canal-lock is absent. This means that it is unclear for tactical and operational departments what measures they should take to reach the goals.

A last cause for the action problem is that the PDCA-Cycle (see 2.1) in the Asset-Management chain does not connect. The chain goes through the plan-do stages but misses the Check-Act steps. This

has multiple reasons, the first is the fact that responsibilities are vague and non-defined. Most of the departments do not know how and from whom they could or should get a check-act on their assumptions. The vague responsibilities mean that the operational layer does not know and see it as a responsibility to feedback on assumptions or even which assumptions are made. The second reason for disconnected PDCA-cycles is the fact that the check that is made, by the Networkmonitoring department, is not integrated in the chain. Which results in the fact that their check is not used. This is a problem in company structure.

1.2.3 Core Problem

In this section the core problem will be explained. A core problem is (Heerkens & van Winden, 2017): "the most important problem in the problem cluster." They also mention: "Core problems are those whose solution will make a real difference." According to Heerkens & van Winden there are four steps to identify core problems:

- "Making an inventory of existing problems;
- Indicating the causes and effects, and use them in a problem cluster;
- Choosing which core-problem to deal with; and
- Making your problem quantifiable."

The first two steps have already been finished, the last two steps will be taken in this section.

There are different problems without a cause that are potential core problems. The potential core problems are: the fact that data is often manually entered, the Networkmonitoring department is not integrated into the chain and the unclear required information exchange between departments on a different planning level.

The first potential core problem about data that is often entered manually cannot be the core problem of this bachelor assignment. Within Rijkswaterstaat multiple initiatives are busy improving the generated data. ODS (Object Data Services) systems are being set up on canal-locks and there is an initiative for quality data entry for executed maintenance. These initiatives are covering most of the generated data and the effects of them should be investigated before further initiatives or solutions are developed.

The second potential core problem, the non-integrated Networkmonitoring department is not a good core problem. The reason for this is the fact that things are just settling down after the reorganisation, changing up the asset management-chain another time could make the chain even more complicated. A second reason is the fact that integrating Networkmonitoring does not really solve all problems, Networkmonitoring does solve a piece of the PDCA-cycle predicament. However, Networkmonitoring is doing a check on a strategic level, which makes the check less useful and interesting for departments working on another planning level. Solving this problem will therefore bring a relatively big risk for a small reward.

The last potential core problem is the actual core problem that is suitable for this bachelor assignment. The core problem is:

"It is not clear which information-exchange is required between the different planning levels"

The core problem is the ultimate cause of the last 2 problems discussed in the explanation of the problem cluster (figure 2). It is the reason responsibilities between departments on different

planning levels are unclear, which results in an asset management-chain busy putting out fires without a closed PDCA-cycle and a non-operationalised vision.

Measurement and Norm

Measuring the core problem is a challenge because there is no straightforward value available that can be measured by a sensor. The measurement value that is used to track the effectiveness of this bachelor assignment and the progress of the core problem is the percentage of aligning KPI information in the NWSP and P-IHP (for explanation of what the NWSP and P-IHP are go to 2.1). KPI information is the information in the asset management-chain that relates to one of the KPIs on the performance dashboard.

The current situation is still unknown but is likely to be very low, because the KPIs are not in use and the documents are in use for half a year now. The norm will be that 80% of the information in the NWSP and P-IHP allign, to allow for some growth room and be realistic in expectations.

1.3 Research Design

In this Section the research design, the method to eventually come to a solution, is explained. In Section 1.3.1 the research questions which need to be answered are described. In Section 1.3.2 the restrictions on the scope of this bachelor assignment are written. In Section 1.3.3 the deliverables and therefore the ultimate goal of this bachelor thesis are given.

1.3.1 Research Questions

To make sure this graduation assignment will deliver a correct and useable solution at the end a research question and sub-questions are set-up in phase 2 of the MPSM. These knowledge questions will be solved as a part of phase 3 of the MPSM.

The main research question, the knowledge question that has to be answered in order to solve the core problem, is:

“Which information-exchange is required to successfully align strategic ambitions for maintenance planning of canal-locks to tactical key performance management.”

In order to successfully solve this main research question, smaller questions first need to be asked and answered. The sub-questions are:

1. Which data structures are eligible for registering and exchanging asset information?

To properly make a flow chart we first need to determine how to typologize information flows. The theoretical foundations will be researched in this first knowledge question by doing another systematic literature review. This research question will be answered by having a list of possible data structures for information flows and different methods of identifying the types of information flow.

2. Which data is registered and how does it flow between the “Netwerkontwikkeling en Visie” (NOV) department (strategic level) and the “Asset Management” (AM) department (tactical level) and which information is missing in these flows?

The expectation is that answering this question will be quite a big process, which is the reason that in the first instance we are just talking about the NOV and AM departments. If answering this knowledge question for these departments turns out to be very easy, the scope can easily be broadened to other departments. Broadening the scope is something the company is interested in, because it provides a better overview of the information flows in the whole chain. The end result of this sub-question is an overview of:

- The different processes and important persons linked to each process.
- The information needs of that process.
- The information each process provides or can provide.
- The data structures to providing or receiving information.
- The frequency to which each information flow occurs.
- The reason for each information flow.

The overview will probably exist out of a flow chart of how in an ideal world, according to the stakeholders, the information and process flows should flow.

Next to this flow chart, two tables will be created with overviews of the ideal and actual state of the information flows. Both these overviews will be constructed by conducting interviews with relevant stakeholders. The reason for these interviews is the fact that the employees have a way better understanding of the current situation, know which problems occur on a daily basis and which information is missing.

3. Which information-exchange is required regarding the KPIs for accurate performance measurement of the constructed Performance Dashboard?

This sub-question is for now optional, which means that it will only be answered if the remaining time allows it to be. Answering this optional sub-question will make sure this gradation assignment fully connects with the performance dashboard the project group at Rijkswaterstaat-Oost is now creating. For the company this sub-question will add an enormous amount of extra value to the graduation assignment. This sub-question will help with the implementation plan of the performance dashboard.

This third sub-question will be answered by mapping the KPI information on the constructed flow-charts. The expectation is that the interviews of sub-question 2 deliver enough information, but if the information available is insufficient extra interviews will be conducted. These extra interviews will be done with a small number of participants and targeted to people who probably know a lot about the targeted KPI information. In the end this sub-question will deliver the sub-question 2 flow-chart with the extra KPI information mapped into it.

1.3.2 Restrictions

Some restrictions for the scope of this research have been set up to act as guidelines when conducting this graduation assignment. The restrictions are the following:

- The first restriction is that this graduation assignment will only take into account Rijkswaterstaat-Oost. Comparable asset management-chains are also present in the other regional districts, however each chain has its own specifics. Taking into account the whole of Rijkswaterstaat would result in way to much work for these 10 weeks.
- A second restriction is the fact that only the asset management-chain of canal-locks is taken into account. Rijkswaterstaat-Oost is responsible for all government infrastructure in the east of the Netherlands, but for this graduation thesis only the canal-locks are relevant. This is again to restrict the scope and make the research feasible in 10 weeks. The restricted scope also creates the room to dive deeper into the specific topic: the asset management-chain of canal-locks.
- A third restriction is the fact that only information flows about the canal-locks are deemed relevant. This restraint will make sure that my graduation thesis will stay on topic and not lose in useability by analysing to much information. This restriction will also increase the clarity for the employees of Rijkswaterstaat.

- A last restriction is the fact that the solutions at the end of this thesis should be useable and relevant for Rijkswaterstaat for the foreseeable future. This restriction will make sure that the solutions can actually have a positive impact at Rijkswaterstaat and this research has not been done in vain.

1.3.3 Deliverables

To solve the core problem and research question we will create a few things for the company, in this small section will be explained what is made and why.

The first object created is a flow-chart with how the process and information flows should ideally flow, according to the stakeholders. This will be created by answering the second sub-question and conducting the interviews. A flow-chart with processes will be created to have a picture in which information flows can be indicated. There are already some different process charts in the company but none is within the scope of this research. Therefore new flow-charts will need to be created, but the accessible flow-charts can be used as a starting point.

A second object created are tables with the ideal and actual state of information flows. These tables will give an image of the ideal information flows between processes. By extracting information out of this flow chart it will be clear for every employee in the asset management-chain which information they should provide to who and from who they should expect certain information.

The last object created is an implementation and evaluation plan for improvement of the asset management-chain of Rijkswaterstaat-Oost. In this plan is an advice written about how Rijkswaterstaat-Oost can integrate the solutions of this bachelor assignment in a correct and effective manner. Next to this integration advise there is also an evaluation part about how the actual effectiveness of the solutions can be measured.

2. Context Analysis

In this Chapter the relevant context to the thesis is illustrated. In Section 2.1 the current situation at Rijkswaterstaat is further clarification given upon Section 1.1. In Section 2.2 relevant concepts are explained, necessary to fully understand this graduation assignment.

2.1 Current Situation

In this Section the current situation at Rijkswaterstaat is further explained. The current situation is further explained to give more context about the situation at Rijkswaterstaat in which this graduation assignment was conducted.

Asset management of the locks

Being the eastern-regional department of Rijkswaterstaat, Rijkswaterstaat-Oost is responsible for all the infrastructure maintenance and construction in the east of the Netherlands. To fulfil this task, Rijkswaterstaat-Oost is divided up in different departments to such an extent that everyone contributes a specific part. Generally, Rijkswaterstaat-Oost is divided into 3 different types of departments: Network development, Networkmanagement and business operations. Each of these 3 types has different departments responsible for its own specific type of infrastructure or supportive function. This bachelor assignment will take place in the asset management chain of canal-locks.

Canal-locks are an important part of the waterways in the Netherlands and have 2 functions. The first function is lockage of commercial and leisure ships. The second function is maintaining water levels. A lock makes sure certain water levels can be maintained, especially important during dry summer times, to have enough water for farms and maintain the water quality. To make sure canal-locks can perform these functions now and in the future, maintenance has to be performed. For this maintenance Rijkswaterstaat-Oost has an asset management-chain, with a lot of departments and personnel al performing a task in the chain. The chain is generally divided up in the three levels of planning (strategic, tactical and operational), however in practice these levels of planning commonly overlap one another.

Reorganization

For Rijkswaterstaat the past years have been dominated by the ramifications of a huge reorganisation in 2015. The whole asset management-chain was reorganized, some people were let go and a lot of new people have been hired since. Aside from reforming the departments and their structure, the reorganisation also introduced two new documents, the P-IHP and NWSP. These documents have the purpose of making the asset management process more structured. All these changes were decided by management without consulting employees who are actually inside the asset management-chain. This meant that a lot of struggles and problems have come up in the asset management-chain of Rijkswaterstaat and the reorganisation is only now settling down.

NWSP and P-IHP

The NWSP and P-IHP are two documents that are filled with necessary information for departments on different planning levels. The documents have been introduced by the reorganisation a few years back. The documents connect departments and planning levels.

The NWSP (NetWerkSchakelPlan in Dutch) can be translated to network-link-plan. The NWSP is meant to connect the strategic departments with the tactical departments. It is an output of the strategic departments with a plan, goals and requirements for an asset the coming 5 to 10 years.

The P-IHP (Prestatie-InstandHoudingsPlan) can be translated to: Performance-ConservationPlan. This document has been invented to make the asset management-chain more proactive. The proactivity comes from having the P-IHP as an interactive document filled with planned maintenance and improvements of a certain asset, all aimed to make sure the asset can fulfil its tasks and performance requirements.

These documents will be used in this bachelor assignment to measure the core problem. The variable of the core problem will be the percentage of aligning KPI-information in the two documents, in this way we measure the amount of information that correctly flows through the asset management-chain.

2.2 Important Concepts

In this Section important concepts for the asset management-chain of Rijkswaterstaat are explained. These concepts are widely accepted throughout the chain, however difficulties were encountered whilst implementing the concepts in each department.

PDCA-cycle

The asset management-chain of Rijkswaterstaat-Oost wants to work according to the latest ISO-55000 standard. ISO is the International Organisation for Standardisation, the ISO-55000 is a standard for asset management. Rijkswaterstaat-Oost itself is not ISO-certified, but they require the contractor to be ISO-certified. Rijkswaterstaat-Oost wants to implement ISO-ideas like the Plan, Do, Check, Act-cycle (PDCA-cycle) in the asset management-chain, but has so far ran into a lot of trouble doing so. Figure 3 shows an image with a visual explanation of the PDCA-cycle.

The main focus point from the ISO-55000 for Rijkswaterstaat-Oost is the PDCA-cycle, which is a 4-step method to manage the change-process of a product or process. The 4 steps are: Plan, Do, Check and Act. The idea is to make sure there is a reflection to changes made or actions taken and to use the reflection as a new input for the next action or change made.

