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Preface

This thesis is the final project for our master's degree in Industrial Economics at the University of Stavanger. The thesis was carried out in collaboration with Aker Solutions AS during the spring semester of 2022.

Working on this thesis has been instructive, giving a new and valuable insight into the risk aspect of digitalization. Digital transformation is currently a very prominent topic in every industry, and we were very excited for the opportunity to write our thesis on this subject.

We are immensely thankful to both our supervisors at Aker Solutions AS for their cooperation, support, and motivation. The resources and guidance provided by them has been vital for the completion of this thesis. Likewise, we are grateful for the large degree of help and resources that Aker Solutions was willing provide us.

We also appreciate the guidance and advice from our supervisor at the University of Stavanger, Sindre Lorentzen.

Finally, a special thanks to our informants who provided us with useful information and shared their perspectives and values throughout our research process.

Abstract

Risk within digitalization is an increasingly relevant subject and there is no established framework on identifying risks in the development of new digital tools and processes. To this end, this thesis seeks to establish a recently developed method of utilizing Bayesian Networks to visualize risk within projects. In cooperation with Aker Solutions, the currently developing NOA Digital Project is analyzed and assessed for its risks and opportunities.

By establishing a risk picture specific to the project, a generalized network of risks within digitalization projects is developed. An emphasis is put on examining how different aspects of project management and company culture affected the project's overall risk picture, helping the identification of risk reducing measures. The generalized network and the proposed risk reducing measures of this thesis can serve as a framework for various projects across different industries and its use is illustrated by the case study of the NOA Digital Project.

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Nomenclature

A	Event with consequences
A′	Specific event with specific consequences
C	Consquences of an event
C′	Specific consequence of a specific event
K	Knowledge
P	Probability
Q	Measure of uncertainty
RS	Risk Source of an event
RS′	Specific Risk Source of a specific event
SoK	Strength of Knowledge

List of Abbreviations

NOA	North of Alvheim
NOAKA	North of Alvheim and Askja-Krafla
PMLC	Project Management Life Cycle
TPM	Traditional Project Management
APM	Agile Project Management
AI	Artificial Intelligence

1. Introduction

1.1 Background

Digitalization has been an increasingly important topic over the last two decades (Kraus et al., 2019). There has been much effort over the years to implement different digitalization measures with many different strategies (Matt et al., 2015). The progress towards digitalization has been remarkably fast in some industries and companies, whilst others are falling behind in this regard (Matt et al., 2015). However, despite using digital tools and programs, some companies do not utilize their full potential. Instead, continuing to follow old work processes and procedures built around analogue tools (Kraus et al., 2019).

The COVID-19 pandemic once again put digitalization into the highlight and reaffirmed the need for digitalization across almost all industries (Almeida et al., 2020). Many industries and businesses, which were in various stages of digitalization, were forced to hasten their efforts. Not only to increase their productivity and gain a competitive edge, but to even function at all during times of crisis such as during this pandemic (Almeida et al., 2020). Lock-downs and governmental limitations on office access forced companies to digitalize many of their work processes and routines (Faraj et al., 2021). With many workers still utilizing the option to work from home, even though governmental restrictions have been lifted (Faraj et al., 2021).

It is in this environment that Aker Solutions initiated their new digitalization project, the North of Alvheim (NOA) Digital project. Aker Solutions has several ambitions and greater goals, among them being to reduce documentation, automate checks and error detection, provide easier access and exchange of data between stakeholders and suppliers, and enabling parallel engineering into the 3D models (Internal Documents, 2022). However, such technical aspects are not the only thing that Aker Solutions is focused on. A core idea is that digitalization can help cultivate collaboration between colleagues and create a better work environment, as well as contributing to an overarching strategy of Aker Solutions to move towards sustainability (Internal Documents, 2022).

1.2 The NOA Digital Project

In March of 2020, when Norway went into lockdown, Aker Solutions revitalized their vision of digitalization and began a new project to transform the way they work (Internal Documents, 2022). By January of 2021 they identified several areas with a high potential for savings through digitalization. What followed has been come to be known as the NOA Digital project, and is developed through the cooperation of Aker Solutions, Aker BP, Cognite, and Aize (Aker Solutions, 2022b). These four companies are a part of the Aker Group.

For Aker Solutions, the goal is to implement the NOA Digital project in both the execution and operation phases of the North of Alvheim and Askja-Krafla (NOAKA) project. The development of NOAKA consists of several fields and is one of the largest and most important oil projects remaining on the Norwegian shelf (Dagens Næringsliv, 2022). In this area, several oil and gas discoveries have been made with gross recoverable resources estimated at over 500 million barrels of oil equivalent, with further exploration and appraisal potential (Aker Solutions, 2022a). The NOAKA field will be developed with a minimal carbon footprint and facilities will be powered from land. In order to achieve high efficiency and low emissions, digital solutions will be widely used. The production in the field is scheduled to start in 2027 (Aker Solutions, 2022b).

Before the NOA Digital project, Aker BP initiated a process of digitalization with the Eureka project in the Autumn of 2018 {8}. From this they developed several valuable tools, but due to constraints on the project, some of the unrealized ideas of the Eureka project would later be carried over to the NOA Digital project {8}.

Tangible work on the NOA Digital project started by September 2021 and some of the promised software and tools has already been delivered as of writing of this thesis (Internal Documents, 2022). The project itself is scheduled to be finished by November 2022, where the different software and tools developed by the project is expected to be used and continuously developed in future projects (Internal Documents, 2022).

1.2.1 The Missions of the NOA Digital Project

The NOA Digital project consists of several *Missions*, these are sub-projects that each develop separate software with different functions and goals. In the initial planning phases, the NOA Digital project consisted of over 20 missions. These were quickly restructured and fused into 11 missions, which once again got reduced to 8 missions.

Each mission is given a *Mission Lead*, which is a field expert from the side of Aker Solutions and Aker BP that is in charge of providing much of the technical requirements and coordination for the developers. Collaborating with the mission leads and other key staff, Aize drives the technical development and coding for the different software in all missions, except for the new data-platform of the Aker Group. This is developed by Cognite and will function as a well-structured and centralized data-platform to be used in future projects and operations.

Development of every missions is based on an Agile Project Management Life Cycle (PMLC). However, the overarching approach of the NOA Digital project is more linear. With deadlines for the missions set according to the Linear PMLC of the NOAKA field development. This is due to the product of each mission being expected to be directly used in the planning and operational phases of the NOAKA field.

The missions of the NOA Digital project, with the description given by Aker Solutions (Internal Documents, 2022), are listed below in Table 1.1.

Mission	Description
Digital Vendor Data	A common web-based portal to upload, collaborate and validate data related to equipment, documents and 3D model. Interface management system connected to 3D model and a web-based portal handling requirements and collaborating on clarifications and deviations.
Digital Engineering Documentation	The main purpose of this digital initiative is to start moving from document-centric engineering to data-centric engineering. The target is to reduce the amount of document-based engineering deliverables.
Digital Engineering Concurrency	The main purpose of this digital initiative is to secure previously harvested value and create new value by migrating existing engineering automations application to a new technology platform.
Constructability Engine	Software-driven detection of constructability issues in the 3D model, with resolution tracking and reporting. Implemented the use of extendable rules engine, with feature extraction from 3D models. Applicable for the design and fabrication phases.
Project Execution Control	Combine data from different engineering and project management software in a web-based application giving a tool that can visualize live data by table or 3D.
Visual Construction Planning	Software-assisted method engineering and schedule generation in the 3D environment.
Digital Design Basis in the Twin	Information model containing a representation of company design documents, environment studies and other relevant design requirements.
Cognite Digital Twin Platform	Platform development to support a common and flexible information architecture, built-up and utilized from concept study, through construction and into operations. The Cognite EPC Extension will enable reduction of development time and cost, avoid complex and rigid source system integrations, and provide unified object data to further support operational efficiency.

Table 1.1: Missions in the NOA Digital project

1.3 Objectives and Limitations

1.3.1 Objectives

The scope of this thesis is to analyze and evaluate the current digitalization initiatives and missions of the NOA Digital project and establish an overview of the existing risks and risk sources. This thesis sets out to display how the risks interact with one another and their interdependencies through a clear and understandable Bayesian Network. Additionally, the thesis also explores the application of Bayesian Networks to assess risks and opportunities related to digitalization and digital projects.

The Bayesian Network is utilized to depict a holistic view of risks and opportunities in digitalization through assessing and evaluating the NOA Digital project. The overall purpose is to generate a generalized set of risks and their logical sequences in an additional, coherent and intelligible, network. By creating a generalized network, key risks are identified and categorized for the different phases of a project's development. Considering the experiences from the NOA Digital project, this thesis aims to provide recommendations on reducing key risks. The research will seek to contribute to Bayesian Networks being applied to other digitalization projects within different industries, as an approach to assess and evaluate risks and opportunities.

Furthermore, this thesis looks into the use of Linear and Agile PMLC models, discussing how each model has affected the risk picture of the NOA Digital project. With the aim of presenting the potential risk-reductive benefits there are from using an Agile PMLC.

To achieve these objectives, the following research questions were established:

1. How is the risk picture of the current digitalization activities of Aker Solutions?

2. What are the key risks and opportunities identified from the NOA Digital project?

3. What are the challenges for the NOA Digital project with the Linear PMLC of Aker Solutions?

As later discussed in the Literature Review (Chapter 2), current research within digitalization uses older and less comprehensive models to study risk. This thesis will thereby try to bridge the gap between the research on risk within digitalization, with the newer methods of risk analysis and risk assessment.

1.3.2 Limitations

This thesis focuses on the NOA Digital project, as well as the further development of the tools after the project's end. The NOA Digital project is an ongoing project and the results of several missions are still unknown. As a result, this leads to a lack of knowledge about the actual implementation of each mission. Furthermore, due to limited expertise in cybersecurity, this area will not be investigated in detail. However, cybersecurity will be mentioned as it is a significant risk factor in any digital project.

Lastly, the theoretical framework of this thesis is mainly focused on risk management and project management. Both project management and risk management are two broad fields of study. Thus, in order to limit the scope of the theory, it was chosen to mainly elaborate on the interactions and interdependencies of risks, and the confliction between agile and traditional project management.

1.4 Structure

The thesis is divided into the 7 chapters. Chapter 1 gave a general introduction of Aker Solutions, the NOA Digital project and the objectives of this thesis. In Chapter 2, the literature review that was conducted for this thesis is presented. Then, Chapter 3 establishes the theoretical concepts used in the thesis. Throughout Chapter 4, an overview is provided of the methodological choices made for this thesis. Furthermore, in Chapter 5 the results are organized and visualized by Bayesian Networks to give a risk picture, and critical risks are identified. Chapter 6 provides a discussion on the results and the theory to answer the research questions. Finally, the thesis is concluded in Chapter 7, with recommendations given for further research.

2. Literature Review

There is a large array of literature and studies on risks involved with digitalization and project risk in general, as well as the use of Bayesian Networks in risk analysis. Yet, these subjects are often studied separately. This literature review will therefore present some of the relevant literature and the methods. The models of 3 studies and 1 report on different industries and digitalization, as well as 2 studies discussing the use of risk matrices are reviewed.

2.1 Risk Matrices

A common method of visualizing risk and to conduct risk assessment is through the use of risk matrices, to such an extent that they are referred to in international standards and industry sector risk management practices (Duijm, 2015).

Risk Matrices were used in a study by Yoo and Park (2021) used qualitative risk assessment to identify areas of cybersecurity vulnerabilities of digitalized ships. From this Yoo and Park (2021) categorized different issues into security areas, and ranked them according to the level of risk. The result of this study is highly relevant for digitalization processes and digital tools, yet a key issue is in their use of risk matrices.

Their model adequately depicts the severity and likelihood of the different events, yet how the risks interact with one another, and the causality of one event to another is not presented through the risk matrix. Moreover, the uncertainty aspect is not discussed in the study.

Literature pointing out the disadvantages of risk matrices has been growing over the years (Peace, 2017). In his study, Duijm (2015) discusses how the uncertainty aspect is not properly represented through risk matrices, where Peace (2017) states that the use of risk matrices increase uncertainty of results in risk assessment. Standalone use of risk matrices is also seen as a major issue, as it gives simplistic results that may conceal important risks in different stages of process (Peace, 2017). A core issue which both Peace (2017) and Duijm (2015) identify, is how a risk matrix does not present causality, interconnectivity and interdependency of risks and events. In Figure 5 of Duijm (2015, p. 28), an alternative way of using risk matrices is proposed. This would map out causality similarly to a Bayesian Network. While Peace (2017) proposes that the use of a goal tree could compensate for the deficiencies of risk matrices.

2.2 Bayesian Networks

The use of Bayesian Networks in risk analysis to present a holistic overview of processes has been proposed over the last 2 decades. A case study of maritime transportation by Trucco et al. (2008) created a comprehensive Bayesian Network of the maritime industry taking into account its different actors and influences. The network of Trucco et al. (2008) put a head consequence (Section 4.6.2) as *Hazard/Failure Identification*, which in the study functioned as an umbrella term for the risk of grounding, striking and collision of ships.

Though it is a generalized network for the entire industry, it displayed how specific events, processes, and conditions lead to the head consequence, as well as their interactions and interdependencies. Their model does not require further calculations to account for the dependencies and probabilities, as the probability of events are based on subjective expert judgements rather than quantitative data (Trucco et al., 2008, p. 832). How significant the risk is for the different events, risk sources and consequences, is likewise not visualized or sufficiently explained. Furthermore, the aspect of uncertainty is also not represented in their model.

A study by Lee et al. (2019) explores the effects of digital twin (Section 3.1.2.1) implementation and how it may improve safety within process industries. This is done so through what they call a fundamental systems thinking approach, where Lee et al. (2019) depicts how different processes and systems are conceptually affected through the implementation of a digital twin. Different interdependencies and interactions between processes are visualized, however only in a conceptual form and not in specific real-life processes and systems. Additionally, the theoretical framework of risk is not represented graphically in the study.

Recently, a new method of presenting risk has been developed by the Norwegian Institute of Marine Research (2021) used in their annual risk assessments of Norwegian fish-farming. Though the report's results and subject is unrelated to digitalization, it is noteworthy, as they use a Bayesian Network similar to Trucco et al. (2008), but with a stronger theoretical basis. The lack of theoretical basis has also been noted as an issue with risk matrices (Peace, 2017).

This method adequately presents the causality, interconnectivity and interdependency of risks and events. Whilst also providing a picture of which risks are more and less severe. Additionally, their innovative method of depicting the uncertainty aspect is notable. It is done so through illustrating a ring with different colouring to show low-high strength of knowledge. The clarity of their networks is also a large advantage over the less structured networks of Trucco et al. (2008) and Lee et al. (2019).

One disadvantage of their Bayesian Network is that probability and severity of a risk is not presented as separate factors, and only the overall assessment of the risk is shown. This is one aspect in which the use of a risk matrix is advantageous. Though, both methods compliment each other and can be used together.

2.3 Summary

In this review it is found that most studies conducted on the risks within digitalization have thus far employed risk matrices or used unclear Bayesian Networks as their models. Where the use of risk matrices is discussed as being less fit for risk analysis than Bayesian Networks. The novel model of the Norwegian Institute of Marine Research (2021) is also viewed as being clear and superior to the other Bayesian Networks.

3. Theory

3.1 Digital Transformation

3.1.1 Historical Context

To understand the importance of digitalization and why Aker Solutions, and so many other companies, are looking to digitalize their work-processes one must consider the historical context of digitalizaion. This new global trend of digitalization is called, or at the least associated with, *The Fourth Industrial Revolution*. The term "Industry 4.0" was coined in 2011 (Hannover Messe, 2014) but later popularized by Klaus Schwab, the founder and chairman of the World Economic Forum. Schwab presented the concept at the WEF Annual Meeting of 2016, where he discussed the subject "Mastering the Fourth Industrial Revolution" (World Economic Forum, 2016).

