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Increasing the quality of information used in office IT applications by developing a Data Management System and Dashboard

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Management summary

Introduction

This research has been conducted for an organisation that wants to shift their focus towards an IT-driven business strategy, so they can keep up with the rapidly changing world of IT. The development of new IT can be a safety threat for the organisation. Hence, they want to improve their current office IT landscape and invest in new secure IT solutions. Therefore, they first need to simplify and reduce the diversity of information and improve the information management skills of their employees. The first step is to improve the insight and overview of data and information by collecting and visualizing management information.

Problem description and motivation

Within the organisation there are different types of IT applications. The problem arises in the four biggest applications of the common IT used by the organisation, these are: Network drives, SharePoint DWR-D, SharePoint PaaS, and MS Outlook. The problem is that the organisation generates a significant amount of data and information, which is stored at more than 10 million different storage location divided over the four applications. This causes challenges in assessing the quality of information used in the office IT landscape. Assessing the quality of information allows employees to improve their information management skills.

The decrease in information quality, is caused by the lack of management information, information management skills and the large amount of unstructured information. This results in employees spending too much time searching for information, negatively impacting work efficiency. This problem has prompted the organisation the question whether it can increase the quality of information used in the office IT landscape.

To address this issue, the organisation is taking steps to improve employee's data management skills by collecting and visualising metadata to gain insight and overview of its quality of information. A dashboard tents to be a good solution as it can provide a data management system (DMS) to structure the metadata and give insights about the quality of information. Problem is that quality is not easy to measure, therefore we divide quality into three categories, namely actuality, reliability, and compliance (ARC) of information:

- The actuality of information is the aspect of maintaining accurate and reliable information from a trustworthiness source or author (authority of information) by identifying popular information topics and the current version of information.
- Reliability refers to the validity and authority of information, based on the connection between the information and its source. Minimizing the distance between information and its source and reducing the number of contributors improves the reliability of information.
- Compliance refers to the adherence of information used in the office IT landscape to the information management rules (IM-rules) set by the organization, which ensures the quality of information by validation.

This leads to the main research question:

"How can a dashboard be designed to help the visualization of managements information and increase the actuality, reliability, and compliance of the office IT landscape?"

Approach

In this research, we utilized the Design Science Research Process (DSRP) to design a dashboard and DMS to visualize key performance indicators (KPIs). Before designing anything, we first conducted a context analysis of the organisation and its stakeholders and reviewed existing literature on dashboard design and KPIs. This allowed us to identify the goals, requirements, and limitations but also a set of guidelines for not only the dashboard but also for determining the KPIs. In the second step we utilised the goals, requirements, limitations and guidelines to define the KPIs. The list of KPIs is used for determining which metadata is needed to calculate the KPIs. Lastly, we used Power BI to make a DMS, based on the metadata we identified, and to design and build the dashboard. After the first dashboard design, we conducted a questionnaire and interviewed the stakeholders about the efficiency and usability of the dashboard. We improved our first design by using the result of the questionnaire and interviews.

Result

During the research we developed a dashboard that successfully measured the quality of information used in the office IT landscape. To achieve this result, we can see in Table 1 the sets of KPIs we developed for each category. These KPIs are calculated and visualized with the use of placeholder data. We concluded that the organisation has not all metadata available. To compensate for the missing metadata we generated placeholder data based on the characteristics of the real situation. The placeholder data allowed use to fill the dashboard and make a DMS that can be used by the organisation as a framework.

Table 1: Information quality categories and their KPIs.

Actuality	**Reliability**	**Compliance**
Most consulted information topics	Employees with most final edits	Orphaned information
Duplicate file names	Number of storage location for a Hotspot	Number of files saved at the wrong place
Emails sent with attachment	Number of persons involved with a Hotspot	
Version indication used in title		

Each KPI is based on a set of requirements and guidelines. Together with their visualisations on the dashboard and the information tooltips the employees are able to analyse the relationship between the KPIs and their categories, as well as between the categories and the overall goal. Figure 1 shows the final design of the dashboard.

The dashboard and DMS offer a framework for the organisation for when all the metadata will become available. The dashboard provides a solution for the organisation to increase the actuality, reliability, and compliance of information by giving employees a better insight on the available metadata and thereby increasing the information management skills. This all leads to a better work efficiency and reduces the average time spent searching for information.

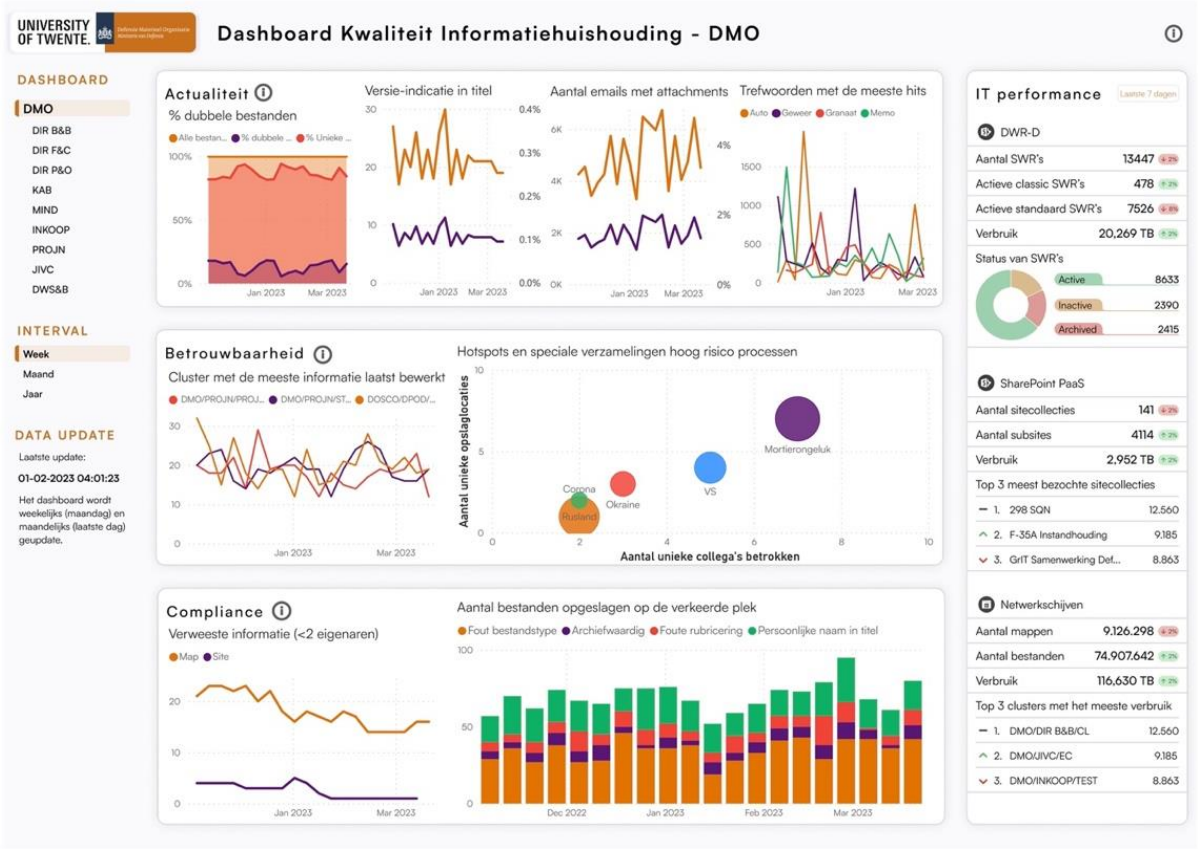

Figure 1: Final dashboard design for measuring the quality of information used in office IT applications.

Recommendations

In this research, we identified several steps that we recommend the organisation to undertake to increase the effect of the dashboard. Therefore, we have the following recommendations for further development:

- *Begin the implementation of the dashboard.*
  We recommend beginning as early as possible with the implementation of the dashboard within the organisation's digital environment, in order to get employees familiar with the dashboard as soon as possible. Therefore, we suggest the following implantation plan:
  1. Rebuild dashboard design in Power BI within the organisation's environments (2 weeks).
  2. Get access to Power BI publication server and set-up scheduled refresh and security levels (1 week).
  3. Implement already available metadata into Power BI's DMS (2 weeks).
  4. Publish dashboard with partly real data and partly with placeholder data so employee can get familiar with the dashboard (1 week).
  5. Start gathering and implementing the missing metadata into the DMS and dashboard (3-6 months).

- *Conduct a follow-up survey on "Survey Information Management, a Baseline."*
  We recommend conducting a follow-up survey not earlier than six months after the implementation and release of the dashboard to assess contribution to possible improvements of the quality of information used in the office IT applications.

- *Periodically evaluate and improve the KPIs.*
  We recommend that the organisation at least every two months or after a significant change in one of four office IT applications, evaluates and improves the KPIs to ensure that the dashboard and its goals remain relevant.

- *Periodically evaluate and improve the dashboard design and functionalities.*
  We suggest that the organisation expands the dashboard's functionalities and periodically improve its information content, design, and features during and after implementation, to improve the user experience and enhance the dashboard's efficiency and effectiveness. This can be combined with the periodical evaluations and improvements of the KPIs.

Based on the experience of working at the organisation and the research we recommend the following future research:

- *Big data collection in the office IT landscape*.
  The organisation needs to collect and store a large amount of metadata. Therefore, it can be beneficial to research effective techniques for managing big data.

- *Research on the CIO-office and the use of information management*
  We recommend researching the use of management information in big organisations, like the Ministry of Defence, and develop an information management strategy for the organisation's CIO-office.

Preface

Dear reader,

This is the research I have written to complete the bachelor assignment for Industrial Engineering and Management. Conducting this research has been one of my biggest challenges and so I am thrilled to present you the findings of my research.

Firstly, I am grateful for the support and assistance from my colleagues at the Ministry of Defence, who gave me the freedom to combine work and study. A special thanks to Mathijs van der Brugge for his valuable feedback and guidance in solving issues during the research and all the positive feedback.

Secondly, I would also like to thank my girlfriend, family, and close friends for their support throughout this journey. Their motivation kept me going during difficult times but also gave me the change to relax.

Lastly, I would like to thank both my supervisor from the University of Twente, Ipek Seyran Topan and Abhishta Abhishta. Ipek, as my first supervisor, played a significant role in completing this research. Thank you for your time and effort in guiding me through the research process and helping me finish. The weekly meeting where a pleasure and did not only help with the research but also with how I was doing. Thank you Abhishta Abhishta for the feedback as my second supervisor.

Roy Maaskant,

Enschede, March 2023

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1 Introduction

For completing the bachelor industrial engineering and management, I performed research at the Dutch Ministry of Defence about an industrial engineering and management related topic. The Ministry of Defence is always active with national and international operations and missions. The current situation worldwide and the ongoing thread of (cyber-)attacks makes it that all information regarding the ministry can be used as an advantage for the enemy. Therefore, we need to be aware that all information and data resulting from the research can be sensitive. To ensure integrity and misuse, we make use of placeholder data for all the values of sensitive information and data in the research.

This chapter will provide a description of organisation in Section 1.1. Then we have a brief look at the scoop of the research and define the problem in Section 1.2. After that, we defined the problem, we set up sub-questions in Section 1.3 and the problem-solving approach in Section 1.4. We end this chapter with the deliverables in Section 1.5.

1.1 Organisation description

In Section 1.1.1 we will have a look at the structure of the organisation and for which part of the organisation we are going to perform the research. Followed by Section 1.1.2 where we discuss the origin of the problem, and we end with the involved stakeholders in Section 1.1.3.

1.1.1 Information about the organisation

The Dutch Ministry of Defence is a complex organisation build out of 7 departments. Figure 1 shows the organisation structure including the 7 departments and the political, official and military leaders. The 4-armed forces are the Royal Netherlands Navy, Royal Netherlands Army, Royal Netherlands Air Force and Royal Netherlands Marechaussee. This group is responsible for getting materials and military personal mission ready. The central staff composes Defence policies and controls the budget. Joint Support Command and the Defence Materiel Organisation have a supporting role. The joint Support Command has the focus on health care, food, and education while the Defence Material Organisation (DMO) focusses on production, maintenance, and sales of materials. Their goal is to provide the latest equipment for the armed forces. The bachelor research is conducted at DMO.

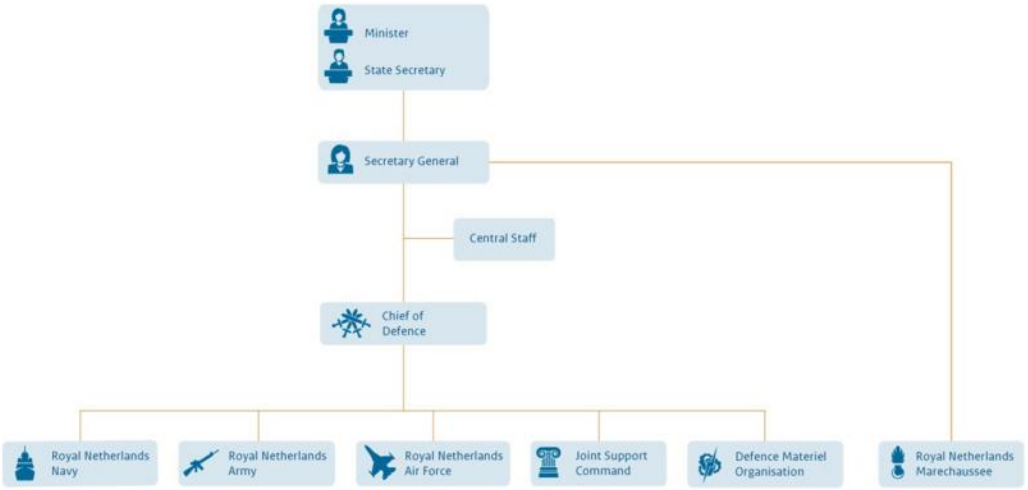

Figure 1: Organisation structure of the Ministry of Defence (Ministry of Defence, 2022)

The DMO has three responsibilities which all have the goal to make sure military personal can trust the equipment they use. They supply modern, robust, and safe equipment for the navy, army, air force and marechaussee. During the whole lifespan of the equipment the DMO arranges the purchase, the maintenance, and the disposal. The armed forces are responsible for the execution and the logistical planning for further distributing and maintenance. The DMO puts a create deal of their time in technical innovation together with research institutes like universities and leading industries. Together the continually try to improve IT and the working conditions of the military personal.

As seen in Figure 2, DMO is further split into (staff)boards. The problem owner and the majority of the stakeholders are situated at the board of management & business operations (bestuur & bedrijfsvoering). This is the board in which I am currently employed and conducting this research. We are a staff department and are, among other things, responsible for managing the organisation from the Strategic Map DMO (see Figure 3). With this research there are more parties from different boards involved. We will further elaborate them in Section 1.3 stakeholders.

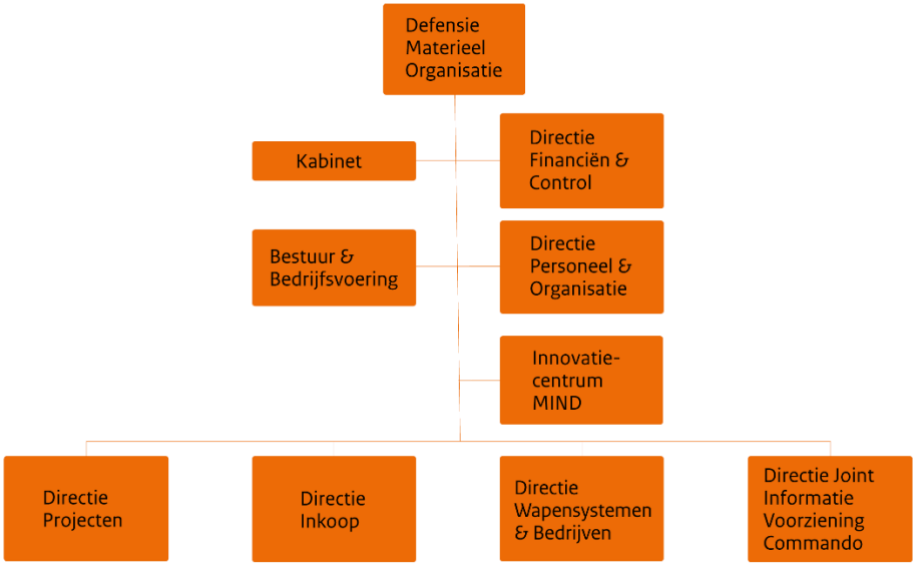

Figure 2: Organisation structure of the Defence Material Organisation (Ministry of Defence, 2022)

1.1.2 Background of the problem

Over the last years, the ministry is trying to shift their attention more and more towards IT driven strategy. The shift to IT and the importance of it is reflected onto the strategic chart. In the outer ring we see that information revolution, exponential developments and the relationship between people and machine have influence on the way the organisation does their work. The DMO employs approximately 5,500 people. Plenty new applications have become available in which you can create, store, use and archive information and data. In recent years, the rate in which new application become available or old ones are updated has increased. This is because of the rapidly changing world in the field of IT. To ensure a protected and reliable IT landscape we must make sure we are up to date.

Figure 3: Strategic map DMO (Ministry of Defence, 2020)

Being up to date means constant data migration form old to new platforms and generation of new data and information from old and new applications. All this information is used to improve data-driven working within the organisation. The problem is the DMO generating and stores so much data and information that it is difficult to make a judgement about the quality of this information. They are not aware if the information is actual, reliable, and compliant (ARC) to the information management rules (IM-rules). At DMO alone, there are 160 million different files located in more than 10 million different places (Brugge & Ministry of Defence, 2019). DMO is on the verge of a digital transition to simplify/lessen the diversity and increasing the information management skills. The first step they are tacking is to improve the insight and overview of data and information by collecting and visualising management information.

1.1.3 Stakeholders

Because the research is about something the whole organisation uses, many stakeholders are involved. In Appendix A we can find all the different stakeholders and the influence, interest and input they have on the research. The stakeholders at the top have the biggest impact and interest. Most stakeholders at the bottom will only be monitoring the result of the research.

1.2 Problem definition

For this research we narrow the scope down to the office IT landscape of the DMO. This contains all applications that are used for everyday work and (online) collaboration. The most used office IT applications are found in the Table 1. Data gathered from weapon systems and enterprise resource planning (ERP) systems will not be included in the research. In Section 2.1.2 we further elaborated on the scope of the research and the included applications.

Table 1: Most used office IT applications at DMO

Office IT	Use
MS SharePoint 2013/2019	Local server based collaborative platform used to work together on projects and is document management system (DMS). We have 2 different versions called "SharePoint PaaS" and "DWR-D". Where the last one is a heavily modified version of the standard.
Xpost	Archive system used for storage of formal documents like memorandums.
Network drives	Drives that are in the windows file explorer. Mostly used for archiving big amounts of data (e.g., old SharePoint sites), personal storage and big/exotic file formats.
Outlook	Used for mail, calendar, and contacts. Mail is the most used method for sharing information.

Because these applications are used every day, they create enormous amounts of information. Collecting and presenting management information is already done with some application but never for the whole office IT landscape. In the current situation, there is no insight on the quality of information. Many documents are duplicated or not the latest version or have names that are not compliant. In Appendix B we can see the result from a survey about the state of the DMO information management. These result show that the ARC is in a general bad state and employees struggle with managing their data in normal working conditions. 52% of the respondents mention that information is hard to find. Approximately 45% of the respondents finds that there are too many storage options. The result is a decrease in productivity. This confirms that the amount of information in circulation is a big problem for the quality of information. To measure the quality we focus on the actuality, reliability, and compliance (ARC) of information. By this we mean the following:

- The actuality of information is the aspect of maintaining accurate and reliable information from a trustworthiness source or author (authority of information) by identifying popular information topics and the current version of information.
- Reliability refers to the validity and authority of information, based on the connection between the information and its source. Minimizing the distance between information and its source and reducing the number of contributors improves the reliability of information.
- Compliance refers to the adherence of information used in the office IT landscape to the information management rules (IM-rules) set by the organization, which ensures the quality of information by validation.

Cluster management and operations want to increase the actuality, reliability, and compliance of information used in office IT application by improving the availability of management information. Therefore, this is seen as the action problem with as main research question:

"Can DMO increase the actuality, reliability and compliance (ARC) of the office IT landscape?"