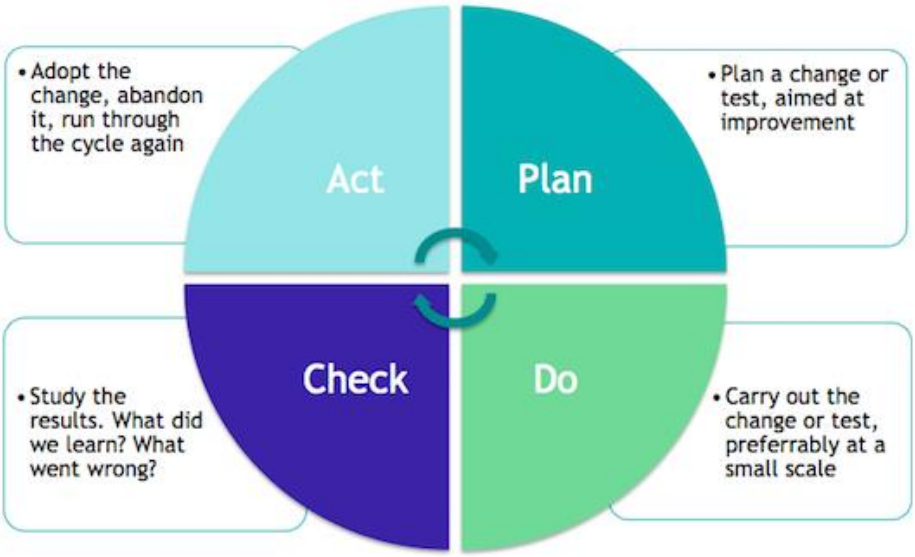

Figure 3:PDCA-cycle (van Otterloo, 2017)

Van Otterloo (2017) describes the PDCA-Cycle as the following: In the first step, “Plan”, a action or change is planned out, which is carried out in the second step: “Do”. After these first two steps the “check” part should be performed, which means reflecting on what has actually been done. The

success should be determined and potential improvement points for improvement identified. In the last phase, “Act”, adjustments should be made to the original plan based upon the results of the “Do” and “Check” steps. After this step the “Plan” phase should be initiated again, continuing the innovation process while taking into account the previous PDCA-cycle.

Strategic, Tactical and Operational

In organisations there are different levels of planning, one of the methods to divide planning is in strategic, tactical and operational planning levels. Figure 4 shows the different levels op planning.

Figure 4: Different Levels of planning (Smalls, 2020)

Smalls (2020) describes the levels of planning: The highest planning level is strategic planning with the main process of defining the strategy or direction of the organisation. Strategic choices generally look at 3 to 5 years, ranging up to 20, therefore this level of planning is also described as planning long-term.

The tactical level of planning emphasizes on the current operations of various parts of the organisation. Short term, generally meaning 1 year or less into the future. Tactical planning is used to outline what an organization should do to be successful at some point one year or less into the future.

Operational planning is planning in the short-term, mainly concerned with day-to-day choices. The choices are about the reality and what is the best for the organisation tomorrow or the next week.

For an organisation to function properly, the levels of planning should work in harmony and be strongly connected. When working in one level of planning, the other levels of planning should always be considered. Consideration and harmony are required to make sure decisions do not contradict each other and there is one common direction within an organisation.

Goals and Requirements in the asset management chain

The goals and requirements of the canal-locks are used and defined in different ways across the planning levels in the asset management-chain of Rijkswaterstaat-Oost. This next section will clarify how each planning level describes and uses goals and requirements for the canal-locks.

At a strategic level the main goals for the asset management-chain are set, these are so called PINs (Performance INdicators) for the asset management-chain. These PINs are different norms and thresholds that the different canal-locks should perform at. PINs could for example be minimum availability or amount of accidents. With the PINs the performance of the asset management-chain in its entirety is measured.

The tactical level works more concretely with goals and requirements. At the tactical level requirements are used to fill an ARSIEM-cost model, which is a risk-cost based model. With this filled in model tactical departments plan the maintenance for the coming year. The struggle for the tactical department is the fact that it is not always clear how the PINs should be interpreted, because PINs in itself are way too broad and not concrete enough.

At the operational level goals and requirements are used in the contract with the contractor. In the contract there are performance requirements to which the contractor has to comply. These goals are set up to make sure there is a fair process of selecting a contractor and to make it clear for both parties how the asset management process functions and what the goals are. The operational level goals are in contrast to the other levels mainly cost-driven, because besides the obligatory performance requirements, contractors are chosen on lowest costs. This results in the fact that most of the time the contractor who meets the minimum performance requirements with the lowest costs wins the contract, not the one who is most likely to meet the goals of the tactical or strategic departments.

3. Literature

In this Chapter the relevant literature for this graduation research is explored. In Section 3.1 similar research projects are described and explained. In Section 3.2 relevant methods of identifying information flows are explained. Section 3.3 is the conclusion of this chapter with a summary of the literature that is used in this bachelor thesis.

3.1 Previous Research Methods

In Section 3.1 the different similar research methods are explained. To offer a general context of the similar literature in which this bachelor thesis is conducted.

Building Information Modelling

One of the methods that might be useful for this graduation thesis is Building Information Modelling (BIM in short). BIM might be useful because the industry in which it is developed very much overlaps with that of Rijkswaterstaat, Bilal Succar (2009) writes: “Building Information Modelling (BIM) is an emerging technological and procedural shift within the Architecture, Engineering, Construction and Operations (AECO) industry.” This quote clearly indicates that the industry of BIM overlaps and therefore the theory might be applicable. In the following paragraphs BIM will therefore be further explained.

BIM is a quite well-known theory in the industry, even acknowledged with its’ own ISO number: ISO19650. Therefore, it is useful to first look into what the industry thinks of BIM. A lead company in the BIM solutions industry is Autodesk, as it released a white paper, named “building information modelling” (Autodesk, 2002), on BIM as one of the first. Autodesk defines BIM as the following:

“Building Information Modelling is the holistic process of creating and managing information for a build asset. Based on an intelligent model and enabled by a cloud platform, BIM integrates structured, multi-disciplinary data to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operations.”

But of course, Autodesk is a commercial company, with a main goal of making profit. Therefore taking into account another description of BIM is appropriate: “Building Information Modelling (BIM) is a set of interacting policies, processes and technologies generating a Methodology to manage essential building design an project data in digital format throughout a building’s lifecycle. (Bilal Succar, 2009)

Autodesk further writes about Building Information Modelling as a process to support the creation of intelligent data. This intelligent data can then be used throughout the lifecycle of a building or infrastructure project. What the exact process of BIM entails changes from project to project, but can be used throughout the lifetime of an infrastructure product. The lifetime of a building can be divided into 4 phases according to Autodesk: Plan, Design, Build and Operate. In each of these 4 phases BIM is used in a slightly different way, but its overall usefulness can be expressed by the main goals and benefits of using BIM. According to Autodesk (2002): “The benefits of BIM are through connecting teams, workflows, and data across the entire project lifecycle – from design and engineering to construction and operations – to realize better ways of working and better outcomes.”

The concept BIM is used a lot, but what it exactly is differs between who it is asked to. Autodesk for example indicates 4 steps in the lifetime process of a building in which BIM can be used, as written in the previous paragraph. Of those 4, Bilal Succar (2009) only identifies three as phases in which BIM is useful. There are more examples like this one to be found, but this indicates that there is not really

one unified view on BIM and that BIM in itself can mean a lot of different things. Bilal Succar (2009) writes about BIM as a term: “While the mere presence of a label or an acronym is viewed by some researchers as a sign of poor lexical literacy, others refer to names as “vital for communication and useful for understanding a situation”. Many industry writers and analysts have contested the many terms available while others have argued the acceptance of BIM *as is* because of its adoption by industry’s major CAD developers.”

As indicated in the previous paragraph the main goal of a BIM is to connect departments and processes. This connection is made by the solution a BIM offers, Autocat writes: “Building information modelling solutions create and operate on digital databases for collaboration”. Autocat further describes: “By storing and managing building information as databases, building information modeling solutions can capture, manage, and present data in ways that are appropriate for the building team member using that data.” A solution is therefore most of the times a 3D, 4D or even more dimensional digital representation of an infrastructure project.

Building Information Modelling is a well-established process within the industry and the term BIM is being used for a wide range of solutions. Therefore, a possible solution for the information-exchange problem of Rijkswaterstaat might be a BIM solution.

Lifecycle Information Transformation and Exchange

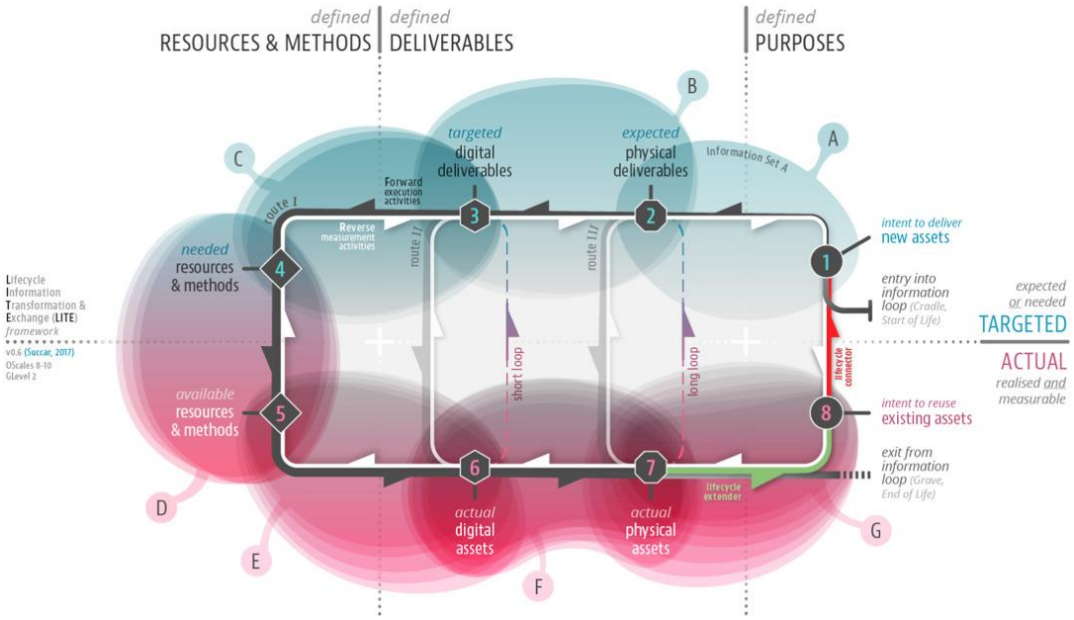

Figure 5: The LITE-framework

This lifecycle information, transformation and exchange, or in short LITE, framework is a method to summarize how information flows and transforms across an asset lifecycle. (B. Succar & Poirier, 2020) The LITE framework contains a lot of small interactions, which together create the whole method.

The first identification that the LITE framework does is about information status, it is written: “a Targeted Status representing what is intended, needed, planned or expected; and an Actual Status representing what is realised, available, executed or measured.”(B. Succar & Poirier, 2020)

The second distinction B.Succar and Poirier make is between different Information States information goes through between being an idea and becoming a functioning reality (2020): “The LITE Framework captures this transformation and represents it as three Information States –

Purposes, Deliverables and Resources and Methods – separated by vertical *state transformation barriers*."

By combining the 2 identification rules above, 8 information milestones are categorized. Information traverses through these Information Milestones throughout an asset's lifecycle. The information flows reflect natural deflection points in information flow. The article further identifies different Information Loops, Routes, Actions and Sets for information flows. These can all be used to further identify how an organisation functions, in which state an object is and how an organisation copes with changing information. In the end the article gives a typology of in which state information can be: Referenced information, Defined information, Managed information, Integrated information and Optimised information. (B. Succar & Poirier, 2020)

For this bachelor assignment the information classification framework could be used, because the research is conducted in the same industry. Especially typologizing the information flows in Referenced, Defined, Managed, Integrated and Referenced could be useful.

3.2 Identifying Information Flows

To identify and typologize information flows, a method has to be formulated for this bachelor assignment. In this Section the different possibilities for typologizing information are explored. First information differentiation techniques used by the LITE-framework are described, after which individual sources are explored.

3.2.1 Inside of LITE

In this chapter the differentiations in information flow made by the LITE-framework are explained in detail. These differentiations might be used later on in this research to identify information flows.

Static or Dynamic

Information can be either static or dynamic. The definitions of the ISO 2382 (2015) will be used to define the attributes of an information flow. The ISO 2382 is an international standard for information technology. According to the ISO 2382 the static attribute is: "pertaining to objects that exist and retain their values throughout the execution of the entire program". Dynamic is according to the ISO 2382: "a data attribute, whose values can only be established during the execution of all or a part of a program." ISO 2382 defines information as: "knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that withing a certain context have a particular meaning.

The definitions of the ISO 2382 are more program oriented, but in the essence the definitions are still useful for this thesis. When combining the definitions for Static and Dynamic with information definition we can conclude the following about static and dynamic information. Dynamic information is information that is changes or is created again and again during the lifetime of an asset. Static information is information that stays the same during the lifetime of an asset.

Targeted or Actual

A second sub-division mentioned by the LITE-framework is the difference between targeted and actual information. The LITE-framework is the promise or need for information, whereas actual information is the information itself. In the article is written: "a Targeted Status representing what is intended, needed, planned or expected; and an Actual Status representing what is realised, available, executed or measured." (B. Succar & Poirier, 2020)

Structured or Unstructured

A third sub-division made by the LITE-framework is the separation of Structured and Un-Structured data. The LITE-framework describes unstructured data(B. Succar & Poirier, 2020): “Unstructured Data refers to data that does not have a pre-defined data model or is not ordered in a pre-defined manner, as well as undocumented, and temporary information (e.g. hand sketches and casual phone chats)” Structured data is described as: “the computable data that can be transformed to/from varied states and exchanged between actors throughout an asset’s lifecycle”. (B. Succar & Poirier, 2020)

In the LITE-framework unstructured information flows are ignored, because in the basis of their definition they are not pre-defined and therefore hard to measure.