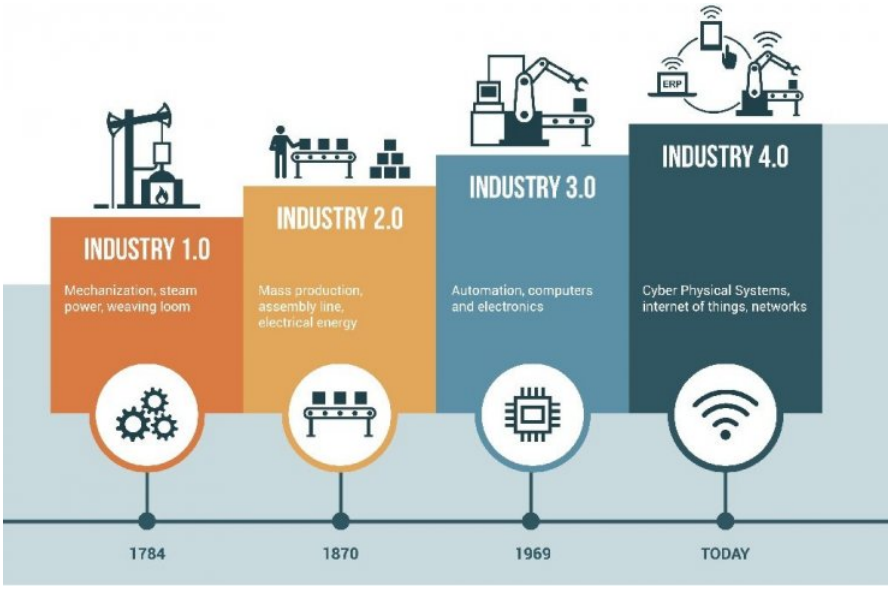

Figure 3.1: The Industrial Revolutions (Dyson, 2018)

Schwab (2017) presents this revolution, as the continuation of the previous phases of the industrial revolution, visualized in Figure 3.1. Schwab (2017) describes that the first industrial revolution emerged from the invention of the steam engine and harnessing steam-power. Following this, the second industrial revolution came as a consequence of inventing electricity, which allowed for the rapid expansion of industries to facilitate mass production.

Furthermore, the third industrial revolution came about from the invention of the computer, which allowed for the automation of simpler work-processes.

In this chronology, the fourth industrial revolution emerged as computer processing-power grew exponentially. The first microprocessor was patented in 1971, which had 8000 transistors. This would increase tenfold in only ten years and by 2016 it grew to 8 million transistors (Neugebauer, 2019).

At its core, the fourth industrial revolution is taking advantage of this immense increase in processing-power and to alter the way industries work. This being achieved through the integration of digital communication, automation of complex work-processes, big data analytics, artificial intelligence, and the Internet of Things (Hanley et al., 2018).

3.1.2 Digitalization vs. Digitization

Two key concepts, which are used when speaking of Industry 4.0, are *Digitalization* and *Digitization*. These terms are often erroneously used as synonyms to each other and it is important to distinguish them (Brennen & Kreiss, 2014)

Digitization refers to the binary representation of analogue objects and the properties of physical objects into a digital sequence of 1s and 0s (Brennen & Kreiss, 2014; Neugebauer, 2019).

To properly construct objects in a digitized form, information about their composition, structure and form is a necessity. The different parameters that are set can then be reconstructed in a digitized format (Neugebauer, 2019). Complex machines, materials and objects can therefore be designed and verified for suitability through simulations, before they are physically constructed (Neugebauer, 2019).

Digitalization on the other hand, refers to a wider concept of employing digitized models, data and new methods of communication (Kim et al., 2021). As well as new tools and software which help sort data and which automates complex analogue processes and decision making (Kim et al., 2021). Digitalization is not simply transferring analogue data and processes to a digital format, but to transform and create new processes facilitated by digital tools (Kim et al., 2021).

3.1.2.1 Digital Twin

Another term, closely tied to both digitization and digitalization, is *Digital Twin*. Wang et al. (2021) defines a digital twin as *"a core technology that enables the integration among physical machines, tools, material handling and warehousing, and real-time manufacturing decisions"*. A digital twin is a virtual model of a physical object such as a production equipment, a drilling rig or even a human. Hence, a digital twin is a digitized reconstruction or a duplicate of something which exist physically in the real world (Wang et al., 2021).

However, a digital twin is a live model, in the sense that it fully reflects the real physical object (Jones et al., 2020). By using sensors, data such as temperature, pressure, and volume can be gathered to create a real-time status (Jones et al., 2020). By collecting operational data from sensors and processing this data using AI algorithms and Machine Learning, a digital twin becomes a useful tool (Jones et al., 2020). For instance, it can be used to simulate and test different scenarios in order to optimize performance, predict events and for training (Liu et al., 2021). Moreover, it is possible to use a digital twin during an engineering phase to evaluate different designs and to simulate operating parameters (Liu et al., 2021). In this way, a digital twin bridges the gap between the concepts of digitization and digitalization, by showing how a digitized model may be used to create fundamentally different and new work-processes (Liu et al., 2021).

3.2 Project Management

3.2.1 What is a project?

There are several definitions of a project, however, it has been challenging to provide one single comprehensive and universally accepted definition. Below a set of definitions have been provided and based on these we can see how the definitions tend to overlap and coincide.

Source	Definition
(Project Management Institute, 2000)	*"A temporary endeavor undertaken to create a unique product, service or result."*
(British Standard Institution, 2000)	*"A project is a unique set of coordinated activities, with a definite starting and finishing point, undertaken by an individual or organisation to meet specific objectives within defined schedule, cost and performance parameters."*
(MacLachlan, 1996)	*"a project is a task with a beginning, a middle and an end, which you as a manager need to complete."*

Table 3.1: What is a Project?

There are some difficulties in defining a propject, as the size and scope can vary to a very large degree (Gardiner, 2005). According to Smith (1995), a project may have many similarities to a previous projects, and the differences may only lay in details in order to suit a change in market or a new site.

Smith (1995) argues that projects may vary in scale and complexity, and the common word "project" is used in all of them as every project is *"an investment of resources for an objective"* and *"a cause of irreversible change"* (Smith, 1995, p. 3). The same principles of project management therefore apply to a project of any size. (Gardiner, 2005).

3.2.2 Project Management

The Project Management Institute formally defines project management as follows:*"The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements."* (Project Management Institute, 2017). However, similarly to projects, there are several different definitions of what project management is.

Source	Definition
(Association for Project Management, 2000)	*"Project management can be defined as the discipline of managing projects successfully."*
(British Standard Institution, 2000))	*"Project management is the planning, monitoring and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality and performance."*
(US Fish & Wildlife Service, 1994)	*Project management is the management process that establishes the standards, techniques, and tools used to ensure that requirements are well defined and reflect end-user performance needs; that the project satisfies the defined requirements; that the products are thoroughly tested; that development costs are properly managed; and that the criteria for implementation, training, modification, and documentation are well defined and appropriate.*

Table 3.2: What is Project Management?

The concept of project management is about managing a process and the people involved (Gido & Clements, 2012). The project management task consists of four activities, including; planning, organizing, controlling, and leading and motivating (Gido & Clements, 2012). The planning phase involves setting the goals, the steps to achieve those goals, and when to take the right steps (Gido & Clements, 2012). The planning phase is essential to the success of the project, thus, asking the right questions and setting the criteria at the planning phase is of great importance (Gido & Clements, 2012). Organizing is about putting together the right people, material, and support resources in a project to achieve on-time project delivery. Organizing also includes clarifying and defining the

roles and responsibilities to ensure the right structure (Gido & Clements, 2012).

According to Gardiner (2005) controlling is ensuring that the project is managed according to the plan. In this phase, the project manager is responsible for meeting the team regularly, reviewing the progress, as well as sorting out minor problems. In order to effectively control and monitor the progress, it is essential to carefully plan each activity (Gardiner, 2005). Finally, leadership is vital for successful project management (Project Management Institute, 2017). Thus, for the staff and and team to stay motivated throughout the project, it is important to have a leader with great team-building skills (Project Management Institute, 2017). Project leadership involves shaping goals, secure resources, clarifying roles and structures, form good communications, and lead things towards a successful end (Project Management Institute, 2017).

Clients are typically looking for a product to reach the market as quickly as possible with the most functionality, and the lowest cost (Gardiner, 2005). In light of Gardiner (2005), project management consists of three fundamental constraints; scope, time, and cost as shown in figure below.

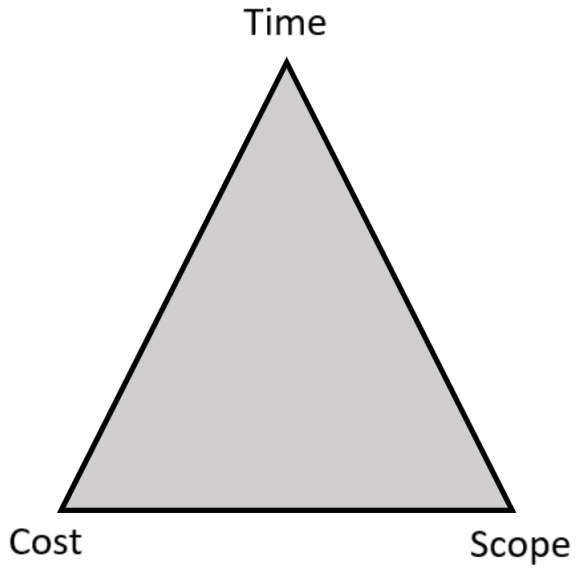

Figure 3.2: Scope-Time-Cost Triangle

A constraint can be defined as follows;

"a system's constraint is anything that limits the system from achieving higher performance towards its goal" (Goldratt, E.M and Cox, 1984).

Project constraints provide clear insight for decision making. As mentioned above, there are three constraints in project management and project managers are often judged based on how well they compete a project according to the scope, time, and costs (Gardiner, 2005). Cullen and Parker (2015) argues that project success should be based on and measures within the constraints of time, scope and cost, whereas quality is a part of the scope. However, Gardiner and Stewart (1999) states that most projects overrun these constraints and, hence, cannot be a appropriate measure of project success.

3.2.3 Project Management Life Cycles

It is essential for planning a project to use a landscape that is simple, intuitive, and which will remain valid despite the volatility of the business environment (Wysocki, 2014). The project landscape will be the foundation for analysis and decision-making. The landscape for every project is not the same, and each model is constructed to meet the specific requirements (Wysocki, 2014).

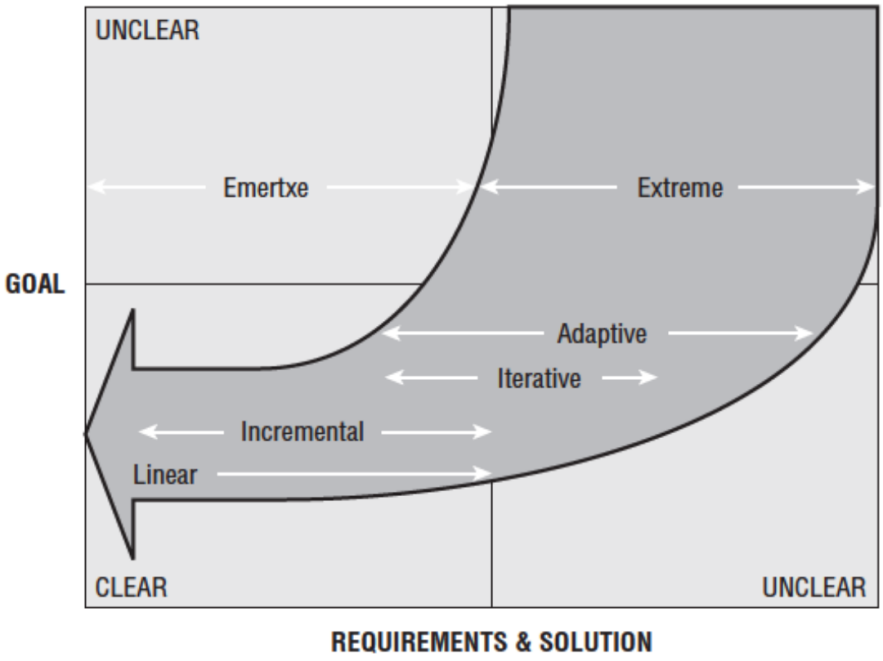

Figure 3.3: PMLC Approaches (Wysocki, 2014)

PMLC selection depends on the degree of uncertainty about requirements, solutions, and the goal of a project. According to Wysocki (2014), there are four different PMLC categories. Each is designed to meet the specific needs associated with a particular project type. As a result, the following models are defined across four quadrants seen in Figure 3.3.

- **TPM**- Linear and Incremental Models
- **APM**- Iterative and Adaptive Model
- **xPM**- Extreme Model
- **MPx**- Emertxe Model

3.2.4 Linear Project Management Life Cycle Model

The Linear PMLC is the simplest model among the five major models (Wysocki, 2014). To use this model one requires adequate information about the project goal and solution, as can reasonably be expected. This information may be obtained from experiences with similar projects, or due to the simple nature of the project. Any deviations in this model can cause changes in the whole project (Wysocki, 2014, p. 360).

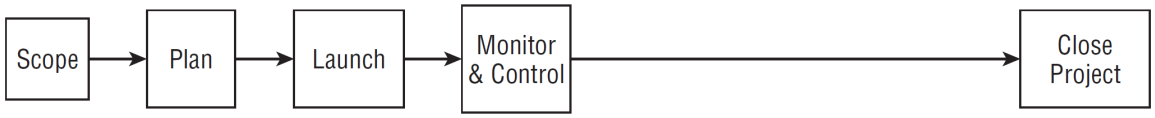

Figure 3.4: Linear PMLC (Wysocki, 2014)

The linear models are plan driven models; that is, a complete plan is made before the work on the project begins. In a Linear PMLC model each phase must be complete before we can start the next phase (Wysocki, 2014). After each phase is completed, there is no opportunity to go back and revise earlier work. As seen in 3.4, there are no feedback loops.

Projects that are not affected by outside factors and are repeated more frequently are most likely to succeed using a Linear PMLC (Wysocki, 2014). The Linear PMLC model is appropriate for situations where the end product is clearly defined and for projects where changes rarely happen (Wysocki, 2014).

3.2.4.1 Stage-Gate Model

The Stage-Gate model is one of the most commonly used linear PMLC models. The Stage-Gate process consists of various stages, where projects teams perform the work, provide the needed information, and conduct the necessary data integration and analysis. The goal of every stage is to gather sufficient information to move the project forward to the next decision point. A decision gate follows each stage, a checkpoint where a go or kill decision is made (Cooper, 2008). Figure 3.5 illustrates a standard Stage-Gate model. The process begins with an idea phase, called discovery to find out the needs and requirements, and ends with the post-launch review.

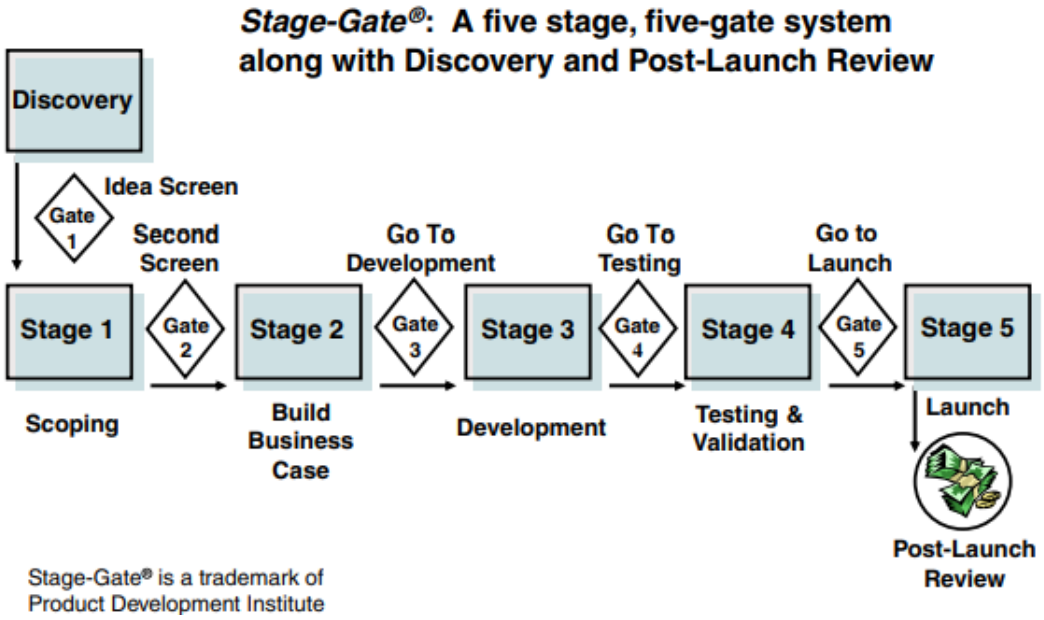

Figure 3.5: The Stage-Gate Model (Cooper, 2008)

3.2.5 Agile PMLC Model

Agile is a set of methods, concepts, and principles that leads to agility. Agility can be defined as:

> *"A continued readiness to rapidly or inherently create change, proactively or reactively embrace change, and learn from change while contributing to perceived customer value (economy, quality, and simplicity), through its collective components and relationships with its environment."*
> (Dingsøyr et al., 2012)

Agile emphasizes the importance of continuously assessing and improving the link between technology, strategy and business strategy (Fritzgerald & Stol, 2015). The term agile describing an important work methodology and a way of increasing the efficiency of projects by continuously adapting to changes in project. The agile methodologies use an iterative work sequences to deliver value at an early stage of a project (Ulusoy & Hazir, 2021).