1.2.1 Problem cluster

To find the possible core problem for the action problem, the actuality, reliability, and compliance of the information in office IT applications is too low, we had several meetings with different stakeholders for information to get a full view of the case. With the information we did a brainstorm with Mathijs van der Brugge and wrote down a list of problems that are associated with the action problem. From there we build up the problem cluster by sliding the different problems around and linking them together. Then we found a possible core problem (Heerkens & Winden, 2021).

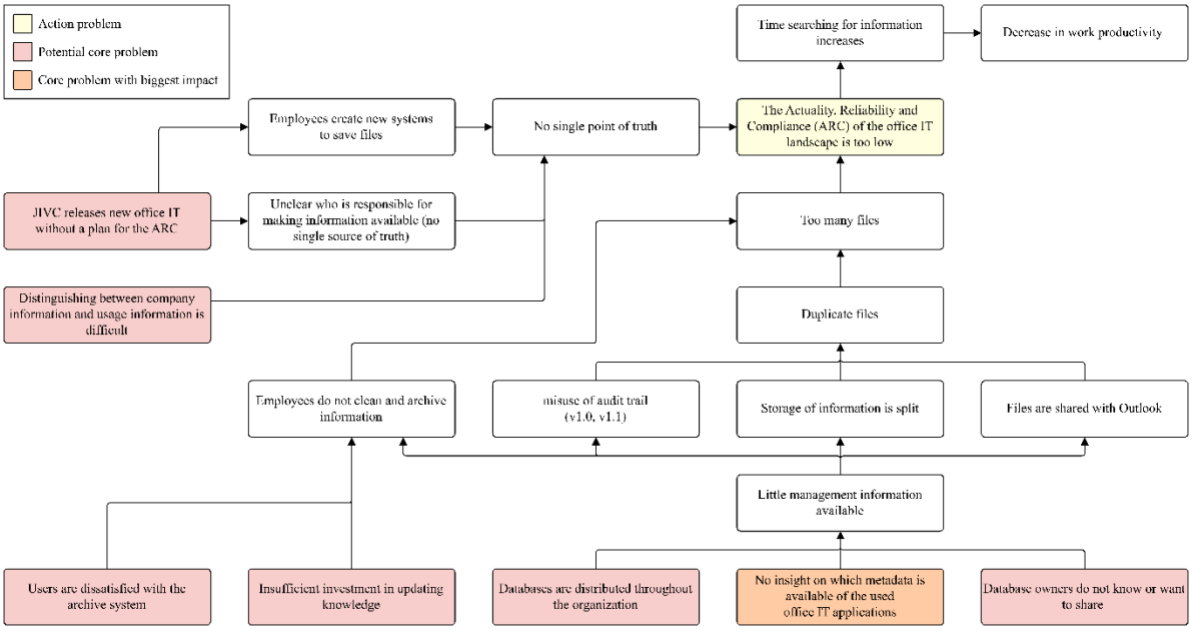

Figure 4: Problem cluster

In Figure 4 we can see the problem cluster with as starting point the action problem. We can divide the problem cluster in sections, and we will discuss each. First, we look at the problems that are affected by the ARC of the office IT landscape being too low and after that look at the problems that causes the ARC to decrease.

A direct result of the low ARC in office IT is the increase in search time for finding information. The low ARC means that documents are not up to date, possibly have duplicates at different storage locations which means no single point of truth and document names are not compliant to the rules. All this has an influence on how long employees are searching. A direct affect is that the productivity decreases because valuable time is lost, and employees get frustrated and sloppy when searching.

There are 2 problems that have a direct influence on the low ARC. The first one is that there is no single point of truth. When there is no single point of truth, it is very hard to know if employees are working with company information, documents that are finished and validated, or with usage information like drafts and unfinished documents. JIVC also releases new office IT without having a plan for the ARC. B&B cannot check all the information that the application produces or how it is used. The users are not aware they create new systems and places too store information and JIVC does not know who needs to be responsible. A big problem is that the release of new office IT increase the overlap between applications and there for makes it difficult to know what is the truthful source.

As mentioned in 1.2 there are too many files, and they have a big impact on the ARC. This is a problem because it makes it hard to monitor the ARC of documents and office IT that are important for the organisation. A way to overcome this problem is decreasing the number of files by removing duplicates and letting employees clean their unused files and archive important information. However, it turns out that employees have insufficient knowledge on how to keep their digital office clean, use the (not-user friendly) archive system “Xpost” and on how to archive a SharePoint site after the project is finished.

At first, decreasing the number of duplicates files looks like a hard problem so solve for the organisation because it gets influenced by three major problems. However, these three problems all are due to the low number of management information that is available about the documents and the different office IT applications. This makes it difficult for the managing boards to specify where the duplicates files are coming from. When this management information is more available, managers can coach employees more effective about data management. Sharing files with Outlook, different storage places for the same kind of information and using audit trail in the file name are the three biggest reasons why information is (unintentionally) duplicated.

Furthermore, the low amount of management information of the office IT landscape has a big impact on the number of files but also on the action problem in general. Without good management information it is near impossible to monitor the different aspects of the office IT landscape, how employees work with these applications and the habits that they have to do with data management. The amount of management information is restricted by the number of metadata there is. The metadata of the application can be used for key performance indicators (KPIs) used in Microsoft Power BI or other business intelligent visualisations. The problem is that databases are distributed throughout the organisation and the owners do not always want to share this information. This could be because of privacy rules or just the lack of knowledge on how too. It is not known within the organisation which metadata is stored and available.

1.2.2 Core problem

Core problems are not affected by other problems and have the highest impact on the whole problem cluster when being solved. We need to determine which core problem has the biggest input on the action problem and will give the most information for solving the research question (Heerkens & Winden, 2021). From the problem cluster we can derive 7 potential core problems. The potential core problems that direct and indirect influence the problem of no single point of truth have a moderate influence on the action problem. The research can only have a small impact because JIVC is another managing board with their own plans and goals. The potential core problems "*Users are dissatisfied with the archive system*" and "*Insufficient investment in updating knowledge*" both have running improvement projects. The potential core problems causing the low number of available management information will have the biggest impact when being solved because managements information is such a big part of monitoring and improving the ARC. We choose the core problem based on the expected effectiveness and efficiency:

"*No insight on which metadata is available from the used office IT applications.*"

Solving this core problem is most effective for the action problem. It has an almost direct correlation between no insight on the metadata of documents and the ARC is too low. When we have no insight on the metadata of documents it is not possible to monitor the quality. With metadata we can measure different aspects of quality, specifically the actuality, reliability, and compliance. The organisation will have new insight of information about possible duplicates, see where data is moving too and which applications are growing, check if a document uses an illegal name convention or learn how employees share information and documents. This can all be accomplished by gathering and visualising metadata from office IT applications. This information will be used in a data management system (DMS) which can be used for determining different KPIs for a dashboard.

The problem started to stand out when board B&B and JIVC started the migration project of SharePoint 2013 to 2019. Insight in the active SharePoint sites was needed for determining a plan of

approach. Project owners struggled to gather and visualize metadata and therefore were not able to use the needed management information to run the project. No clear data owner was assigned, and many obstacles occurred. There is also nobody specialized in data visualisation and the small amount of visualization that was available was not up to date. For current/future projects and the continuous business operations it is important that the know which metadata is available, how we store it (DMS solution) and how we visualise it.

In the current situation there was only a small amount of metadata available form two office IT applications and there was no insight on which metadata still needs to be gathered to measure the KPIs and design a dashboard. As a result, each day employees were spending too much time searching for information (Appendix B.2). The aim is to reduce the average time employees are searching for information per day with 50%. We closed the gap between the norm and reality by selecting KPI to measure the different quality aspects of information (Section 4.1), determining which metadata is available and which metadata still needs be gathered (Section 4.2), and by visualizing the data using a DMS (Section 4.3) and dashboard design (Section 4.4).

Before the gap between the norm and reality can be closed, we define indicators that make it able to measure the norm and reality. A recent survey, earlier mentioned above and can be found in Appendix B, critically examines the current state of the information management of the DMO. These result not only show the time lost for searching information, which has a direct correlation with the productivity of employees, but also indicate how employees are working. The survey has several topics like "*How do you share information?*", "*How do you store information?"* and "*how do you search for information?*" which all give an indication on how the employees work and why search times are so high.

Using the before mentioned aspects of the core problem we can determine that the best solution for solving the core problem is making a dashboard design with KPIs to measure the quality of information based on the actuality, reliability, and compliance. The goal is to improve the amount of management information available and increase employees' information management skills. This leads to the following research question of the core problem:

"*How can a dashboard be designed to help the visualization of managements information and increase the actuality, reliability, and compliance of the office IT landscape?"*

1.3 Research questions

The core research question cannot be solved directly. Therefore, we divided it in smaller sub research questions. With the following knowledge problems, we researched different aspects for visualising management information by providing a framework for a DMS and dashboard design. With the literature research and testing different methods we found answers and gather information for the final solution. In Appendix C we will discuss the used data gathering and processing methods, possible limitations, descriptive or explanatory and why this knowledge question is useful for solving the research question.

It is necessary for the table in the Appendix C to clarify the difference between an explanatory and descriptive knowledge question. Explanatory knowledge question can be defined as the "why" and "who" questions. They are often used when there is not much information available (George, 2022).

Descriptive knowledge question can be defined as the “what”, “where”, “when” and “how” question. The goal is to describe the topic in an accurate or systematic manner (McCombes, 2022).

Sub research questions:

1. What is the current situation on availability of metadata and the corresponding management information?
2. Which aspects should be kept in mind when determining KPIs for monitoring the quality of information used in office IT applications?
3. What are the requirements for a DMS?
4. How to design a dashboard?
5. What KPIs are useful for monitoring the quality of information used in office IT applications, and how to measure these with the available metadata?
6. What is needed to implement the DMS and dashboard within the organisation?
7. Can the DMS and dashboard improve the availability of management information and thereby increase available management information and improve employees’ insight on the quality of information?

In order to conduct the research in a successful manner, different theoretical frameworks were taken into consideration. These theoretical frameworks show theories for solving different parts of the (sub) research questions. These different theoretical frameworks can be used to tie existing methods, models, and theories together to form the base for the arguments answering the research (Vinz, 2022). In Chapter 2 we give answer to the first 2 research question. Followed by Chapter 3 were we performed two literature researches to answer sub research questions 3 and 4. Question 5 and 6 are answered in Chapter 4. The last sub research question is answered during the evaluation and conclusion in Chapter 5 and 6.

1.4 Problem solving approach

For this research we used The Design Science Research Process: A Model for Producing and Presenting Information (DSRP) since the main goal is to identify KPIs and build a dashboard for measuring and improving the quality of information used in office IT applications. This is a form of producing and presenting information with the use of design process where we use existing knowledge to come up with a solution for the research question of the problem owner.

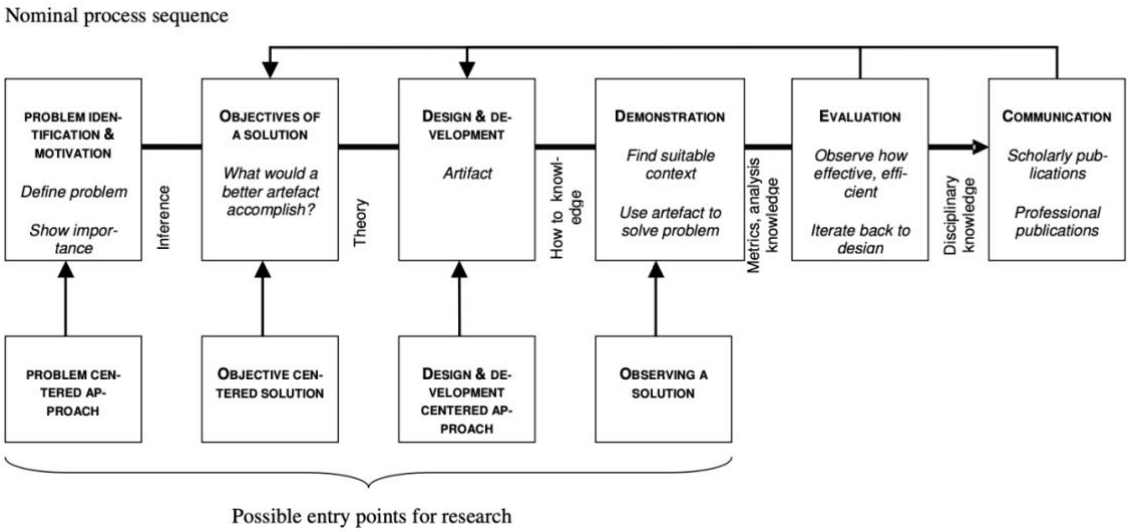

Figure 5: Design Science Research Process (DSRP) model (Peffers, 2008)

As seen in Figure 5, the DSRP is split into 6 different phases. The first 4 phases are all possible entry points for the research, but this research starts at the beginning of the model. Phase 1 (Chapter 1), problem identification & motivation, is done with identifying the core problem and the matching research question. This is supported by the problem cluster. In this phase the organisation, as problem owner, is important for the information it can provide about the action problem and is able to validate the core problem. A couple of meeting were required to know what the required resource are, the current state of the problem and what impact a solution can have. In phase 2 we defined the research design and answered the sub research questions about the current situation on the availability of metadata and the determined the limitations and requirements for KPIs that monitor the quality of information (Chapter 2). In phase 2 we also performed two literature researches to answer the sub research questions about the DMS, dashboard design and KPI selection (Chapter 3). In phase 3 (Chapter 4), design & development, we answered the sub research question about which KPIs are useful for monitoring the quality of information, data collection and and implemented these into the dashboard design. The implementation of the dashboard into the organisation is answered in phase 4 of the model (Chapter 4). In phase 5 (Chapter 5) we validated and improved the KPIs and dashboard design and phase 6 (Chapter 6) we answer the last sub research question and the main research question and presented the results to the university of Twente, the problem owner, and the stakeholders.

1.5 Deliverables

The research has three main components and therefore the research provides the following deliverables:

- A framework for a DMS that contains available and unavailable metadata.
- List of KPIs for measuring the quality of information used in office IT applications.
- Functional dashboard design.

2 Context analysis

We start our research by collecting more information about the background of the organisation and the current situation of the problem. The focus in this chapter is to retrieve this information so we can determine a list of requirements and limitations based on the organisation and the most important stakeholders. This is the basis for the decision made later in the research. First, we look more at the current situation in Section 2.1. After this we will make a business process model based on this current situation in Section 2.2. In Section 2.3 and 2.4 we analyse the survey “information management, a baseline” and an interview with 2 of stakeholder to retrieve information about the requirements and limitations.

2.1 Current situation

As described above, we will first look at the current situation and the different aspects that have an ensured this current state of the available management information. We will research how this organisation deals with the low ARC of information and how this influences the way of working and critical business operations. The research strategies for are observations and literature research of organisation documents. We research three aspects of the current situation so that we have broad overview with is important for composing the list of requirements and limitations. The background information and lists can be used later for the design of the dashboard and DMS.

2.1.1 Organisation analysis

There are currently 2 major projects at DMO that are aiming to increase the ARC of information and data or aiming to give more structure to the whole information management system. Let us first turn to the second project, the establishment of the CIO-office DMO.

CIO-office DMO

CIO or chief information officer can be generally defined as the chief director of all the information and data within an organisation. It encompasses all the information and data used in the office IT landscape and other application that produce information and data that can be used to improve the business.

At this moment the DMO is at the start of the establishment of a CIO-office. The CIO-office at the organisation has a different approach and structure than the “normal” CIO-office. The CIO-office is later implemented within the organisation because the need for a more information driven, and technology high quality armed forces increases. The CIO-office DMO Includes (almost) all parts of the information & information Technology domain used in the organisation (I&T domain). The I&T domain includes all information and data that the organisation generates, needs, processes, and uses to improve the digital defensibility and achieve its own objectives. This includes all employees, business processes, and technology within the organisation that contribute to these goals.

Figure 6: Organisation structure of the CIO-office DMO (Ministry of Defence, 2021)

Figure 6 highlights the four themes that are established for the whole Ministry of Defence and how the correlation is between them. The general idee is that under need the chief CIO and manager information planning and strategy there are two themes that are more familiar with the employees and are already integrated in the organisation. Those are manager Information Provision (IV) and manager Information Management (IM). Projected horizontally on IV and IM are the themes Information Security and Cyber (CISO) and Data & Data Sciences (CDO). These are less familiar subject for the employees because the activities of the CISO happened more in the background and data sciences is a whole new subject for the organisation.

The implementation of a CIO-office in such a late phase is difficult because there are many existing policy frameworks, laws, and instructions that have an influence on the I&T domain. With this CIO-office the DMO tries to improve the I&T domain by improving the organisation structure for this line of business and giving the current business management consultants, data analysts and information management officers more influence and mandate. This last part is very important because it decreases the time and steps it takes to implement new rules or innovations which is important for the rapidly changing data driven industry. In general, there are four main goals stated for the implementation of the CIO-office:

- A stable basis for continuous digital transition.
- Actual and reliable organisation information for Information-Based Action and Work (IGO)
- Being compliant for the i-domain and maintaining this.
- Efficiency and simplicity of the I&T application landscape

The CIO-office controls fundamentally the whole I&T domain. The exceptions are design and implementation responsibility for domain specific I&T. However, all common I&T (the office IT landscape) is fully within scope of the CIO domain. We will further elaborate the difference and the reasons why in Section 2.1.2.

Analysing and understanding the goals of the CIO-office gives us insight into the desired structure and processes of the information management at the DMO. This research and the deliverables are going to be an important basis for the CIO-office. Because the goals of the CIO-office and the full managerial

control of the office I&T landscape, the CIO-office can capitalise on the KPIs of the dashboard. The other way around this also implies. The DMS and the implementation of the warehouse can be taking into consideration with the planning, designing and development of the CIO-office. The CIO-office imposes no limitation or requirement just because it is in such an early phase, and it encourage this research to start with a blank slate.

B&B op Orde

The second project we mentioned in the beginning of this section is "B&B op Orde" (B&B in Control). The aim of this project is to increase the ARC of the information for the board of management & business operations (bestuur & bedrijfsvoering, B&B). This project has a different approach then the CIO-office on how to increase the ARC of the information. The aim is to increase the current knowledge and skills of the employees about their own information management. To achieve this, the project is divided into four different consecutive steps:

- I-Knowledge
- I-Skills
- I-Quality
- I-Discipline

During these steps employees need to get a certificate to prove that they are up to date with their knowledge about information management (I-knowledge). After, they are put into small groups and get an intensive guidance on how to use this knowledge and develop the needed skill to keep their information tidy (I-Skills, I-Quality, and I-Discipline). Prior to testing their knowledge, they are provided with a set websites and documents with information about information management. One document is in particular important for this research. "Prescription information management digital office IT DMO" provides a set of basic rules and instructions on how to handle information at the organisation. It also covers some specific rules for certain (web) applications. These set of rules can later be used in the chapter where we choose the indicators for measuring the ARC of the information. Comparing the values of the indicators with the rules about information management makes it easy to validate if an indicator will be useful or not. Furthermore, these set of rules can support or explain certain limitations or validations for this research. The document has rules and instructions about the following topics:

- **Basic rules of information management**
  These rules are the foundation for information management. The basic rules always apply regardless of the activity you perform or the application you use.
  - **Create**
    The life cycle of information starts with the creation or compilation of information.
  - **Store**
    The way information is stored has an impact on the further life cycle of information.
  - **Use**
    From every employee can be expected that information is handled with care.
  - **Archive**
    Archiving is important to ensure that information can be found efficiently, sustainable, and easily.
  - **Applications**
    Which applications do you use for different task and how do you use them?

- **Specific rules**
  For some subject and application additional and more specific rules apply.
  - **Personal data**
    When and which personal data of employees is forbidden to use or share?
  - **Classification and marking**
    Information can have a level of classification or marking. These are determined and applied with special methods. In addition, each classification or marking needs to be handled differently.
  - **Signature**
    Instruction for digital signature.
  - **SharePoint 2013**
    Rules and instructions on how to apply information management in a SharePoint.
  - **Outlook**
    Rules and instructions on how to apply information management when sending emails and using the calendar.
  - **Intranet**
    Special sites for sharing corporate information.
  - **Internal regulations**
    As a government organisation, DMO must deal with all kinds of laws. The Ministry of Defence has internally translated these laws into applicable rules. The DMO refers to these rules as internal regulations.