Digital assets

For digital information assets there is a subdivision used by in types of information flows used by the LITE-framework, made by the article *Model Uses: Foundations for a modular requirements clarification language* (B Succar et al., 2016). In the article the subdivision for digital information assets is: Document, Model and Data.

The LITE-Framework (B. Succar & Poirier, 2020) describes a document as: “A medium (e.g. an email, web page or a PDF document) carrying a variety in information including text, metadata, or embedded 3D models.” In contrast to the article *Model Uses: Foundations for a modular requirements clarification language* (B Succar et al., 2016), the LITE-framework also considers physical document flows: “When referring to non-digital documents, the term will be qualified (as in *paper* document).” (B. Succar & Poirier, 2020)

A Model is described by the LITE-Framework as: “In this study, unless qualified, the term Model will refer to a three-dimensional digital medium carrying a variety of information and – potentially – embedding or referencing both Document and Data sets.” The word “model” in itself can mean a lot more: “As a term, it may refer to digital models (e.g. shell/boundary or solid geometry graphical models); physical models (e.g. sandcastle, LEGO, or 3D printed shapes); financial, mathematical and conceptual models.” In the LITE-framework a conscious choice was made to narrow the term “model”. (B. Succar & Poirier, 2020)

The data term means according to the LITE-framework(B. Succar & Poirier, 2020): “A digital sequence of symbols – typically letters and numbers – that can be collected and parsed/interpreted by an actor. Data may be statically *embedded* within Documents or Models or *drive* their dynamic generation/modification”. In the LITE- framework it is used in the following way: “the term Data will refer to digital computable data. Data from analogue device … needs to be digitalised before it can be utilised or managed.” (B. Succar & Poirier, 2020)

3.2.2 Outside of LITE

Outside of the LITE-framework there are different information categorization techniques, in this chapter some of them will be explored.

Up-Down-Horizontal information flows

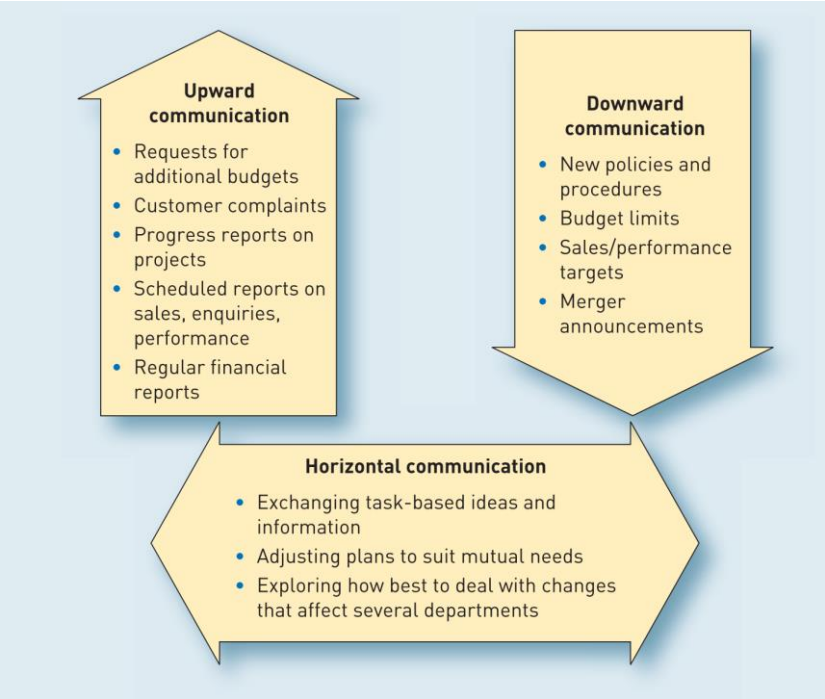

Figure 6: Directions of formal communications in organisations (Boddy, 2008)

In the book *Management An Introduction* (Boddy, 2008) a distinction in information flows is made between upward, downward and horizontal communication. These are described as formal communication directions, by using these formal communication flows people can make sure that they know about changes that affect them. Boddy (2008) describes the 3 directions, which can be seen in figure 6: “Management uses downward communication when they try to ensure coordination by issuing a plan and expect those lower in hierarchy to follow it.” “Upward communication refers to systematic methods of helping employees to pass on their views and ideas back to management.” “Horizontal communication crosses departmental or functional boundaries, usually connecting people at broadly similar levels within an organisation.

Categories of information flow

In the article *Information flows and business process integration* (Berente et al., 2009) the amount of process integration is measured with four principles: accessibility, transparency, timeliness and granularity. To measure these 4 categories interviews were conducted and the activities regarding information flows were identified which resulted in a list of 18 categories regarding tasks with information flows was created. The table with all the 18 categories can be seen in figure 7.

Principle	Non-integrated behaviors
Timeliness	Waiting for person (input)
	Waiting for technology (input)
Granularity	Reformatting for appearances (output)
	Getting more information (input)
	Summarizing for management (output)
Accessibility	Keying in known data (output)
	Keying in search criteria (output)
	Navigating computer interface (input/output)
	Documenting work the first time (output)
	Documenting work redundantly (output)
	Finding/obtaining information (input)
	Circumventing the system (input/output)
	Transferring data from one document to another (output)
	Checking for correctness (input)
	Manually performing automatable process (input/output)
Transparency	Requiring clarification (input)
	Clarifying for others (output)

Figure 7: Table with details of process integration properties (Berente et al., 2009)

Push vs Pull

Information flows can be either push or pull. A push information flow means that "sender of the message decides who receives it"(R. Hughes, 2013). A pull information flow on the contrary: "A pull information flow puts the recipient in control by letting them choose what information wants to receive from everything that is available to them." (R. Hughes, 2013). R. Hughes further describes that the description from push to pull is seen as "the holy grail" of business communication and something businesses should strive for.

3.3 Used Information Typology

In Section 3.2 different information categorizations and methods for differentiation methods for information flows have been given. This chapter will explain the information differentiation methods used in this graduation research.

Structured vs Unstructured

The first difference that will be made is whether or not an information flow is structured. Only structured information flows will be taken into consideration by this graduation research. The reason for this can be found in the explanation of unstructured information in 3.2, because unstructured information can be undocumented, temporary and is not pre-defined. Leaving out unstructured information may result in gaps in information in the models created. This will however result in an advice to define this information flow, which is in the case of unstructured data a valid solution.

By focusing on just the structured data, this bachelor assignment will not become overly complicated and understandable for everyone.

Static vs Dynamic

A first aspect of information flows that will be used to make a distinction is static and dynamic. As already described in 3.2 static or dynamic indicates whether or not an information flow changes during a time period. This means that what is perceived as static for one department can be dynamic

for the other, depending on the time periods in which a department operates. By paying special attention to the static or dynamic aspect of an information flow, this could give the research a good angle to analyse the BPM from.

Targeted or Actual

This is a second aspect used by the LITE-framework, which will also be used in this graduation research. This aspect will differentiate between the information flows in the extend to which they are already functioning. Is the information flow already functioning right, or is it only an ambition to have the information flow in place. Just using targeted or actual can be quite blunt and is not too accurate. Therefore the full 8 levels, used by LITE (B. Succar & Poirier, 2020): "Targeted Status representing what is intended, needed, planned, or expected; and an Actual Status representing what is realised, available, executed or measured."

Digital Assets

A next categorization method for information flows that will be used, is what kind of digital asset the information flow is. Due to the corona situation all structured information flows are now digital, which makes this categorization method very useful. The distinction in digital assets made in 3.2 is: Document, Method and Data. By using this distinction in the graduation research, the information flows will get an extra dimension and some anomalies between information flows can be explained. An information flow with a model can be something completely different from an information flow with a document.

Up-Down-Horizontal

The last difference made between the types of information flows will be the formal communication direction in the asset management-chain. The direction of information determines what kind of information is useful and necessary. Management probably has other interests than the department next door.

4. Mapping the Information Flows

Chapter 4 is showing the results of conducted interviews with the employees in the asset management-chain of Rijkswaterstaat. The goal of these interviews was to create an overview of the processes and information flows present at Rijkswaterstaat-Oost. In Section 4.1 the BPMN, the method of constructing a Business Process Model (BPM), is explained. Section 4.2 will explain the different sub-processes that have been identified. In Section 4.3 the process with KPI information will be described. Lastly, in Section 4.4 the main differences between the ideal process and KPI integrated process are explained.

4.1 BPMN (Business Process Modelling and Notation)

In this Section the BPMN notation will be explained. Similarly the method of applying the BPMN to this bachelor assignment will be covered.

To map all the processes and their corresponding flows in a model, BPMN is used. LucidChart was chosen as the website to make the model on, therefore also their BPMN model definitions are used. The BPMN definitions are based upon the book “Business Process Management”.(Weske, 2012) LucidChart was chosen since the researcher was already familiar with the software and the models are easy to share. Lastly the models are also easy to work on from different locations, which is a must due to the Corona situation.

The models will be built up out of the elements shown in figure 8.

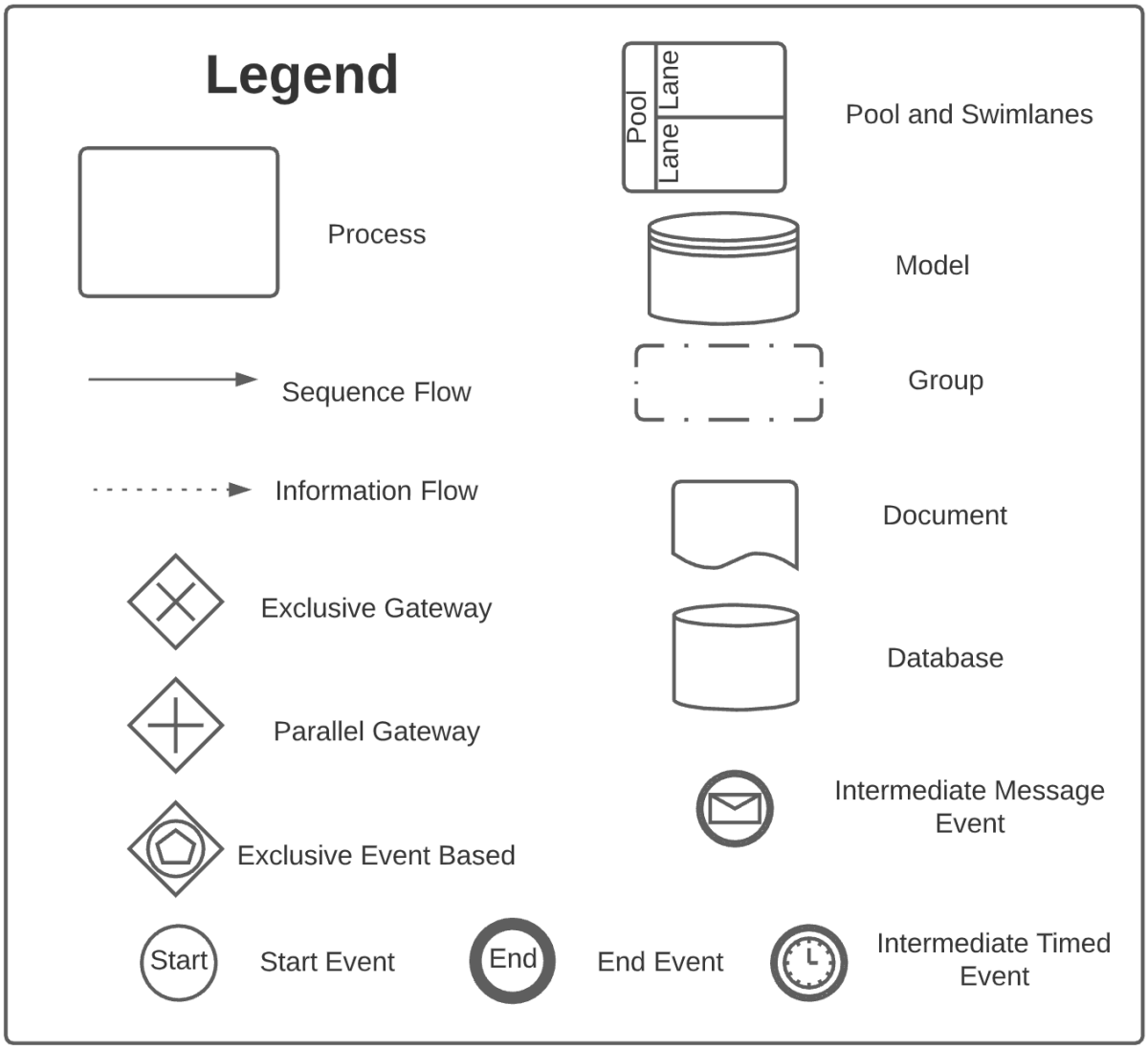

Figure 8: Elements used in the Business Process Models in 4.3

4.2 Main Processes in the Chain

In this Section is explained how the asset management-chain was mapped. After the mapping process the asset management-chain was divided up into 4 parts. These sub-processes are the basis of the models used in the upcoming sections. The reasoning why this division was made and what the parts are, is also explained in this section.