There is a focus on daily communication and a flexible reassessment of plans as a result of short and iterative phases. Instead of going through a comprehensive long-lasting planning phase, the focus is on delivering smaller value, but more often (PMI, 2017). However, the planning process is still an important part of project management, but it happens more frequently and for shorter periods of time (PMI, 2017). In digital projects, agile approach is often preferred due to its ability to enable to change details, as well as the final goal of the product, during the course of the project.

3.2.5.1 Iterative PMLC

By the definition, *"an Iterative PMLC model consists of a number of process groups that are repeated sequentially within an iteration with a feedback loop after each iteration is completed"* (Wysocki, 2014, p. 335). The iterative PMLC model is appropriate for projects in which an initial version of the solution has already been identified, but it is known to lack certain features and perhaps functions (Wysocki, 2014). The iterative cycles aims to discover, select, and integrate the missing pieces of the solution (Ulusoy & Hazir, 2021). The intermediate versions provide the client with something to work with as they learn and discover the features they need (Ulusoy & Hazir, 2021).

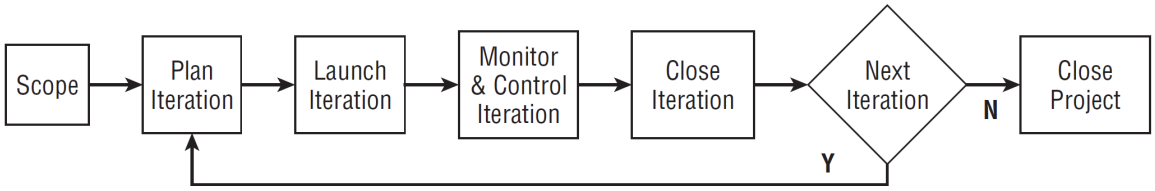

Figure 3.6: Iterative PMLC (Wysocki, 2014)

The process and structure of the Iterative PMLC model is illustrated in Figure 3.6. The iterative PMLC model includes several types of iteration. These iterations can be on design, functionality, development and other components of the solution (Wysocki, 2014). In this model prototypes, or intermediate solutions, are developed and tested in iterations. After each intermediate solution, feedback from the clients is examined for a new iteration of the product deliverable. This continues until the solution is clear, and the final deliverable is produced (Wysocki, 2014).

3.3 Project Risk Management

Every projects carries some level of risk, and how this is handled determines the success of the project (Gido & Clements, 2012). Project risk, as with most concepts in project management does not have a single universal definition. Several definitions of project risk is put forth in the table below:

Source	Definition
Gardiner (2005, p. 161)	*"any event with an undesirable outcome for the project that may happen sometime in the future."*
Gido and Clements (2012, p. 285)	*"A risk is an uncertain event that, if occurs, can jeopardize accomplishing the project objective"*
Project Management Institute (2017, p. 397)	*"an uncertain event or condition that, if it occurs, has a positive or negative effect on a project outcome."*

Table 3.3: Project risk definition

In all these definitions a crucial component is uncertainty. That is, in order for an event to be classified as a risk, the outcome of the event must unknown prior to the realization of the event (Ulusoy & Hazir, 2021). Consequently, if we know with full certainty that a negative outcome will occur, then it is not a risk (Ulusoy & Hazir, 2021). The difference between these definitions has to do with whether we allow for occurrence of positive outcomes. In all definitions there must be the possibility of at least one negative outcome, but only the latter definition allows for one or more positive outcomes.

One definition of uncertainty, given by the Society for Risk Analysis (2018, p. 4), is *"[an] imperfect or incomplete information/knowledge about a hypothesis, a quantity, or the occurrence of an event"*. Knowledge is therefore a key aspect of uncertainty and has a vital role in risk analysis and management. In this sense, it is also important to consider the strength of the knowledge when discussing uncertainty.

3.3.1 The Frequentist Approach

The mathematician, Jacob Bernoulli (1654-1705), tried to determine probabilities of different types of events by establishing accuracy. A frequentist probability represents the fraction of times the event considered occurs if the situation can be repeated under similar conditions repeatedly (Aven & Thekdi, 2021).

A classic interpretation of frequentist probability is that a P=P(A) exists for the occurrence of event A, defined as the fraction of times event A occurs if the situation was hypothetically repeated an infinite number of times(Aven, 2020).

Thus, a frequentist probability is a model concept based on the law of large numbers. According to Aven and Reniers (2013), we must assume that the situations repeated are independent of each other. A risk assessment estimates the probability P of the true "objective" probability, and must therefore describe uncertainties resulting from the analysis in terms of deviations between the estimate P* and from the assumes true value P (Aven & Thekdi, 2021). When adopting the frequentist approach in risk assessments, the uncertainty is essential and an issue that must be assessed (Aven & Reniers, 2013).

3.3.2 The True Bayesian Approach

According to many risk analysts the subjectivist probability is considered as the "true Bayesian approach" to risk assessment. In this approach probabilities are used as a means of expressing uncertainty associated with whether a specific future event or scenario will occur or not (Aven, 2020).

The subjective theory of probability was introduced by Bruno de Finetti (1906-1985) and Frank Ramsey (1903-1930). According to this theory probabilities are subjective assessments of degrees of belief and thus, no underlying true beliefs exist (Aven, 2020)

The concept of subjective probability is also referred to as knowledge-based or judgemental probabilities (Aven & Thekdi, 2021). Knowledge-based probabilities are personal and dependent on the assigner and the knowledge supporting the assignment (Aven, 2020). Hence, the probabilities are used to express the uncertainties related to a specific future event, and whether or not this event will occur. Thus, the probability p of an event A is based on some knowledge K, which can be written as P(A | K). The knowledge K is based on some justified beliefs, data, information, models, testing and debate (Aven, 2020). Thus, if the background knowledge is weak, the probability assignment is less solid and the risk assessment is not valid. However, strong background knowledge may contribute to a high quality scientific risk assessment (Aven, 2020).

3.3.3 The Uncertainty Aspect

According to Aven and Thekdi (2021), uncertainty is not knowing the severity of the consequences of an activity. Consequences and uncertainties are both two key components of the risk concept. At the same time, uncertainties and probabilities are linked together (Aven & Thekdi, 2021). Aven and Reniers (2013) argues that a risk problem is uncertain if there is difficulty in predicting the occurrence of an event and the related consequences. Uncertainty is a result of lack of knowledge, insufficient or invalid databases, lack of understanding of a phenomenon, and inaccuracies (Aven, 2020).

Addressing the uncertainty is of high importance as there is uncertainty associated with future events. Risk sources may lead to the occurrence of unwanted events with undesirable consequences (Aven, 2020). For instance, the severity of some consequences related to an event may be unknown due to weak knowledge. Hence, including the uncertainty aspect associated with a future event should be noted in order to provide a more precise risk picture (Aven, 2020).

In the view of Aven and Reniers (2013), to be able to address the uncertainty associated with an event, emphasis should be put on the strength of knowledge . Strong background knowledge creates less uncertainty as probabilities are based on the general knowledge that is available to assess a risk. However, weak or moderate knowledge base creates a higher degree of uncertainty associated with the risks and it's outcomes.

3.3.4 Black Swans

Where there is little or no knowledge, or where the strength of knowledge is weak, there exists a place for large uncertainty and potential surprises (Aven, 2020, p. 77). This is what Aven (2020) refers to as a black swan. A more comprehensive description of a black swan can be given as,

> *...an event with the following three attributes. First, it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable.* (Aven & Thekdi, 2021)

Aven and Thekdi (2021) defines three categories of black swans: ¨

- **Unknown unknowns**, which are events where there is no previous knowledge of the events occurring or which are difficult to imagine until they actually occur.
- **Unknown knowns**, which are events unknown to the present experts or analysts, but which someone else has knowledge of.
- **Known knowns**, which are events where knowledge of the events exists, but are believed to not be occurring or of negligible probability.

The nature of a black swan makes the identification of them very difficult. However, one way to discover black swans is through scrutiny of existing knowledge, judgements, and other sources of information (Aven, 2020, p. 249)

3.3.5 Characterizing Risk

Risk is most commonly described as (A, C, Q), where A is an event or activity that leads to the consequences C, with a measure of uncertainty Q (Aven, 2020). Though this gives us a simple picture of how a risk can be characterized, it is missing several variables which explain the sources of a risk, and what information and knowledge this risk is based on.

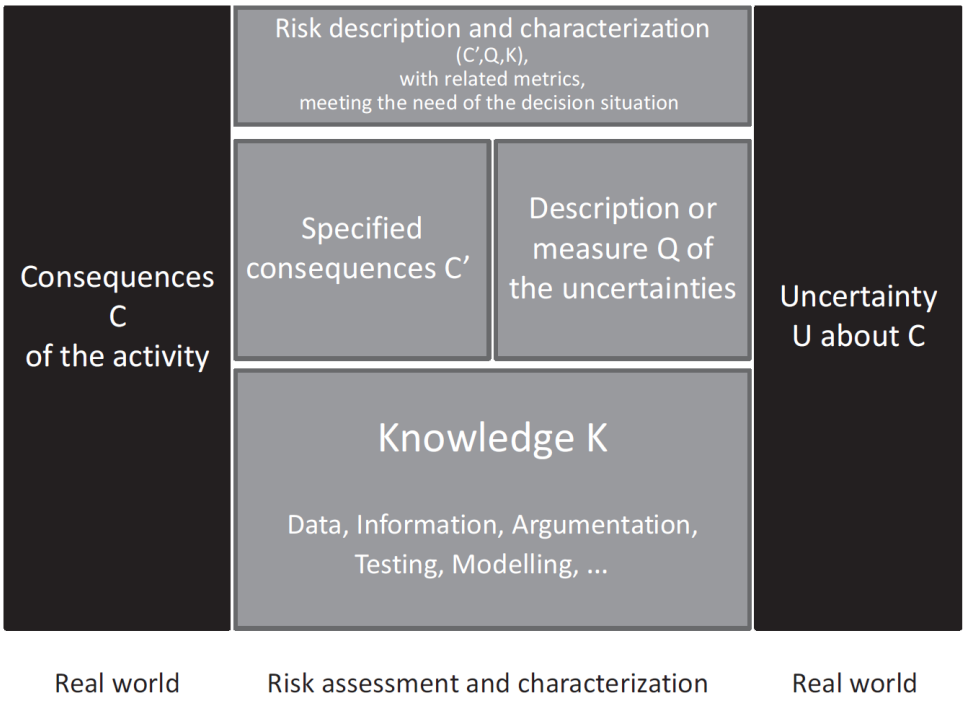

Figure 3.7: Characterization of Risk (Aven, 2020)

The characterization is therefore often expanded upon and more comprehensively be described as (RS', A', C', Q, K). Here, RS' are the specific risk sources that affect the specific events A' leading to specific consequences C' of the activity (Aven, 2020, p. 61). Q is then a measure of uncertainty of RS', A' and C' occurring, and K is the knowledge supporting RS', A', C' and Q.

3.3.5.1 Characterizing Probability

The true Bayesian approach is employed, and probability is defined as a degree of belief that the specific events will occur given the available knowledge, and can be described as P(A', K) (Aven, 2020).

3.3.5.2 Characterizing Uncertainty

The measure of uncertainty Q is defined as (P, SoK, K), where P is the subjective-based probability, SoK is a judgement of the strength of the knowledge K supporting the probability (Aven, 2020).

4. Methodology

This chapter presents an overview of the methodological choices made for this thesis. Beginning by explaining the research design and research strategy. Then the research process and the data collection process are explained. In the subsequent section are some reflections on the validity and reliability of the thesis. Next, the ethical considerations that have been taken into account in this thesis are discussed. At the end of this chapter, the method of using a Bayesian Network is presented and its use in this thesis is explained.

4.1 Research design and strategy

4.1.1 Research Design

Research design is a systematic approach and a framework which determines the subject of the study, the way in which data is collected, its relevance, and how the analysis of the results should be conducted (Philiber et al., 1980).

In the view of Yin (2018) a research design is *"a logical plan for getting from here to there, where here may be defined as the set of questions to be addressed, and there is some set of conclusions about these questions"*. The major steps in this process include a collection and analysis of relevant data (Yin, 2018).

As the subject being looked into is not well-researched, an exploratory research design was determined to be the most suitable approach. The subjective nature of the concepts and tools employed in this thesis also favours an exploratory research design. Exploratory research design is a necessity when little is known about the research topic. The purpose is to gain a clear understanding of the problem by looking for and learning important data. Blaikie (2010) underlines that this purpose is better achieved by using a qualitative method of collecting data.

This thesis is based on the qualitative method, using literature review and semi-structured interviews as a way to collect data for the thesis. The purpose of semi-structured interviews was to collect data from respondents within the NOA Digital project in order to investigate the risks and opportunities. Further explanation is given in Section 4.3.2.

4.1.2 Research Strategy

The principal aim of choosing a research strategy is to achieve the best procedure for addressing a research problem, and particularly to best answer the research questions formulated (Blaikie, 2010). Blaikie (2010) introduces four different strategies and underlines how it may be necessary to use different strategies for different research questions. The four strategies are known as the inductive, deductive, retroductive and abductive strategies.

This thesis is based on a inductive research strategy. The inductive research strategy aims at establishing limited generalizations and theories based on specific observations (Blaikie, 2010).

The purpose of this strategy is to create an overview and to make predictions by examining the available data, both current and past. By formulating certain outcomes for the three problem statements of this thesis, put forth in Section 1.3, a generalization may be made.

4.2 The Research Process

Below, we have presented a table providing an overview of activities during the research process. There were made continuous readjustments of the theories, frameworks, data collection, discussions and the research problem in the research process.

Period	**Activity**
December 2021	1. Proposal of topic 2. Discuss topic and issues with supervisor from Aker Solutions 3. Research on risk theory and project management 4. List relevant articles and other sources 5. Prepare a preliminary project plan for the thesis
January 2022	1. Update and prepare project plan for the thesis 2. Approval of topic 3. List relevant literature relating to risk and opportunities within digitalization and PMLC models 4. Guidance and information about the NOA Digital project and digitalization at Aker Solutions 5. Formulate a first draft of research problems and questions 6. Formulate questions for the interviews 7. Start interviewing candidates
February 2022	1. Aker Solutions will provide access to necessary software and documents, as well as their offices in Stavanger 2. Develop a first draft of research design and strategy 3. Create first draft of introduction and theory 4. Create first draft of methodology 5. Continue with the interview sessions with candidates 6. Discuss topic and issues with supervisor from University of Stavanger 7. Review internal standards and procedures

March 2022	1. Continue on draft of the theory and methodology 2. Revised research questions 3. Create a risk picture of NOA Digital project 4. Continue with the interviews
April 2022	1. Continue with the interviews 2. Transcribe the interview recordings 3. Work on introduction, theory and methodology 4.Start on gathering the results and create draft of the results
May 2022	1. Last two interviews 2. Create a draft of the discussion 3.Update and complete introduction, theory and methodology 4. Create a general risk picture 5. Update and complete the results 6. Update discussion and conclusion 7. Review references
June 2022	1. Complete discussion and conclusion 2. Write abstract 3. Proof-reading and readjustments 4.Readjustments based on the supervisor‘s comments 5. Final readjustments 6. Proofreading

Table 4.1: Research Process

4.3 Research Triangulation Methodology

A triangulation strategy is typically used for enhancing the validity and reliability of research, or for evaluating the findings. (Mathison, 1988; Golafshani, 2003) describe this by saying:

> *"Triangulation has risen an important methodological issue in naturalistic and qualitative approaches to evaluation [in order to] control bias and establishing valid propositions because traditional scientific techniques are incompatible with this alternate epistemology."*

A triangulation method can include different methods of collecting and analyzing data, but it does not suggest a fix way to do this for all studies. It depends on the criterion of the research how triangulation can be used to test validity and reliability of the study (Golafshani, 2003). Triangulation is defined to be:

> *"A validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study"* (Creswell & Miller, 2000, Golafshani, 2003).

The method used to collect data in this qualitative study was done by using a case-based approach and conducting semi-structured interviews. As the NOA Digital project is an ongoing project there is no available data or studies on it. Moreover, similar projects of the same scope and size are difficult to find.

4.3.1 Case-based Approach

As the subject being studied in this thesis is a contemporary phenomenon, that is being investigated in depth within a real-world context (Yin, 2018), a case-based approach was chosen for this thesis. According to Yin (2018) a case study deals with distinctive situation where there are many more variables of interest than there are data points. A case-based approach therefore benefits this thesis, as there are is a myriad of risks and variables that may be inferred from a few data points.

4.3.2 Interviews

The informants were interviewed with a semi-structured approach, as it allows specific issues to be addressed in greater detail. Additionally, it grants leeway to pick up valuable information which may not be directly related to the specific questions asked (Bryman, 2015). The goal of semi-structured interviews is to create an open discussion where participants share their experiences and opinions with respect to the research topic (Tjora, 2021).