2.1.2 Scope of the research

The CIO-office describes a clear scope which can also be applied to this research. As stated earlier in 2.1.1, the scope of activities of the CIO-office are wide and they cover all I&T and IT that the organisation uses. As seen in figure 7, this is divided into four categories. However, for information management there is a constraint. Designing, publishing, and information management is for specific business operations the responsibility of the process line and not a responsibility of the CIO-office. Therefore, the IM manager coordinates with the process line about which information should be stored in which systems and which information should possibly be included in the common IV. Mainly to avoid duplications or contradictions in business information and to avoid doubling in management burdens. Because of this, the focus of the CIO-office and therefore also for this research is on management information of common I&T.

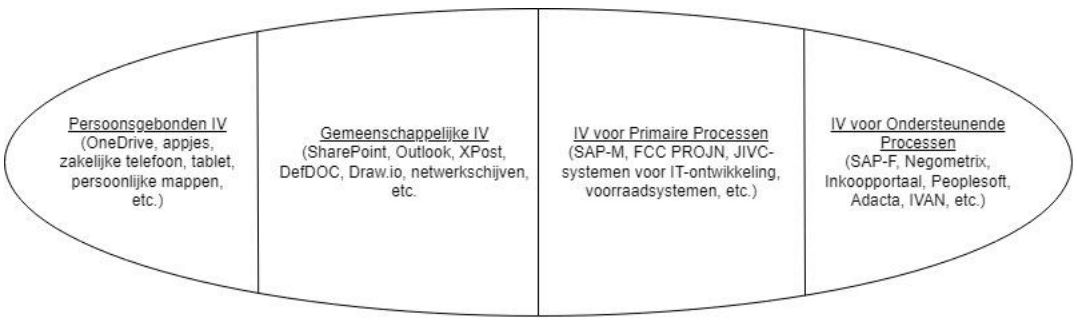

Figure 7: Different types of IT used at the organisation.

However, the scope of common I&T is still way too broad for this research and needs to be more specific. Therefore, we are going to specify the focus group for the dashboard but first we are going to set the goals of the KPIs. The problem owner stated that there are two options for the kind of information that the indictors can produce about the office IT landscape.

1. General management information about the office IT landscape
2. Quality of the information used in the office IT landscape.

The first option is focussed on general information like the amount or size of sites or documents used in an application or in fact all I&T. This can be useful for specific projects that are focussed on migrating information like the SharePoint 2013 to 2019 project. However, this will not cover the whole scope of the research question. The research question focusses on improving the actuality, reliability, and compliance of information and therefore option 2 is more in line with the research question. So, the focus for the key performance indictors will be on measuring quality and because of this the scope of this research is narrowed even further.

When we need to determine what the focus group is for the dashboard, we first need to look at the stakeholders and their interests in the research. From the stakeholder analysis in Appendix A, we can see that Mathijs van der Brugge, the CIO-office, the IMO's and the chief officers DMO are the focus groups of the dashboard. These 4 stakeholders all have a kind of managerial function and play a role in improving the information management at the organisation. Because of this, these 4 stakeholders can benefit from the dashboard by using the information, that is focussed on the quality of their information, to improve their department inside the organisation as well as use this information to support decision. Hence, the dashboard must have the focus on making the indictors useful and easy understandable for employees with managerial functions but also use combination of indictors to show dependencies that can support decision making.

2.1.3 The IT application landscape

In the previous section we talk a lot about the office IT landscape, I&T, and the common IT. But how are these applications connected with each other and how are they used? In Figure 8, application who are used in the office and are in the category common IT are placed in the life cycle of information. The applications mentioned in the visualisation constantly change therefore we will not dive in to deep. Nevertheless, it is good to look at this visualization because it can help to get a better understanding of the connection different application have to other applications and how they are used in the information management process.

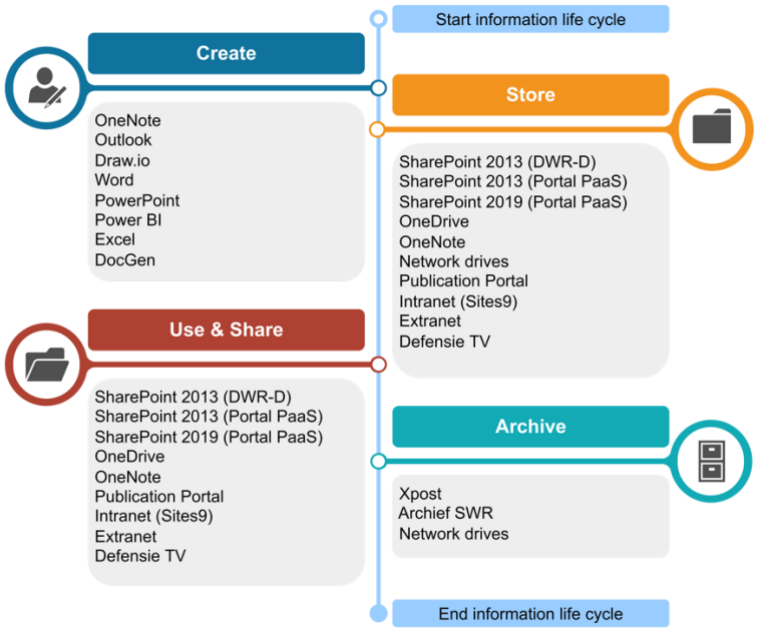

Figure 8: Office IT applications structured in the life cycle of information.

In Figure 8, we see that the life of information starts with creating something. The scope of this research is about common IT; hence we see that mostly MS Office application are used for creating information. Apart from this, the ministry of defence also has some application made by their technical department (JIVC). A good example is DocGen. This application is used to create formal documents like memorandums.

The created information needs to be stored. When this information is meant for projects where several people work together at the same time, the information is stored on SharePoint sites. At the organisation these are called: standaard SWR (DWR-D), Classic SWR (DWR-D) and Portaal. When information is for personal use, application like OneDrive and OneNote are most common. For more general static information, like news or official publications, Intranet and publication portal is the application of choice.

The use & share part is bit vaguer. The reason is that information can be used with applications in the create section. In particular the applications of MS Office. It goes without saying that these are the most used application to modify information. On the other hand, when the information is modified, we can see this as creating 'new' information. Therefore, we refer by 'use' more to reading and using information for corporate tasks. This is possible within SharePoint itself. The web versions of MS Office applications are accessible via SharePoint itself, hence it is the best option for project to store, use and share information.

The last stage in the information life cycle is archive. During the creating stage of information and SharePoint sites is determined how long it should be stored. Because of the importance or the classification this is different every time. Formal information is archived in Xpost. Archive SWR and network drives are informally used to archive. Sometimes information is archived their first before is goes into Xpost.

2.1.4 Metadata

Figure 9 is an expansion of Figure 8 that we elaborated in the previous section. With this visualization we add the metadata, and the metadata flows to the whole information life cycle with the office IT applications (common IT). This helps to give an insight on which metadata is available now and what kind of metadata still is missing. This is important because the metadata is the input for the deliverables (SOLL situation).

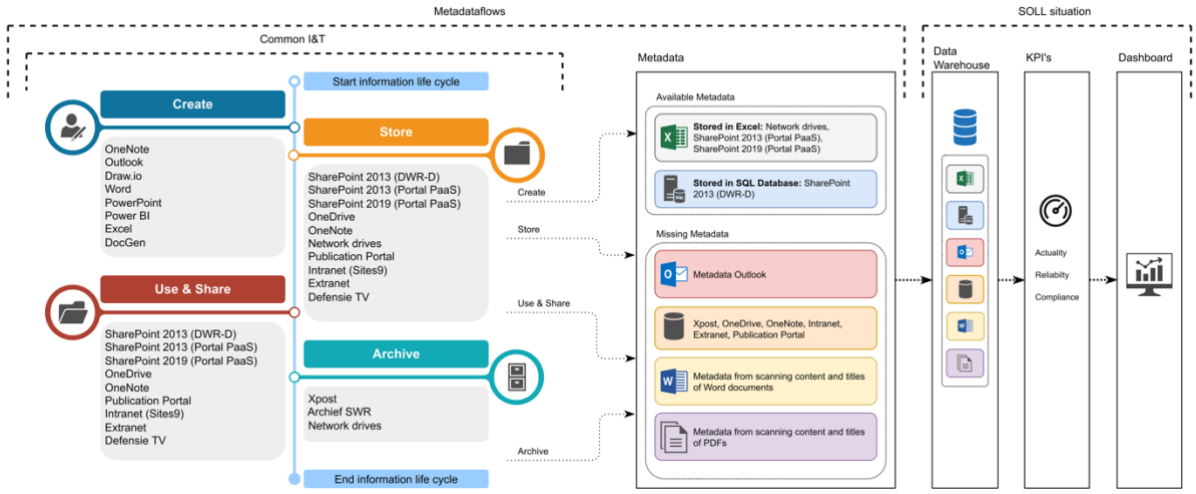

Figure 9: Metadata of common IT

The section metadata gets its information from all the four steps of the information life cycle (create, store, use & share, archive). There are different types of metadata from this information life cycle stored within different types of databases. To improve the actuality, reliability, and availability of metadata during and after the research it is important come up with a new DMS. The basic principle of this DMS is to gather all metadata of common IT in one centralised data warehouse. This includes the already available metadata as well as possible extra metadata that is now missing. Hence, the data warehouse needs to be easily expandable. In addition, the data warehouse will remove the different types of databases which improves reliability and compatibility with other applications like Power BI.

Available metadata:

- Excel
    - Network drives
        - Structural metadata (e.g., name of files and folders, name physical hard drive)
        - Technical metadata (e.g., size of files and folders, amount until hard drive is full)
    - SharePoint 2013 & 2019
        - Descriptive metadata (e.g., name of site, URL)
        - Technical metadata (e.g., number of subsites, size sites and subsites)
        - Rights metadata (e.g., name of site owner)
- SQL database
    - SharePoint 2013 (DWR-D), classic and standaard sites (SWR)
        - Descriptive metadata (e.g., name of SWR, changes in basic lay-out and site description)
        - Structural metadata (e.g., URL, file, and folder location)
        - Technical metadata (e.g., size of SWR, last modified, number of hits)

- Rights metadata (e.g., archive information SWR, classification, login data of owners and members of SWR)

What influences the metadata collection

For this research there is a limited number of metadata directly available. A consequence of this, is that the data warehouse does not contain all the potential valuable metadata as seen in the SOLL situation. The data warehouse has an influence on the KPIs and the dashboard because it is the basis (see Figure 8).

Collecting the missing existing and new metadata can be a problem. Within the organisation the corporate culture is not so willing to share information. There is no clear explanation why this is, but a couple of reasons could be:

- *Ignorance*
  Data owners do not know how they can share information in a correct way or are not able to maintain the data available.

- *General Data Protection Regulation (AVG wet)*
  Employees are scared they accidentally share privacy sensitive information, or they do not know to how to handle this kind of information.

- *Data leaks*
  They want to prevent that data gets to the wrong people. Most of the time they do not have an overview of who has (reading) permission to their data.

- *Laziness and anxious*
  Most of the time it is a form of laziness. They do not want to keep all employees that have permissions up to data about possible changes.

- *Anxious*
  Data owners do not like the idee of other people controlling what they are doing.

However, the problem owner, Mathijs van der Brugge, stated that this research should start fresh, and that the availability of metadata cannot be a limitation. Hence, collecting the missing metadata is out of this scope for this research.

2.2 Survey and end-user analysis

The Ministry of Defence has established the programme “Defensie Open op Orde” (DOO) which will coordinate the improvements in the period 2021-2026. Therefore, DOO combined the decisions of the parliamentary with the strategy chart of the organisation and DMO to set two goals:

1. Develop an information strategy (the establishment of the CIO-offices at the different departments)
2. Perform a series of baseline measurements about the current information management and strategies.

As a result of the second goal, a survey was conducted in medio 2020 about the current quality of the information and the knowledge of employees about office IT applications. In Section 1.2 and Appendix B we mentioned the key finidings of this survey. In this section we will not focus further on those result but shift more to the limitations and requirements based on the result.

The biggest part of the survey was made up of questions with pre-formulated answer choices where the respondents could choose from. Some of those question had an open-ended follow-up question where the respondent had the choice to provide feedback on their given answer to the closed question. In this section we will look at answers to open ended questions that are of interest for the research limitations and requirements. All employees and stakeholders are users of office IT applications and are responsible for their information management. These answers/result give a view of the user side. Not only will it explain the user’s behaviour but also what they find annoying about the current state of their information.

Suggestions for improving information management

The first question we look at is: Suggestion for improving the information management. The question has 7 pre-formulated answer options where the respondents were able to choose none or multiple answers. There was also an eighth options where the respondents were able to formulate their own suggestion for improving the information management. Below we will quote the most common answers and elaborate why they are interesting for the research. The result of the pre-formulated answers can be found in Appendix B.3.

There are 2 quotes that sum up most of the irritations of the user and substantiate why they struggle with their information management:

> *“Put the information at one place, and don't use 10 applications to store and archive information. That only makes it more complex and untraceable.”*
>
> *“A good document management system including version management. Clear agreements about meta-data (in connection with search functions), and workflow management for sending documents that require input from others.”*

From these we can conclude two important aspects why the information management is in this poor state according to the users. First, there are too many places to store information and second the search function overall and in application is poor. This result in not knowing were to store or find information which result in a negative impact on the actuality and reliability of the information as well as bad compliance of the information. Information in general does not get the correct meta-data assigned with as consequence that information is not findable anymore. Therefore, the dashboard

and KPIs need to provide insight on how information is stored, and witch metadata is assigned so the number of duplicates can be reduced with increases the findability of information. Also, the dashboard needs to provide information about which applications are used. This is so that the managerial stakeholders can control and correct employees and reduce the unnecessary use of different applications.

The following quotes are useful to mention. They support the two quotes from above and improve the understanding of the user.

> *"LESS EMAILS; MORE COLLABORATE WORKING ON DOCUMENTS"*
>
> *"SharePoint works slowly and takes too much time."*
>
> *"1st, remove dead hyperlinks. 2nd, remove old and obsolete data (information). 3rd, No clarity in designations (e.g., F16 or F-16 or F 16)"*

The current state of information management at the DMO

The second question is an all-open-ended question and is not a follow-up question. Respondents were asked if they had an opinion about the current state of information management at the DMO. Most answers are about the life cycle of their information and about the possible improvements for different types of communication during this life cycle. We will quote some of the more unique answer that are of interest for this research.

> *"Many storage systems are structured hierarchically. That makes no sense, given the many levels of abbreviations that no one understands anymore. Always store information independently of the organisation based on topic and make it searchable with a good enterprise search (that function is completely missing). Enforce the use of metadata for filtering. Completely phase out the use of folder storage systems at the department and team level of shares. Only allow shares for personal use of temporary or reference data used to produce more formal documents and archive them so that older versions can be retrieved, and regulatory compliance is met."*
>
> *"Consider the long term. So many new systems have already been rolled out without a long-term vision and management structure."*
>
> *"It is important that it is accessible to everyone. Keep it simple!"*

Concluding

Throughout the whole survey we see the same problems. There is just too much information and application with as consequence bad quality information. In fact, these problems are all in the problem cluster in Section 1.2.1. Limitations, requirements, and possible indicators mentioned in the survey answers and from the analysis can be found in Section 2.4.

2.3 Stakeholder analysis

Stakeholder analysis was be done by walk-in interviews. These stakeholders both have a lot of knowledge about information management, the office IT landscape, and the different strategies the organisation follows. Both stakeholders have many years of experience on these subjects, but they have a different function in the organisation. Both have a big influence on the research and therefore are regularly informed.

Mathijs van der Brugge is the supervisor of this research as well as ethe problem owner. Mathijs is the team manager for business operations and information management. His main projects are the establishment of the CIO-office DMO and supporting the data migration from SharePoint 2013 too SharePoint 2019. The tasks he fulfils are setting policies, establishing, and monitoring existing and new laws and regulations regarding business operation. His manager roll gives him a good overview of the current situation and the ability to think about the current and possible future requirements and limitations.

The second stakeholder is Eline den Boer. She fulfils the rolls as information management officer for the board of management & business operations (Directie bestuur & bedrijfsvoering). She supports Mathijs van der Brugge with the establishment of the CIO-office and is the chief of the project “B&B op Orde” (B&B in Control).

The questions for the interviews are divided into three categories. The goal of these questions is to start a discussion about the different topics regarding the current situation of the office IT landscape and how the organisation wants to improve this in the future. The three categories and questions are:

The current situation

- What is your opinion about the current situation/state regarding the available management information?
    - Why would this research improve the current situation?
- Which active projects, like the establishment of the CIO-office DMO, could have an influence (negative or positive) on the current ARC of information.
- What can the CIO-office DMO contribute when we want to increase the available metadata and management information?

Requirements

- Are there existing requirements (like law and regulations) that are important for the development of the DMS and data warehouse?
- What requirements do you have for a DMS?
- What requirements do you have for a dashboard?
- What set of requirements do you have for choosing the KPIs?
- What metadata fields are important for your roll as IMO or problem owner?

Limitations

- What are possible limitations from the organisation for the research?
- What are possible limitations for a DMS?
- What are possible limitations for a data warehouse?
- What are possible limitations for a dashboard?

During the discussions of the walk-in interviews, different limitation and requirements are mentioned. The limitations and requirements can be found in Section 2.4.

2.4 Summarize

In this chapter we analysed the current situation, the survey, and the stakeholders. During this analysis we constructed lists of limitations, requirements and KPIs. These lists are used in Chapter 4 were we finalize the KPI selection and design the dashboard. The list of limitations and requirements can be found in Table 2 and Table 3, respectively. The list of KPIs can be found in Section 4.1.

Table 2: List of limitations

Limitation	Source	Reasoning
The dashboard cannot initiate conclusions	Stakeholder	An employee needs to draw a conclusion from the indicators in the dashboard because there are too many variables or reasons that can influence the data. The indicators can show thresholds.
Dashboard showing information about individual persons	Research	Because there is a lot of personal information in the metadata (e.g., owners and member logins of SWRs), we are not able to ask permission to each employee individually and General Data Protection Regulation (AVG wet).

Table 3: List of requirements

Requirement	Source	Reasoning
Dashboard shows real time data	Stakeholder	The dashboard is used in the decision-making process of the stakeholders and cannot show outdated information, hence real time data is important to ensure an accurate and reliable dashboard.
The focus of the dashboard and indicators is measuring the quality of information.	Stakeholder and research	The research question has the focus on improving the ARC of information. Long-term, the stakeholder is interested in the quality because they do not have to compute information themselves and are able to react quicker to changes in their information management.
The DMS needs to be based on a SQL platform made available by the organisation.	research	Because of the strict security rules, it is not possible to introduce new SQL platforms. The most suitable platform made available by the organisation is Oracle.
The dashboard must consist of three layers in which you can drill down to the next layer (interactivity): 1. DMO 2. A specific DMO-board 3. Specification of the indicator of the other two layers	Stakeholder	When implementing the three layers you improve the reach of the dashboards. The result is that more employees can benefit from it as well as the ability to choose how detailed they want information about the quality of the information.
Graphs and indicators need to be clear in a glance (minimal complexity).	Research	Clear graphs and indicators give the dashboard a professional appearance and make it more accessible for wide group of employees

Specific stakeholders need to have the option to obtain the raw metadata of important indicators.	Stakeholder	Gives the stakeholder the option to compute their own indicators as well as the needed freedom to improve their quality of information or the information management.
The dashboard needs to show the trend of a KPI over time.	Stakeholder	
SharePoint, Outlook, and Network drives are the main applications of the dashboard and KPIs.	Stakeholder	To improve the feasibility of the research.
Dashboard should include indicators about how and where information is stored (beside the focus of measuring the quality)	Survey	The most common problem of employees is the number of places to store information. Showing this data in the dashboard makes it possible to improve the overview of employees and is good complementary data for the indicators about the quality of the information.