The mapping of the processes and information flows has been done in two stages. The first stage was drawing up a concept and the second stage were structured interviews. This initial concept was made from the viewpoint of the “adviseur assetmanagement”, which meant it was bound to be incomplete and wrong in some points. However, the reasoning for building this initial concept was to make sure that the second stage was more useful. By having this initial concept the interviews conducted in the second stage were more structured, as the concept could be used as a backbone for these interviews.

After going through the two stages of constructing a Business Process Model (BPM) of the whole asset management-chain it became clear that the BPM needed to be split up. The reason for having to split up the BPM was the fact that the BPM as a whole was too complicated and almost impossible

to use or understand. By cutting up the BPM, specific points in the asset management-chain could be focused upon and the information flows between these parts could be investigated.

The whole asset management-chain has been divided in 4 sub-processes. In reality these four sub-processes are very much connected and depend a lot on each in other. The decision to divide the whole chain into four sub-processes has nevertheless been made to make sure the Business Process Models stay readable and understandable. The four sub-processes are:

- Vision Formulation
- Planning Creation
- Contract Composition
- Contract Execution

For the four sub-processes categorization multiple divisions were tried. The first division that was by simply dividing the process by the different levels of planning (section 2.2). However, this division still resulted in a huge tactical level BPM. Therefore it was decided to search for a logical separation of the tactical level into two pieces. This division was found by splitting up the process in “Planning Creation” and “Contract Composition”. The Strategical and Operational process, the “Vision Formulation” and “Contract Execution” processes, were of an appropriate size and were therefore not split up. Figure 9 visualises the division of the different sub-processes in the asset management-chain.

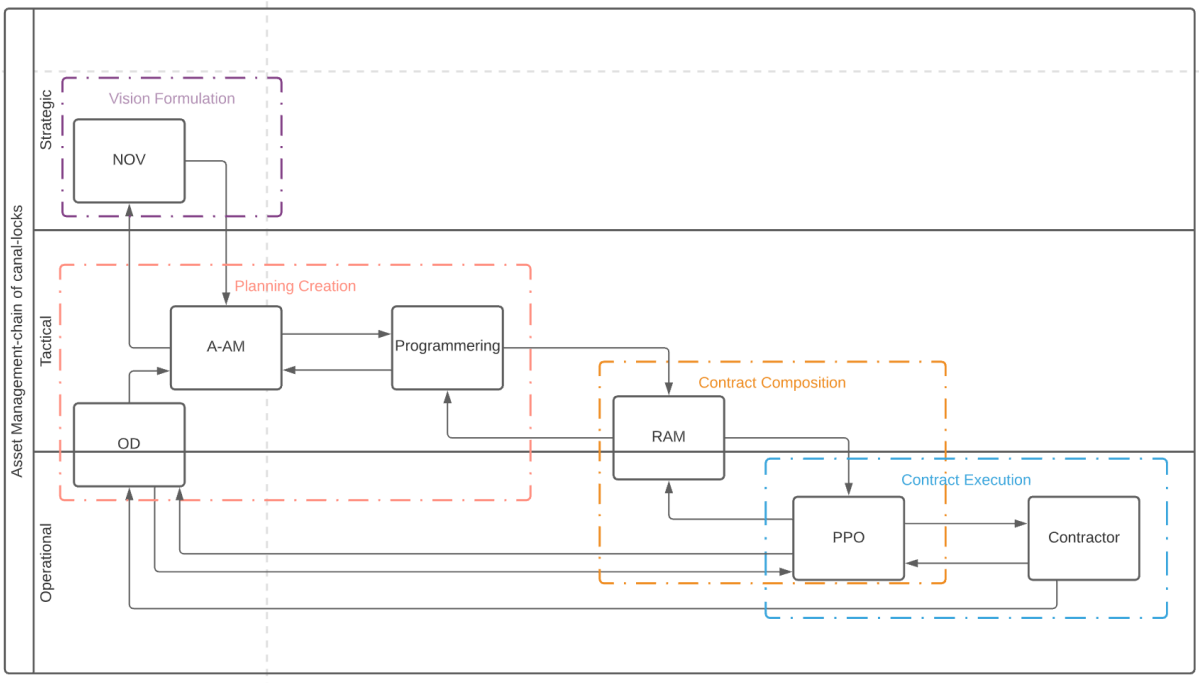

Figure 9: The Division of the four sub-processes

The abbreviations in Figure 9 are used throughout Rijkswaterstaat and can be found in the Abbreviations Section. For clarity the relevant abbreviations will be explained here again:

Vision Formulation

- NOV = Netwerkontwikkeling en Visie. NOV as a department is responsible for the long-term, strategic, vision of Rijkswaterstaat.

Planning Creation

- OD = Objectdeskundige. The OD is the person within the asset management-chain with all the knowledge about the canal-lock. His or her job is to know everything about the current state, future maintenance and risks of an object.
- A-AM = Adviseur-Assetmanagement. The A-AM is the person responsible for the tactical planning level of an object.
- Prog: The programming department is responsible for the decision whether or not to plan maintenance requested by the A-AM.

Contract Composition

- RAM = Regisseur Asset Manager. The RAM, who works in the SLU department, is responsible for constructing and gathering the information for the "Project Opdracht Formulier" (POF) which is necessary for PPO to start working on a contract.
- PPO = Programma's, Projecten en Onderhoud. PPO is the responsible department for outsourcing the necessary maintenance of locks. Outsourcing is done by constructing contracts when a POF came in.

Contract Execution

- PPO = Programma's, Projecten en Onderhoud. PPO is the only department present in two sub-processes. In the "Contract execution" process PPO is responsible for monitoring the contractor and passing on necessary changes to the current asset management programming.
- Contractor: The contractor is responsible for doing the day-to-day preventive and corrective maintenance of a canal-lock.

4.3 The Asset Management process

In this Section the four sub-processes are explained in detail. The sub-processes are mapped as a BPM and are the ideal situation of the interviewed employees. This means that not everything that has been drawn actually functions correctly in reality. The drawn-up BPM is a representation of how the interviewed employees see the correctly functioning asset management-chain. When analysing the information flows in chapter 5 the reality will be taken into account.

The ideal situation will be explained by talking about the goal, input and output of each sub-process. In this way each sub-process is described in a structured way.

4.3.1 Vision Formulation

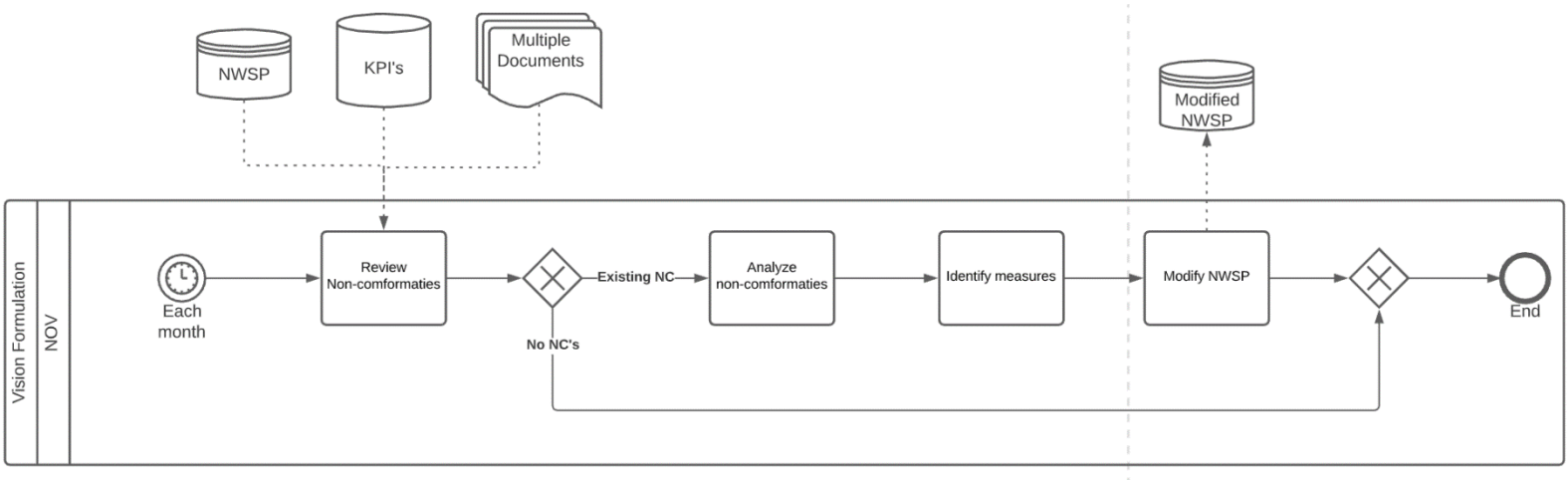

Figure 10: "Vision formulation" sub-process

Goal

As can be seen in Figure 10, only the NOV department is present in the "Vision Formulation" sub-process. This means that within this sub-process no information is transferred between departments and that this sub-process is the easiest to interpret. The goal of this sub-process is to give the whole asset management-chain a long-term vision and strategy.

Input

At the start of the process the NOV department goes through a process of analysing the available agreements made with for example the skippers, the companies using the "Twentekanaal" and the Ministry of Infrastructure and Water Management. By correctly interpreting and comparing these agreements with the current NWSP discrepancies can be identified.

Output

Figure 10 also shows that the main output of the NOV department is an updated NWSP (see Abbreviations). This NWSP can be updated by correctly analysing and acting upon discrepancies between the inputs of the process. Identifying the correct measures to put into the NWSP is critical.

4.3.2 Planning Creation

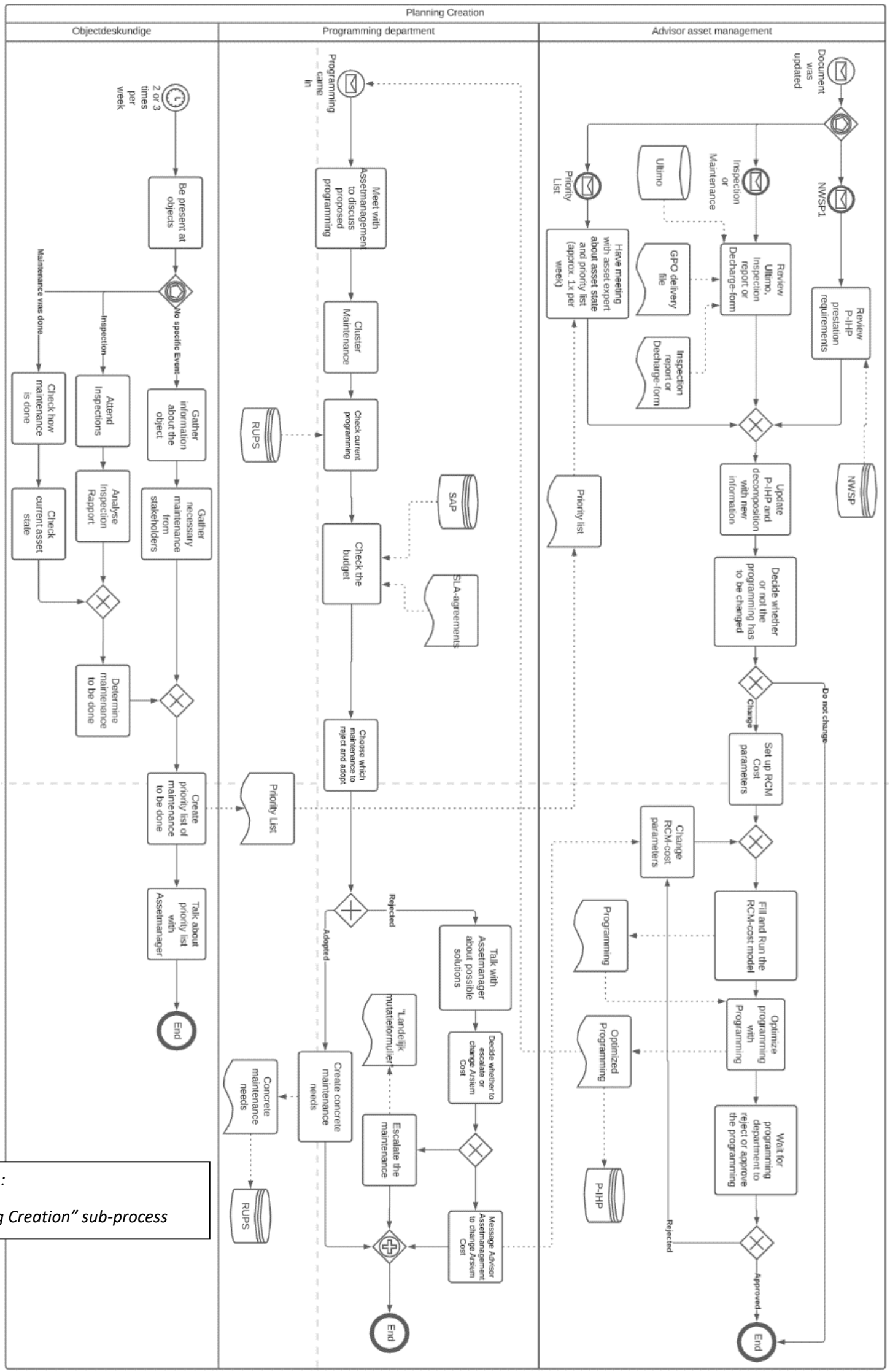

Figure 11:

"Planning Creation" sub-process

Goal

The main goal of the “Planning Creation” sub-process is to plan and update the maintenance for canal- locks for the coming 5 years. This means this sub-process is responsible for the tactical level of planning (section 2.2) in the asset management-chain. In this sub-process three different departments are involved, which results in a lot of communication between them. The structured information flows between these departments can be seen in Figure 11.