The interviews were conducted via video conferencing tool Microsoft Teams since the informants were in different places around Norway. The informants had been notified in advance what the interview was about and an interview guide was provided. In our interviews, we began by presenting information about our thesis, the interview process, and how the data would be used. Additionally, audio recordings were taken during some of the interviews, where consent was given. The questions are included as attachments in Appendix A. In total, 13 general interview questions were prepared, which were combined with additional targeted questions for the individual interviews based on their background.

The interviews were conducted with the key personnel who were directly involved with NOA Digital project during spring 2022. The informants were selected in collaboration with our supervisors at Aker Solutions. Both authors were present during every interview where one asked questions and led the conversation, while the other took notes and ensured the interview guide was followed. The ethical considerations that were made for the interviews are stated in Section 4.5. A list of all the interviews are presented below in Table 4.2, these will be referenced throughout the thesis in the form of curly brackets and the number of the interview.

#	Date	Location	Relevance (Job Title)	Duration (Min)
1	28.01.22	Meeting through Microsoft Teams	Business Manager FFA, Aker BP	40
2	01.02.22	Meeting through Microsoft Teams	Mission Lead within the NOA Digital project, Aker Solutions	30
3	02.02.22	Meeting through Microsoft Teams	Program Manager for NOA Digital project, Aker Solutions	30
4	03.02.22	Meeting through Microsoft Teams	Head of Digital, Aker BP	25
5	10.02.22	Meeting through Microsoft Teams	Delivery Lead within NOA Digital project, Aize	25
6	21.04.2022	Aker BP Office, Stavanger	Project Improvement Manager, Aker Solutions	45
7	04.05.2022	Meeting through Microsoft Teams	Project Manager for Frøy, Aker BP	30
8	12.05.2022	Meeting through Microsoft Teams	Digital Development Manager, Aker BP	30
9	19.05.2022	Meeting through Microsoft Teams	Competence Development lead for Digital, Aker Solutions	25

Table 4.2: Interview list

4.3.2.1 Supervisory Meetings with Aker Solutions

Regular meetings were held with Aker Solutions to supervise for the writing of this thesis. Additionally, these meetings would share information explaining the work-processes and standards of Aker Solutions, and give guidance on the risk analysis tools used by Aker Solutions. The table below documents these meetings.

Date	Location	Relevance (Job Title)	Duration (Min)
04.01.22	Meeting through Microsoft Teams	Quality Risk Manager & Project Improvement Manager	50
05.01.22	Meeting through Microsoft Teams	QRM & PIM	60
05.01.22	Meeting through Microsoft Teams	PIM	50
11.01.22	Meeting through Microsoft Teams	QRM & PIM	30
14.01.22	Meeting through Microsoft Teams	QRM	20
18.01.22	Meeting through Microsoft Teams	QRM & PIM	25
25.01.22	Meeting through Microsoft Teams	QRM	30
01.02.22	Meeting through Microsoft Teams	QRM & PIM	15
08.02.22	Meeting through Microsoft Teams	QRM & PIM	30
09.02.22	Meeting through Microsoft Teams	QRM	30
15.02.22	Meeting through Microsoft Teams	QRM	30
15.03.22	Meeting through Microsoft Teams	QRM & PIM	15
05.04.22	Meeting through Microsoft Teams	QRM & PIM	20
19.04.22	Meeting through Microsoft Teams	QRM & PIM	15
25.05.22	Meeting through Microsoft Teams	QRM	30
30.05.22	Meeting through Microsoft Teams	PIM	50

Table 4.3: Supervisory Meetings with Aker Solutions

4.3.3 Literature Review

The third approach of obtaining data was by conducting a literature review. This thesis used a systematic and critical review of official literature, i.e. web articles, reports, books and official documents of the chosen problem. The literature review itself is presented in Chapter 2. The aim of literature review is not to create new knowledge from its own empirical data and analysis, but uses existing knowledge obtained from the different data bases and puts them together in a new angle (Støren, 2013). Thus, the data in this thesis is based on a thorough review of official documents and reports etc (Dalland, 2017).

These documents, articles and books were used to explore and create an overview of risk and opportunities within digitalization, and terminology related to this. In addition to using available literature, the NOA Digital project was studied from documents provided by Aker Solutions. While conducting the literature review, we were provided with Aker Solutions's internal documents on their procedures, terminology and theoretical basis for these procedures. Another input to this thesis were frequent meetings with supervisors at Aker Solutions.

The advantages of conducting literature reviews are that it illuminates a topic and a problem statement from several different perspectives and angles. However, a disadvantage is that one already uses "interpreted truth" which involves an analysis and meaning-making that the author has created (Forsberg & Wengström, 2013).

4.4 Validity and Reliability

Validity and reliability are two pertinent concepts to any research, as many ideas and models are ambiguous and non-observable. Neuman (2014) states that validity means truthfulness, and refers to how well an idea matches with actual reality. However, in qualitative research one strives to achieve authenticity, rather than a singular truth.

Reliability, Neuman (2014) defines as the dependability or the consistency of the research and results. However, whereas in quantitative research considers a result reliable if it can be replicated, reliability in qualitative research considers a result reliable if it has a range of sources and employs multiple measurements. Also accepting that different researchers using different methods of measurements may find distinctive results (Neuman, 2014).

The concepts of validity and reliability help establish credibility to the research and the findings of studies (Neuman, 2014). Therefore, it is important to judge the quality of the research design, to this extent there exist several tests to determine the quality. According to Yin (2018) there are the four following tests:

- Construct validity: identifying correct operational measures for the concepts being studied
- Internal validity: seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions as distinguished from spurious relationships
- External validity: showing whether and how a case study's findings can be generalized
- Reliability: demonstrating that the operations of a study, such as its data collection procedures, can be repeated with the same results

These four tests were developed to establish the quality of empirical social studies, but as case study research falls under this umbrella they are also applicable to case studies (Yin, 2018). It is stated by Yin (2018) that internal validity used as a test criterion only for explanatory or causal studies. Thereby, it will not be considered in this thesis. Furthermore, Yin's defines reliability in a way that is more fitting of quantitative research and therefore this thesis will focus more on Nueman's definition instead.

4.5 Ethical Considerations

When researching the ethical aspect of how information is gathered is important, not just simply what information is gathered. According to Neuman (2014) the law and codes of ethics have some few clear prohibitions:

> *"Never cause unnecessary or irreversible harm to participants, secure prior voluntary consent when possible, and never unnecessarily humiliate, degrade, or release harmful information about specific individuals that was collected for research purposes."*

Given this, careful consideration was taken as to not expose the interviewees to any harmful consequences and no significant personal information was gathered from them. Though the names of the interviewees are not presented, their positions and their field of work is provided to lend validity to the data that was gathered from them. The decision of not giving total anonymity was based on the fact that no intimate personal information was gathered, and possible repercussions if their identity is discovered was considered insignificant.

Moreover, there are unethical practices that extend beyond the ramifications of people that are interviewed. Such as research fraud, where one might falsify data by either fabricating data or by omitting vital data which may run counter to the goals of the researcher. Additionally plagiarism is a serious breach of ethical standards and proper conduct (Neuman, 2014).

A significant amount of information on the procedures, plans and standards used by Aker Solution, that are relevant to this thesis, was gathered from their internal servers. Complete access was granted to the internal documents, so that the data could be as accurate and useful as possible to the writing of this thesis. As to not divulge sensitive data and information, the documents and information used in this thesis was checked by the assigned supervisors from Aker Solutions. Additionally, a declaration of confidentiality was signed by the authors of this thesis.

4.6 Bayesian Network

To illustrate the findings of this thesis, a Bayesian Network derived from a risk report by the Norwegian Institute of Marine Research (2021) is used.

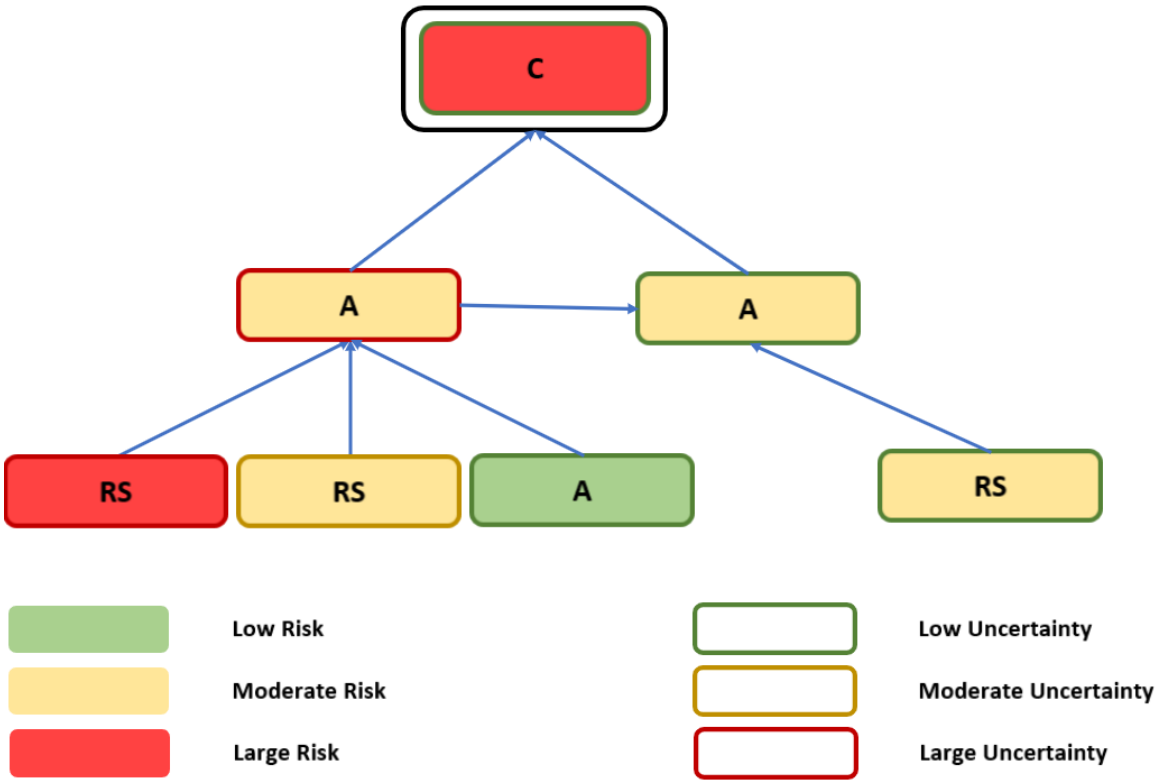

Figure 4.1: Example of a Bayesian Network

4.6.1 Events (A)

The different events, consequences and risk sources that are identified, according to the theory set out in Section 3.3.5, are put into nodes. These are then connected to each other with arrows based on how they relate to one another. How a specific risk source leads to a specific event is thereby visualized.

What constitutes a risk source, event and consequence in this form of Bayesian Network may be difficult to distinguish. This is due to the continuous structure of the network, where the consequence of one event, is an event in and of itself. Making the previous event the risk source for this event. Therefore, an event may lead to another event.

4.6.2 Consequences (C)

A head consequence is identified and the different events are then ultimately connected to this consequence. Alternatively, several head consequences could be chosen, where some events may not lead to both of these at the same time. In this thesis, the head consequence is visually distinguished in the network through a black outline, as seen on Figure 4.1.

4.6.3 Risk Sources (RS)

Risk sources in this network are considered to be those which are at the very base of several events. These are intuitively understood by being mentioned, but which would require an overly complex analysis to describe their causality.

4.6.4 Uncertainty (Q)

The uncertainty is assessed through a subjective knowledge-based assessment, according to the characterization set in Section 3.3.5.2. Which is displayed in the network as shown in Figure 4.1.

A key difference in the Bayesian Network of this thesis and the report from the Norwegian Institute of Marine Research (2021) is how uncertainty is depicted. The Norwegian Institute of Marine Research (2021) depicts the strength of knowledge instead of uncertainty as a whole. Though strength of knowledge is a aspect part of uncertainty, the two other main aspects are ignored and not displayed through their network.

Therefore, this thesis depicts uncertainty as a whole in the Bayesian Network, where the probability, knowledge, and the strength of knowledge are all assessed and explained in the report.

4.6.5 Risk Assessment

The severity and risk of the different nodes are assessed through a subjective knowledge-based assessment. This assessment being laid out in the report itself and the severity being illustrated in the network as shown in Figure 4.1.

4.6.6 Category Network

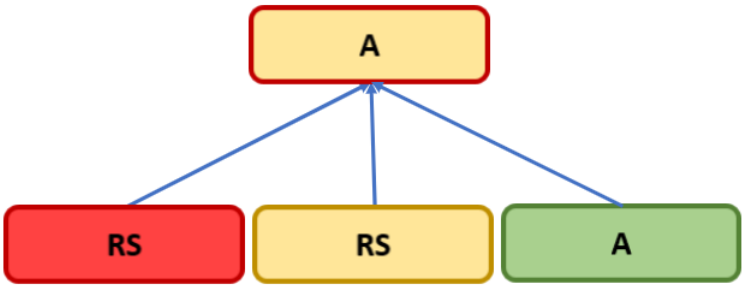

Figure 4.2: Example of a Category Network

Separate networks are created to make the greater network more manageable, as well as to categorize the risks into the different phases of a project, the departments accountable for these risks, and other general categories. These networks function as sections of the greater network, but are altered through the removal of events and risk sources unrelated to the category itself as shown by the difference in Figure 4.2 and Figure 4.1.

4.6.7 Critical Risk Network

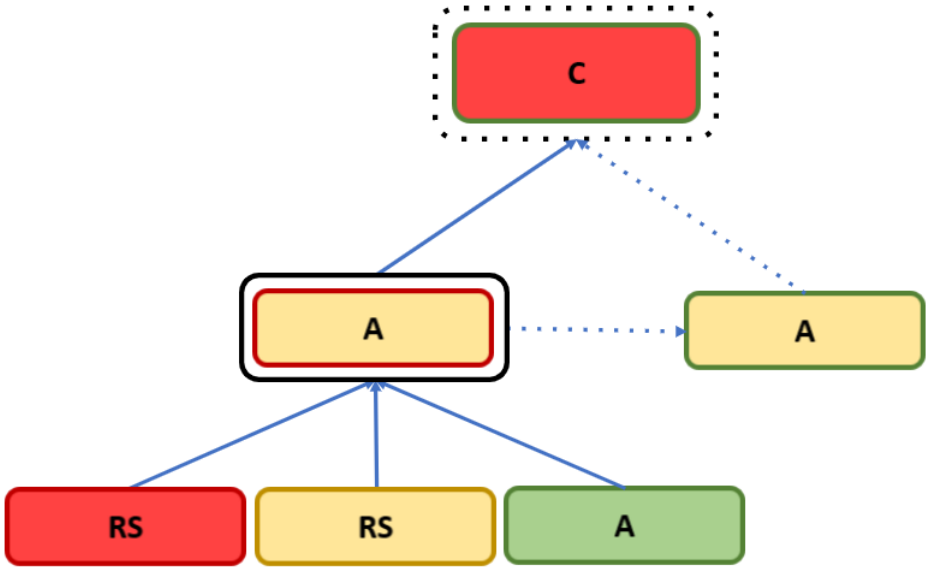

Figure 4.3: Example of a Critical Risk Network

Networks similar to the category networks are made to illustrate the critical risks. These show how different events and risk sources bottleneck at the critical risk nodes, and how the critical risks affect the overall risk picture. The critical risk is highlighted by a black outline, as seen in Figure 4.3, where some of the lines are dotted to put an emphasis on the causality of the critical risks and their direct consequences.