3 Literature research

In this chapter we are going to combine the analysis of the organisation from the previous chapter with literature research on dashboards and KPIs. Each literature research has two objectives: create insight in the different parts of a dashboard/KPI and provide information for choosing the right dashboard/KPIs with the given limitations and requirements. After we formulated answers to the two objectives, we can select the KPIs and the design of the dashboard in the next chapter. In Section 3.1 we performed literature research on dashboard design and in Section 3.2 we performed literature research on KPI selection. At the end of this chapter in Section 3.3, we summarize the important findings and corresponding conclusions for the research.

3.1 Literature research on dashboard design

In this section, we will cover the findings of the literature research on dashboard design. In previous chapters we already set a scope for the research. For this reason, we only include the findings that could be applicable to the dashboard made for our organisation.

3.1.1 What is a dashboard?

A dashboard is used to visualize data of a certain topic. Most of the time and in this research, a dashboard provides the ability to monitor the performance of business issues. The dashboard consists of a combination of text, indicators, and graphs which are arranged on a single “view”. The main purpose of a dashboard is to provide information or data at-a-glance (Few, 2006). Dashboards make data accessible and understandable for more people and therefore can support the decision-making during business issues. Dashboards are used as a tool in data analytics. The domain data analytics covers the whole process of the deliverables of this research (data collection, data processing, trend analysis, modelling). Data analytics and therefore also the dashboard can be divided into 2 areas. Each area has a unique purpose, but both have characteristic that overlap:

- Descriptive analytics: data summarization and condensation for statistics and data patterns.
- Predictive analytics: future predictions based on models from data.

Now a days, dashboards are mostly business intelligence (BI). Business intelligence uses a combination of data analytics and data warehousing to support decision making with indictors based on management information systems (Orlovskyi et al., 2021).

A dashboard is a powerful tool because the user can monitor, analyse, and manage with one application (Eckerson, 2006). To get the most out of a dashboard it is important that from the start a dashboard is well thought out and with the user in mind. Burnay et al. (2020) developed a framework were during the implementation phase of a dashboard the quality of a dashboard could be check based on user experience. As seen in Figure 10, the framework introduces 3 important aspects of a dashboard. This framework of Burnay also overlaps with both methodologies of Few and Erickson when they write about the different characterises of dashboards.

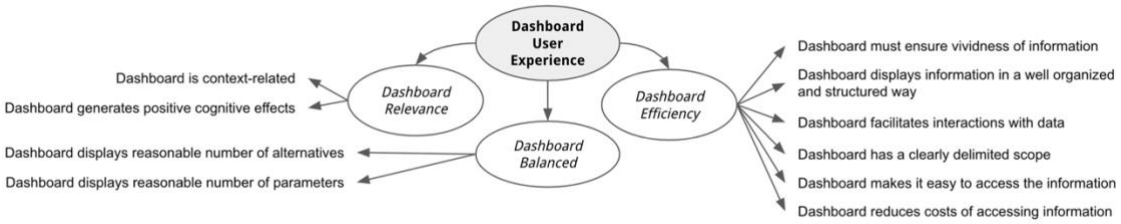

Figure 10: Dashboard quality framework, BIXM (Burnay et al., 2020)

3.1.2 Types of dashboards

Each dashboard is unique and uses different visuals to help the users to monitor, analyse and manage (Eckerson, 2006). All those unique dashboards have overlapping characteristics and because of this they can be categorized. Categorizing dashboard gives us the ability to know which type of dashboard suits best for the situation or business issue (Few, 2006). Because each dashboard is unique and each characteristic of that dashboard has a variety of possible values, it is rare for a dashboard to be of one type. Hence, the many characteristics by which we can categories, however we are categorizing by the type of business activity the dashboard supports. We call this the role of a dashboard (Few, 2006). Both the frameworks of Few (2006) and Eckerson (2006) have defined the same type of roles. In Table 4 we see a combination of both frameworks.

Table 4: Characteristics of dashboard types (Eckerson, 2006, and Few, 2006)

	Operational	**Tactical/Analytic**	**strategic**
Purpose	Control operations	Optimize processes	Manage strategies
Stakeholders	Employees+	Managers+	Executives+
Goal	Grab your attention when an operation fails	Discover cause-effect relationships	Improve long-term strategic direction
Time Focus	Current	Past	Future
Data Refresh	Real-time	Daily/weakly (static snapshots)	Monthly/quarterly (static snapshots)
Visual	Simple	Detailed	Simple
Interactive	Yes	Yes	No

Operational dashboards are used for monitoring business issues as they occur. The data used is from core systems. Those cores systems are monitored to check if they stay between predetermined limits. Hence, these dashboards are mostly used to improve productivity, quality, and efficiency of an organisation (Eckerson, 2006). Because of these characteristics, the dashboard should be designed with dynamic or interactive features in a simple and easily understood design (Few, 2006). Tactical or analytic dashboard gives a more detailed visualization of a process. These types of dashboards need a more information so it can discover corelation and therefore support the decision-making process. These dashboards should support drilldowns and show more detailed information when wanted by the user (few, 2006). Lastly, strategic dashboards provide a quick overview for decision makers to monitor the business. Most strategic dashboard use predictive analytics to show trends and the possibilities of the future. The most measures are focus on high-level performance measures supported by contextual information, such as simple performance evaluators or target comparisons (few, 2006). These dashboards need to be kept simple to prevent distraction of the primary goal: top-down management of business strategies (Eckerson, 2006). The data in operational and tactical/analytic dashboard frequently comes from data warehouses. These data warehouse most of the time store up to seven years of data in multidimensional databases. These warehouses enable

tactical databases to show extensive historical data (Eckerson, 2006). Current warehouses make it also possible to show real-time data for operational dashboards because the speed of query and analytic calculations improved enormous. Strategic dashboards are less dependent of big data warehouses and can be run with a simple Excel sheet (Eckerson, 2006).

3.1.3 Components of a dashboard

When designing a dashboard, it is important to understand the different components that together form the dashboard. The three most important components are indicators, Data & Model, and Graphs. These components also overlap with the deliverables for this research. Therefore, we will further explain these three topics in this section. Smaller components are dashboard software with their corresponding features, organisation name and username.

Indictors

Indicators are used to show information of an organisation or system (Franceschini et al., 2007). When an organisation of system is large, it produces a lot of information. This information can be used to formulated indicators. When designing a dashboard and KPIs it is important that the number of indicators is not too high. This prevents unnecessary complexity and a possible wrong interpretation of the organisation or system (Melnyk et al. 2004).

There are two ways to classify indicators. Indicators are classified as objective or subjective. Or indicators are classified as basic or derived. Subjective indictors are depended by the subjective perception or the opinion of people. Objective indicators are not influenced by people and cannot be interpreted differently by different people. Indicators in both cases are not necessarily measurements (Franceschini et al., 2007). Basic indicators are a direct observation, where derived indicators are based on 1 or more basic or derived indicators (Franceschini et al., 2007).

KPIs are most of the time derived from other indicators. We perform a more extensive literature research on KPIs in the Section 3.2.

Data & Model

According to Lempinen (2012), having a supporting infrastructure for storing data is crucial, where the size of the available data determines the complexity of the supporting infrastructure. Analytical dashboards, the type of dashboard most suited for this research, require good data integration and warehousing (Eckerson, 2006). When measuring KPIs, it is essential to motivate the connection between the data used to measure the KPI and the KPI itself (Heerkens et al., 2021). In addition, providing enough context for the KPIs is necessary to interpret and act on them effectively (Few, 2006). The most commonly used data type in dashboards is quantitative data, therefore it is important to encode quantitative values accurately in graphs to avoid misinterpretation (Few, 2006). Finally, the completeness of data is crucial to ensure that KPIs are measurable with the available data (Heerkens et al., 2021).

Graphs

Graphs and other forms of data visualization become more and more important for business communication and decision making. Therefore, dashboards need to be kept simple to make the information understandable at-a-glance but without sacrificing anything important. Hence, each component needs to be clear and efficient with as little space as possible (Few, 2006).

> *"Dashboards and visualization are cognitive tools that improve your "span of control" over a lot of business data. These tools help people visually identify trends, patterns and anomalies, reason about what they see and help guide them toward effective decisions. As such, these tools need to leverage people's visual capabilities. With the prevalence of scorecards, dashboards, and other visualization tools now widely available for business users to review their data, the issue of visual information design is more important than ever."*
> *(Brath & Peters, 2004)*

Few (2006) talks about "an ideal library of dashboard display media". With his framework he defines 6 categories for displaying information.

- Graphs
- Images
- Icons
- Drawing objects
- Text
- Organizers

A dashboard always show a variety of different data and measures and they all require a form of data visualisation. Each type of data has its preference of visualization. One of the most important categories of the framework of Few (2006) is Graphs, namely the majority of data use in dashboards is quantitative. In fact, most of the data used for the dashboard in this research is quantitative.

Choosing the rights graph for the data, KPI, measure, or other type of indicator you want to visualize is very important. The graphs determine how the user interprets the data. In Appendix E you can find the chart chooser of Andrew V. Abela (2010). The diagram he made can be used to quickly determine what graph to use based on the goal, time, and number of variables. Many authors, like Few (2006) and Eckerson (2006), have written about what type of graphs there are and how to use them. In the literature they also write about the most common mistakes made when working with diagrams in dashboards. One of these mistakes is supplying inadequate context for the data (Few, 2006). This results in wrong interpretations of the data. Few (2006) describes two other common mistakes: encoding Quantitative Data Inaccurately and not reducing the non-data pixels. The last common mistake worth mentioning is the bad balance between the expressiveness and efficiency of a graph (Burney at all., 2020).

3.1.4 Structure of a dashboard

When researching for the structure of dashboard we can distinguish two parts. A dashboard must provide information at-a-glance, elaborated in previous section. Therefore, all the KPIs about a subject must fit in one view. This view can be structured in an optimal design. The second part is the overall structure of the dashboard. This includes the different layers and how they are connected and the ability to drill-down and be interactive with the dashboard. We first discuss the last part.

According to Eckerson (2006), a dashboard can be structured with the MAD framework. This framework lets the user get access to information in a way that is most natural for the user to solve a business issue. This natural sequence of handling information is Monitor → Analyse → Drill down to detail (Figure 11).

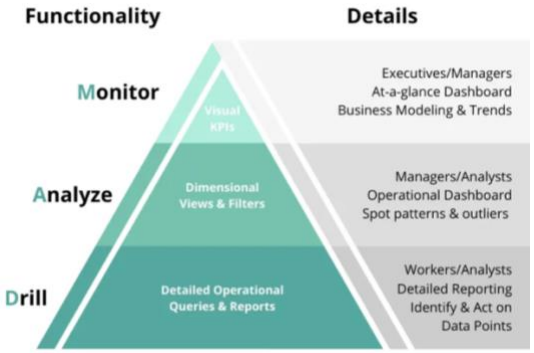

Figure 11: The MAD framework of Eckerson (Sauder, 2020)

The top layer focusses on KPIs and other performance measures. This layer has a high graphical view and is used by users to monitor essential information. This layer can be used to alert users when data exceeds a threshold. In our case, this top layer will focus on the overall performance of the organisation. The second or the middle layer is most used for dimensional data that user can use to get more details about a subject or hierarchy form the top layer. We can use this layer to focus more on the boards of the organisation. The last layer focusses on detailed information about a subject or hierarchy (Eckerson, 2006). This detailed information can be the raw data of the measure that we use to measure the ARC of information. This layer will be mostly used by the CIO-office and the IMO's.

The framework of Eckerson overlap with the requirements stated in the previous section. The requirements are that there will be three layers and users need the option to access the raw metadata. Both of those are requirements are in MAD. Users can enter the dashboard at any layer and are able to interact or drill down or up (Eckerson, 2006). Drilling down or up is the way to navigate between layers. The top and middle layer will be in the same view. This means that all KPIs and other components should be fitted in on screen. This is to ensure that user can lay connection between measures and understand meaningful relations.

As mentioned in Section 3.1.3, there are 6 different components in a dashboard. These 6 components can be structured in every possible variation but, will not all make a good dashboard. Fortunately, there are many guidelines to ensure that a dashboard can be used to monitor, analyse, and manage with its full potential. In this research we use the guidelines of the following publications. The books of Eckerson (2006) and Few (2006) and the papers of Burney at all. (2020) and Orlovskyi et all. (2021).

3.2 Literature research on KPIs

In this second literature research, we try to understand the different aspects of a KPI. With this research we can improve our methodology for selecting and deriving KPIs. With the found literature form previous section and new literature form this research, we will make a list with important ideas, rules, and requirements for deriving and validating KPIs for the research question. This list creates an overview and a set of requirements we can use when deriving the final list of KPIs in the next section. We will conduct this research based on the systematic literature research (SLR) method. All detailed steps of the review can be found in Appendix D.

3.2.1 Search strategy

The second knowledge question of this research is meant to improve the understanding of KPIs. There are many different methods and aspects that are involved when deriving KPIs. The SLR will let us make a list of methods that are used to improve the quality of KPIs that we will derive for measuring the quality of the information used. We can measure quality based on the Actuality, Reliability and Compliance (ARC) of information. For the SLR we will use the following research question:

"Which aspects should be kept in mind when determining key performance indicators (KPIs) for monitoring the ARC of documents and data used in office IT?"

The research question is used as input for a couple of steps of the SLR. In Appendix D.1 until D.4, we explain which databases are used for the research. The databased need to have a good number of peer-reviewed articles for different subjects of study. The research question form above is stripped down so the key concepts are left and search terms can be defined. These are used in combination with the exclusion and inclusion criteria to build the search string. After many search-iteration this search string is adapted so it finds the articles that are most useful for this research (see Table 5).

Table 5: Final search string

Search String	**Databases**	**# of Hits**	**Explanation plus relevance of hits**
TITLE-ABS-KEY ((kpi* OR "Key performance indicator") AND (database OR repositor*) AND ("Business Intelligence")) Sorted on: relevance Filtered on: language (English), type of document (Article)	Scopus	5	Good number of useful results. Will export this result in Mendeley and read through all abstracts plus conclusions to select the useful sources.
	Web of Science	4	Will export this result in Mendeley and read through all abstracts plus conclusions to select the useful sources.

3.2.2 Study selection

With the use of the determined inclusion and exclusion criteria and after reading all the found articles we found 4 articles, as seen in Table 6, that we can use. When selecting the useful sources, we focussed on articles that said something about the data used for KPIs, the actual indicators for measuring or the goals of a KPI. Articles that said something about topic specific KPI selection or about the evaluation of the KPI were exclude. KPIs used for topics other than measuring quality of information or decision support systems are not useful for this research and therefore the method in

that article used to selected KPIs are therefore not reliable. Evaluations of KPIs is not relevant yet because we do not have a list of KPIs or a dashboard at this moment of the research.

Table 6: Selected sources

Title of article or book	Authors	Source	Year
Designing business intelligence (BI) for production, distribution, and customer services: a case study of a UAE-based organisation.	Nuseir, M. T.	Business Process Management Journal, 27(4), 1275–1295.	2021
Development and Implementation of the Balanced Scorecard for a Higher Educational Institution using Business Intelligence Tools.	Valdez, A., Cortes, G., Castaneda, S., Vazquez, L., Medina, J., & Haces, G.	International Journal of Advanced Computer Science and Applications, 8(10).	2017
Managing big data in coal-fired power plants: a business intelligence framework.	Chongwatpol, J.	Industrial Management & Data Systems, 116(8), 1779–1799.	2016
Strategic business modelling: representation and reasoning.	Horkoff, J., Barone, D., Jiang, L., Yu, E., Amyot, D., Borgida, A., & Mylopoulos, J.	Software & Systems Modeling, 13(3), 1015–1041.	2012
Management by Measurement: Designing Key Indicators and Performance Measurement Systems.	Franceschini, F., Galetto, M., & Maisano, D.	Book	2007
Information Dashboard Design the Effective Visual Communication of Data.	Few, S.	Book	2006

3.2.3 Integrated review

Deriving KPIs is one of the most important steps of building a dashboard. Deriving the KPIs is also one of the more difficult steps. The measures and indicators that make up the KPIs need to be selected with great thought. This to ensure the KPIs show the user only the information that is important or necessary. With the literature research we found 4 new sources. From previous literature research we also found 2 useful sources. In the Table 7, we summarize the most important theories for deriving KPIs.

Table 7: Theories used for deriving KPIs.

Theory	Elaboration	source
Make data warehouse based on a scheme that connects databases.	Good database connections are important for creating and seeing important relationships between data. The research showed that an optimized scheme for a certain (business) goal will provide better quality data and therefore creates the possibility to measure more complex indicators.	Nuseir (2021)
Set goals for the KPIs	These goals need to be quantifiable, ambitious, measurable, controllable, and achievable. With these goals we can determine what type of indicators, data, and relationships between data we need.	Valdez et al. (2017)
Make a KPI measurable.	This theory uses indicators in combination with the determined goals to make a hierarchy scheme. Then he sets values to indicators and determine the KPI. After the KPI is chosen we can set performance values and performance regions to make the KPI measurable. This theory is useful for when it is difficult to measure a KPI.	Horkoff et al. (2012)

Focus the KPI on the end user.	KPIs must be focused on the end user to improve the decision-making process of the top management. To make this work the top management, the data analysts and data owners need to have the same perceptions of the benefits of data, analytics and KPIs in the long run. This can be achieved by conducting interviews with the users and stakeholders.	Chongwatpol (2016); Nuseir (2021) Few (2006)
Enrichment through comparison	Measures display information by themselves but making comparisons with other measures improves the quality. Comparing to one or more related measures increases the meaning and provides more context about the issue that is measured. A time series is a good example of comparing measures.	Few (2006)
Check the relationship between the goals and the KPIs	With the use of a matrix, we can check if there are any relationships between the goals of the dashboard and the performance measures. With this information we can determine if we need more or less information about a certain topic.	(Franceschini et al., 2007)

3.3 Summarize

A dashboard is the perfect method for visualizing the performance of the organisation. In this research we are going to measure the quality of the information used in the office IT landscape. Therefore, we do not need to make future predictions hence the dashboard will be a descriptive analytic dashboard. The type of descriptive analytic dashboard we choose for this research depends on the set of requirements and limitations we have. A combination of a tactical and operational dashboard would fit best for this research. From the requirements we see that the dashboard needs to focus on the past but also on the current situation. Therefore, real time and historical data is needed. These requirements tend to focus on monitoring the ARC of information, which can be visualized with an operational dashboard. On the other hand, the research question indicates that we want to optimize our processes and hence a tactical dashboard would fulfil. To ensure the dashboard is relevant and has a good user experience we will use the framework of Burnay et al. (2020).

Another method we will use to make the dashboard relevant is by structuring the dashboard with the MAD framework. We will provide 3 layers of information so all stakeholders can find relevant information. Each layer has it's one set of indicators with matching graphs. We will apply different theories during the process of KPI selection and graph selection.

4 KPI selection and dashboard design

In this chapter we will combine the findings of all previous chapter. We start in Section 4.1 by determining the KPIs for measuring the quality of information based on four categories . Then we start in Section 4.2 with determining the metadata we need to measure these KPIs and for the missing metadata we generate placeholder data. From their one we explain the selection of the software used for the data management plan and dashboard in Section 4.3. In Section 4.4 we combine all gathered knowledge and design the dashboard.

4.1 KPI selection

In the previous chapters we selected the goal of this research and narrowed down the scope. After, we identified the requirements, limitations, and goals of the dashboard. With this information we can focus on selecting the KPIs that will be visualized with the dashboard. The interview with the stakeholders and the context analysis provides information about the goals and the KPI that would fit those goals. This also provides information about how to measure certain indicators and the argumentation for why the choices in the following sections are made. The literature research helps to select the optimal KPI for measuring the goals.

The literature states that before determining and measuring the KPI we need to set the goals. The research question states that the management information needs to increase the actuality, reliability, and compliance of the office IT landscape. Management information mentioned in the research question refers to the KPIs of the dashboard. In combination with the interview, we can say that the main goal is to measure the quality of information used in the office IT landscape. However, according to the literature this goal needs to be quantifiable, ambitious, measurable, controllable, and achievable. Quality in general is hard to measure with quantitative data because it involves many qualitative information used to support why certain quality threshold are reached. Hence, we will split the goal in four. This will be actuality, reliability, compliance, and basic performance indicators. These smaller goals represent the main goal but are easier to measure with quantitative data and therefore better achievable. The KPI are divided into those 4 categories.