Input

The “Planning Creation” sub-process has lots of inputs, most of which are an output of a department from within or outside of the sub-process. Inputs include: the updated NWSP from NOV, Inspections and maintenance done by the contractor, all sorts of meetings, SLA-agreements and SAP. In reality there are probably lots of more unstructured inputs, however these are left out in this model.

Output

All the many inputs this sub-process has are transformed into one main output, the “concrete onderhoudsbehoefte” which is put into RUPS (see the Reader’s Guide). This output is used by the “Regisseur Asset-Manager” (RAM) to set-up contracts.

4.3.3 Contract Composition

Goal

The main goal of the “Contract Composition” sub-process is to correctly transform the wishes from Rijkswaterstaat-Oost into a contract with a contractor. In this sub-process, as can be seen in figure 12, two different departments are active to realize this goal. The SLU department is responsible for constructing and coordinating the POF (Project Opdracht Formulier) creation. The PPO department is responsible for transforming the POF into a contract. These departments work closely together and there is a lot of communication between them to for example make sure that a POF is actually realistic and doable.

Input

The main input of this process is the “concrete onderhoudsbehoefte” made by the programming department and put into the RUPS model. This RUPS model initiates this process. Next to this main input there are many smaller inputs from of all the stakeholders which help with constructing the POF and Decharge-form.

Output

The main output of this sub-process is the signed contract with an actual contractor. This contract is then again a main input for the last sub-process in section 4.3.4. Next to the contract as an output, there are smaller outputs like meetings with the rest of the asset management-chain about the current state of an asset and potential problems in the programming. A last output is the Decharge-form, which reflects upon a contract, its intended purpose and the realized outcome.

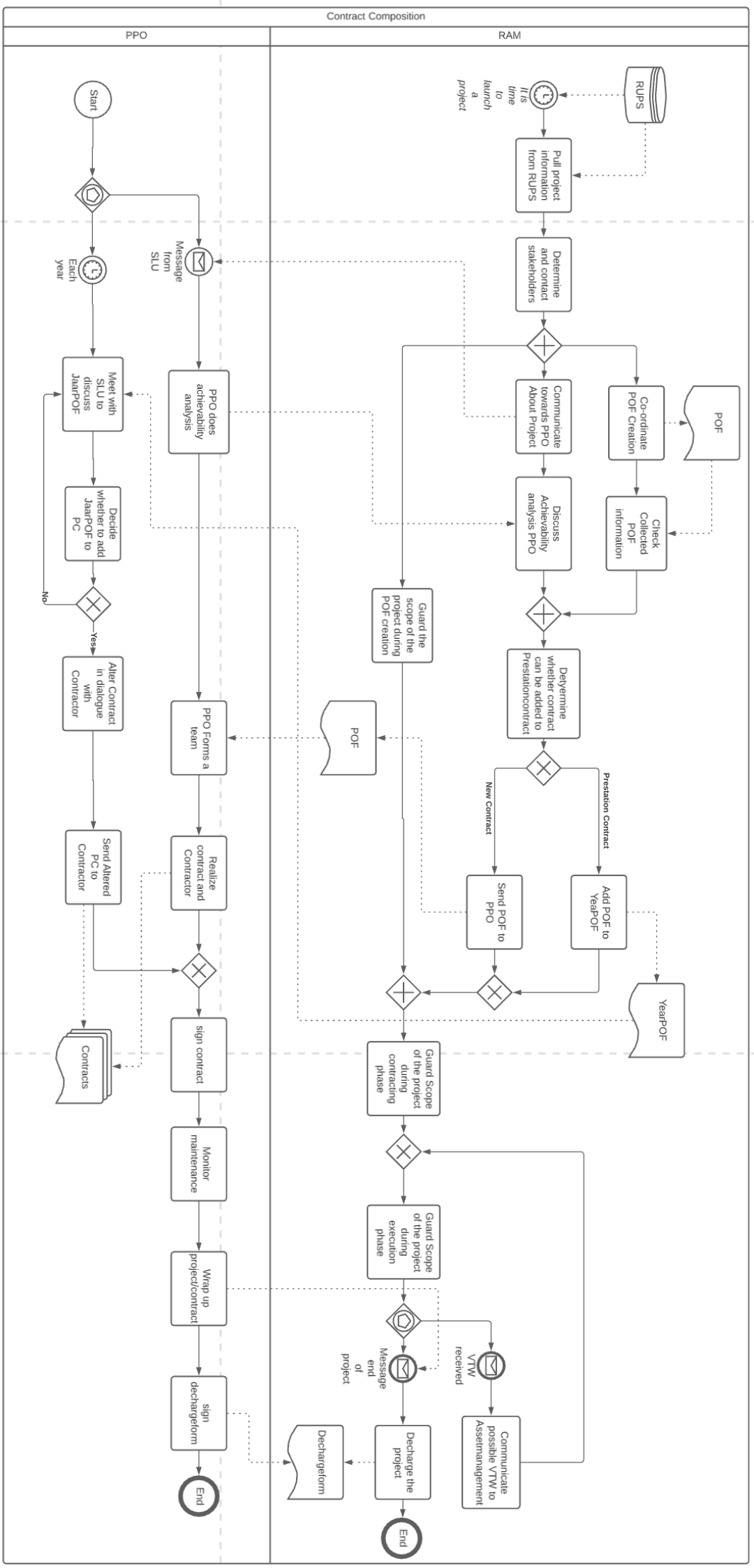

Figure 12: "Contract Composition" sub-process

4.3.4 Contract Execution

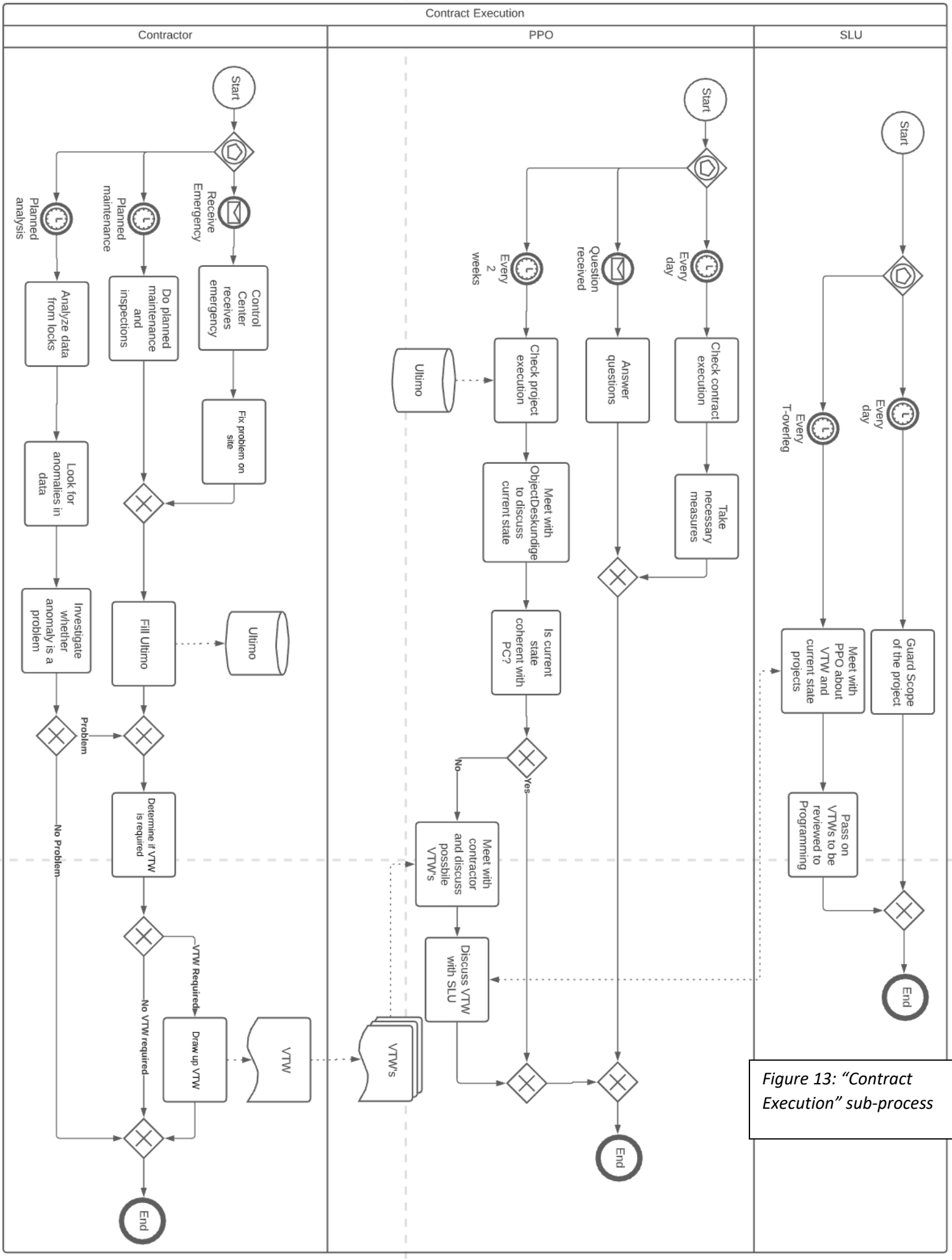

Figure 13: "Contract Execution" sub-process

Goal

In the “Contract Execution” sub-process, visualised in figure 13, the main goal is to correctly and efficiently execute the constructed contracts. This sub-process is responsible for the actual maintenance of the locks and is the final responsible for keeping the canal-locks available and in a respectable state. In theory this operational layer of the asset management-chain realizes the wishes of the tactical and strategical layer of the asset management-chain and realizes certain availability percentages or durability goals. However, in practice the operational layer mainly operates focused on costs.

Input

The main input of the “Contract Execution” sub-process is the contract made in the “Contract Composition” process. However, there are also smaller inputs like questions from within or outside of the asset management-chain or emergency reports.

Output

The main output of the “Contract Execution” sub-process is the actual maintenance provided and the corresponding data in Ultimo. Next to this main output there are outputs like VTW (see Abbreviations) and meetings with the tactical planning departments within Rijkswaterstaat.

4.4 Current Process

The current process and information flow of the asset management-chain is hard to visualize. The main reason for this is the fact that in the current asset management-chain a lot of information flows are unstructured or non-existent. Especially the process flow in the asset management-chain is not as structured as it is drawn up in section 4.3. It would be impossible to take into account all of the small steps that are happening in reality, especially since at the next canal-lock the process is again different.

A second reason the reality is hard to visualize is that the asset management-chain is still in transformation. The reorganisation that has been described in section 2.1 still has its ramifications. This means that it differs per canal-lock to what extend the reorganisation has been successful and the proposed changes in the asset management-chain have been implemented. As a result it is unclear in which state the current asset management-process resides, even for the employees within it. Therefore trying to make a BPM out of the current process would take a huge amount of time, whilst the usefulness of the BPM would remain questionable.

Because of the reasons mentioned above, the decision was made to not draw up the current process in a BPM. However, the information flows that happen in reality will be analysed in chapter 5 thus creating an idea of how much attention and work should be put into changing the information flows for the better.

5 Analysis of the Asset Management Process

In this chapter the information flows in the asset management-chain process are analysed. In section 5.1 the method of analysis and the process of filling in the tables are explained. In section 5.2 the filled in tables are visualized with the reasoning for certain typologies. In section 5.3 the tables are analysed and potential solutions given.

5.1 Method of Analysis

In this section the method of analysing the information is explained. First the procedure for determining which information is relevant will be described, after which the analysis approach is explained.

Relevant Information

In the asset management-chain of Rijkswaterstaat-Oost lots of information flows are present, therefore decisions had to be made about which information flows are relevant. In this research only information flows about the core asset management-process are taken into account. This means that only information flows about the current, future or desired state of the canal-locks can be considered as relevant.

The remaining, potentially relevant information flows were then divided into two groups, structured information flows and unstructured information flows. The unstructured information flows are irrelevant for the rest of this graduation research because the lack of consistency and predictability, as can be read in 3.2. The structured information flows are the relevant information flows and can be analysed in the following paragraphs.

The relevant information flows are analysed by using the identification techniques described in section 3.3. To correctly study the flows in the asset management-chain, the information flows are investigated on two levels. The first level is between the different main roles in the asset management chain and the second level is between the 4 main different processes in the asset management-chain. The levels are visualized in the figures below.

Analysis Approach

The constructed BPM that is pictured in chapter 4.3 can be drawn as one BPM with a lot of internal, small information flows. However analysing one huge BPM is difficult because of the complexity. Therefore the choice is made to analyse the main information flows in two levels. The first level, on a process level, is between the four different sub-processes and the second level, on a department level, is between the different departments within a sub-process.