5. Results

5.1 The Risk Picture for Aker Solutions

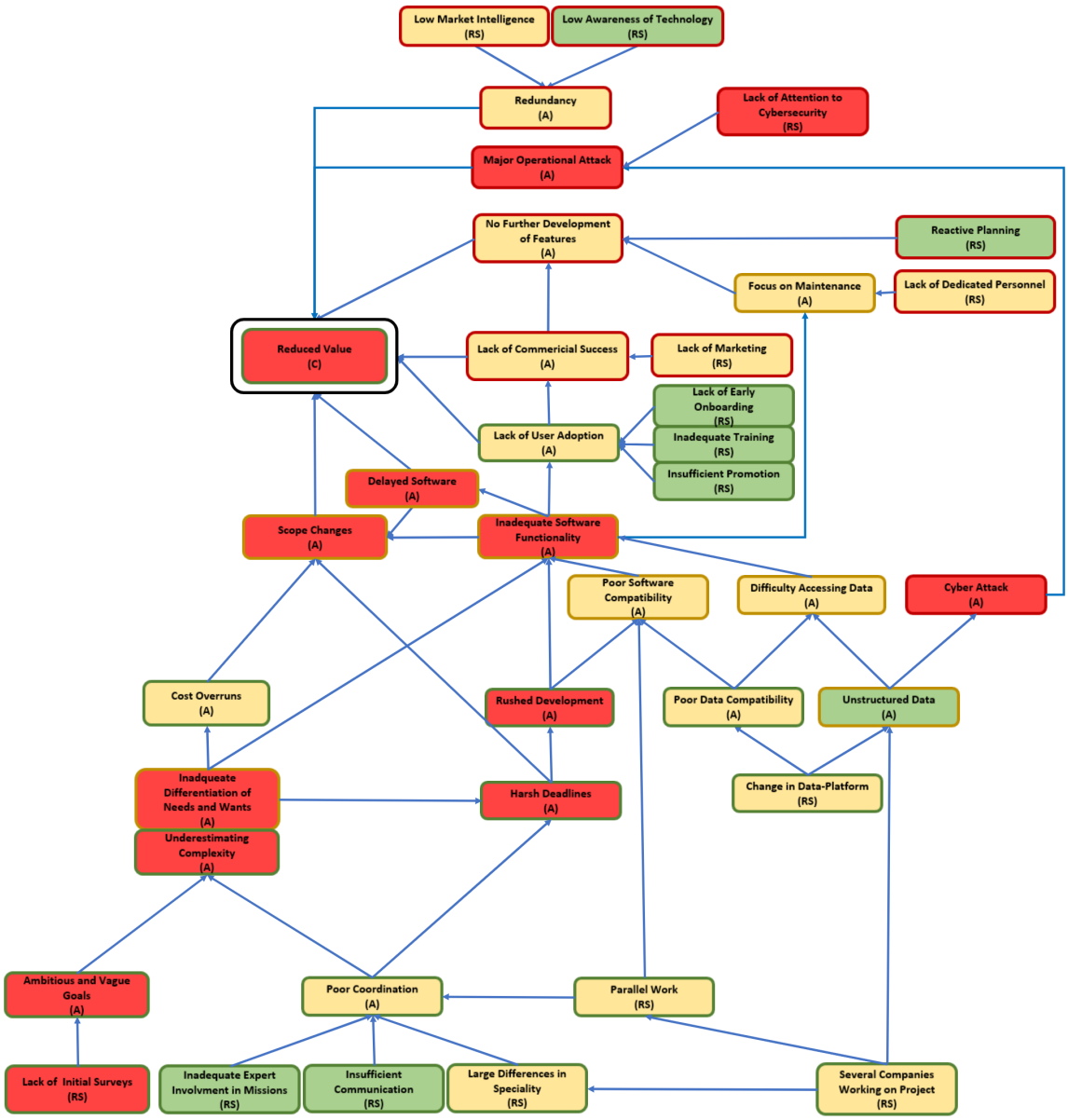

Figure 5.1: Complete Risk Network

Through the analysis of internal documents, presentations and interviews, the risk picture for the NOA Digital project is established and displayed in Figure 5.1. This picture is then subdivided into five categories, where the description and assessment of each individual risk is explained under each of these categories.

5.1.1 Organizational Risks

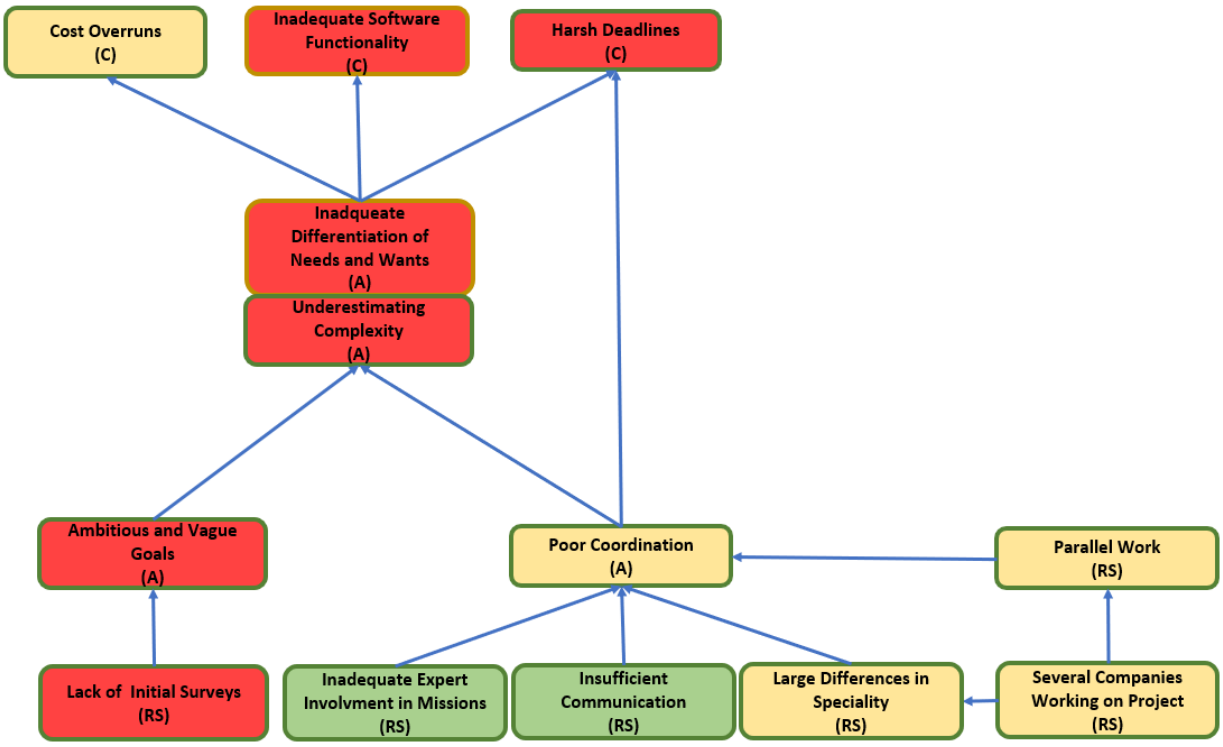

Figure 5.2: Organizational Risk Network

5.1.1.1 Ambitious and Vague Goals for Digitalization

Aker Solutions has ambitious goals set with the NOA Digital project. There are put forth 8 missions which are meant to automate, simplify and digitalize several of the processes involved in the construction and operation of oil platforms. Among those working with the NOA Digital project, there is a mutual understanding that the project has been very ambitious with rather vague goals {1-7}, such as to *"developing more efficient engineering processes"* and *"improve the processes for suppliers"* {6}.

Consequences

The large ambitions and scope of the NOA Digital project leads to a great number of risks. Though a large scope by itself may not necessarily lead to many significant risks, it does so when the scope is vague and imprecise.

The most significant and direct influence the vague scope has, is that it may lead to a difficulty in differentiating the actual requirements of the digitalization process. Focus may shift to many brainstormed ideas which Aker Solutions may desire, however may not in reality need. Without more specific and tangible goals the complexity of the project and the complexity of developing features might be underestimated.

Risk Sources

One significant risk source is in the method of how Aker Solutions came forth to their ambitious digitalization projects and the large scope of the NOA Digital project.

Based on their own wish, the top management decided to initiate a digitalization effort. Different fields of Aker Solutions' operations were examined to see which areas would yield a potential benefit from digitalization and where significant resources could be saved by digitalizing different processes {6}.

The employees and the potential end-users were themselves not surveyed and asked for which areas they feel would benefit from digitalization or what processes being digitalized would assist them in their field of work.

Uncertainty

There is little uncertainty involved with this risk, as it has occurred and is a well-understood issue within the project, with a strong strength of knowledge {1-7}.

Assessment

As the consequences are large, vague goals is assessed as a significant risk, which has already lead to many difficulties in the NOA Digital project and will continue to do so.

5.1.1.2 Poor Coordination

The NOA Digital project is a comprehensive project with many stakeholders. It is a collaboration between Aker Solutions, Aker BP, Aize and Cognite, meaning a large quantity of people are involved in this project. Good communication among the stakeholders is an essential factor to reach the project goals. The lack of proper communication and good coordination may have several severe consequences.

Consequences

Misunderstanding and misinterpretation in the project can lead the development of software astray. Ending up developing features or solutions that are out of alignment with the end-users needs. Furthermore, the true nature and complexity of the scope can be severely underestimated through insufficient communication and coordination. In addition, it will consume a considerable amount of the project's time correcting misaligned development and can affect the project's deadline.

Risk Sources

Workers of different background areas have to cooperate and understand each other in the execution of the NOA Digital project {3,9}. Specifically the different speciality base in engineering and IT generate challenges {3,5}. Aize develops the software, writes the code and is responsible for technical aspects, while AkerBP and Aker Solutions has to ensure their needs are met and manage the adoption of the software {5}. As there are several missions being developed in parallel, coordination across the mission can also be affected.

Despite some early difficulties in communication, emphasis was put on stronger communication and the different parties developing the NOA Digital project did not face severe issues {3}, making it a minor source of risk for the project.

Another potential source of risk can be the lack of adequate leaders and expert involvement in the development of the software. However, Aker Solutions involved competent experts with a good grasp of their respective subject matters {5,6}, reducing the risk source significantly.

Uncertainty

The project already experienced early challenges related to communication {2,3,5}. But once the issue was recognized they managed to resolve it. However, the probability of further issues with poor coordination and miscommunication is nonzero, even if considered low.

Assessment

The different companies involved with the NOA Digital project have shown a strong capability in handling coordination and communication. Yet issues have been noted. The consequences of this risk can be rather dire if coordination is not kept well, however a failure of this is considered to be of low probability. Thereby, the risk is determined to be moderate risk for Aker Solutions.

5.1.1.3 Inadequate Differentiation of Needs and Wants

There is a potential risk that Aker Solutions may not have properly analyzed what the different requirements are for the missions of the NOA Digital project. Of critical importance is that vital and necessary features are properly identified and differentiated from optional features.

Consequences

If the wants and needs of each mission are not adequately differentiated, the software will not have the necessary functions it requires to be useful to the end-users. Significant time will be spent developing excessive features and may detract from developing important features.

Missions becoming bloated with many excessive features can create many bugs within the products which will have to be ironed out, either taking away time from developing more necessary features or being delivered with several bugs.

The original plans may end up not properly adjusting to the bloated scope of the projects, meaning that the allocated budget will not be sufficient and set deadlines may not be met.

Risk Sources

As a consequence of the vague scope of Aker Solutions, it is difficult to properly distinguish what is considered a necessary feature and what is a desired feature for the different missions. The lack of preemptive internal surveying of which functions employees feel are currently lacking in their work-processes, means additional work must be done to identify these functions.

Compounding this risk is the risk of poor coordination in the different missions. Different stakeholders in the different missions not coordinating sufficiently, with information being misinterpreted or lost on the different parties developing the software, can further complicate what features are interpreted as important.

Uncertainty

There is a moderate degree of uncertainty within this risk. Strong knowledge exists on the overall scope of the project being ambitious and that the goals are vague. Moreover, there have been some difficulties with the coordination of the different missions {2,3,5,6}, most heavily in the early stages.

Also in the early stages, were issues with creating a real correspondence between the actual needs of the end-users and the ones developing software {1}. Still, to what degree the specific features being developed in the missions are necessary or not for the end-user, is far less certain.

Assessment

The likelihood of the risk is determined as large. This large probability, in conjunction with the large consequences of not adequately differentiating the necessary features from the desired ones, leads this to be considered a significant risk.

5.1.1.4 Underestimating Complexity

When developing software there is always some degree of complexity involved. The codes that are written and the engines that are employed may not always function as expected, creating several bugs that must be ironed out. Processes that one wishes to digitize can have a great deal of complexity, where it may be simple to understand the process theoretically, but be difficult to implement features to adequately meet the requirements to digitize the process. To a large degree this happened to the Digital Vendor Data mission of the NOA Digital project {6} and to a lesser degree to the Constructability Engine mission {2}.

Consequences

If the complexities of what needs to be developed are not assessed adequately, it may lead to considerable work to rework the software and iron out bugs. Leading to cost overruns and missed deadlines, or inadequate software functionality if the issues cannot be fixed.

Risk Sources

As the NOA Digital project had a large scope with some very vague goals it had lead to several of the missions. When the processes are vague it leave significant room for underestimating the magnitude and complexity of work that must be done. Difficulties in communication and poor coordination are other factors that may contribute to underestimating complexity.

Additionally, there is a wide range of specialists with different knowledge involved in the development of the software. If the requirements and processes are not explained sufficiently by the different parties, they may end up underestimating the complexity of the project.

Uncertainty

The degree of uncertainty is considered to be low. An underestimation of complexity has to varying degrees happened in several missions. That it happened is also understood by Aker Solutions with a strong strength of knowledge {2,5,6}.

Assessment

The risk of underestimating complexity is determined to be high, as there was a large degree of underestimation on several missions, where the consequences were significant.

5.1.2 Developmental Risks

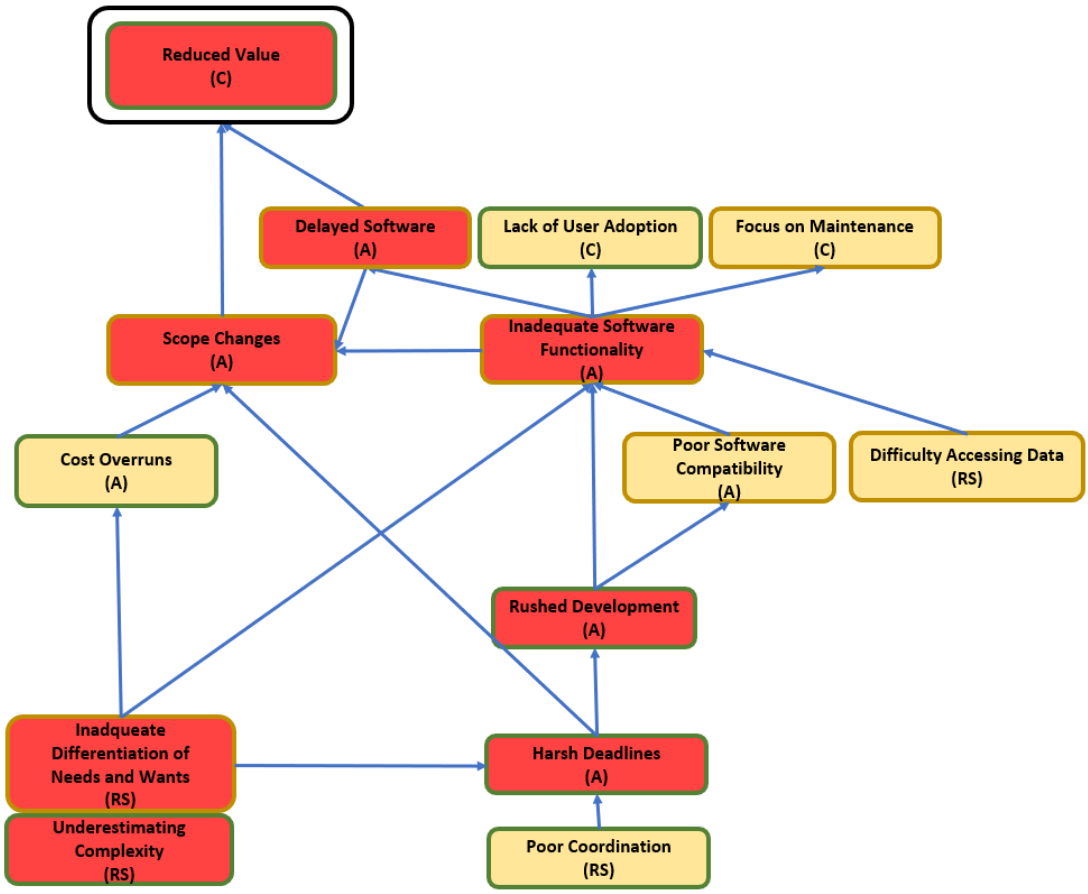

Figure 5.3: Developmental Risk Network

5.1.2.1 Cost Overruns

There was no budget set in advance for the missions of the NOA Digital project, because the scope was not completely known. Though some estimates and expectations were established for how much would be spent.

Yet after a budget was established, Aker Solutions did not concentrate on limiting themselves to the budget of the NOA Digital project {6}, as the costs incurred in the development are expected to be offset by the value generated by the tools they receive {1,6}.

Consequences

The main consequence of cost overruns for the NOA Digital project is that significant overruns can lead to large scope reductions. As costs increase, the perceived benefit and the estimated value generated by a mission may decrease to the point where the scope may be either partially or entirely reevaluated. Reducing the overall features in the software produced by a mission, potentially having it scrapped entirely.

Risk Sources

There can be several reasons for cost-overruns and exceeding budgets. Often they are reducible to a lack of not having adequately differentiated which features are necessary and which are simply desired, as well as underestimating the complexity of the project that is undertaken (Wysocki, 2014).