During the selection of the KPIs we took in consideration the different layers of the dashboard with their focus group in combination with the goals. A KPI needs to be informative for all end users to improve the use and implementation of the dashboard. The goal ensures that the stakeholders (like the CIO, the IMO (information specialists) and data owner) have the same perspective of the KPIs. To further improve this the KPI needs to be kept simple and need to be able to be compared to themselves or other indicators. This enriches the information of the dashboard and allows the CIO and IMO's to make complex relations but keeps the overall dashboard simple for normal employees and potential top managers.

Actuality

Actuality implies that no confusion can arise as to which version of information is from a trustworthiness source, that information is up to date and that the information is accurate. In this research, actuality refers to the authority of information, which focusses on the trustworthiness and reliability of the source of information. By verifying the authority of information sources and ensuring the actuality of the information, we can prevent the spread of false information. In summary, the actuality of information is the aspect of maintaining accurate and reliable information from a trustworthiness source or author by knowing which information topics are popular and which version is up to date.

Actuality is hard to measures because most of this is based on compliance rules about actuality or authority and both are forms of qualitative information. Before we can verify the authority of information sources and ensuring the actuality of the information, we determine which information and topics are now actively used in the organisations business operations. The first KPI is “most consulted information topics” and shows the stakeholders the topics that are currently most consulted based on the files, folders, and sites with the most hits.

The following thee KPIs focus on the possible confusion that can arise when there are multiple versions of the same information. From Chapter 2 and the interviews we know that sending attachments with the e-mail is the most common method for duplicating files. The KPIs “Emails sent with attachment” and “Duplicate file names” will be both included in the dashboard even though the number of emails sent with attachments is indictor for duplicate file names. The KPI “Emails sent with attachments” visualizes a behavioural aspect of employees that is not disable. For this reason, we will use both KPIs to track down the employees who still use attachments instead of hyperlinks and where the most duplicates in general are. The other KPI is “Version indication used in title” is specific for sites on SharePoint PaaS and DWR-D. The DMO formulated in the Regulations for Information Management that information stored on those sites need to make use of the automatic version management function. Not using this function and uploading separate version of the same document will introduce confusion about actuality and decreases the overall quality of the information management. When a version indication (V1.0, V2.0, V2.1, etc.) is used in the title of a document, we can assume that the automatic version management function is not used.

Table 8: Actuality KPIs

KPI
Most consulted information topics
Duplicate file names
Emails sent with attachment
Version indication used in title

Reliability

Reliability implies that no confusion can arise about the validity and authority of information. Reliability focusses on the source of information. Information needs to have a connection with their source to ensure that the information it contains is reliable. The further information is away from the source, as well as the number of contributors can have a negative impact on the quality of the information. Apart from this, measuring reliability has to same difficulties as actuality in terms of measurability. Both are depending on IM compliance rules.

All three KPIs in the reliability categories are more for data specialist and managers. They will be useful for all end users of the dashboard, but the employees with more knowledge about information management we be able to make relationships between de data and the business operations. “Employees with the most final edits” shows who are involved with the most amount of information. In most cases, are employees are focussed on 2 or 3 subjects. If someone has exceptionally more final edits than average, there is a change they use the common I&T application not as intended. Most of the result will be as expected but the IMO’s and the CIO-office will be able to spot the odd one out and take further action.

As mentioned earlier, reliability focusses on the source of information. The organisation has a selection of subjects and projects identified that are big risk factors or projects. These are called *Hotspots and Special Collection High-risk Processes (*in research referred to as Hotspots). The stakeholders are interested in the development of these Hotspots. The KPIs "Number of storage location for a Hotspot" and "Number of persons involved with a Hotspot" are used to monitor where these documents are located and if this amount increases or decreases over time. The same applies for the number of persons involved. These two KPIs give a good indication about the fragmentation of the information. The more fragmentation, the greater the changes is that information is not connected to the source. This can have a negative impact on the reliability of that information.

Table 9: Reliability KPIs

KPI
Employees with most final edits
Number of storage location for a Hotspot
Number of persons involved with a Hotspot

Compliance

Compliance checks if information complies with applicable laws and regulations set by the organisation themselves. Compliance is important category of the dashboard. Mainly because of the compliance rules set for the information management of the organisation. These rules provide clear boundaries for validating information used in the office IT landscape. When information is not compliant to these rules, the quality of the information cannot be guaranteed. Hence, the KPIs in this category are a good measure for the overall quality of the information of the office IT landscape. The KPIs are based on the applicable laws and regulations that are most often violated.

The KPI "Orphaned information" shows the number of folders on network drives, sites on SharePoint PaaS, and DWR-D that have zero or one owner. Owners have full management control of the site and can manage site permissions, settings, and edit information. It is mandatory that sites and folders have at least 2 owners. This prevents that a single owner of a site of folder leaves the organisation and leaves the information behind. As a result, that these files are often forgotten or no longer available for other employees.

There are many laws and regulations about how and where to save and store your information. Saving and storing information at the right place increase the findability of information. Employees can easily find what they need and less likely to save a copy of their own. The KPI "Number of files stored at the wrong places" is a combination of 4 measures that counts the number of files that are not compliant to these types of rules. The 4 measures are:

- Number of files stored at the wrong place based on their file name extension.
- Number of files, folder and sites that have "archive" in the title. Most of the time, this information must be sent to Dynamic Information Management (DIB) help desk and archived in Xpost.
- Number of files that are classified higher then Departmental Confidential (DV). Files that are classified as Confidential, Secret and Top Secret are not allowed in the standard office IT landscape.
- Number of files and folders that have a personal name in the title. Personal information should be stored on the MySite-application.

Table 10: Compliance KPIs

KPI
Orphaned information
Number of files saved at the wrong place

Basic performance indicators

This last category is meant to support the other three categories. These performance indicators measure the overall performance of the four main common I&T applications used in the dashboard. For instance, it shows the total number of sites with the percentages changed compared to previous period. For the stakeholders these basic performance indicators are a requirement. Comparing the KPIs about the actuality, reliability and compliance with the basic performance indicators improves the quality of the dashboard and enriches the data used for decision-making processes.

Table 11: Basic performance indicators

Application	Basic performance indicators
DWR-D	Number of total sites
	Number of standard sites
	Number of classis sites
	Ratio active, inactive, and archived sites
	Amount of stored data
SharePoint PaaS	Number of sites
	Number of subsites
	Amount of stored data
	Most visited sites
Network drives	Number of folders
	Number of files
	Amount of stored data
	Cluster with most data

4.2 Data collection

Now the 4 categories and their KPIs are defined, we can determine the needed data to measure these different indicators. The data needed for these KPIs needs to be gathered, stored in a well-designed data warehouse, and needs to be of good quality. In Table 12, we can what data we need and how this data will be used to measure the KPI or basic indicator. The table also shows if the data is already available.

Table 12: Data needed for measuring KPIs.

Category	KPI	Data available	Data measuring KPI
Actuality	Most consulted information topics	No	Document, folders, and sites titles with most hits compared to a popular topic reference list. New list with topics with the most matches.
	Duplicate file names	No	Total file names – unique file names = number of duplicate file names.
	Emails sent with attachment	No	Summation of all emails sent with attachments.
	Version indication used in title	No	Document titles compared with reference list. Summation of documents that contain version indication.

Reliability	Employees with most final edits	No	List of names with summation of last edited files. Names are linked to place in organisation.
	Number of storage location for a Hotspot	No	List with site, folder, and document titles and their source path + last edited. List compared to Hotspot reference list. New list with Hotspots and a summation of unique sites and folder source paths + summation of unique employees last edits.
	Number of persons involved with a Hotspot	No	
Compliance	Orphaned information	Partially	Summation of sites and folders with <2 owners.
	Number of files saved at the wrong place	No	List with site, folder, and document titles. List compared to four reference lists. New list with summation of matches between the list with titles and the reference lists. .
DWR-D	Number of total sites	Yes	Summation of unique URLs
	Number of standard sites	Yes	Summation of unique URLs with the value “standaard”
	Number of classis sites	Yes	Summation of unique URLs with the value “classic”
	Ratio active, inactive, and archived sites	Yes	Summation of unique URLs with the value “active” or “inactive” or “archived” divided by summation of unique URLs
	Amount of stored data	Yes	Summation of data used
SharePoint PaaS	Number of sites	Yes	Summation of unique URLs
	Number of subsites	Yes	Summation of the value in the column “number of subsites”
	Amount of stored data	Yes	Summation of data used
	Most visited sites	Yes	-
Network drives	Number of folders	Yes	Summation of unique folder source paths
	Number of files	No	Summation of unique file source paths
	Amount of stored data	Yes	Summation of data used
	Cluster with most data	Yes	For each unique cluster organisation path: Summation of data used by sites that have the cluster organisation path as a value.

As we can see, all the data for the KPIs of the first three categories is not available at this moment. This data needs to be requested by the application owners and database managers. Because the needed data is generated by the organisation themselves, data gathering methods and checking the quality of the data is out of this scope and not our responsibility. When the data will become available, we have a framework for storing and processing this information. This framework is mainly based in the DMS. We will further explain the DMS in Section 4.3.2.

To replace the missing data, we made placeholder data. The graphs and indicators in the dashboard will be based on the placeholder data and therefore does not reflect the real-world situation of the organisation. There are two reasons why we are unable to provide the actual data: firstly, the data is just not available yet, and secondly, due to security reasons, we cannot publish the research with the actual data as input for the graphs.

The placeholder data is generated in such a way that it closely mimics the characteristics of the real-world data, thereby serving as a framework for future data collection and DMS (Section4.3). Our data generation process involved several steps, using our experience working with the organisations data and prior observations. We start by identifying the necessary data. Therefore, we use the data collection table from which we compiled in two tables: the Placeholder Table Small and Placeholder

Table Big, along with a Randomizer Table. With the majority of the table columns determined, we proceed to define the parameters for the exports.

One requirement in Chapter 2 was the need to visualize progress over time for the majority of the KPIs. Hence, we generated 20 weekly and 12 monthly exports, resulting in a total of 32 exports. This number of exports allow for enough data points to visualize progress over time. In the sheet with the Placeholder Table Big, each export contained 1000 rows of documents and 200 rows of sites. We chose this export size so we can later introduce enough irregularities to the data so we can see fluctuation in the visuals. All this while keeping the amount of data manageable. On the other hand, each export in the Placeholder Table Small consisted of a single row, containing data points for the total emails sent, emails sent with attachments, the number of documents, and the number of unique documents. This table/metadata was generated separately to simplify the Placeholder Table Big.

Figure 12 displays the first ten rows and columns of the first export of the Placeholder Table Big. The columns are:

A. Unique ID for each export. This simplifies managing the relationships between tables in the DMS.
B. Date of the first Monday of the week or month when the metadata was exported.
C. Whether the metadata was exported weekly or monthly.
D. Whether the data is for a document or site.
E. For documents, the file extension; for sites, the type of site.
F. Title of the document or site.
G. Title of the document or site with added irregularities.
H. Source path of where the document is stored, including the title and file extension.
I. Source path of where the document is stored, used to identify the folders.
J. Last person who edited the document or site.
K. Number of times a document or site was clicked or visited the previous week.
L. Number of times a document or site was clicked or visited the previous month.
M. Number of owners.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Export ID	Export Datum	Export Type	Type	Soort	Title	Title Extented	Source Path	Source Path short	User Last Edited	Hits Week	Hits Maand	Owners
2	1	07/11/2022	Week	Document	.gif	DuiVel	DuiVel	NETWERKSCHIJF/ DMO/JIVC/ARCH/DuiVel.gif	NETWERKSCHIJF/ DMO/JIVC/ARCH	Jacquelin Kapelhof	37	148	3
3	1	07/11/2022	Week	Document	.xlsm	SitAmetConsectetuer	SitAmetConsectetuer	DWRD/google/GB/SitAmetConsectetuer.xlsm	DWRD/google/GB	Edith Duligal	78	312	4
4	1	07/11/2022	Week	Document	.accde	AnteVestibulum	AnteVestibulum	NETWERKSCHIJF/ DMO/JIVC/LANDGEB IT/AnteVestibulum.accde	NETWERKSCHIJF/ DMO/JIVC/LANDGEB IT	Hermine Aldersey	126	504	3
5	1	07/11/2022	Week	Document	.mp3	Quam	Quam	DWRD/livejournal/GB/Quam.mp3	DWRD/livejournal/GB	Darya Pirrone	75	300	5
6	1	07/11/2022	Week	Document	.html	Lectus	Lectus	DWRD/zimbio/GB/Lectus.html	DWRD/zimbio/GB	Winne Terbeck	6	24	2
7	1	07/11/2022	Week	Document	.accde	ProinEuMi	ProinEuMi	NETWERKSCHIJF/ DMO/F&C/ADC WS&B/ProinEuMi.accde	NETWERKSCHIJF/ DMO/F&C/ADC WS&B	Lowell Biggerstaff	6	24	4
8	1	07/11/2022	Week	Document	.mp3	AcDiam	AcDiam v2.6	DWRD/amazonaws/GB/AcDiam.mp3	DWRD/amazonaws/GB	Luigi Drinkel	30	120	4
9	1	07/11/2022	Week	Document	.jpg	Ut	Ut	DWRD/salon/GB/Ut.jpg	DWRD/salon/GB	Adrienne McCray	139	556	4
10	1	07/11/2022	Week	Document	.accdt	CurabiturConvallisDuis	CurabiturConvallisDuis	NETWERKSCHIJF/ DMO/DIR P&O/ADV MO&ST/CurabiturConvallisDuis.accdt	NETWERKSCHIJF/ DMO/DIR P&O/ADV MO&ST	Smith Berg	116	464	2
11	1	07/11/2022	Week	Document	.accdr	CuraeDuisFaucibus	CuraeDuisFaucibus	SharePoint/blogspot/CuraeDuisFaucibus.accdr	SharePoint/blogspot	Willie Niccolls	143	572	2

Figure 12: First rows of the table "Placeholder data big"

After determining the necessary parameters for the exports, the first export was populated with data and served as the foundation for future exports. To accomplish this, we used the randomizer Table. This table contains short reference lists, that we use for the VLOOKUP function and in the dashboards DMS to calculate KPIs. Below we give the function of column G, H and K as an example for how we utilized the Randomizer Table populate number and text columns and introduce variations. These three columns show a good variety of use cases of the Randomizer Table and VLOOKUP function.

G. We introduced irregularities to the fixed title. For documents and sites, we applied a different formula. A 5% probability was introduced for the title to mention a topic or hotspot, and an additional 5% probability was added for it to violate one of the IM compliance rules.

DOCUMENT =IF(RAND()>0,95;VLOOKUP(RANDBETWEEN(1;15);Alles3;18)&" ";"")&F6&IF(RAND()>0,95;" "&VLOOKUP(RANDBETWEEN(1;52);Alles3;19);"")

SITE =IF(RAND()>0,95;VLOOKUP(RANDBETWEEN(1;15);Alles3;13)&" ";"")&F1002

H. The source path of a document has three variations. A 40% probability for it to be stored on a network drive, a 30% probability for it to be stored in a DWR-D site, and a 30% probability for it to be stored on a SharePoint site.
=IF(RAND()<0,4;"NETWERKSCHIJF/"&VLOOKUP(RANDBETWEEN(1;63);Alles2;6)&"/"&F2&E2;IF(RAND()<0,5;"DWRD/"&VLOOKUP(RANDBETWEEN(1;150);Alles2;7)&"/"&IF(RAND()<0,5;"GB/";"OB/")&F2&E2;"SharePoint/"&VLOOKUP(RANDBETWEEN(1;50);Alles2;10)&"/"&F2&E2))

K. We recognized that certain sites and documents are consulted more frequently than others. To reflect this, a 5% probability was introduced for a document or site to be visited significantly more often than others.

=IF(RAND()<0,75;RANDBETWEEN(1;75);IF(RAND()<0,8;RANDBETWEEN(75;150);RANDBETWEEN(150;2000)))

To improve the realism of the generated data, new exports were based on the previous export. This approach lowered fluctuations in the data, resulting in more realistic visualizations in the KPIs in the dashboard design. The following two examples show how the previous export was used to generate the new export.

G. We first checked whether the type (column D) was a document or site. If so, a 5% probability was introduced to regenerate the irregularities.

=IF(D2402=D2;IF(RAND()>0,95;VLOOKUP(RANDBETWEEN(1;15);Alles3;18)&" ";"")&F2402&IF(RAND()>0,95;""&VLOOKUP(RANDBETWEEN(1;52);Alles3;19);"");IF(RAND()>0,95;VLOOKUP(RANDBETWEEN(1;15);Alles3;13)&" ";"")&F2402)

K. The number of hits could increase or decrease by 10% based on the previous export.
=(1-(RANDBETWEEN(-1000;1000)/10000))*K1202

4.3 Software selection and DMS

The organisation's online environment is highly secure and makes use of their own data warehouse. Each employee uses either a thin- or fat-client to get access to their own cloud-based environment. Access to the internet is tightly regulated and only granted under strict protocols. This secure setup significantly impacts the implementation of the dashboard. In the following section, we will discuss the software used for creating and implementing the dashboard.

4.3.1 Software

The secure environment within the organisation allows us to use Power BI, which is an excellent tool for creating dashboards and performing analysis. Power BI focuses on data visualization and can collect data from various sources. Additionally, the seamless communication between Power BI,

SharePoint, and other commonly used office IT applications from Microsoft allows for minimal dataset preparation.

Power BI can be used to build the entire dashboard and the DMS behind it. However, there are some restrictions when editing the incoming data with the Power Query Editor. All changes made to the data are tracked by the Power Query Editor, which allows other editors to easily see what has happened. Nonetheless, large datasets can cause performance issues when making many edits. Therefore, it is crucial that the incoming data in Power BI only consists of the data necessary for measuring the KPIs, as previously defined in Section 4.2.

Although Power BI is an effective tool for creating the dashboards, it does not have a built-in option for publication. To solve this issue, the organisation has implemented a separate server and website within the secure environment dedicated to publishing dashboards. This application enables users to edit published dashboards, set authorizations for different roles (such as read-only or editor), and schedule automated refreshes of the connected databases. The publication server and website allow us to keep the dashboard up-to-date and easily accessible for all stakeholders.

4.3.2 DMS

As previously stated in the section above, we make use of the built-in DMS of Power BI. However, due to the use of placeholder data, we cannot display the full DMS for the actual situation. Nonetheless, we can provide a comprehensive DMS model for the placeholder data that serves as a suitable framework. This DMS model will increase the understanding of the data management of the dashboard.

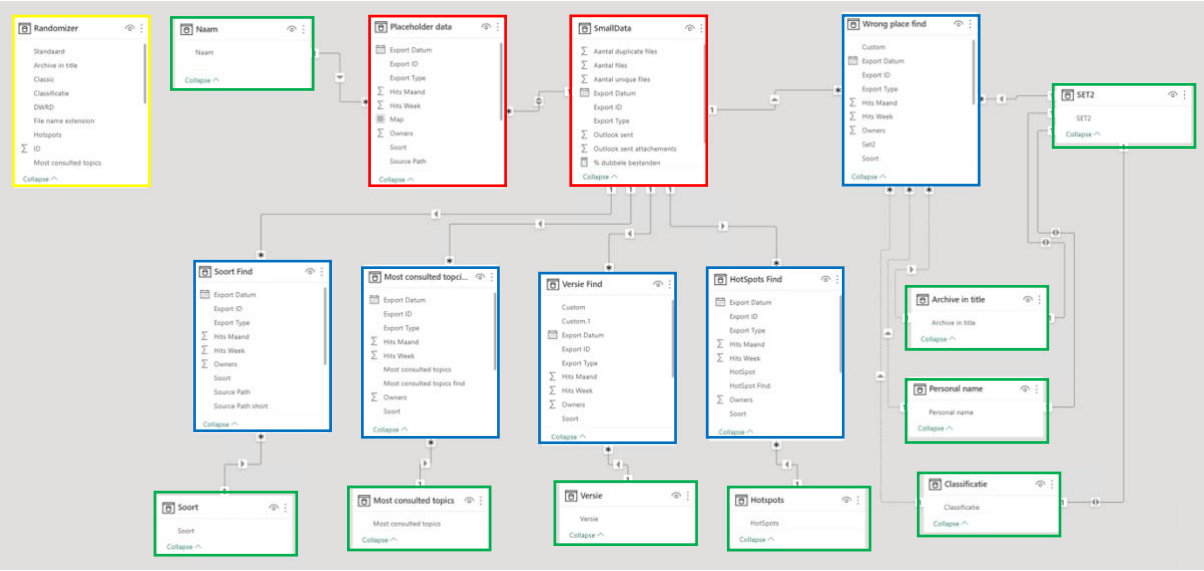

Figure 13: Dashboard DMS model

Figure 13 shows the DMS model for the dashboard. The DMS includes all the tables required to calculate the KPIs and basic performance indicators used in the dashboard. The model provides insight into the types of data contained within each table and the relationships between them. We can customize these relationships to enable drill-down and filter functionality to work in one or both directions. The DMS creates a good understanding of the different data flows.