Analysing the information flows between sub-processes is a logical method of analysing the information flows, mainly because the different sub-processes have already been constructed to depict the BPM in a manageable way. However, there are more benefits of analysing the information flows between the different sub-processes. The sub-processes in some way identify the four main goals of the whole asset management-chain, each with their own in and outputs (as can be read in 4.3). These inputs and outputs can therefore be seen as the most important information that flows within the asset management-chain.

The second level of analysing the information flows are the important information flows that remain after the first analysis level. Analysing on the process level means a lot of information flows between departments are already covered, however the information flows between departments within a sub-process are not covered. A logical step is therefore to look at these information flows between

departments within a sub-process, because these highly influence how a sub-process functions and the quality of a sub-process output.

The identification process of the information flows will be to firstly number all logical possible information flows and then try to give each information flow that comes up during the interview a number. In this way each information flow is placed within the model. After analysing the current and desired information flows the state of each desired information flow categoriser is visualised by a colour code:

- Strong existing point(green)
- Weak point, in improvement(yellow)
- Weak point, no improvement planned (red)

5.2 Analysing the Information Flows

As explained in the previous section, the information flows within the asset management-chain are analysed on two levels. The process level and the departmental level. In Section 5.2.1 the process level of analysis is done. In Section 5.2.2 the departmental level of analysis is described.

5.2.1 Process Level

In this section the information flows between the different sub-processes will be identified. In Figure 14 the logical possible information flows are drawn. Figures 15 and 16 shows the tables with the identified current and desired information flows.

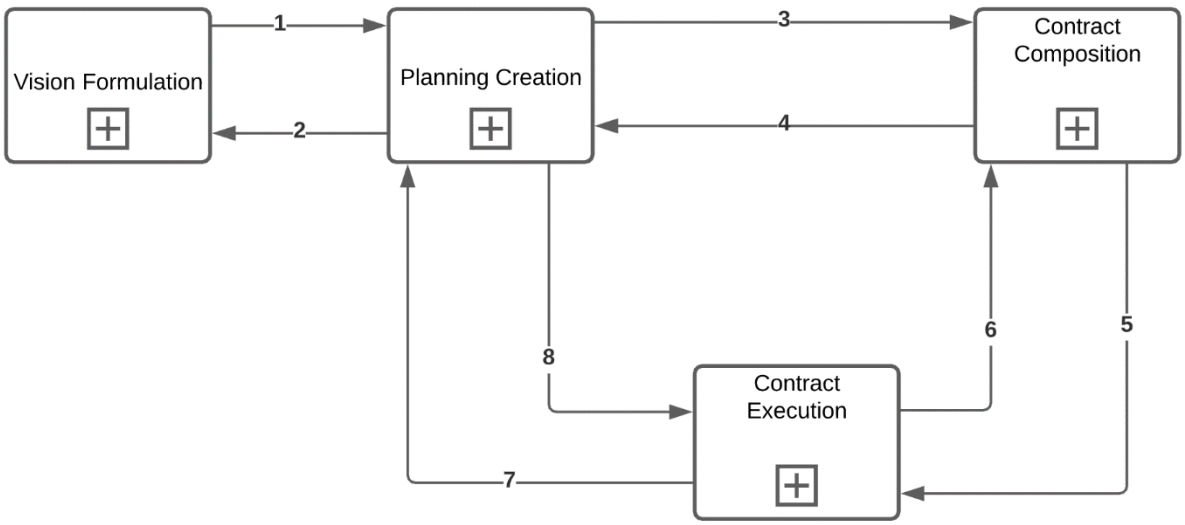

Figure 14: Process level information flows

Current Information Flows

Flow #	Information flow	Sender	Receiver	Static/ Dynamic	Type of Digital Asset	Message direction in organisation	Push/ Pull	Frequency
1	NWSP1	NOV	A-AM	Static	Document	Downwards	Push	No frequency
2	-							
3	Actual Programming	Programming	SLU	Dynamic	Model	Horizontal	Push	When necessary
4	"Uitvoeringstafel"	RAM	Prog	Dynamic	Meeting	Horizontal	Push	1 /month
4	Decharge	RAM	Prog/A-AM	Static	Document	Horizontal	Push	Every project
5	Contract	PPO	Contractor	Static	Document	Downwards	Push	Every project
6	"Groene Kamer"/"T-overleg"	PPO	RAM	Dynamic	Meeting	Upwards	Push/Pull	~1/month
7	VTW	SLU	Programming	Static	Document	Horizontal	Push	Every 4 weeks
7	Ultimo/ inspections	Contractor	A-Am/ Programming	Dynamic	Data	Upwards	Pull	Every maintenance
8	"Operationeel overleg"	OD	PPO/ Contractor	Dynamic	Meeting	Upwards	Push	1 /month

Figure 15: Current information flows between the different sub-processes

Desired Information Flows

Flow #	Information flow	Sender	Receiver	Static/ Dynamic	Type of Digital Asset	Message direction in organisation	Push/ Pull	Frequency
1	NWSP1	NOV	A-AM	Static	Model	Horizontal	Push/ pull	1 per update
2	Feedback on goals	A-AM	NOV	Dynamic	Document	Horizontal	Pull	1 per update
3	Actual Programming	Programming	SLU	Dynamic	Model	Horizontal	Push	Every update
4	"Uitvoeringstafel"	RAM	Prog	Dynamic	Meeting	Horizontal	Pull	1 /month
4	Decharge	RAM	Prog/A-AM	Dynamic	Document	Horizontal	Pull	Multiple times per project
5	Contract	PPO	Contractor	Dynamic	Document	Downwards	Push	Every project
6	"Groene Kamer"/"T-overleg"	PPO	RAM	Dynamic	Meeting	Upwards	Push/Pull	~1/month
7	VTW	SLU	Programming	Dynamic	Document	Horizontal	Push	Every week
7	Ultimo/ inspections	Contractor	A-Am/ Programming	Dynamic	Data	Upwards	Pull/ Push	Every maintenance
8	"Operationeel overleg"	OD	PPO/ Contractor	Dynamic	Meeting	Upwards	Pull	Each week

Figure 16: Desired information flows between the different sub-processes

5.2.2 Departmental level

In this section the information flows between the different departments within a sub-process will be identified. In Figure 17 the logical possible information flows are drawn. Figures 18 and 19 shows the tables the identified current and desired information flows.

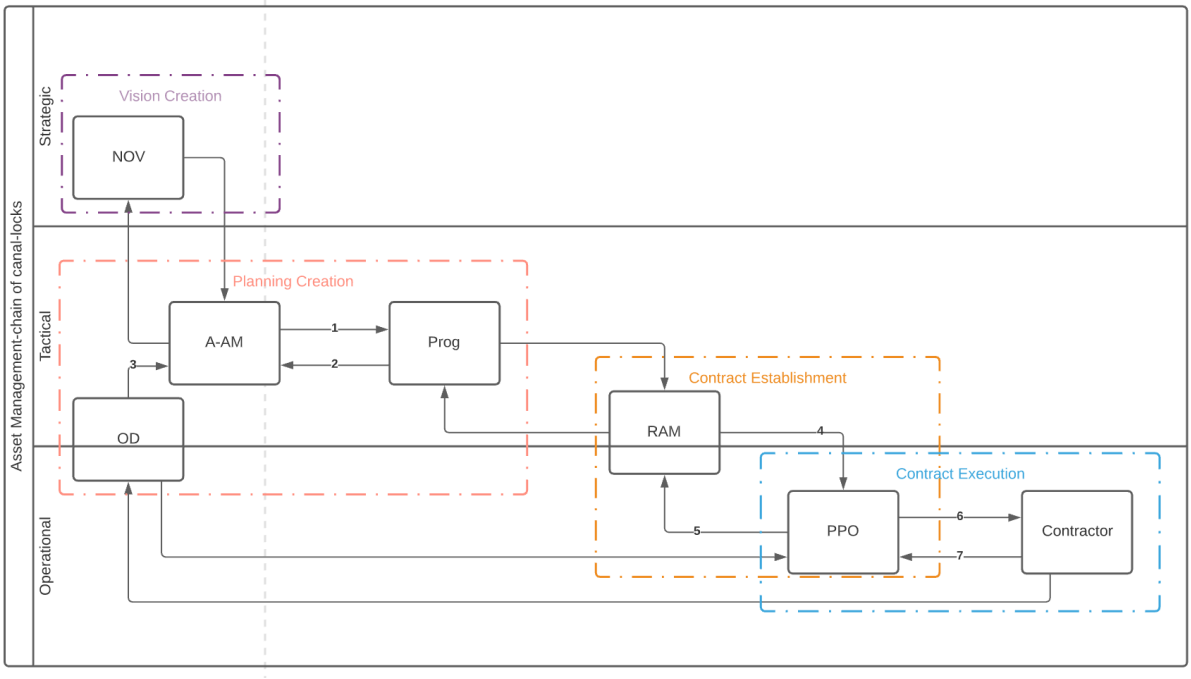

Figure 17: Departmental level information flows

Current process

Flow #	Information flow	Sender	Receiver	Static/ Dynamic	Type of Digital Asset	Message direction in organisation	Push/ Pull	Frequency
1	Desired Programming	A-AM	Programming	Static	Document	Horizontal	Push	1 /month?
2	Feedback on programming	Programming	A-AM	Static	Document	Horizontal	Push	1 /month?
3	Priority list	OD	A-AM	Static	Document	Horizontal	Push	/2 weeks?
4	POF	RAM	PPO	Static	Document	Downwards	Push	Each new project
5	“Groene Kamer”/”T-overleg”	PPO	RAM	Dynamic	Meeting	Upwards	Push/ Pull	~1/month
6	Contract Updates	PPO	Contractor	Static	Document	Downwards	Push	When necessary
7	VTW	Contractor	PPO	Static	Document	Upwards	Push	When necessary
7	Ultimo	Contractor	PPO	Dynamic	Data	Upwards	Pull	Less than every maintenance

Figure 18: Current information flows between the departments

Desired Flows

Flow #	Information flow	Sender	Receiver	Static/ Dynamic	Type of Digital Asset	Message direction in organisation	Push/ Pull	Frequency
1	Desired Programming	A-AM	Programming	Dynamic	Document	Horizontal	Push	Each Update
2	Feedback on programming	Programming	A-AM	Dynamic	Document	Horizontal	Push	Each Update
3	Priority list	OD	A-AM	Dynamic	Document	Horizontal	Pull	2 weeks
4	POF	RAM	PPO	Static	Document	Downwards	Push	Each new project
5	"Groene Kamer"/"T-overleg"	PPO	RAM	Dynamic	Meeting	Upwards	Push/ Pull	2 weeks
6	Contract Updates	PPO	Contractor	Static	Document	Downwards	Push/ Pull	When necessary
7	VTW	Contractor	PPO	Static	Document	Upwards	Pull	When necessary
7	Ultimo	Contractor	PPO	Dynamic	Data	Upwards	Pull	Every maintenance

Figure 19: Desired information flows between the departments

5.3 Conclusions about the information flows

In this section the conclusions about and improvement points for the information flows are described. In section 5.3.1 the results of the Process level analysis are displayed, whilst in 5.3.2 the results of the Department level analysis are displayed.

The analysis results of 5.2 are be presented by ranking the core properties of information flows as: existing, in progress and non existing. Core properties are the most important aspects of an information flow. Core properties are necessary for the information flow to function as needed.

In the tables in section 5.3.1 and 5.3.2 the desired information flows are visualised with a colour code about the state of their core properties. The colour code for the properties of information exchange is:

- Strong existing point(green)
- Weak point, in improvement(yellow)
- Weak point, no improvement planned (red)

5.3.1 Process Level Conclusions

Flow #	Information flow	Static/ Dynamic	Type of Digital Asset	Message direction in organisation	Push/ Pull	Frequency	Conclusions
1	NWSP1	Static	Model	Horizontal	Push/ pull	1 per update	NWSP1 is still in development and not yet integrated. Main improvement point is frequency.
2	Feedback on goals	Dynamic	Document	Horizontal	Pull	1 per update	This information flow is non-existent in the organisation. An information flow should be integrated.
3	Actual Programming	Dynamic	Model	Horizontal	Push	Every update	This programming flow is going quite well. An

							improvement point is the frequency at which RUPS updates.
4	"Uitvoeringstafel"	Dynamic	Meeting	Horizontal	Pull	1 /month	This flow is in general quite well already. The main downside is that this is a meeting, which means it lacks a concrete structure for feedback.
4	Decharge	Dynamic	Document	Horizontal	Pull	Multiple times per project	The Decharge is an information flow that should occur more often and is very bad integrated right now.
5	Contract	Dynamic	Document	Downwards	Push	Every project	The main downside of the current contracts is that they lack easy altering opportunities. Furthermore the contractor is very much outside of the chain.
6	"Groene Kamer"/"T-overleg"	Dynamic	Meeting	Upwards	Push/Pull	~1/month	This is again an information loop back that completely depends on a meeting. This means it can lack structure. Furthermore there is still a quite upwards structure.
7	VTW	Dynamic	Document	Horizontal	Push	Every week	VTW is a perfect feedback loop for a contractor. But the flow is now too slow and static once submitted.
7	Ultimo/ inspections	Dynamic	Data	Upwards	Pull/ Push	Every maintenance	Ultimo is an information flow that is now functioning quite well. The main issues that the data is not up to date and incomplete are being solved.
8	"Operationeel overleg"	Dynamic	Meeting	Upwards	Pull	Each week	This information flow is in a quite good state, the main problem is that the initiative is now still with the sender and not with the receiver. Furthermore the frequency could be better.