Uncertainty

Aker Solutions has already used more resources in a shorter time span than they initially expected {3,6}. There is a high probability that they will continue to see this happen and this is well understood by Aker Solutions {1,3,6,8}. Therefore, there is a low degree of uncertainty of cost overruns.

Assessment

Despite the large potential consequences, they are considered less significant in the long term for Aker Solutions since they are willing to accept the cost overruns. Because of this, the risk is determined to be moderate, as the probability is rather high for cost overruns occurring.

5.1.2.2 Harsh Deadlines

The missions in the NOA Digital project are developed with an Agile PMLC, yet the project as a whole is dictated by concrete deadlines. These deadlines were put in place in early stages and several of the missions are contingent on a previous one being released with the promised features. This is seen as an important issue, as the usefulness of one software is amplified by another in the case of the NOA Digital project.

Consequences

When the set deadlines are in danger of not being reached, there are two issues that arise. A choice may be made to make significant scope changes such as discarding the mission altogether and avoid further costs. Alternatively, one might rush development to meet the deadlines. This would be done so to avoid cost overruns and to ensure that the product is released and not discarded.

Risk Sources

Complications arise as a result of not having adequately distinguished which features that are most necessary to develop. The missions getting bloated with excessive features will necessitate more time being spent on developing these features and testing them for stability. This issue is amplified significantly if the features are more complex than anticipated.

Poor coordination between the different parties may also lead to delays, as well as having to rework different features when it is apparent that they do not coincide with the intended function for the end-users.

Uncertainty

Uncertainty is considered to be low for this risk. The established deadlines are known to be tight and understood with a good strength of knowledge {2,5,6}.

Assessment

The risk is considered high as there has already been issues reaching the deadlines, where some have been partially delayed and others where both of the identified consequences played out.

5.1.2.3 Rushed Development

Aker Solutions has to develop many missions within a limited time-frame. As a result, several of the missions in the NOA Digital project have had some degree of rushed development {5,6}.

Consequences

The main consequence of rushed development is that it can lead to inadequate software functionality. Different features are implemented and insufficient time is spent testing the features and correcting bugs in the software.

Risk Sources

Rushed development is usually a consequence of poor timing and harsh deadlines. The latter of which is the main source of rushed development in this project. The NOA Digital project must be ready and applicable to a specific time for the development of the NOAKA field. Therefore, the strict deadlines and the necessity of the project create an impetus to rush development.

Uncertainty

Some missions of the NOA Digital project are rushed in some aspects {5,6}. In some missions there was miscommunication regarding the schedule of when usable prototypes of software should be ready and when complete versions should be ready. Leading to some issues that hastened development in some missions {6}. As the event has occurred with a good strength of knowledge, the uncertainty is considered to be low.

Assessment

The risk is considered to have a high probability, as it is known to be an issue. Combined with the large consequences which stem from rushed development, it is considered to be a significant risk.

5.1.2.4 Inadequate Software Functionality

A software can be released being unable to meet the requirements of the end-users. In addition to missing key features, it may be unable to operate properly and have low stability.

Consequences

There are several significant consequences that may follow from this event. One, that has already played out in the NOA Digital project, is significant reduction in scope. The Digital Vendor Data has been canceled as it did not have adequate functionality and did not contain key features {6}.

However, other missions, where software does not function adequately, may not be canceled. Leading to large delays and additional costs. The former of these being a possibility that Aker Solutions cannot easily accept {6}. Meaning that the software may be released in an inadequate state. Consequently, this may lead to a lack of user adoption, due to the tools provided by the software not being sufficient for their work. Forcing them to employ older or different methods.

Low software functionality after release, will also force Aize to focus on stabilization and maintenance of the different programs rather than developing new features {5}.

Risk Sources

Inadequate differentiation between the necessary and desired features of a mission, as well as the underestimation of the complexity to develop these features is the main risk source for this event. Though there are several secondary risk sources that lead to it.

Poor software compatibility with data and between the different programs developed in the project may cause the programs, that would otherwise function adequately, to be difficult to operate and use. Difficulty in accessing data may also cause the software to function inadequately, as explained in Section 5.1.4.3. Moreover, if a decision to the rush development of features is made, it will exacerbate all the aforementioned issues.

Uncertainty

Though a large mission was canceled after it failed to deliver a fully functional software according to its scheduled release date {6}, other missions seem to function as intended {2,5}. On the other hand, several of the solutions and software is developed during the transition of the current data platform and a new one developed by Cognite. As a consequence of this several solutions are temporary solutions which may require significant reformatting to function properly once the transition is complete {3,6}.

The probability of the event occurring is therefore seen as moderate, yet it is difficult to predict due to a moderate strength of knowledge. Thus the degree of uncertainty is assessed to be moderate.

Assessment

The risk of inadequate software functionality is determined to be high as the consequences are severe and with a moderate possibility of occurring.

5.1.2.5 Scope Changes

It is natural for a project to have scope changes underway, especially so with those developed through an Agile PMLC, as is the case with the individual missions of the NOA Digital project. However, the overarching goals of a project based on a Linear PMLC are not changed significantly unless something goes wrong. Therefore, there lies an inherent risk when these two PMLCs are used in combination.

The NOA Digital project started with 20 missions in total, yet many of these missions were either canceled or merged with other more critical ones in the early phases of the project, which was planned for. Ending up with 8 core mission. There have however, also been large scope reductions in the late stages of the project which were not planned for. Notably the Digital Vendor Data mission being unable to deliver a fully functional software according to its schedule {6,7}.

Consequences

A reduction in the scope of both the NOA Digital project and the individual missions directly cause a reduction in the potential benefits that Aker Solutions estimates. If several features for the different software are removed during development, then the software do not contribute the value which was originally expected from the project. Moreover, if entire missions are canceled, large reductions in the value it could generate is not realized. This has already been the case for the Digital Vendor Data, which reduced the estimated value of the NOA Digital project by approximately 37,5% {6}.

Risk Sources

Leading to scope changes is a combination of cost overruns, deadlines that are not met, and inadequate software functionality. Discussed more extensively in Sections 5.1.2.1, 5.1.2.2, and 5.1.2.4

Though Aker Solutions is willing to accept cost overruns to some extent {1,6}, a mission that also fails to meet its deadlines with a notable lack of functionality will force a re-evaluation and cause reductions in either the scope of the mission or the scope of the overall NOA Digital project.

Uncertainty

There has already been a significant reduction in the scope of the overall project as a consequence of canceling the Digital Vendor Data. However, there is some uncertainty as to how likely it is that other missions will face significant changes to their scopes. One mission, the Digital Engineering Concurrency, has already been successfully released {6} and the Constructability Engine, though facing some issues due to complexity, is expected to be released on schedule {2,5}. The level of uncertainty is therefore considered to be moderate.

Assessment

The scope of the NOA Digital project has been downgraded several times and the probability of additional scope changes is considered moderate. Yet, scope change is a critical risk which may directly lead to the loss of value for the entire project. As a result, the risk is considered high.

5.1.2.6 Delayed Software

Delays are to be expected in any project, and they are often planned for ahead of time with a course of action for when they inevitably happen. Despite this, there sometimes emerge large delays which were not planned for and which cannot easily be corrected.

Consequences

Dependent on the course of action, there are two main consequences for a delay in software delivery. One is to discard the software altogether, significantly reducing the overall scope. The second is to continue development and use additional time and resources on the project, creating delays in the overarching project. Ultimately, both these consequences lead to a significant reduction of the estimated value the software would have generated.

Risk Sources

In the given context, such a delay is caused primarily by the lack of software functionality. If the software, at the scheduled date of release, does not function as it should and lacks necessary features, will force further action to be taken.

Uncertainty

The degree of uncertainty for this risk is regarded as moderate. Such delays have occurred for some missions in the NOA Digital project {4,6,7}, yet due to the varied nature of the missions and the things that are developed, they do not indicate if other missions will be delayed {2,5,6}. There is also a good degree of knowledge on how other missions are progressing, which indicate that they may not be subject to delays {2,5,6,7}. This puts the probability of delays at a moderate level.

Assessment

Given the moderate level of probability and the substantial consequences a delay in software delivery has, this risk has been assessed as being high.

5.1.3 Post-Developmental Risk

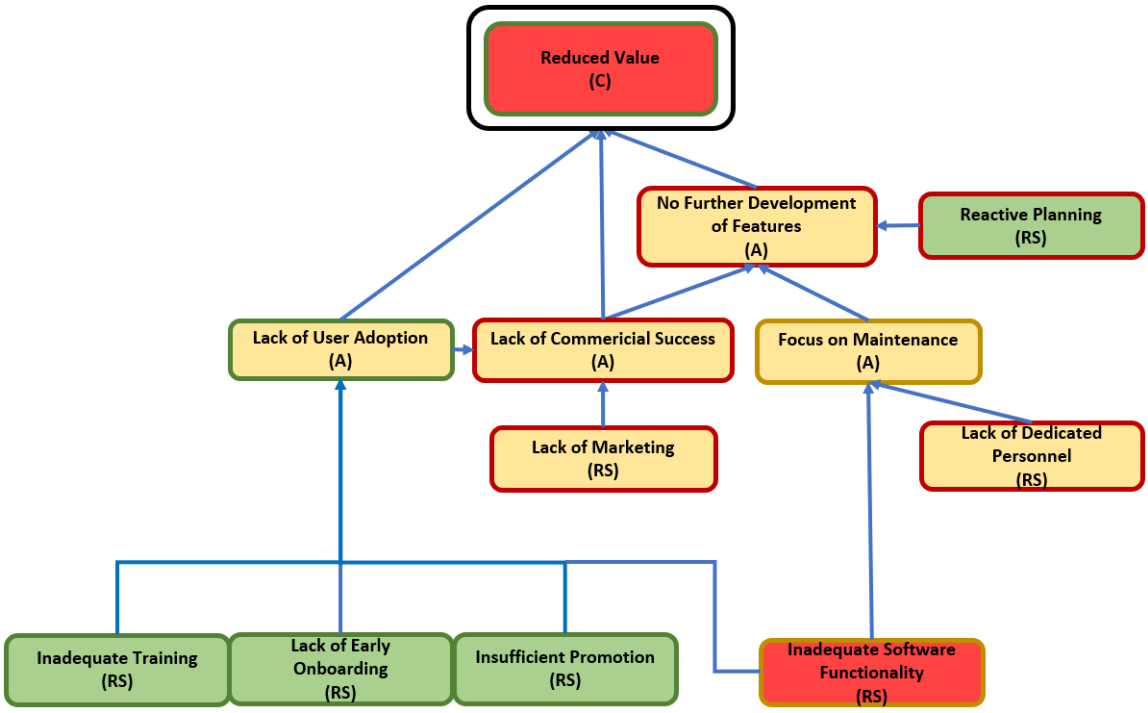

Figure 5.4: Post-Developmental Risk Network

5.1.3.1 Lack of User Adoption

An employee will willingly adopt a new tool and adhere to new processes if they are suitable to them and if they are given some familiarity to the tools. Unless they are suited to the employee's needs and unable to perform the tasks they need, the employee may end up not adopting them. Despite being obligated to do so by the leadership.

Consequences

Lack of user adoption can have major consequences for the project. If the end-users do not find the software useful and not use them, it will directly lead to a loss of the estimated value.

If software is not adopted by the employees at Aker Solutions and Aker BP, Aize may end up scrapping them altogether rather than releasing them on the greater market. On the other hand, if Aize releases the software in such a scenario, the lack of user adoption at the Aker Group will negatively influence the perception of the software on the market.

Risk Sources

In the early stages of making new software, end-users need to be involved in the development. The developers should receive feedback from people who will be actively using the software and implement new solutions based on the feedback. This will ensure that features are developed after the requirements of the end-users, whilst also familiarizing the end-users with the new programs. Early onboarding therefore serves a large role in the end-users adopting the software.

Insufficient promotion on the new software and digitalization process is another potential risk source. If the new tools are pushed onto the end-users without sufficient prior notice or enthusiasm, the end-user may opt to ignore the new tools.

Giving proper training and familiarizing the employees in how the new software functions and how their work-processes will change is likewise important for the adoption of the software.

Aker Solutions has introduced strong measures which reduce these risk sources to a low risk level {6,9}, further discussed in Section 6.2.3.

Arguably the most important risk source for the lack of user adoption is *Inadequate Software Functionality*. If the software that the employees are given is simply unable to meet their needs to adequately complete their tasks, then they will employ different tools and methods to complete their work.

Uncertainty

Aker Solutions has set clear expectation for their employees and compels them to use the software developed in the NOA Digital project {9}. Moreover, the new software and tools integrate many of the earlier tools, already familiar to the employees {3,6,9}. Along with the measures reducing the risk sources, the probability can therefore with a strong certainty be considered low.

Assessment

Despite the possible consequences of this event, the probability is deemed to be so low that the risk is assessed as a moderate risk.

5.1.3.2 Lack of Commercial Success

The software that are built in the NOA Digital project, are under the ownership of Aize. Their goal is to sell and distribute the programs to other companies in a variety of industries {1,5,6}. After the release of software, it is important for the Aker Group that they are a commercial success {6}. A wider array of companies may come with different requirements for the software and introduce new features which were not thought of during the initial development.

Consequences

If software fails to be a success on the greater market, then a direct consequence is that Aize will be subject to developing only the features which Aker Solutions requires. Leading to the lack of new and innovative features, which could be introduced by working with different industries and acquiring additional data and knowledge.

Moreover, it will also incur a greater cost to the Aker Group, as they will be forced to fund all of the development and foot the bill, without getting any additional revenue from the sale and distribution of software.

Risk Sources

There are two significant risk sources that may cause a lack of commercial success. A lack of user adoption at Aker Solutions means that the primary client is not using the developed products. Not only does this mean that the products sold poorly in the first run, but may also negatively affect marketing in the future.

This can be further compounded if there is a general lack of marketing. If the products are not adequately marketed for new costumers in different industries, it will drive down sales.

Uncertainty

The uncertainty of this risk is considered to be large. How likely it is to occur is difficult to ascertain, as the the amount of knowledge of what will happen is low and the strength of the knowledge is likewise difficult to determine. Despite this, the probability is considered to be low.

Assessment

The potential consequences are of a moderate size to Aker Solutions. Though they might have to take on more costs in the long term, it is a cost they can sustain if the software itself is useful to their operations. The risk is therefore assessed as being a moderate risk.

5.1.3.3 Focus on Maintenance

After development, a software must continuously be updated and maintained to iron out bugs and to keep it secure for the users. Although maintenance is vital, it is likewise important to continuously improve the software for further growth and additional revenue from new customers.

Consequences

If Aize develops a focus on maintenance of the software produced in the NOA Digital project, the most notable consequence can be that they will no longer try developing new features and improving the software.

Risk Sources

If the software is riddled with bugs, poor cross-compatibility and poor data-compatibility, then emphasis will be put in rectifying these issues.Though it has grown significantly, Aize is also a rather young company and may also have a lack of specialized personnel dedicated to continue a focused development after the NOA Digital project is complete. With the group that worked on this project potentially getting prioritized for different projects.

Uncertainty

There is a moderate degree of uncertainty involved with this risk. There is strong knowledge indicating that significant work must be done post launch to reformat and restructure the programs to read data {3,6}. Stemming from the change of the data platform {6}. Yet, the probability of the event occurring and to what degree the consequences will play out is difficult to ascertain.

Assessment

The probability of Aize becoming concentrated on bug-fixing and maintaining software is determined to be low, despite the moderate strength of knowledge. Whilst the consequence may not be overly significant, it is still of a noteworthy level. As a whole, the risk is therefore considered to be moderate.

5.1.3.4 No Further Development of Features

Consequences

If there is no further development of new features or improvements on established features, then there is a significant reduction in the future value of the NOA Digital project. Established features may not always be the most optional ones and may need to be reworked, improved, or replaced by better features.

Furthermore, potential features may be discovered, which would simplify or improve work-processes. If these are then not developed and implemented into the programs, there is a clear reduction in productivity. Additionally, software remaining stagnant may be phased out by new software from competitors.

Risk Sources

The largest risk source which may prevent further development, is the *Lack of Commercial Success*. If there is not enough revenue from sales, then it will be unprofitable to continue development post release. Various factors may also force Aize to focus on maintaining software, where development of new features may be neglected in favour of stabilizing the programs.

Though unlikely, there is a risk of Aize falling into the habit of engaging with issues as they come, and creates a strategy of reactive planning. A proactive strategy must be upheld so that emphasis is put on discovering new solutions.

Uncertainty

The probability is determined to be moderate, yet there is rather a significant lack of knowledge around this event. Moreover, the strength of this knowledge is poor, meaning that there is a large degree of uncertainty.

Assessment

The consequences are considered to be of a moderate size for Aker Solutions. Given that the software developed is functional, potentially after some degree of rework or maintenance post launch, their generated value will outweigh their cost despite the potential lack of further development. This, in conjunction with the moderate degree of probability, makes the risk a moderate risk.