The red tables serve as the primary data source. These tables are connected to the product owners' databases and are refreshed on a weekly basis. The blue tables, on the other hand, serve as references to the red source tables. These reference tables essentially act as copies of the original data. In most cases, calculating KPIs requires making significant modifications to the tables. However, with reference tables, we can make these calculations without changing the source data. Additionally, the reference tables have the benefit of automatically updating when changes or updates are made to the red source tables. This ensures that the reference tables always contain the most up-to-date information.

The yellow table functions as a "reference" table, which is used to generate the green "reference" lists. In this context, the term "reference" has a different meaning. The reference tables and lists contain a predefined set of data that does not change when the databases are updated. Unlike the red and blue tables discussed earlier, reference tables and lists require manual updates. The green reference lists enable us to search for a specific piece of text within a larger string. For instance, the reference list of hotspots enables us to search through all the titles of documents, sites, and folders to identify the ones connected to a hotspot.

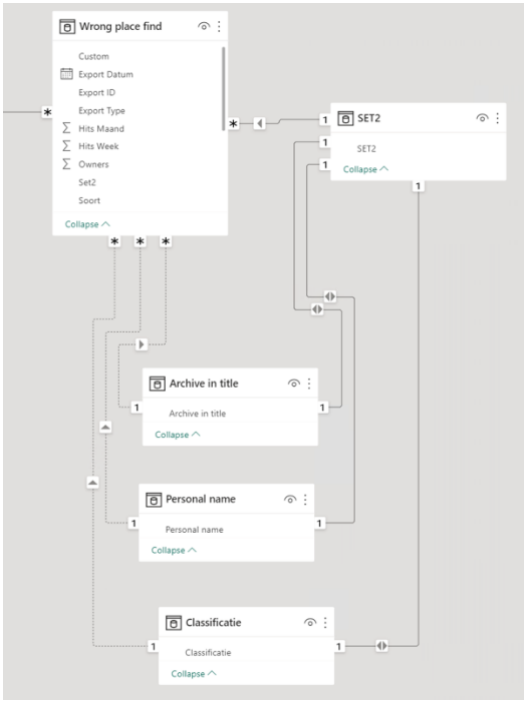

Figure 14: Relations between tables

In the DMS model, certain relationships between tables are indicated by dotted lines, which indicates that the relation is redundant. In Figure 14, the archive title, personal name, and classification data are all contained with SET 2, which is connected to the table wrong place find. However, the relationship indicated by the dotted lines are necessary to allow Power BI to use the "RELATED" function. This function allows to find and filter matching data between two different columns in two different tables. In the dashboard we use the following measure:

```
WRONG CLASSIFICATION = COUNTROWS(FILTER('WRONG PLACE FIND',
RELATED('CLASSIFICATIE'[CLASSIFICATIE]) = 'WRONG PLACE FIND'[SET2]))
```

4.4 Dashboard Design

I In this section we explain the different steps of the design process of the dashboard. The first step is to determine fitting graphs for each of the selected KPIs. We do this based on the findings of the literature and the needed data to calculate the KPIs. The second step is to design a lay-out. This lay-out will ensure that the dashboard will be efficient and effective. The last step is to introduce the overall dashboard design, graphs, and dashboard functionalities.

4.4.1 KPI visualisation

With the KPIs determined and all the needed data identified, we will choose a fitting visualisation for each KPI. The visualisations are chosen based on the findings of the literature research in Chapter 3.

Table 13 contains the list of KPIs and basic performance indicators and the chosen visualisation. In this table, we will briefly explain for each KPI which visualisation is the best option. The visualisations need to effectively show the goals of the KPIs and highlight/draw attention to the important data points. Furthermore, these visualisations need to follow the framework guidelines, so they are clear, simple, and accurate to provide meaningful insights of the data.

Table 13: KPI visualisation

Category	KPI	Visualisation	Comment
Actuality	Most consulted information topics	Multiple line chart	The chart shows the top 5 most consulted topics. Each line in the chart is for a topic.
	Duplicate file names	Stacked 100% area chart	We want to show the relation between the number of unique and duplicate files names. The 100% is the total number of files. We do not use a pie chart because the KPI is not static, and we want to show the change over time.
	Emails sent with attachment	Single line chart	With both KPIs we want to show the trend over time of a single variable.
	Version indication used in title	Single line chart	
Reliability	Employees with most final edits	Multiple line chart	The chart shows the top 5 employees/organisation paths with the most final edits. Each line in the chart is for a topic.
	Number of storage location for a Hotspot	Scatter chart	We can combine the two KPIs in a chatter chart to show the relation between the two and the relationship between the Hotspots
	Number of persons involved with a Hotspot		
Compliance	Orphaned information	Single line chart	Show the trend over time.
	Number of files saved at the wrong place	Stacked column chart	The stacked column chart allows to show the trend over time and shows absolute numbers of each of the 4 indicators.

DWR-D	Number of total sites	Scorecard with percentage change previous period	Important to keep visualisation of the basic performance indicators simple and small so it does not distract the stakeholder of the KPIs. Percentage change is a space efficient way of enriching the data with a comparison. tables allow for a simple visualisation for a top 3 list.
	Number of standard sites	Scorecard with percentage change previous period	
	Number of classis sites	Scorecard with percentage change previous period	
	Amount of stored data	Scorecard with percentage change previous period	
	Ratio active, inactive, and archived sites	Percentages bar graph	
SharePoint PaaS	Number of sites	Scorecard with percentage change previous period	
	Number of subsites	Scorecard with percentage change previous period	
	Amount of stored data	Scorecard with percentage change previous period	
	Most visited sites	table with rank, rank change previous period, title site and number of hits current period	
Network drives	Number of folders	Scorecard with percentage change previous period	
	Number of files	Scorecard with percentage change previous period	
	Amount of stored data	Scorecard with percentage change previous period	
	Cluster with most data	Scorecard with percentage change previous period	

4.4.2 Dashboard layout

To ensure an efficient dashboard, the first step in the design process is to create a structured layout. As mentioned in Section 3.1.1, we can improve the efficiency of the dashboard by displaying information in a well-organized and structured way, make the data and information easily accessible and making interaction with the dashboard intuitive. By prioritizing the layout, we can focus on the overall user experience without getting distracted by the visuals design of the dashboard.

Figure 15 shows the different components of the dashboard and the optimal placement of the KPIs within these components. This lay-out is a rough outline which will be used to during the design phase.

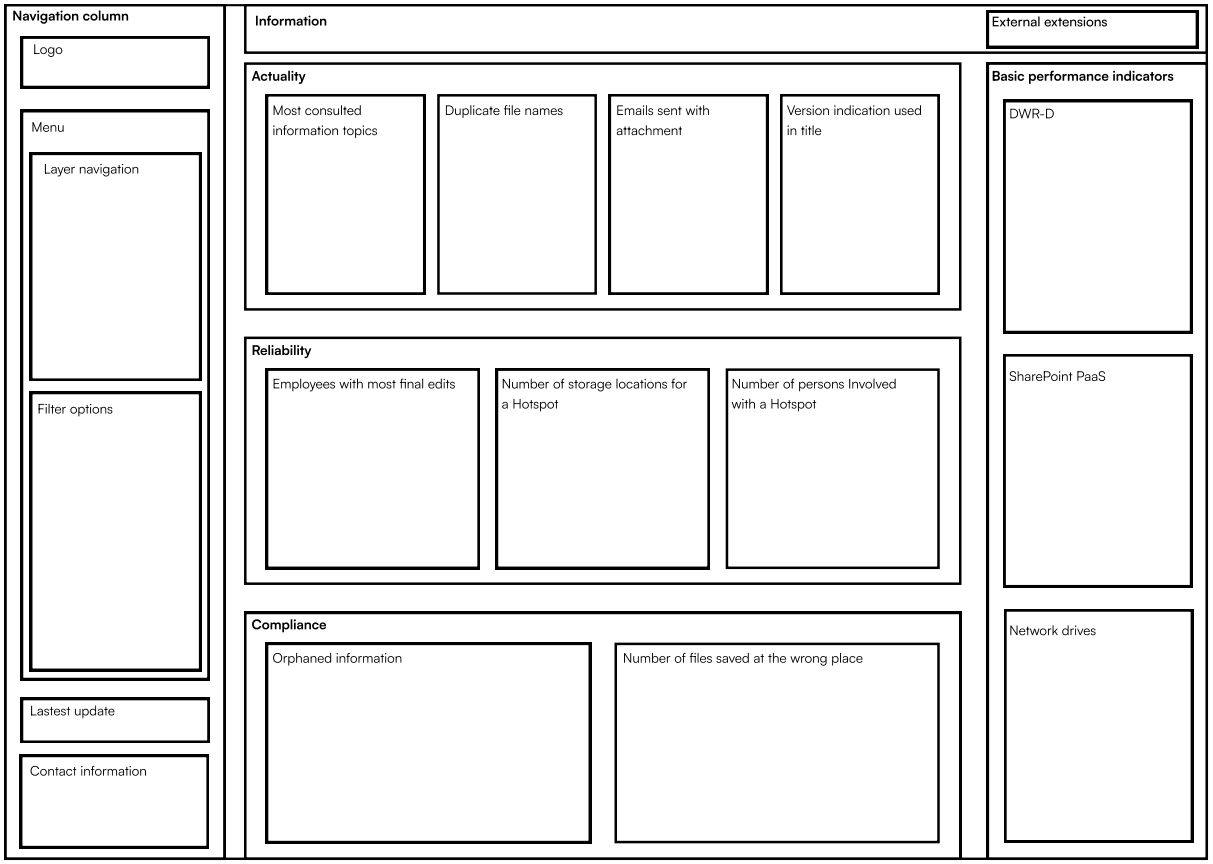

Figure 15: Lay-out dashboard and KPI placement.

By following guidelines, we can create a dashboard that not only looks visually appealing but also provides the stakeholders with the information they need in an efficient and intuitive manner. We will elaborate on the placement and the function of these components. As recommended, all components of the dashboard are placed in one view.

The first component of the dashboard is the navigation column, located on the left-hand side. This component allows the end-user to navigate between different layers and set filters for the visuals. It also contains information about the last data update and its frequency. The placement on the right is chosen for the same reason the most important KPI should be placed in the top left corner or in the middle of the dashboard. End-users will first see the settings of the dashboard before seeing the KPIs. This enhances their understanding of the KPIs purpose and the interpretations of the visuals.

At the top of the dashboard, a small component displays simple and brief information such as the dashboard title and external links. The aim is to quickly grab the user's attention and providing a brief overview of the dashboard.

The dashboards three main components, which correspond to the three categories of KPIs we previously determined (Actuality, Reliability, and Compliance), are in the centre of the dashboard. As expected, these components take up the largest area of the view. This highlights the importance of the categories and ensures that they are the focus of the dashboard. Each component is represented by an equally spaced horizontal rectangular box that contains the corresponding KPIs. This clear distinction between the categories helps the end-user to understand and analyse the performance data better. The rectangular boxes also enable related KPIs to be placed next to each other, making it

easier for the end-user to identify patterns and relationships between the KPIs. This layout is particularly useful for descriptive analytic dashboards, as end-users can easily compare KPIs across the different categories.

The basic performance indicators are the last component of the dashboard and are positioned on the right-hand side. They are designed to support the KPIs, providing additional information that can help end-users make better analysis by identifying trends and relationships. The component is placed on the right-hand sight because it is the least important and does not need to distract the end-user from the important KPIs.

4.4.3 Dashboard design

In this section, we will explain the overall design and the different design functionalities of the dashboard. Just like with the layout, the guidelines mentioned in Section 3.1, can improve the overall user experience, efficiency, and relevance. It is important to note that the graphs and indicators in the figures are based on the placeholder data and do not reflect the real-world situation of the organisation. Furthermore, it is important to note that the dashboard is in Dutch since that is the primary language used by the end-users.

Figure 16 shows the complete dashboard design. As seen, we can still recognize the lay-out designed in previous section. The white boxes contain the KPIs for actuality, reliability, compliance, and the basic performance indicators (IT performance). On the other hand, the information component and the navigation column are not placed in white boxes as they do not contain any KPIs or indicators.

The colour scheme for the dashboard is based on the organisation’s colours (orange-dark blue), along with the use of red-orange-green as indicators for good or bad performance. The organisation's colours make the dashboard more recognizable and familiar for the end-user. The colour scheme is consistent throughout the dashboard, but less vibrant for the basic indicators to focus the end-user’s attention on the middle section.

In designing the dashboard, we followed the guidelines to reduce non-data pixels by making the visuals of the KPIs as large as possible while removing unnecessary information. We aimed to find a balance between expressiveness and efficiency, while providing adequate supporting content without overcrowding or making the dashboard chaotic.

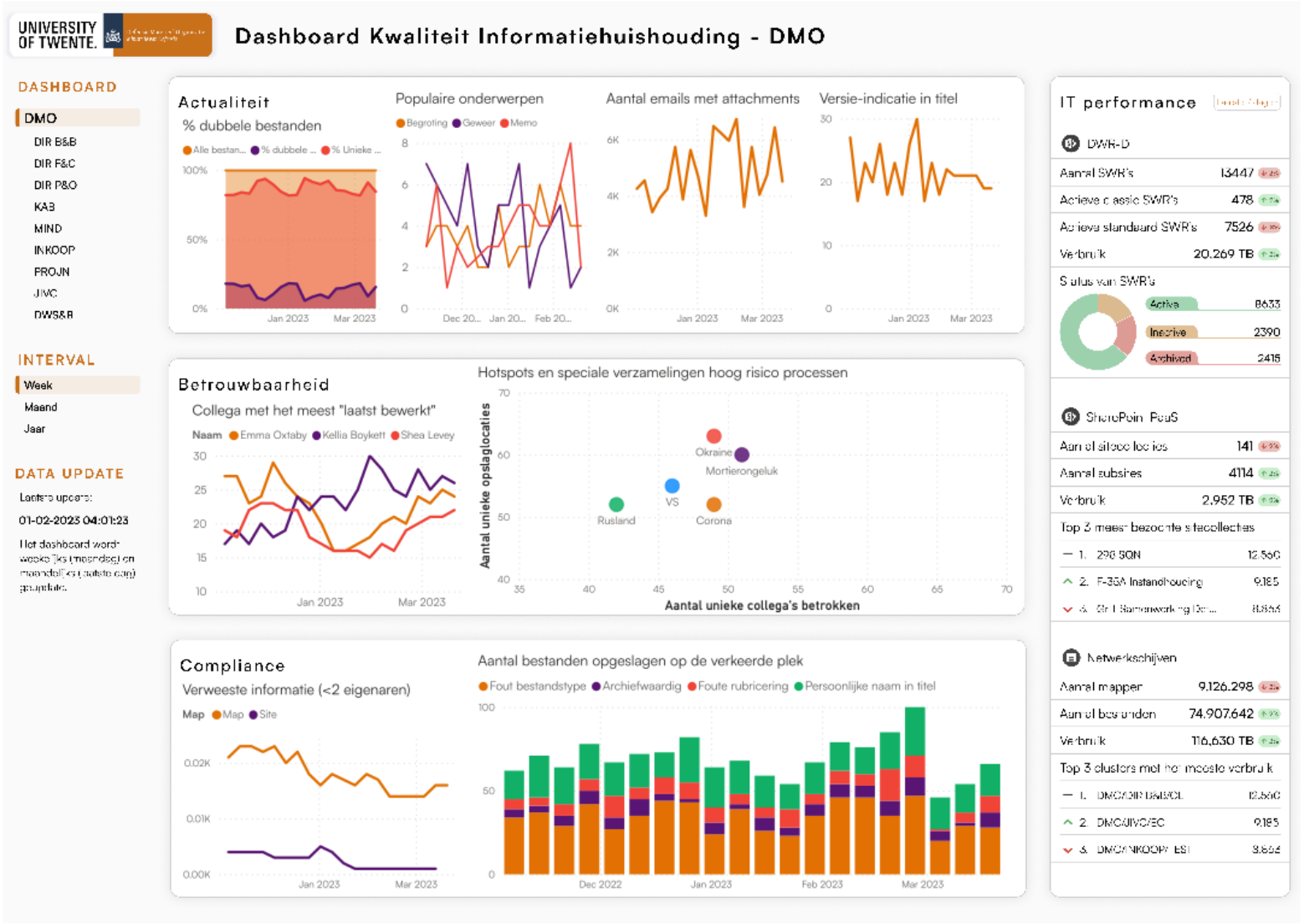

Figure 16: Complete dashboard design

Graphs

As seen in Figure 17, we used separate graphs for each KPI in the actuality category. Each graph uses the data warehouse updates as the intervals on the x-axis. The data warehouse is updated weekly on Monday and on the first Monday of the month. The x-axis can be adjusted to weekly, monthly, or yearly intervals using the filter on the right-hand side of the dashboard. In the next section, we will provide a more detailed explanation on how these filters influence the drill down option between the layers.

For the number of duplicate files, we used a 100% area chart to provide a clear overview of the total number of files and the ratio between unique and duplicate files. The graph has a correlation with the number of emails sent with attachments, which is the primary reason for creating duplicate files. As the number of emails sent with attachments increases, the number of duplicate files will also increase. This is just one example of the many relationships between the KPIs.

We also included visualisations for the most consulted information topics and version indication used in the title, which both show the change over time. For version indication used in the title, the goal is to get the line as low as possible. The most consulted information topic visualisation should provide a clear indication of which topics are relevant and for how long.

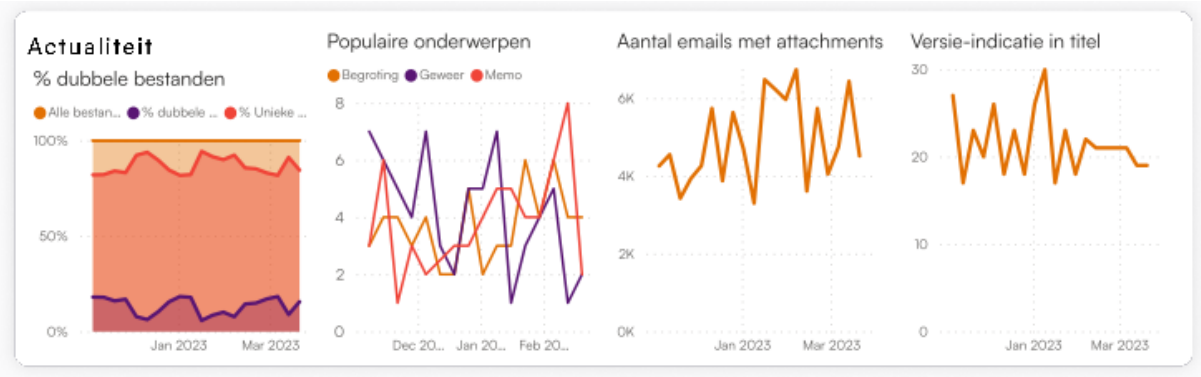

Figure 17: Actuality dashboard design

In the reliability category, see Figure 18, we used two visuals for tracking the three KPIs. On the left side, we see a graph that shows the employees with the most final edits. This graph allows end-users to identify outliers and check over time if how the number of edits develops. It is important to note that within an organisation, some individuals or workgroups are expected to have more last edits than others. This information will be most useful in the middle layer of the dashboard.