Figure 20: Conclusions about desired process level information flows

In the information flows between sub-processes there is still a lot of room for improvement. The main problem that came up is the lack of information flow back towards the NOV department, which results in the fact that the NOV department does not get any feedback on upfront determined goals for the asset management-chain. Next to this, there are a lot of frequencies of information flows that need to be improved to create more accurate information within the chain.

A last information flow property that can be improved a substantially is the dynamic property of information flows. For many information flows it is just waiting till the next information flow moment, however having a bit of dynamicity in the flows will greatly decrease the need for frequent information flows and steer towards a more coherent asset management-chain.

A single information flow that is quite weird is the fact that the OD gives feedback on the operational situation. This is probably an information flow that should be changed.

5.3.2 Department Level Conclusions

Flow #	Information flow	Static/ Dynamic	Type of Digital Asset	Message direction in organisation	Push/ Pull	Frequency	Conclusions
1	Desired Programming	Dynamic	Document	Horizontal	Push	Each Update	The desired programming has as a main problem its frequency and its static nature once submitted.
2	Feedback on programming	Dynamic	Document	Horizontal	Push	Each Update	The feedback on programming has again as a main problem the frequency.
3	Priority list	Dynamic	Document	Horizontal	Pull	2 weeks	The priority list has as a main problem that the A-AM is not initiating the flow and the static nature once received.
4	POF	Static	Document	Horizontal	Push	Each new project	The POF is functioning quite well. The small inconsistency that exists is the fact that communication overall is horizontal. But the idea is that the information flow is downwards.
5	“Groene Kamer”/”T-overleg”	Dynamic	Meeting	Upwards	Push/ Pull	2 weeks	This information flow is again solely dependent on a meeting which is suboptimal. Next to this the frequency is insufficient.
6	Contract Updates	Dynamic	Document	Downwards	Push/ Pull	When necessary	The contract updates are too static, furthermore there could be a higher frequency and better push/pull ratio (now it is one or the other).
7	VTW	Static	Document	Upwards	Pull	When necessary	The VTW is functioning very well, main problem is that the contractor has to fully initiate the information flow.
7	Ultimo	Dynamic	Data	Upwards	Pull	Every maintenance	Ultimo is already functioning quite ok and has been improved. However as mentioned before information now is not up-to-date and can be too static towards PPO.

Figure 21: Conclusions about desired department level information flows

The department level information flows are overall well regulated, however there are some weak points present. The main weak point is the frequency of the information flows, which when increased could improve the reliability and accuracy of the available information. Another main improvement point is the fact that most information flows are static and that not all departments feel the need for a feedback loop into their process. More information flows should be pull, instead of push.

6 Improvement for the Future: Solutions

In this chapter the possible solutions for the problems found in Chapter 5 will be covered and explained. Section 6.1 will start with the management dashboard that is currently in construction and the potential uses to solve some of the found problems. In Section 6.2 some possible solutions, not related to the dashboard, are covered.

6.1 How KPIs help

In this section the dashboard in construction by the workgroup Performance Management in the Asset Management-chain will be explained, with the possible applications to improve the information flow between different departments.

The dashboard created by the workgroup Performance Management in the Asset Management-chain at Rijkswaterstaat-Oost is far from the only dashboard in development or circulation. However the goal for the dashboard is to enable performance management in the asset management-chain, as the name of the workgroup suggests. For the dashboard five different focus fields have been defined: Availability, Customer Satisfaction, Maintenance Costs, Safety and Sustainability. For each of these fields 2 to 3 Key Performance Indicators (KPIs) have been defined.

The dashboard and the KPIs will have a different use for each of these departments. For most of these departments the dashboard will fulfil the role of a check on assumptions. In figure 22 for each department the main use of the KPIs and the dashboard is explained. This use could range from filling a gap in the information flow to just an extra information source to check your already available information against. The explanations of the used abbreviations can be found in the Abbreviations section.

Department/person	**Use for the dashboard**
NOV	The NOV department is probably the department which can benefit the most from the dashboard. There is currently no feedback on their goals, as can be seen for flow 2 in chapter 5.2.1. The dashboard can function as a feedback or be the core of an information flow between the A-AM and NOV.
A-AM	For the A-AM the dashboard can mainly be used to check whether different assumptions are correct. The A-AM uses a lot of assumptions to create a desired programming, however whether these are actually correct is unknown.
Programming	For the Programming department the cost side of the dashboard is interesting. The Programming department decides whether or not to actually conduct maintenance by the available funds. However in reality the details of how the money is spent is often unknown, here the dashboard could be of use.
OD	The OD is one of the persons who will probably make less use of the dashboard. The OD could mainly use the dashboard to check upon whether the reality that is observed can also be found in the KPIs. The KPIs could also influence the priority list that is created.
SLU	The SLU department is the department responsible for monitoring the state and effectivity of projects/contracts. The dashboard could be used by the SLU department to monitor the scope of the contracts and in the end fill in the Decharge form.
PPO	The PPO department could use the dashboard to monitor the current state of the canal-locks and to which extend the contractor is doing the maintenance correctly and effectively.

Contractor	The contractor is for now not allowed to look at the dashboard. Allowing the contractor to see the dashboard could however be beneficial for the whole chain as the goals and norms set for the rest of the chain would become visible. As this way the contractor could steer more on the goals set for the whole chain and would better understand the decisions made by the rest of the chain.

Figure 22: Different ways the dashboard can be useful for departments.

6.2 Improvements outside Dashboard

In this section possible improvements for the asset management-chain outside of the performance dashboard will be covered. The improvements are heavily based upon the problems identified in Chapter 5.

The main problem that came up in both the department and process level analysis, was the fact that the frequency of information flows was insufficient. A solution for this problem might sound easy, just increase the frequency at which meetings are hold, documents are sent or models are updated. However, a change like this is not done easily. To make sure the frequency can be increased, the working environment should be able to sustain such a high information frequency. This means that throughout the asset management-chain employees should be explained and understand what the value of increased information frequency is. Increased information frequency means that each time a smaller amount of information is transferred and in this way processes can go faster. This could be a cultural problem due to the longer lengths of time asset management functions on.

A second problem that came up during this bachelor thesis, was the fact that the NOV department did not have feedback on their actions and goals they set. In an asset management-chain that wants to implement the PDCA-cycle (section 2.2), this means there is a huge problem because there is a "Check" missing. One possible solution is the performance dashboard, as pointed out in section 6.1. However just creating a dashboard will turn out to be insufficient. A more cultural related change should happen by convincing the employees of the NOV department of the necessity to reflect on the goals they set for the whole chain. Next to that guide should be offered about how to analyse the dashboard or how another information flow should be set up from the A-AM to the NOV department. This information flow could for example be a document filled with feedback about vaguely defined or unrealistic goals and the results setting a certain goal had on the asset.

Next problem that came up multiple times when analysing the information flows, were static information flows. The correct information may flow from one department to another, but the information is not able to be changed once sent. This results in inaccurate, unrepresentative information used by departments. By making information flows more dynamic the used data and information will be more accurate. A possible solution for having more dynamic information flows is by digitalizing the documents. This way any document can be altered and downloaded from the internet by each department.

A fourth problem that was found in the analysis a few times was the fact that most information flows are push flows. Which means that one department constructs a document or model and just sends it to the next department. As a result not each department wants to actually receive information. By analysing the information needed more at each department, departments will be more likely to use information effectively. This way the information flows transform from push to pull. This will also result in more motivation to build a useful and complete report, as the document or model is actually wanted. In general it will be more clear for both the receiver and sender what information shall be in an information asset and how the information shall look like.

A last problem identified is a single quite strange information flow. This concerns flow number 8 on a process level. The flow is, as can be seen in Section 5.2.2, a meeting between the OD, Contractor and PPO. The weird thing is that the OD, which is officially a tactical level of planning role, provides operational information for PPO and the Contractor. The OD is currently still the only one in the asset management-chain who frequently visits the actual canal-locks. This means that only the OD actually sees the consequences of the decisions made in the asset management-chain. Solution for this problem is to urge employees to go regularly, for example once or twice per two months, to a canal-lock. This way employees will increase their awareness of the actual reality of the asset, instead of just some digital information.

7 Discussion

In Chapter 7 the research in this graduation thesis is reviewed and the value determined. In Section 7.1 the situation at Rijkswaterstaat is reviewed and remarkable observations are outlined. In Section 7.2 the limitations of this graduation research are identified and explained. Section 7.3 describes the value of this research. Lastly, in Section 7.4 the notable differences between the graduation research and literature are pointed out.

7.1 Analysis of the Researched Case

In this Section 7.1 the Rijkswaterstaat-Oost case is investigated. Several noteworthy observations are made and will be explained. This Section will focus on describing what made this research at Rijkswaterstaat special. A general explanation of what Rijkswaterstaat as an organisation is and does can be found in Section 1.1.

The main point of interest of this graduation research, related to the context is the fact that Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and Water Management. This means that Rijkswaterstaat has a strong responsibility to the people to make sure the tax-money is spent correctly and infrastructure is effectively maintained. This responsibility is something that has to be taken into account at almost each decision and therefore is really something that stood out when this graduation research was conducted.

The second point of interest could again be a result of Rijkswaterstaat being under the government. It stood out that Rijkswaterstaat is a huge company with a lot of different regional departments and a complicated company structure. A reason for this could be that Rijkswaterstaat as an organisation has a huge amount of infrastructure to maintain in good condition, which means a lot of different departments and personnel is necessary. Therefore every employee only contributes to a small part in the big picture. This results in a loss of vision on the bigger picture and the fact that only a limited number of managers keep overview of the whole organisation. For this research it meant that almost all different interviewed employees have a different vision of how the chain looks and should develop in the future. All these reasons mentioned above contribute to a more complicated company structure than necessary, because the overview is lost.

It was noticeable that certain improvements from the past were still not properly integrated in the asset management-chain of Rijkswaterstaat. A reason for this could be the fact that the whole asset management-chain was functioning fully online, without any physical person-to-person meetings, for a small year when the research started due to COVID-19. Not being able to talk face-to-face in an office can have a substantial impact on the functioning of an asset management-chain. In general it is easier to understand each other when talking face-to-face, therefore it could be that certain improvements, for example the NWSP1 and P-IHP, are less well implemented as they would have been if COVID-19 had not happened. The fully online asset management-chain could also have had

other impacts like employees working less efficient or being able to have more meetings because employees do not have to travel, however these impacts were not able to be observed by the researcher, mainly due to the fact that the researcher was not knowledgeable of the situation before COVID-19.

A last noticeable characteristic of the asset management-chain of Rijkswaterstaat was the will to improve the chain. There are across Rijkswaterstaat lots and lots of initiatives to improve parts of the asset management-chain. For example, just for creating a dashboard there is one national project and around 3 to 4 regional projects running all with their own approach and requirements for the dashboard. This requires a lot of communication and effort from the employees to keep in touch with the developments across Rijkswaterstaat. In the end all these initiatives are a positive force across Rijkswaterstaat. However, as a downside these many developments reduce the trust of employees that these development projects are actually going to change the asset management-chain. As a result, in some projects the same positive energy that started it is lost due to the effort it requires to keep up to date with rest of the asset management-chain and the difficulties implementing the improvements.

7.2 Limitations of the Research

In this Section the limitations of the conducted research assignment at Rijkswaterstaat are discussed.

The main limiting factor of this research is the small scope, which means that his thesis is only applicable for a small part of Rijkswaterstaat. The main reason for this restricted thesis scope was lack of time, due to restrictions. These restrictions can be found in section 1.3.2. In short, only a very specific and limited part of Rijkswaterstaat has been taken into account. By limiting the scope in this way the research was more focused and resulted overall in more specific and useable solutions and recommendations. The limited scope does not mean this research is irrelevant for the rest of Rijkswaterstaat, as for example the regional departments do not differ that much.

A second, very obvious limiting factor that had impact on this particular research case, was the COVID-19 virus. The research was conducted during a national lockdown, which meant that everything was done from home and interviews via Microsoft Teams. Doing the meetings and interviews online means that misunderstandings are in general more likely to happen and just asking a small question at the coffee counter is impossible. Next to the easy misunderstandings, the COVID-19 virus meant that only the online and more official side of the asset management-chain was analysable. Without the virus the asset management-chain could look completely different.

A last limiting factor is a result of the limited time. Asset management is a process that is really focused on the long-term. This means that for example contracts, which form the backbone of the asset management-process are only signed once per five years. This research was conducted in a period of half a year, which means that only a small portion of the asset management-cycle occurred during the research. Therefore, a lot of the information was completely depended on the interviewed employees instead of own experience of the asset management-cycle. This is a limiting factor in the objectivity of this research.

7.3 Value for Future Research

In this Section the value of this bachelor research for future research is explained. Which parts can be used for future research and what lessons have been learned?