5.1.4 IT Related Risk

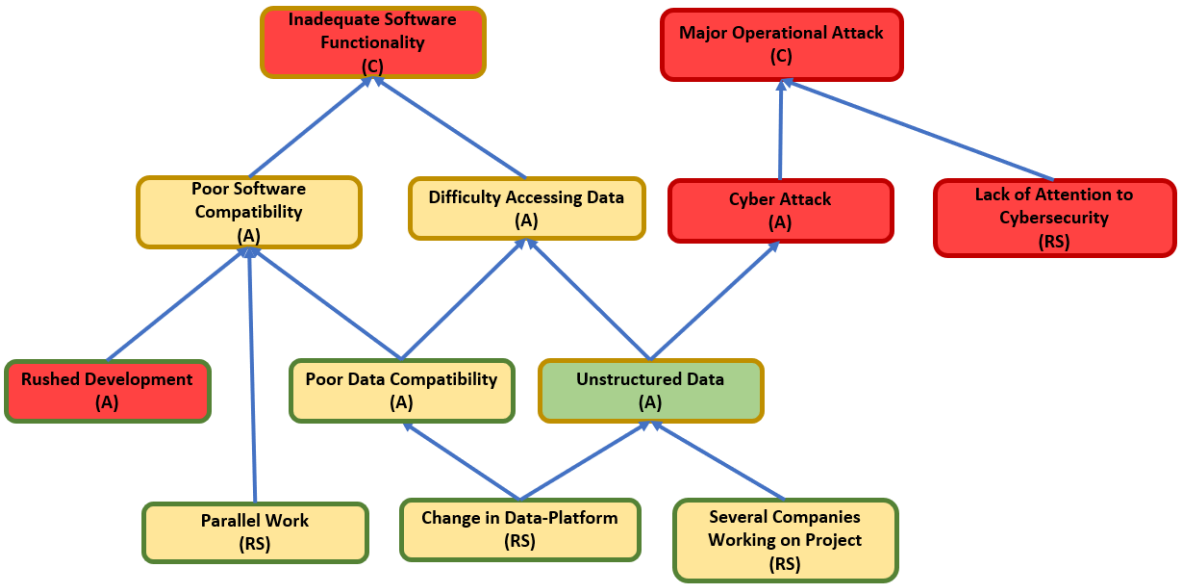

Figure 5.5: IT Risk Network

5.1.4.1 Poor Data Compatibility

Poor data compatibility may be defined as a poor flow of data across the source systems, where different data and files are not compatible with different systems due to a disparate data structure.

Consequences

When data is unable to be read by different software and systems, it may cause difficulty in accessing necessary data. Poor data compatibility may also cause software developed during the NOA Digital project to be incompatible with one another to differing degrees. Different features in different software may require a multitude of data to function adequately. When data cannot be read by the software, large bugs may occur without the code of the software itself having technical issues.

Risk Sources

Currently the Aker Group sits on enormous amounts of disparate data, which is not sufficiently organized {3}. To rectify this and to centralize the data, Cognite is developing a new data platform which will be the basis for the entire Aker Group {3,5,6}. This change in data platform is a large risk source for poor data compatibility, as many issues may occur and the data may not be adequately formatted and organized.

Uncertainty

There is a low degree of uncertainty for the risk occurring, stemming from the fact that software is currently being developed on the old platforms. Software will have to be reformatted once the new platform is adopted {3,6}. It is therefore well understood by the developers, with a degree of certainty that some compatibility issues will arise in the short term.

Assessment

In the short term, specifically for the duration of the NOA Digital project, poor data compatibility will have an effect. It will require additional resources and time to deal with, however in the longer term the consequences are seen as small. Though the probability is considered high, the risk is therefore determined to be moderate.

5.1.4.2 Unstructured Data

Unstructured data is when data-sets are no storied in a structured database format, It has an internal structure, but is not predefined through data models (NettApp, 2022). The data itself may be properly formatted and readable across the different systems, yet still create issues from being unstructured.

Consequences

Unstructured data will directly lead to difficulties in accessing data. As it may be difficult in simply finding the necessary data amongst the vast quantities of data that the Aker Group has generated over the years. This may also cause difficulties in finding malware and spyware that has slipped past the cybersecurity systems, which may lead to both smaller and larger cyber attacks.

Risk Sources

The fact that there are multiple companies cooperating on the NOA Digital project, currently with disparate systems, is a source for the data being unstructured {3,6}. As the different companies generate and save data differently.

As previously mentioned, Cognite is changing the data platform into a central platform for all these companies. Thereby mitigating the risk source above. However, in the process of changing the platform, there is a major risk if the data is not adequately restructured {3,6}. Potentially creating new sets of unstructured data.

Uncertainty

The probability of data being unstructured after the change in platform is considered to be low. Though Cognite is believed to have sufficient expertise, it is based on a weak strength of knowledge. Therefore, uncertainty is determined to be at a moderate level.

Assessment

Generally the consequences of data being unstructured are not large. Though some consequences may be considerable, such as large cyber attacks, they are considered to be very unlikely in getting past cybersecurity.

5.1.4.3 Difficulty Accessing Data

There may be both authorized access to data, and unauthorized access to it. When working, a user will need to access data to store, change, and move data. However, difficulty in accessing data may occur due to intended reasons, such as data being classified, or unintended reasons.

Consequences

Difficulty in accessing data may cause the software to function poorly. Even if the code functions as it should, if the underlying system of data requires different levels of authorization to access data or faces other difficulties with access, the program may not function.

Risk Sources

Issues with authorization will directly lead to difficulties with data access. However, this is most often solved through authorizing the ones that need the data. It is therefore the more structural issues, such as poor data compatibility and unstructured data, that are significant risk sources.

Uncertainty

Uncertainty on this risk is considered to be at a moderate level. The probability of the risk occurring is considered to be low. Yet, this is based on little knowledge with low strength, as the interviews did not give any information on this risk. However, the omission of it being mentioned indicates that there have been little or no issues with the access of data.

Assessment

The consequence of this event is considered to be high, but the probability being low makes this a moderate risk.

5.1.4.4 Poor Software Compatibility

A major part of the NOA Digital project is the interconnectivity of the different software that is produced. The data that is generated from them are meant to be readable through various means in some or even all of the different programs. It is therefore of critical importance that the different software are compatible with one another.

Consequences

The whole is considered to be greater than the sum of the parts in the NOA Digital project. The Digital Twin mission is dedicated specifically to integrate the different software into a single interface and to improve readability and accessibility.

The software by themselves may separately function properly. Yet, if they have poor compatibility with one another then, not only may they be difficult to operate in the intended manner, but also make the aforementioned mission redundant.

Risk Sources

Several risk sources can result in poor software compatibility. Parallel work on multiple missions at the same time will make it difficult to harmonize the different software, directly impacting software compatibility.

Moreover, rushed development to meet project deadlines may also negatively impact software compatibility, due to software bugs and other issues.

Uncertainty

Though alluded to as a possible event {3,6}, the programs thus far in the development seem to be compatible with one another. Knowledge is limited, but sufficiently strong.

However, the probability of this event to occur is moderate as for two reasons. There has been some rushed development in the NOA Digital project, making the possibility of poor compatibility more likely. Additionally, the change in data-platform and necessity to rework software after the change, may cause compatibility issues. The uncertainty is therefore determined to be moderate.

Assessment

Generally, the consequences of poor software compatibility can be dealt with, but may put strain on resources. This may throw the development itself into jeopardy when compounded by strict deadlines and rushed development. The consequences are therefore considered to be at a moderate level, and with a moderate probability the risk is determined to be moderate as well.

5.1.4.5 Cyber Attack

Cybersecurity is about protecting the confidentiality, integrity, and availability of important assets (von Solms & van Niekerk, 2013). Thus, a cyber attack is potentially a major issue with severe consequences for a company and in all digitalization projects. The company's IT team evaluates potential threats and security breaches based on these principles and then implements security measures to different degrees of necessity.

Consequences

If the cybersecurity is not sufficiently able to deal with a cyber attack, the confidentiality, integrity, and availability of assets may be compromised. Some of these successful attacks may cause relatively low or moderate degrees of costs. However, in some extreme cases the core operations of Aker Solutions and their larger assets, such as oil platforms, can be targeted.

Risk Sources

There are several risk sources leading to a cyber attack. In the NOA Digital project, *Unstructured Data* is identified as a major factor that may lead to a cyber attack, potentially with severe consequences.

Uncertainty

There is a high degree of uncertainty in this case. Though the probability of the event is assumed as low, cyber attacks cannot be foreseen, making the likelihood difficult to determine. Additionally, there is lack of knowledge about the scope and consequences of a potential cyber attack.

Assessment

A major cyber attack is unlikely to occur, however, if it occurs the consequences can be extreme and the costs can be very high. Hence, a cyber attack is an intolerable risk as the consequences are extremely harmful to all projects of the company.

5.1.5 Black Swans

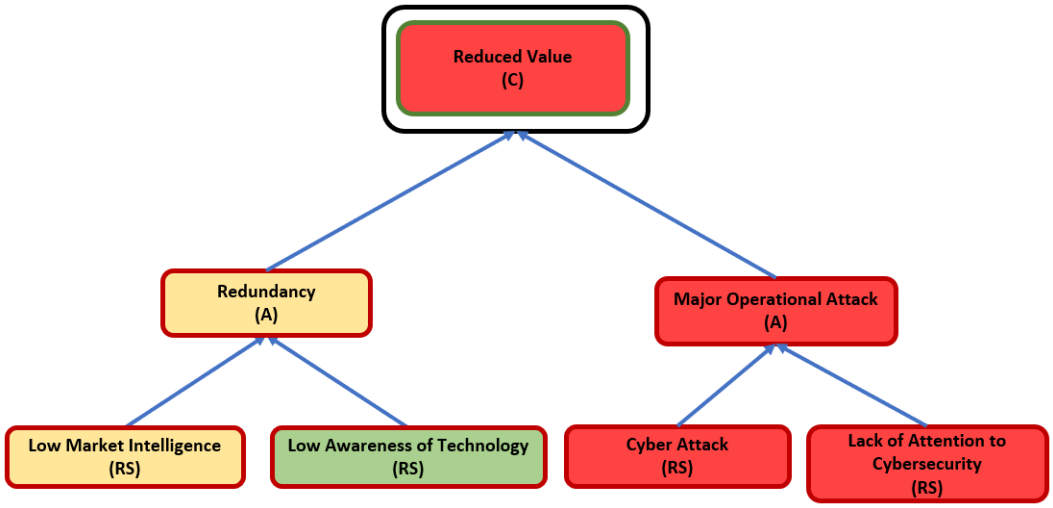

Figure 5.6: Black Swan Network

5.1.5.1 Risk of Redundancy

Redundancy occurs when something is no longer useful and where something else can do necessary work in a better and more efficient way. In history, we have seen this happen through technological innovation, such as the invention of the car which made transportation by horse mostly redundant.

Consequences

The NOA Digital project has the benefit of developing several parallel software. This may reduce the likelihood of the project as a whole becoming redundant. Yet, even one of the missions becoming redundant will significantly decrease the expected value of the overall project, in addition to taking on a large loss from the development itself.

Risk Sources

This risk is considered to be an unknown known, as defined in Section 3.3.4. To the Aker Group it is unknown if some entirely new technology or product from a competitor is in the development, which could make either parts or the entirety of the NOA Digital project redundant. Being unaware to technological advancement is therefore a large potential risk source, making it vital to be aware of technological advancements and ongoing research.

There is a global trend towards digitalization and major digitalization efforts are made by many national and international companies. Though Aker Solutions is a robust company with large revenues, there are still larger corporations both nationally and internationally. Potentially employing greater resources to develop software that may out-perform what Aker Solutions produces.

Uncertainty

As this risk is considered as a black swan, a high degree of uncertainty is to be expected. It is difficult to determine the possibility when there is a significant lack of knowledge. What other companies and industries are planning or in the process of, is often difficult to know and there are many things which may be confidential. Moreover, exactly how new technological advancements or other software on the market may affect Aker Solutions's digitalization is likewise difficult to know.

Assessment

The probability, despite being difficult to determine, is considered to be very low. However, it is important to be aware of this possibility, as the most extreme consequences are very dangerous. The risk is therefore considered to be moderate.

5.1.5.2 Major Operational Attack

A major operational attack is when unauthorized parties successfully infiltrate the systems where the operation and production at a facility is disturbed and hampered with, sometimes with long-lasting consequences and significant costs.

Consequences

For Aker Solutions a major operational attack can cripple them. If highly malicious actors manage to successfully hack their systems, many of the physical assets may be damaged and large environmental damage can be afflicted. The reputation of Aker Solutions may also be damaged.

As an example, censors may be manipulated to show that the system is stable, while the system may in reality be hampered with. Discovering such manipulation, once a hacker has gotten past the security measures, would be difficult when an oil platform is unmanned.

Risk Sources

There are numerous cyber attacks which are conducted. The cybersecurity may prevent most such attacks, yet some may slip through regardless.

Mentioned by several respondents, there has not been any focus on the cybersecurity in the missions of the NOA Digital project itself {3,5,6,7}. Issues regarding cybersecurity was expressed to be the purview of the cybersecurity department, and not much of a concern during development. Creating a potentially dangerous avenue for cyber attacks.

Uncertainty

This risk is also considered to be an unknown known, as defined in Section 3.3.4. Aker Solutions may not know who is targeting them, why or to what ends. However, such attacks are still caused by a malicious actor that would be aware of the attack. The likelihood of the systems being infiltrated, where all security measures are circumvented, in addition to a major attack actually being conducted is deemed highly unlikely. Yet, there is no solid knowledge on when or how such an attack may happen or by who, meaning the degree of uncertainty is very high.

Assessment

The nature of a digitalized workspace, where entire oil platforms are unmanned and controlled through different digital tools and systems, means counteractions are mostly limited to digital measures once a major operational attack is conducted. Therefore, despite the probability of occurrence being exceedingly low, the consequences are so significant that it is regarded as a serious risk.

5.2 Generalized Risk Picture

The events and risk sources identified in the NOA Digital project are of such a nature that these risks may apply to any digitalization project. The most notable difference being the severity of the risks, their sources, and the uncertainty involved. A generalized risk picture has therefore been created and is shown in Figure 5.7 below.

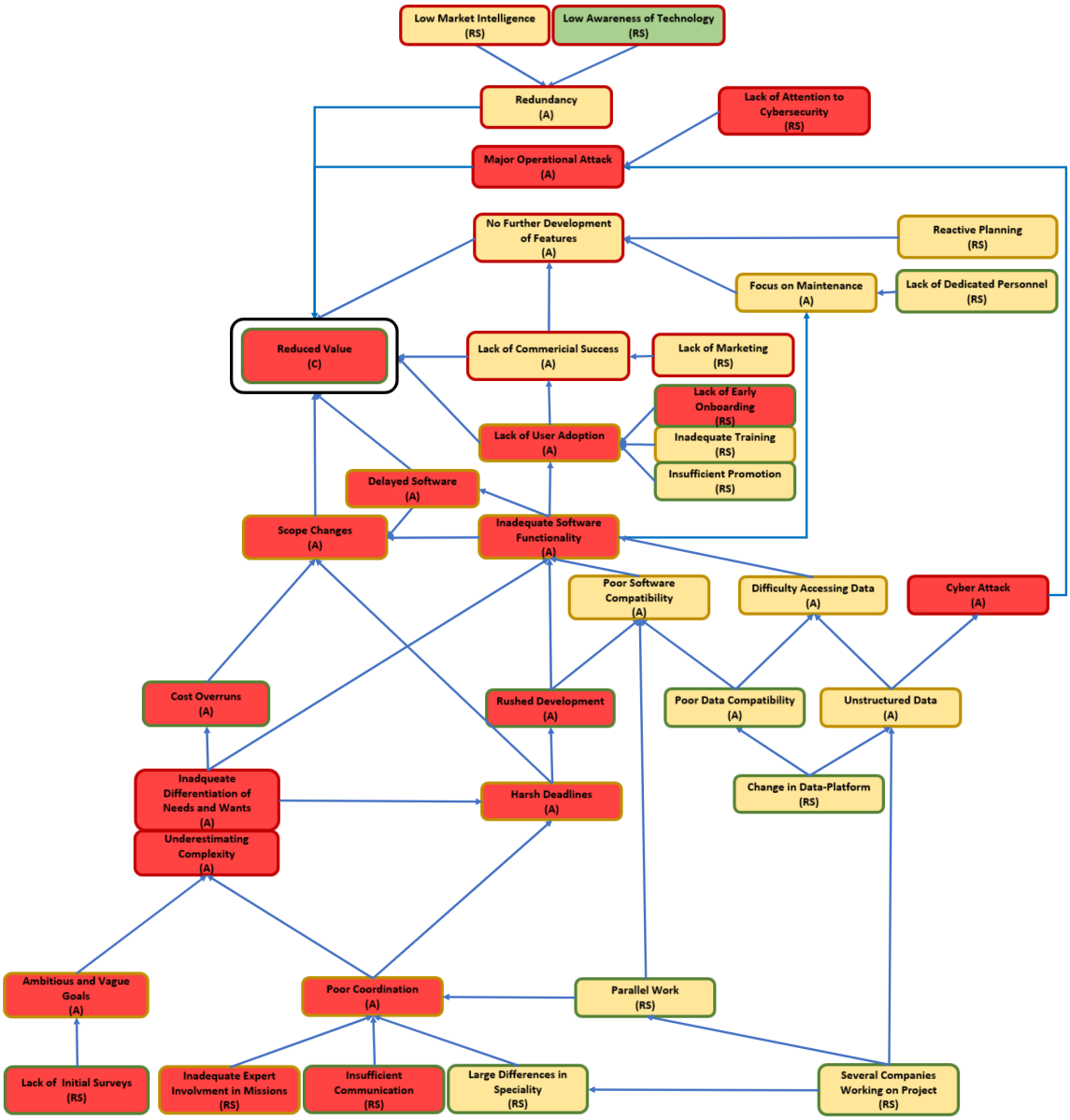

Figure 5.7: Generalized Risk Network

5.2.1 The Uncertainty Aspect of the Generalized Risk Picture

Leaders and managers of a different project, from a different firm, will have a different base of knowledge that applies to their projects. Thus, the knowledge, and the strength of this knowledge, of Aker Solutions may not sufficiently describe the uncertainty of a generalized picture. The uncertainty aspect depicted in the generalized picture is therefore different than from the one specific to Aker Solutions. The uncertainty here is the expected degree of uncertainty of an event, rather than the actual uncertainty as described in Section 3.3.5.2.