On the right side, we have a scatter plot that shows the relationship between the number of storage locations (on the y-axis) and the number of unique employees involved (on the x-axis). By analysing the relationship between the two KPI, the end-users can determine if there are any irregularities regarding the ratio employee involvement and storage locations.

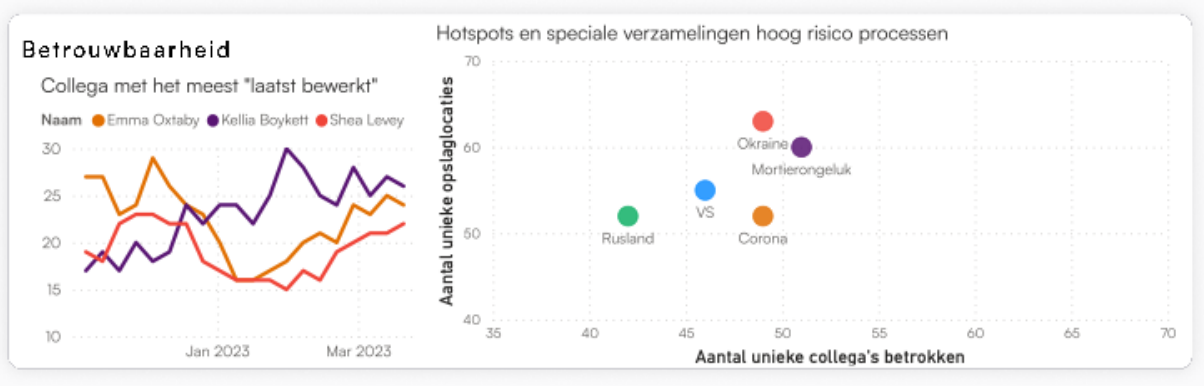

Figure 18: Reliability dashboard design

Figure 19 shows the design of the compliance category which consists of two graphs. On the left-hand side, the graph shows the number of folders and sites that have two or less owners (orphaned information). The goal is to minimize the number of folders and sites and ensure that two or more owners are defined for all folder and sites.

The stack bar graph tracks the most often violated compliance rules. Each bar in the graph is a snapshot of the situation and consists of four indicators. These indicators are used to determine the total number of files that are stored in the wrong location. Ultimately, the compliance category is the best measure for the overall performance of information management at the organisation.

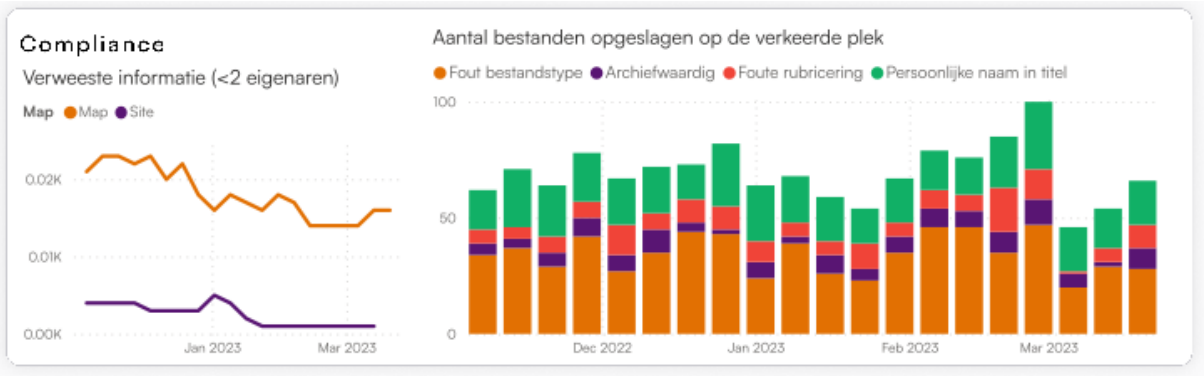

Figure 19: Compliance dashboard design

Figure 20 shows the IT performance design, which primarily consists of scorecards. The top right of the component indicates if the data is in weekly or monthly intervals based on the set filter. Most scorecards feature a gauge meter that display the percentage change compared to the last period. As this component is primarily used for comparison, the data can change dynamically when end-users select a specific bar or data point from an earlier interval. This allows for a more comprehensive analysis of previous periods and enables the end-user to identification what went wrong last time.

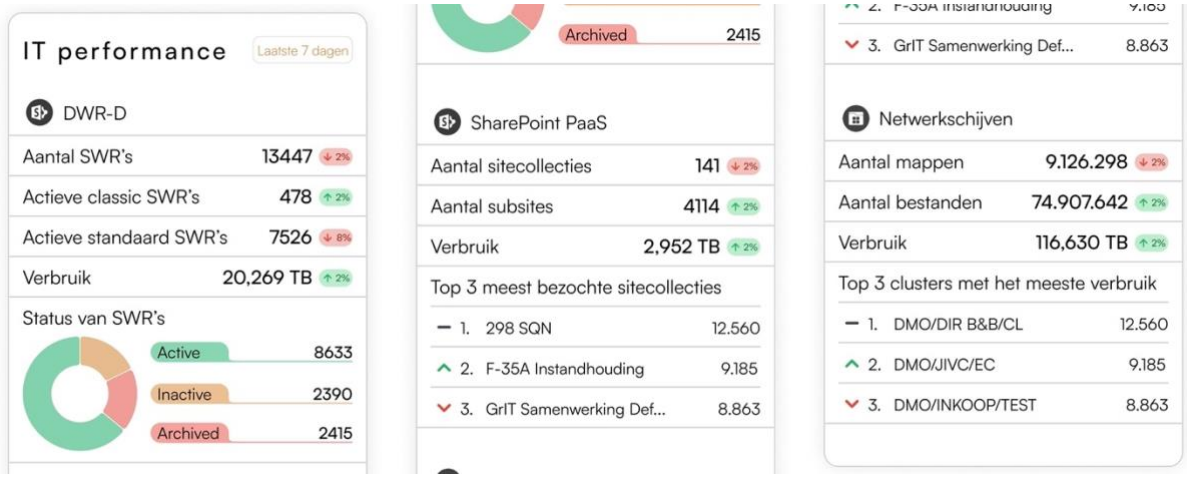

Figure 20: IT performance dashboard design

4.4.4 Layers and navigation

As mentioned in Section 2.4, one of the stakeholder's requirements is the ability to navigate between three predefined layers: DMO, DMO-board, and Data of KPI. These layers correspond with the layers of the MAD framework of Eckerson (2010) discussed in Section 3.1.4. Figure 21 shows an example of how to navigate between these layers. On the left-hand side of the dashboard, in the navigation column, the user can click on a board and visualisation will change accordingly. As they do, the title of the dashboard changes to reflect the current layer they are viewing.

Figure 21: Layer navigation buttons and title changes

4.5 Summarize

The primary objective of this chapter was to provide a description of the various steps involved in creating an efficient and effective dashboard. During KPI selection and dashboard design process we used the research question, requirements, limitations, and dashboard goals as guidelines. The first step involved determining KPI categories for the dashboard. The categories were based on different aspects of information management in office IT, namely actuality, reliability, and compliance. To make the categories measurable, we selected KPIs. The second step involved identifying the type of data required to calculate the KPIs and determining if the data was readily available. Placeholder data was generated based on the organisation's characteristics for any missing data and security reasons. A DMS was created using Power BI, which can be used as a framework when the actual data becomes available. Before working on the dashboard design, the next step was to determine the visualizations

of the KPIs and the dashboard layout to ensure that the dashboard was efficient and easy to use. The KPI visualizations and layout were combined in the final step to create the completed dashboard design. The organisation's colours were used throughout the dashboard to make it recognizable for the end-users. In total, the dashboard has nine KPIs and thirteen basic performance indicators that can be used to make comprehensive analysis of the quality of the office IT landscape. In the next chapter we are going to evaluate the current dashboard design, evaluate the feedback from a questionnaire and interviews and implement the suggested improvements.

5 Evaluation and improvement of the dashboard

In this chapter, we aim to evaluate the dashboard and compare its final design with the predetermined goals and research question. The evaluation of the dashboard is done by conducting unstructured interviews, a questionnaire survey, and an analysis of the requirements to see if they are implemented correctly. Additionally, we check whether the KPIs meet the objectives. However, due to limitations in the software version of Power BI and time constraints, the dashboard is not entirely operational. Consequently, during the stakeholder interviews, we did online demonstrations to illustrate the dashboard's various components. Also, we added a document to the questionnaire that explained all the elements of the dashboard. The primary objective of this chapter is to use the feedback of the stakeholders, our findings from Chapter 4, and our evaluation of the dashboard design and KPIs to improve the dashboard's overall efficiency and effectiveness. In Section 5.1 we explain the questionnaire and the unstructured interviews. We evaluate the feedback in Section 5.2 and implement improvements based on the feedback and our findings in Section 5.3.

5.1 Questionnaire and unstructured interviews

The questionnaire aims to assess user experience of the dashboard and determine if the established goals and requirements are incorporated correctly into its design. The questionnaire is divided into two parts. The first section features 26 questions with two contrasting properties that the employee can experience during the use of the dashboard. We use the User Experience Questionnaire (UEQ) framework developed by Dr. Martin Schrepp (2023) along with the corresponding data analysis tool. The second segment of the questionnaire extends the UEQ with five open-ended questions. The first two questions are about the dashboards impact on measuring the quality of the information used in office IT, while the remaining three questions review the dashboards design and visualizations. The complete questionnaire is available in Appendix F.

The stakeholder interviews kicked-off with a demonstration of the dashboard in Power BI. The stakeholders had the opportunity to ask questions about the KPIs or components during the demonstration, allowing us to observe their initial experience with the dashboard. In total we received four filled in questionnaires and form these four, two were also interviewed. The feedback is evaluated in Section 5.2 and is used for implementing improvements.

5.2 Results evaluation

The goal of this research is to improve the quality of information used within the office IT landscape. To achieve this goal, a dashboard has been designed to offer improved insight into the information quality through dividing the quality into three categories (ARC) and a category with basic performance indicator. We make this division, so the goal becomes quantifiable, ambitious, measurable, controllable, and achievable. Measuring quality can be challenging since it involves multiple qualitative aspects that support why specific information quality thresholds have been reached. So, during the interviews and the questionnaire, employees have been asked to evaluate whether the dashboard has enhanced their understanding of the quality of information, if the connection between the KPIs and categories is clear, and if the categories are well-connected with the goal. Here are some quotes of the employees:

> *Employee 1: "Certainly! It is (for us) very new to use data to make statements about information quality. In practice, one KPI may say more than another KPI. We really want to get started with this dashboard. I have not found any dashboards with KPIs that try to indicate the quality of information. We are pioneering, certainly within*

the organisation, probably throughout the government. Gradually we will have to find our way in which KPIs are most effective."

Employee 2: "Yes, the dashboard quickly and easily shows whether the IM (information management) rules are being complied with, making it easier for us to focus on improving the quality of information management."

Employee 3: "The indicators/KPIs are good measures of quality."

Employee 4: "To start, I think the ARC principle is a good starting point for highlighting the usefulness and necessity of good information management and that other employees need to be more aware."

The feedback obtained from employees has been very positive, indicating that the dashboard has indeed improved their understanding of the information (management) quality. The use of the Actuality, Reliability, and Compliance (ARC) categories has been particularly well-received, as the ARC has been used in other information management projects. In fact, the information presented on the dashboard may be used in future projects to validate the impact of the projects on the information quality and information management skills. Employees are also impressed by the dashboard's depth of information and its suitability for a diverse range of end-users. Another issues that the organisation had was that it was not clear what metadata was available and what metadata is needed to measure the quality of information. To address this issue, we determined the needed metadata and the available metadata to calculate KPIs, providing the organisation with essential information to start metadata collection and structuring. The organisation has expressed great satisfaction with the dashboard's DMS framework, as it allows the organisation to start metadata collection and structuring. While most employees found the categorization of information to be clear and intuitive, some experienced confusion regarding category definitions. In Section 5.3, we will introduce a solution to clarify the connections between the dashboard's objectives, categories, and KPIs for all current and future end-users.

In both the interview and the last three questions of the questionnaire, the focus shifts to the layout and visualisation of the KPIs within the dashboard. The feedback gives valuable information that can be used to enhance the dashboard's usability and comprehensibility. Below are some quotes about the KPI visualisation and dashboard design of the employees:

Employee 3: "Super nice layout and the use of colour makes it clear what the main and what the side issues are. Certainly, good that there are a few visualizations that show the development over time so that the direction of development is also visible."

Employee 4: "I like the design with the different categories. Immediately you can see the KPIs and to which category they belong. The ARC and the separation of the KPIs allows us the focus and steer on a specific category."

The feedback received regarding the dashboard layout has been generally positive, with users appreciating the separation and the placement of the categories, which allows for efficient and effective analysis of KPIs within their respective categories. Although the amount of information presented on the dashboard initially appeared overwhelming to some, employees found it easy to establish a connection with the overarching goal. Some users expressed difficulty in interpreting

certain visualisation titles or values, highlighting the need for further clarification. In Section 5.3, we will review and update all titles, values, and tooltips to improve the dashboard's usability. Additionally, one employee suggested the inclusion of target values within the visualisations, which is a valuable recommendation. However, the lack of reference data and the use of placeholder data make it challenging to come up with well-founded target values for most graphs.

The feedback obtained from the UEQ questionnaire aligns with the results from the open-ended questions and interviews. As seen in Figure 22, all categories received a score of +1.5 or higher. However, due to the limited sample size, these values may not be entirely representative. The variance, as indicated by the black bar, provides a better indication of the dashboard's overall performance. Notably, the dashboard scores the highest in the attractiveness category, with the highest score and smallest variance. The attractiveness category reflects the dashboard's visual aesthetics and overall appeal (Schrepp, 2023). On the other hand, the dashboard's lowest score is in the perspicuity category, which indicates how easily users can familiarize themselves with the dashboard (Schrepp, 2023). This finding is consistent with other feedback received, indicating that the dashboard may initially appear overwhelming.

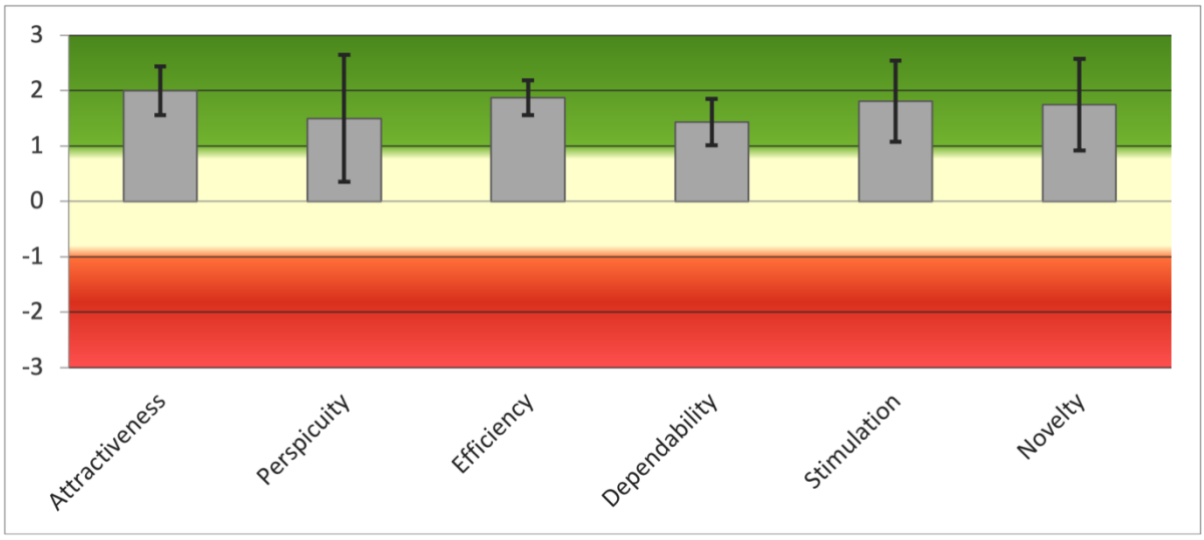

Figure 22: UEQ results

In Figure 23, the UEQ results are compared with those of other studies. The mean values are represented by the black diamond, while the black bars indicate the variance. Two categories received scores that were below average or worse. As previously noted, it was anticipated that the perspicuity category would score poorly due to the potentially overwhelming nature of the dashboard. However, in comparison to the benchmark, the dependability dimension also received a below-average score. Dependability is a measure that assesses the extent to which users feel in control of the dashboard and is regarded as a goal-oriented metric (Schrepp, 2023). One reason for this lower score may be caused by the challenge of initially establishing a clear link between the dashboards goals and the dashboards KPIs. In Section 5.3, we propose a solution to improve this issue.

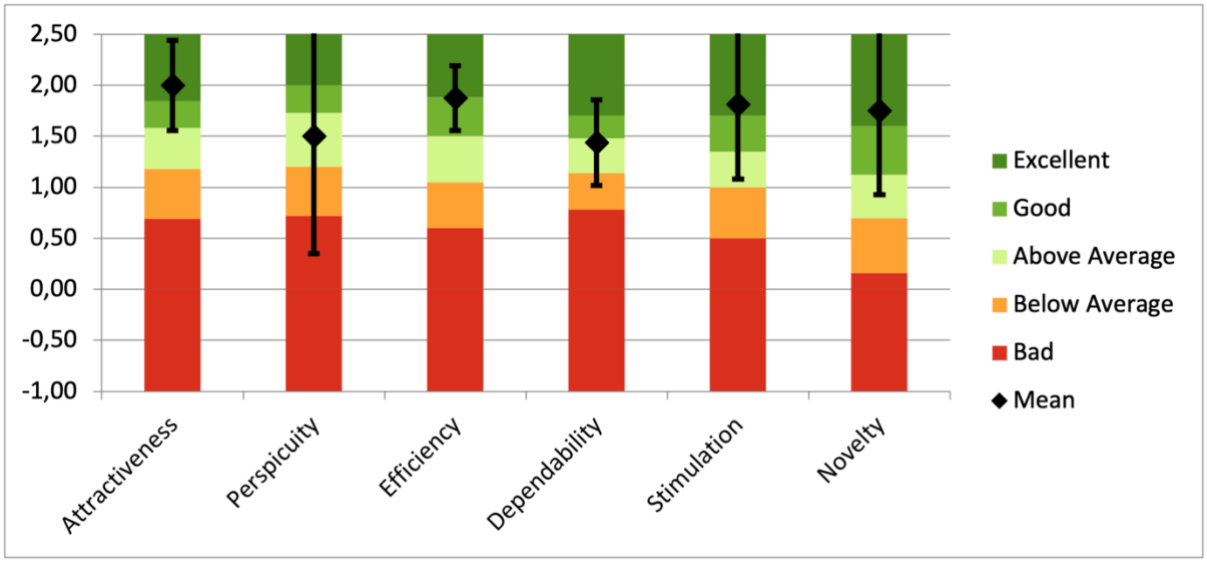

Figure 23: UEQ results compared to benchmark.

5.3 Implementation of improvements

In this section, we will describe the improvements made to the dashboard with regards to the parts that employees found hard to understand, while also adding our own findings from writing chapters 4 and 5. While the feedback received was mostly positive, there were two areas in which employees struggled, as seen in Section 5.2. Specifically, the first issue is about the lack of clarity regarding the relation between the goal, components, and KPIs of the dashboard. The second issue mentioned by the employees was related to unclear visuals.

To address these problems, we have implemented several improvements, which we will explain and compare to the design presented in Chapter 4. The changes are numbered. These numbers correspond with the circled numbers in Figure 25.

1. *Information buttons*
   Our analysis revealed that the dashboard can be overwhelming, particularly for employees who have limited knowledge about information management, the ARC, and dashboard/KPI reading skills. We further observed that the relationship between the KPIs and their categories, as well as between the categories and the overall goal, can be challenging to understand. To solve this issue, we have introduced information buttons as a solution. Clicking on these buttons will display a pop-up window containing relevant information, such as details about the compliance categories. The information presented will include the definition of compliance, its relationship with measuring the quality of information, and how to interpret the KPIs. The addition of these buttons is expected to make the dashboard more user-friendly, particularly for employees who are new to information management. This enhancement will enable the dashboard to stand on its own, without requiring explanation or support from others.