For Rijkswaterstaat the value of this bachelor assignments is more than just the deliverables at the end of this thesis. At Rijkswaterstaat there were already some “models” about how the asset management-chain should look like, however the models were descriptive and vague. For example,

Rijkswaterstaat knew they wanted to implement the PDCA-Cycle in each of the three levels of planning and drew some arrows, however it was not clear what the different links between the PDCA-Cycles should actually be. In this case the models created in this bachelor assignment could be a solution by indicating which information flows and how the information flows influence the process flows. So to implement PDCA in an infrastructure organisation, using a concrete process flow model is crucial.

Next to the combination of PDCA with BPMN, this graduation assignment made clear that information flows can be overlooked easily. At the start of this bachelor assignment, very few employees mentioned the problem of unclear and insufficient information flows. However, when analysing the information flows, it can really identify weird structures or information flows. For example, the lack of feedback for the NOV department and the operational information that a tactical department is delivering to the operational layer (Section 5.3). Next to Rijkswaterstaat, the literature most of the times just moves to inserting a BIM (Section 3.1) whenever information flows are mentioned. However this process should at least include some sort of analysis of the different information flows between departments, as done in this bachelor assignment. The reason for this is simple, as there are probably cheaper and less invasive solutions to be found by analysing information flows before changing up the information infrastructure of an organisation.

7.4 Different from Literature

In Section 7.4 the differences between this bachelor assignment and relevant literature (Chapter 3.1) will be explained. Differences range from the type of company to the approach and solutions at the end of the conducted research.

A difference found between relevant literature and this graduation research is the fact that Rijkswaterstaat is under the government. The other sources are also about the infrastructure industry, but do describe organisations with a profit motive. In the execution of the maintenance exist different motives and goals. However, there are definitely similarities as for example both types of organisations aim to satisfy the customer and reduce costs. Therefore, even though the exact ranking of goals might differ, the types of organisations in the infrastructure industry have a lot in common. The reason that not much is known about infrastructure organisations under the government can be because lots of governments have outsourced the maintenance and construction of infrastructure to private companies. Another reason can be that organisations under the government are less likely to care about optimizing and improving their company and information structure, as a consistent income is guaranteed.

Another difference between this graduation thesis and literature in is the fact that this graduation research explicitly focused on canal-locks. In literature there is almost nothing known about the analysis of information flows in an asset management-chain of canal-locks. For this difference is probably quite an easy reason, as there are just not that many countries that have canal-locks. Even though there is quite a difference between literature and this graduation research, there is not that big of difference between a canal-lock or a bridge in the way an asset management-chain is organised. However, this could be quite an interesting point for further research.

The last difference between this graduation research and relevant literature is the way an information flow problem is handled. Especially BIM-literature tends to focus immediately on constructing the ideal information structure, where an analysis of the current information flows can reveal lots of useful information about the current organisation structure. This was definitely the case at Rijkswaterstaat-Oost.

7.5 Generalisations

In this Section 7.5 the main generalisations and takeaways of this bachelor thesis are described.

The main thing this bachelor thesis adds to the current information available in literature, it the conformation that the current methods also apply to canal-locks. The general problems found in this bachelor thesis are not really revolutionary, because the problems have arisen in other organisations. For example, R.Hughes (2013) describes the fact that most organisations should strive to change their information flows from the push to the pull type. This bachelor thesis provides additional confirmation that this is also true for a governmental organisation which manages a canal-lock.

A second challenge in general found in this bachelor thesis that is of conforming nature, is the relationship between the three planning levels. The problem was that the strategical planning level in the asset management-chain of Rijkswaterstaat-Oost is not receiving any feedback from the other two planning levels. This problem has also been identified by H. Smalls who describes harmony as a challenge: “The three levels must be in harmony with each other and if you work on one level, you must always consider the other two levels.” The discovery of this problem at Rijkswaterstaat-Oost proves this is also a challenge in the asset management-chain of canal-locks.

8 Conclusion

In Chapter 8 the conclusion of this graduation thesis is written. In Section 8.1 a small summary is written. In Section 8.2 the main research question and sub-questions are answered. In Section 8.3 the recommendations for future research are explained. In Section 8.4 the advice as a result of this bachelor assignment is given with an explanation why certain advice is given.

8.1 What was the Thesis?

In this Section 8.1 a small recap of this bachelor assignment is given. The reason for writing this summary as part of the conclusion is to create a recap before reflecting on the results.

The bachelor assignment consists out of three sub-questions, which are covered in more detail in Section 8.2. To answer the three sub-questions, different research methods had to be conducted. The first research method was a literature study to identify the different methods of identifying and categorizing information flows. The result of this literature study can be found in Chapter 3 and delivered some differentiations between information flows which were used during the continuation of this bachelor assignment.

The second research method used were interviews with the employees of Rijkswaterstaat-Oost to create a BPM with the process and information flows between departments of the asset management-chain of canal-locks. These interviews resulted in one BPM with was too big to interpret in a correct way. To increase readability and make the BPM easier to understand, the BPM was divided up into four parts: “Vision Formulation”, “Programming Creation”, “Contract Composition” and “Contract Execution”. The results and BPM models can be found in Chapter 4. After creating the results, the results are analysed in Chapter 5.

The explanation of how to integrate KPI information into the chain is part of Chapter 6. The last research question was answered by interpreting the interviews, attended meetings and the created BPMs. In this chapter solutions and recommendations to improve the asset management-chain are written. The recommendations and solutions are made based upon the problems that came up whilst analysing the results in Chapter 5.

This bachelor thesis is finished by the discussion in Chapter 7 and the conclusion in Chapter 8.

8.2 Answering Research Questions

In section 8.2 the main research question is answered, which is formulated in Section 1.3.1. However, to answer the main research questions, first the different sub-questions are covered.

The first sub-question

"Which data structures are eligible for registering and exchanging asset information?"

This research question is answered by the literature displayed in Chapter 3. The different types of online data structures found in the literature were BIM and the LITE framework. In raw data structures a differentiation was found between "data", "document" and "model". Whilst searching for the different data structures, multiple differentiations to be made for information flows were found, which were used in the continuation of the bachelor assignment. The differentiations were ideal to visualize the difference between how the flows were present in reality and how the information should flow in the perfect world.

The second sub-question

"Which data is registered and how does it flow between the "Netwerkontwikkeling en Visie" (NOV) department (strategic level) and the "Asset Management" (AM) department (tactical level) and which information is missing in these flows?"

In the explanation of the sub-question in Section 1.3.1 was already written that the scope of this question depended on how easy identifying the necessary information flows was. After a few interviews, which were the research method for this sub-question, it became clear that it was easier to just take into account the whole asset management-chain instead of just these two departments. This was mainly due to the fact that in the asset management-chain all the information flows are somehow connected. Therefore, to understand one information flow correctly, information about other information flows is necessary.

This second sub-question was answered by creating one big BPM model, which was then divided up into four parts: "Vision Formulation", "Programming Creation", "Contract Composition" and "Contract Execution". In the BPMs the list of required end results of this sub-question, written in 1.3.1, is visualized.

In the end the information flows of the asset management-chain have been analyzed on two levels: between sub-processes and between departments withing sub-processes. After the BPMs the difference between the ideal and actual information flows is visualized by two tables. After the visual difference between the ideal and actual information flows conclusions and an advice could be made, which are written in Chapter 6.

The third sub-question

"Which information-exchange is required regarding the KPIs for accurate performance measurement of the constructed Performance Dashboard?"

This last sub-question was at the beginning of this bachelor assignment regarded as optional and was to be answered if the time allowed it. However, during the execution of this bachelor research, it became clear this sub-question was of high importance for Rijkswaterstaat-Oost. For this reason, answering this research question became a necessary part of this bachelor assignment.

This sub-question was answered by asking the employees of the asset management what they believe the added value of the dashboard to be. After knowing the different values of the dashboard,

it was researched whether missing or wrong information flows, identified in Chapter 5, could be filled by the Performance Dashboard that was being constructed.

The information-exchange required regarding the KPIs mainly means that existing information flows should occur more frequently and become more dynamic. Both of these changes will result in more flexibility in the chain and act more effectively upon changing KPI values.

Main Research Question

"Which information-exchange is required to successfully align strategic ambitions for maintenance planning of canal-locks to tactical key performance management."

In order to successfully solve this main research question the outcomes of the smaller research questions are necessary. It is therefore logical that parts of their answers are used in the answer of the main research question below.

The answer to this main research question can be found in Chapter 6 and Section 5.3. The main attention points for information flows, to successfully align strategic ambitions for maintenance planning of canal-locks to tactical key performance management, are the following: Have a high frequency of information exchange, keep information flows as dynamic as possible, have "pull" type information flows and make sure every department receives feedback on their information flow output. These four attention points all result in a dynamic and flexible asset management-chain, which can steer efficiently and effectively on changing goals, ambitions and KPIs on a Performance Dashboard.

Action and Core Problem

The action problem is formulated in Section 1.2 as the following:

"The Asset Management Chain of Rijkswaterstaat-Oost functions short-term without an overview, the goal is to function long-term with a performance dashboard as steer on the chain."

The core problem is formulated in Section 1.2 as the following:

"It is not clear which information-exchange is required between the different planning levels"

The core problem has been solved by this graduation assignment, because a clear description is given about which information flows are present and how they should change. Next to these already present information flows, recommendations are made (see Section 8.4) about which information flows to add and how to implement the performance dashboard.

The improvement in the action problem is less easy to prove, because the action problem is more of a structural, cultural problem. This problem will ultimately be solved by having employees acting differently in certain situations and actually using the dashboard. The improvement made by this graduation research for the action problem is by giving advice about how to implement the performance dashboard in the asset management-chain. Next to this advice about the dashboard use, a situation of continuous improvement was recommended to make sure the asset management-chain of Rijkswaterstaat-Oost can use the performance dashboard as a "steer for the future".

8.3 Future Research

In this Section 8.3 recommendations for future topics to be research are given. By researching the topics proposed in this section the literature in this research field can make additional steps forward.

The first field for further research would be in the asset management-chains of canal-locks and their structure. It is unknown how the asset management-chain of a canal-lock should look like or if the chain should be marginally different from other infrastructure objects. Therefore research into the optimal structure of an asset management-chain of canal-locks could be very valuable.

A second topic interesting for future research would be to investigate further into the possibilities of information flow analysis. It is unknown whether the differentiation techniques used in this bachelor thesis are the right ones, or if there are more useful or important information flow differentiations that should be taken into account. This could justify the analysis decisions made in this bachelor assignment or reject the approach taken in this bachelor assignment.

A last interesting future research topic would be to investigate more concretely how the corona crisis impacts an asset management-chain. This bachelor research was done during corona, which could have impacted the asset management-chain in a big way. Therefore it would be useful to know whether the problems found in this bachelor thesis are structurally or just an effect of the Covid-19 virus.

8.4 Advice towards Rijkswaterstaat

In this last Section of this bachelor thesis, the advice for Rijkswaterstaat-Oost is written. The advice is based upon the results and analysis of this bachelor thesis, written in Chapter 5 and 6.

The most obvious improvement point encountered during this bachelor assignment was the fact that the NOV department did not receive structured feedback on their actions and goals they set. The performance dashboard that is in construction might be the solution to this problem, mainly because the results of certain goals changes can be monitored through the dashboard. However just creating a dashboard will turn out to be insufficient. A more cultural related change should happen to convince the employees at the NOV department of the necessity of reflecting on the goals they set for the whole chain. Next to that some guide should be offered about how to analyse the dashboard or a whole another information flow should be set up from the A-AM to the NOV department. This information flow could for example be a document filled with feedback about vaguely defined or unrealistic goals and the results setting a certain goal had on the asset.

A second improvement point might be the information flows between the “ObjectDeskundige”, PPO and the Contractor. The role of the OD is now formulated as tactical, however the OD is right now functioning as the source of operational information for the operational departments. This makes for a big contrast and inefficient flow of information in the asset management-chain. An information flow that should instead be implemented is information about the tactical decisions that have been made. By sharing the tactical decisions and the reasoning behind them it becomes clearer for operational layer what the focus point of Rijkswaterstaat-Oost are and why certain maintenance is conducted. Overall, this will increase the effectivity of maintenance, because the Contractor and PPO are also thinking about ways to improve the goals tactical and strategical departments have set.

Some general improvement points for the information flow between departments are the frequency, dynamicity and initiators of information flows. Overall information flows are slow, static and the information flow has to be pushed by the sender to the receiver. By making information flows overall more frequent and dynamic the whole asset management-chain will become more flexible and dynamic as a whole. Therefore, it becomes easier to steer on unexpected events and changing goals for the chain. Next to increasing the frequency and dynamicity, the information flow initiative should generally change from the sender to the receiver. By making the receiver responsible for the information flow, the chances that the actual necessary information is transferred increase a lot.

Both these proposed changes are not easy to implement or change overnight, these changes should be slowly implemented and set as a clear goal for the asset management-chain.

Overall change does not happen overnight, especially at bigger organisations like Rijkswaterstaat. The main priority for the coming period should be integrating the performance dashboard and solving the biggest problems in the information flow structure. The two problems that would yield the biggest reward when solved are the feedback on the goals the NOV department makes and the information flow from the “Programming Creation” to the “Contract Execution” sub-processes. Therefore, the advice is to start improving these flows, after which a gradual process of improvement for the asset management-chain can be started.

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