2. *Percentages to "Emails sent with attachments" and "version indication used in title".*
   The two KPIs, namely, "Emails sent with attachments" and "version indication used in title", are both visualized through a line graph. To improve these KPIs, we have added a secondary line that displays the ratio between the metric and the total. The addition of this line provides

the user with a more comprehensive understanding of the situation. While the original line on the graph provides information regarding the size of the problem, the ratio enables the user to understand how much of a habit this is among employees, thereby putting the original line more into perspective. Consequently, this improvement allows for a more detailed analysis of the current situations and development over time.

3. *Top 3 of "Most consulted information topics" based on number of hits.*
   The KPI was based on the number of documents, folders, and sites titles containing one or more of the predefined topics listed in the reference list. In the original visualisation, the top three topics were based on the number of times they were found. However, this approach created two problems. First, some employees found the presented numbers vague and therefore the KPI hard to understand. Second, the previous method did not provide a clear indication of the most frequently consulted topics. To solve these issues, we have recalculated the KPI by measuring the popularity of each topic based on the number of hits. This modification offers a more realistic indication of the most frequently consulted topics, making it easier for end-users to interpret the presented data.

4. *Rearrange "version indication used in title" and "most consulted information topics".*
   We have rearranged these two KPIs, so the KPIs "version indication used in title" and "duplicate file names" are placed next to each other on the dashboard to enable end-users to see the possible correlation between them.

5. *Improved scatterplot for hotspot KPIs*
   The scatterplot displays the number of involved employees and unique storage locations for information linked to a particular hotspot. This visualization enables end-users to compare different hotspots and identify any outliers. However, the presented values are challenging to put into perspective. To solve this, we have added a new dimension to the scatterplot by including the number of hits for each hotspot. A hotspot's popularity is visualized by increasing the size of its corresponding point based on the number of hits. This improvement enables the end-user to gain a better understanding of each hotspot's usage. For instance, hotspots with numerous storage locations and involved employees but a low number of hits may suggest a decrease in popularity, indicating the need to gather and archive information. Therefore, this improvement provides a more comprehensive representation of which data is in use and reliable.

   During the process of adding the number of hits, it came to our attention that the data presented on the x and y axes were the summation of the number of employees or storage locations from all the exports combined. To improve the accuracy and relevancy of the dashboard, we made a modification to only display the most recent export. This change was made to provide the most up-to-date representation of the hotspots.

6. *Switched from employee name to organisation path for "Employees with most final edits".*
   During the evolution process, we identified a contradiction with one of the KPI "Employee with the most final edits" and the limitations outlined in Chapter 2. As per the limitations, the dashboard should not display any information about individual persons. To solve this issue, we replaced the personal names with the organisation path. By doing so, we ensured anonymity since the organisation path includes a group of employees rather than a specific

employee. Additionally, this change does not compromise the ability to analyse the reliability of information.

7. *Update to titles, legend, axis, and tooltips.*
   During the implementation of the improvements, several titles, legends, axes, and tooltips were updated to enhance the understanding of the dashboard based on employee feedback and our own findings. The following changes were made:

   a. New title and Legend lay-out for “Employees with most final edits”.
   b. Axis and Legend lay-out for “Orphaned information”.
   c. New title for “Most consulted information topics”.
   d. Update tooltips for “Version indication used in title”.
   e. Update tooltips for “Emails sent with attachment”.
   f. Axis lay-out and update tooltips for the Hotspots scatterplot.

Figure 24 shows the updated dashboard design that incorporates all the improvements. The improvements are further shown in Figure 25, we compare the new design with the design of Chapter 4. The changes are indicated by red circles with numbers that correspond to the explanations provided above. Note, some numbers can occur more than one time if the change is applied at different places in the dashboard.

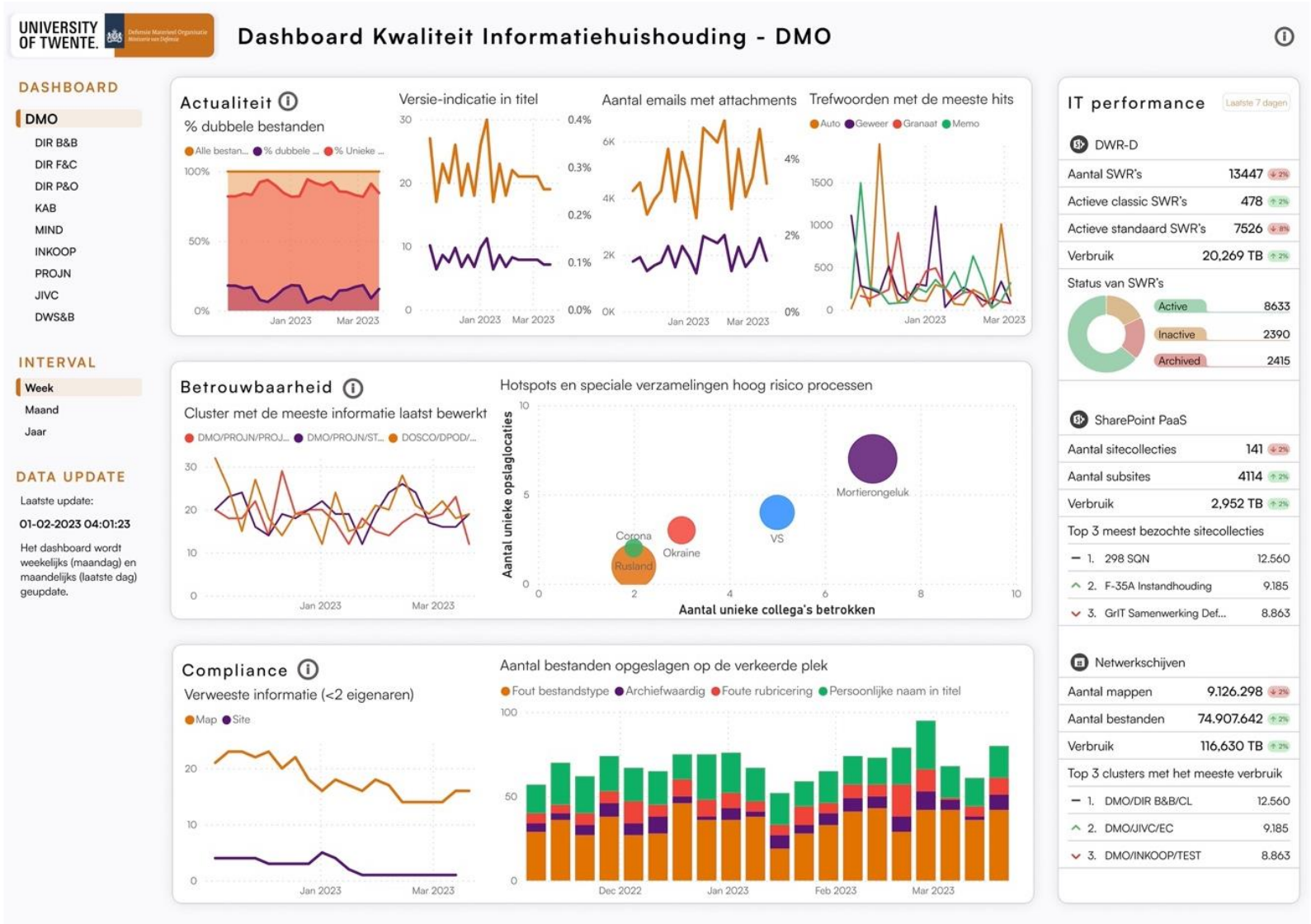

Figure 24: Dashboard after improvement

Figure 25: Dashboard Chapter 4 compared to dashboard with the added improvements.

5.4 Summarize

In this chapter we conducted an evaluation of the dashboard design provided in Chapter 4. The purpose is to evaluate if the dashboard meets the goal of improving the quality of information used in office IT applications by improving employees' information management skills. For the evaluation we gathered feedback from four questionnaires and two unstructured interviews. The feedback showed that the dashboard had indeed improved the employees' understanding of information quality and information management. The feedback also showed that the use of the Actuality, Reliability, and Compliance (ARC) categories is well-received including the layout and visualization of the KPIs within the dashboard. The UEQ questionnaire results showed overall good scores for most categories, with the highest score in the attractiveness category and the lowest score in the perspicuity category. In the last part of this chapter, we made improvements to the dashboard based on employees' feedback and our own findings. We identified two main subjects for improvements: a lack of clarity regarding the relationship between the goal, components, and KPIs of the dashboard, and unclear visuals. The following improvements were implemented in the dashboard:

- Information buttons
- Percentages to "Emails sent with attachments" and "version indication used in title".
- Top 3 of "Most consulted information topics" based on number of hits.
- Rearrange "version indication used in title" and "most consulted information topics".
- Improved scatterplot for hotspot KPIs
- Switched from employee name to organisation path for "Employees with most final edits".
- Update to titles, legend, axis, and tooltips.

6 Conclusion and recommendation

This chapter concludes this research by giving the conclusion for the research question but first, we give a brief recap of the problem and the conducted research. In Section 6.1, we present our conclusion and provide an answer to the research question. Subsequently, in Section 6.2, we discuss the limitations we encountered during the research. Next, we give our recommendations for the company in Section 6.3, followed by the suggestions for future research in Section 6.4. Finally, in Section 6.5, we discuss the practical and theoretical contribution of our research.

The organisation has been shifting its focus towards an IT-driven business strategy. However, the organisation generates a significant amount of data and information, which causes challenges in assessing the quality of information used in the office IT landscape. The organisation is not able to determine the quality based on the actuality, reliability, and compliance because of having no single point of through for many information topics and the significant amount of files used by the organisation. The last problem is caused by the lack of management information. The low information management skills of employees and the large amount of unstructured information has resulted in employees wasting too much time with searching for information, negatively impacting work efficiency.

This problem has prompted the organisation to question whether it can increase the actuality, reliability, and compliance (ARC) of the office IT landscape. To address this issue, the organisation is taking steps to improve its data management skills by collecting metadata and visualizing it to gain insight and overview of its quality of information and the corresponding metadata. A dashboard tents to be a good solution as it can provide a DMS and insights about the quality of information. A dashboard is also the preferred solution of the organisation. Given that quality is not easy to measure, it has been divided into three categories, namely actuality, reliability, and compliance of information. This led to the main research question:

"How can a dashboard be designed to help the visualization of managements information and increase the actuality, reliability, and compliance of the office IT landscape?"

In this research, we utilized the Design Science Research Process (DSRP) to design a dashboard and DMS. The dashboard is used for visualizing KPIs measuring the quality of information used in the office IT landscape. Quality of information is measured using actuality, reliability, and compliance. To achieve this, we conducted a context analysis of the organisation and its stakeholders and reviewed existing literature on dashboard design and KPIs. A list of KPIs and the necessary data was derived from a combination of these findings. We also generated missing data to design and evaluate the dashboard, which we then improved.

6.1 Conclusion

In this research, we conducted a thorough investigation of the current situation within the organisation to determine the scope of our research. This involved identifying the office IT landscape, as well as the structure and availability of metadata. From the problem cluster in Chapter 1 we identified that no insight on the available metadata is the core problem. Through our analysis in Chapter 2, we found that the organisation recognizes four types of IT applications, but we narrowed our focus to common IT applications. Common IT includes the four largest office IT application and are used for creating, storing, using, sharing, and archiving information. We concluded that for these four applications within common IT, there is no centralized location for storing metadata. Rather, the

metadata is scattered throughout the organisation and often contains limited information for sites or folders. Moreover, detailed metadata is unavailable for documents.

To determine the KPIs for measuring the quality of information, we took several aspects into consideration. Firstly, we interviewed the problem owner and at least one other important stakeholder to gather information for a context analysis and create a list of requirements and limitations. Secondly, in Chapter 3 we conducted literature research on KPIs to identify the aspects that KPIs should have for measuring the quality of information. During the KPI selection in Chapter 4, we combined the requirements, limitations, research goals, and KPI quality aspects. The list of KPIs focusses on solving the problem of the organisation by measuring the actuality, reliability and compliance of information. These findings confirm that there is a need for improvement in data management skills, specifically in the organisation's ability to collect and visualize metadata, to enhance the quality of information used in the office IT landscape. Table 14 shows the information quality categories and the KPIs that will help to gain more insight and achieve the needed improvement.

Table 14: Information quality categories and their KPIs

Actuality	**Reliability**	**Compliance**
Most consulted information topics	Employees with most final edits	Orphaned information
Duplicate file names	Number of storage location for a Hotspot	Number of files saved at the wrong place
Emails sent with attachment	Number of persons involved with a Hotspot	
Version indication used in title		

In addition, incorporating basic performance indicators into the KPIs significantly enhances their utility, allowing stakeholders to perform more advanced analyses and gain a more comprehensive perspective on the data.

We have also identified in Chapter 4 that the organisation has limited options for a DMS, with only MS Power BI being used due to the highly secure online environment that runs on their own data warehouse. We have designed a DMS around three tables containing metadata and reference lists, which works well for incoming metadata that does not require many modifications. The incoming metadata is determined by the KPIs, as detailed in Section 4.2.

For visualizing the KPIs, we have used a descriptive analytic dashboard that allows for data summarization and analysis of data patterns, which is essential for measuring the quality of information. Based on systematic literature research, from Chapter 3, we have designed a dashboard that fits within a single view and follows the MAD framework, showing KPI visualization at the organisation, board, and KPI levels. The dashboard design and visualizations are based on the guidelines, requirements, and limitations identified in Section 2.4. In Chapter 5, we have evaluated the dashboard using a questionnaire and interview and incorporated the feedback form the employees to optimize the dashboard further.

In conclusion, we have utilized all the information gathered in this study to design the most effective and efficient dashboard for the organisation to measure the quality of information used in the office IT. The final dashboard can be found in Section 5.3.

In response to the research question, " *How can a dashboard be designed to help visualize management information and increase the actuality, reliability, and compliance of the office IT landscape?*" we have determined that the dashboard significantly enhances employee knowledge about the quality of information used in office IT. This dashboard can be a critical tool for employees to improve actuality, reliability, and compliance (ARC) of their information, and our KPIs meet set requirements and provide insights into each ARC. With the addition of tooltips, employees can better understand and analyse the relationships between the KPIs and their categories, as well as between the categories and the overall goal. However, as measuring the quality of information is uncommon, we must evaluate the effectiveness of all KPIs over time.

Overall, the dashboard provides several advantages, such as making management information easily accessible for employees, providing real-time insight into the performance of information used in the office IT landscape, establishing a framework for a DMS, and offering a storage location for metadata. Through our research, we have identified limitations and requirements for the organisation, which we discuss in Sections 6.2 and 6.3, respectively. We have also contributed practically and theoretically to the field of information management, as discussed in Section 6.5. Concluding, by answering our research question, we can improve the organisation's original question of how to increase the ARC of the office IT landscape.

6.2 Contribution to practice

This research offers a relevant framework for the organisation to implement a dashboard that addresses the research question of whether the organisation can increase the actuality, reliability, and compliance (ARC) of its office IT landscape. Our research identifies the current availability of management information and metadata, as well as the information still needed, which provides the organisation with a starting point for the development of a data warehouse. Moreover, we make the quality of information measurable, which can help improve employees' knowledge of information management skills and rules. Which all leads to better work efficiency and ultimately reducing the time spent searching for information.

6.3 Limitations

During the course of this research, several factors significantly influenced our research approach. Conducting the research for a large government organisation, the way of working is heavily influenced by bureaucracy, meant that the organisation's development and adaptation occurred at a slow pace. Consequently, obtaining information or data from sources and accessing software, other than Power BI, for developing a data warehouse and DMS took a considerably long time. As a result, the research focus shifted from DMS planning to dashboard design and KPI selection with placeholder data. Thus, we lack clarity on the dataset's size when we gain access to it, which could potentially destabilize the framework and software's stability and computational power when working with larger datasets. This limitation must be considered when using the DMS as a framework.

Another limitation is that we cannot measure the dashboard's and KPIs full effect. While the questionnaire and interviews provided an excellent understanding of the employees' first impressions of the dashboard and its potential usefulness and value, this dashboard is new to the field of information management, and its true effect can only be determined over an extended period.

6.4 Recommendations

In this research, we discovered that many of the requirements and goals were met but, we also identified several critical steps that we recommend the organisations to undertake to ensure the success of the dashboard's implementation and improvement of the main problem. Therefore, we have the following recommendations for further development:

- *Start the implementation of the dashboard.*
  Despite the lack of available metadata, we strongly recommend that the organisation begins the development and implementation of the dashboard as early as possible. In our research, we constructed the dashboard on a newer version of Power BI on a private computer, but we suggest beginning the development within the organisation's digital environment, even with the absence of data. Starting the development process earlier allows the CIO-office to incorporate the dashboard as a strategic tool during the establishment phase, enhancing its importance and facilitating quicker access to metadata and better software solutions. Furthermore, by starting the development early we create a framework, the organisation will be better positioned to begin data visualization and analysis as soon as the data becomes available. We suggest the following implementation plan:
  1. Rebuild dashboard design in Power BI within the organisation's environments (2 weeks).
  2. Get access to Power BI publication server and set-up scheduled refresh and security levels (1 week).
  3. Implement already available metadata into Power BI's DMS (2 weeks).
  4. Publish dashboard with partly real data and partly with placeholder data so employee can get familiar with the dashboard (1 week).
  5. Start gathering and implementing the missing metadata into the DMS and dashboard (3-6 months).

- *Conduct a follow-up survey on "Survey Information Management, a Baseline."*
  Medio 2020, the organisation conducted a survey to evaluate the overall performance of its information management. The survey revealed that only 10% of employees were satisfied with the state of their information management, prompting the organisation to start this research. We recommend that a follow-up survey will be conducted not sooner than six months after the implementation and release of the dashboard. The survey will show whether there have been any improvements and to determine if the dashboard contributes to these improvements.

- *Periodically evaluate and improve the KPIs.*
  The organisation is evolving all the time and the KPIs used in this study were based on the stakeholders' current needs. We recommend that the organisation at least every two months or after a significant change in one of four office IT applications, evaluates and improves the KPIs to ensure that the dashboard and its goals remain relevant. Brainstorming sessions, stakeholder feedback, the organisation's own experience, and the follow-up survey, if conducted, could all be used to identify new areas of improvement. For example, new KPIs could be developed to visualize the age of used information, the speed at which information is accessed, and the path taken to find information.

- *Periodically evaluate and improve the dashboard design and functionalities.*
  We suggest that the organisation expands the dashboard's functionalities and periodically improve its information content, design, and features during and after implementation. This can be combined with the periodically evaluations of the KPIs. Evaluating the dashboard will improve user experience and enhance the dashboard's efficiency and effectiveness. For example, we recommend exploring the use of the advanced drill-through function in Power BI to allow users to easily visualize the relationships between KPIs. Additionally, keeping the filters up to date and expanding them to accommodate larger datasets will make analysis easier.

6.5 Future research

In this section we give two recommendations for a new research based on this research and the organisation's needs:

- *Big data collection in the office IT landscape*
  As highlighted in this study, the organisation needs to collect and store metadata for a large number of files across various applications. To achieve this goal, the organisation needs to adopt the best methods for collecting, cleaning, and storing big data. Therefore, future research can focus on exploring effective techniques for managing big data and even delve into the possibility of content scanning of documents. Our recommendation is to begin by using this research as a foundation and improve the identification of available metadata and the needed metadata. Following that, explore various data collection and cleaning techniques that can be employed within the organization's constraints. Subsequently, analyse the potential consequences of the chosen approach, and finally, construct and implement a new data warehouse and DMS.

- *Research on the CIO-office and the use of information management*
  With the establishment of the CIO-office, the organisation has yet to prioritize information management. Therefore, it would be useful to conduct research on the use of management information in large organisations, like the Ministry of Defence, and develop an information management strategy that is adjusted to the CIO-office's needs. This research can help the organisation in managing information and support the data-driven strategy. We recommend starting with a comprehensive literature research about information management and the use of management information in large organisations, like the Ministry of Defence. Followed by identifying the goals and current information management strategies of the organisation and stakeholders. Based on these findings develop an information management strategy that aligns with the CIO-office's needs and supports the data-driven strategy of the organization.

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