5.2.2 Differences in the Risk Pictures

5.2.2.1 Organizational Risks

Of the organizational risks in the generalized picture, having an *Ambitious Scope with Vague Goals* is still considered a significant risk. However, it may be difficult to understand exactly how certain goals may be vague. A larger degree of uncertainty is therefore to be expected on how probable the event is to occur.

Poor Coordination is also a far larger risk in the general picture than for the NOA Digital project. This is due to the fact that Aker Solutions, very early on, organized the necessary structure and personnel with good routines to establish strong communication and good coordination. If large emphasis is not put on communication and coordination in the early phase of a project, then there may be a greater degree of uncertainty as well as significant risks further down the line in the later phases of the project.

It may be difficult to assess for the leadership if it has underestimated the complexity or not if it is not communicated well across the different levels in the hierarchy. As a result of this, the uncertainty of *Underestimating Complexity* and *Inadequate Differentiation of Needs and Wants* are both very high.

5.2.2.2 Developmental Risks

The developmental risks are generally similar in both networks, with the two exceptions being the uncertainty of *Harsh Deadlines*, and the severity of *Cost Overruns*. With a heightened risk and uncertainty of poor coordination, the uncertainty of harsh deadlines is also expected to be higher. Additionally, less knowledge will exist to understand how deadlines affect later issues and how well the risk is understood.

Cost Overruns are also seen as a large risk in the generalized picture, as it may be unacceptable to smaller companies to take on cost overruns. Aker Solutions has sufficient capital and resources that it is both willing and able to take on greater costs than they may have estimated {1,6}. As the value of digitalization is expected to outweigh it heavily in the long run for Aker Solutions {1,6}.

5.2.2.3 Post-Developmental Risks

The difference in *Lack of User Adoption* stands out. Aker Solutions has successfully reduced the risk of end-user non-adoption to a moderate level. Having reduced the probability of this event by addressing the risk sources through early onboarding, adequate training, and promoting the NOA Digital project sufficiently to the end-users {3,9}.

In the generalized network, these risk sources have a higher probability and the uncertainty of *Inadequate Training* is higher, as how well the training is may be difficult to assess unless it is well-communicated . *Lack of Early Onboarding* has low uncertainty as this is known at the inception of a project. If the end-users are directly involved with the development or not, is something which should be known. However, the probability for the risk is higher as early onboarding may be neglected if not pointed out and planned for in the project.

As regards to risk sources for *No Further Development of Features* and *Focusing on Maintenance*, the expected uncertainty is less than the uncertainty for the same events in the NOA Digital project. Given that a company would have more and stronger knowledge on how much personnel they have with what skills, as well as their strategy when it comes to planning. However, the risk for *Reactive Planning* is larger, as the probability is higher on a general basis.

5.2.2.4 IT Related Risks

There is little difference on the severity of most risks in this category. Though some qualitative differences exist in why and how the risks play out in the generalized picture. Here, *Poor Data Compatibility* and *Unstructured Data* is not a result of a change in a data-platform, but rather the data-platform that is currently available to a company.

If a company has not recently gone through the process of developing a central data-platform which is the single basis for all data flow, then issues with the *Data Compatibility* across systems can arise. The risk of *Unstructured Data* is also higher as the probability of data being unstructured is higher in such a scenario.

5.2.3 Black Swans

Black Swans are considered to be similar in both the picture for the NOA Digital project and in the generalized picture, as large and unexpected risks are difficult to identify and assess for any project. The two major Black Swans that were identified in regards to digitalization projects are seen as having the same likelihood and consequences for both Aker Solutions and on a general basis.

5.3 Critical Risks

Analysing the generalized risk picture (Figure 5.7), bottlenecks in the network can be identified. If these bottlenecks are significant risks, then they are considered as critical risks. Thus, three critical risks have been identified, these being *Inadequate Software Functionality*, *Inadequate Differentiation of Needs and Wants*, and *Underestimating Complexity*. The latter two are categorized together, as these events have the same risk sources and similar consequences.

5.3.1 Underestimating Complexity & Inadequate Differentiation of Needs and Wants

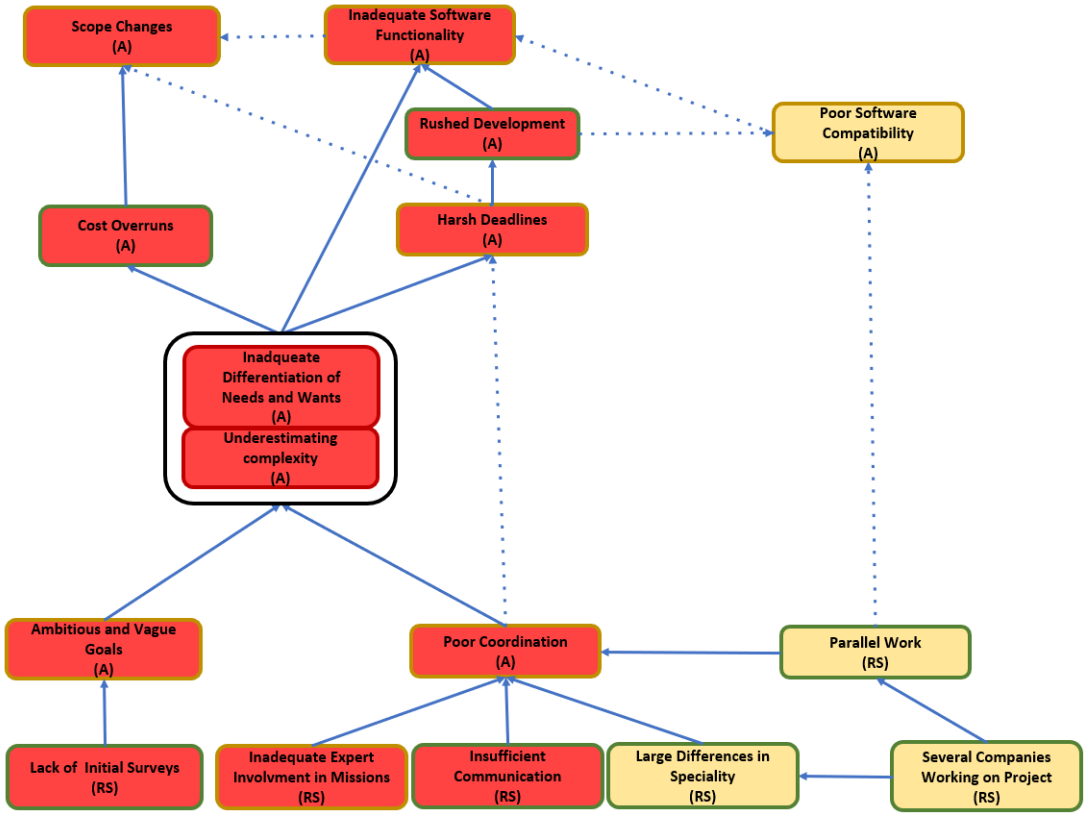

Figure 5.8: Critical Risk Network

Visualized in Figure 5.8, the organizational risks bottleneck at these two events. Moreover, most of the risks in the developmental phase of a digitalization project arise as a direct consequence of these two events.

5.3.2 Inadequate Software Functionality

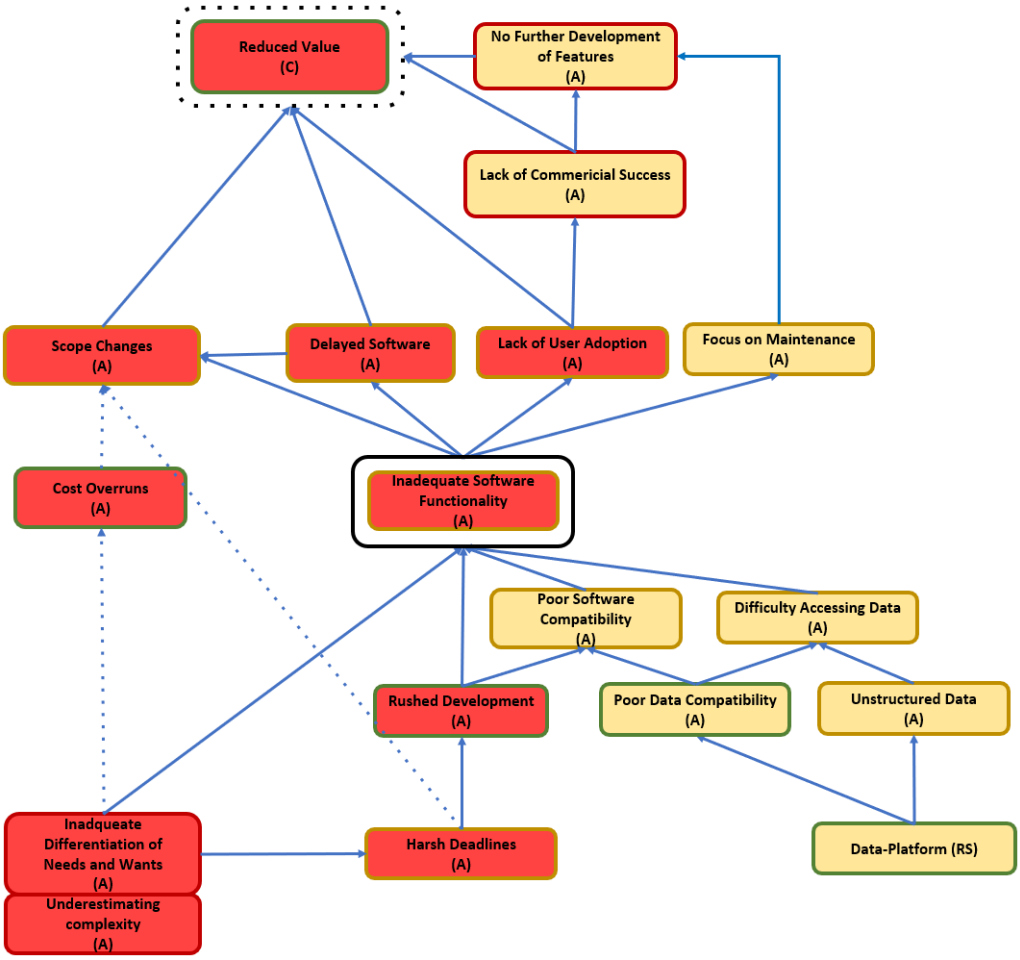

Figure 5.9: Critical Risk Network

How the risk of *Inadequate Software Functionality* is a bottleneck is seen in Figure 5.9. Most of the developmental risks lead directly to this event, even if they also contribute to the risk related to *Scope Changes*. The IT related risks, except for the risk of *Cyber Attack*, likewise bottleneck at this point. When ignoring the loose risk sources for the consequent events of *Inadequate Software Functionality*, it apparent that the event of *Inadequate Software Functionality* is the most critical risk. For all risks in the post-developmental phase of such a project, which directly lead to a reduced value, spring forth from this point in the network.

6. Discussion

6.1 Opportunities

From the analysis of the risk networks and seeing how Aker Solutions has managed the NOA Digital project, two opportunities can be identified.

6.1.1 Commercializing the Products of Digitalization

A general opportunity identified from the NOA Digital project is to further commercialize the different tools and methods developed through the digitalization process. In the NOA Digital project, Aize develops a core set of software which will be further licensed out to other companies, possibly developing additional add-ons specific to the requirements of the different clients.

If the software is successfully sold to new customers across different industries, it will provide an additional source of revenue and generate additional value for the project. Moreover, it also opens up for the possibility to develop new features for the core products which otherwise may not have been conceived previously. If chosen not to commercialize the software, then the consequences of *Lack of Commercial Success* (Section 5.1.3.2) will apply, where all the cost of development and continued maintenance will fall entirely on the initial client.

From this example we see that commercialization of software is an opportunity not just for the software developer, but also the clients and end-users. Software companies will be able to have a good income from selling their products, and end-users can expect better products and solutions.

6.1.2 Reuse Unfinished Projects

From attempting a digital transformation, large amounts of data, resources and knowledge will be generated on how to develop and undergo such a transformation. Several projects and features may be cut out for various reasons, yet the knowledge and data from gathered them is still a valuable resource.

In a global study by McKinsey & Company, they discovered that 62% of companies had stalled in their digital progress (Blackburn et al., 2020). There are 8 primary reasons identified by Blackburn et al. (2020) for why they stalled, with the most relevant being:

Primary Reason	% of Stalls
Resourcing issues	20%
Lack of core competencies	15%
Lack of clarity on transformation strategy	14%
Insufficient alignment and/or commitment across organization	14%
Ineffective design of transformation	7%
Ineffective or misinformed transformation strategy	7%

Table 6.1: Primary Reasons that Momentum Stalls

From the perspective of Aker Solutions, the Digital Vendor Data is a project that could be reused and developed for future purposes. Several of the reasons listed in Table 6.1, such as a lack of core competencies is not seen as an issue, nor is there an insufficient commitment across the organization. However, the issues regarding the lack of clarity do apply, and are discussed in Section 6.2.1.

Blackburn et al. (2020) identifies several interventions strongly associate with success. Among them, pertinent measures such as *securing funding and personnel dedicated to continued work* and *building a more rigorous model of the transformation's timing and economic impact*, could set the basis for continued development of the unfinished projects. Ensuring that lost value is restored and potentially generating additional value.

6.2 Risk Reducing Measures

By examining the shortfalls of the NOA Digital project and the actions taken by Aker Solutions during the planning and development of the project, some risk reductive and risk preventive measures have been identified.

6.2.1 Clear Goals

Granted that one has sufficient resources and technical skill, a large scope with a broad range of objectives is in itself not a major risk. According to Laczkowski et al. (2019) a more comprehensive scope increases the likelihood of value-generating opportunities. Companies that undergo successful digitalization favour an all-in, enterprise-wide transformation (Laczkowski et al., 2019), similar to what Aker Solutions intends with the NOA Digtial Project.

Yet, Bloch et al. (2012) state that IT projects with a size of over $15 million (in 2010 dollars) have an average cost overrun of 45%. 13% of the average cost overrun was due to unclear objectives and a lack of business focus, another 9% of the cost overrun came from shifting requirements and technical complexity, and 11% from unrealistic schedules and reactive planning (Bloch et al., 2012). The latter two are to a large degree a consequence of vague goals, seen in Figure 5.8. It is one of the two direct factors contributing to underestimating complexity and not adequately differentiating between necessary and desired functions in a project.

With an APM approach it is regarded that the final solution cannot be known, and that there is uncertainty of the overall scope of a project (Wysocki, 2014). However, clear goals should be set, and what a project is intended to produce or achieve must be known, even though the specifics of how the final product should be can be unknown (Wysocki, 2014).

Bughin et al. (2019) finds that laying out clear priorities in the form of hard-to-reverse choices and clarity of the digital themes, each increase the likelihood of surpassing expected performance by 8%. Serrador and Pinto (2015) likewise finds that the quality of vision is a significant moderator in the relationship between using an Agile PMLC and a project's success.

A way to avoid some of the pitfalls of the NOA Digital project, would be to set goals based on several internal surveys. As discussed in Section 5.1.1.1, the NOA Digital project set its scope based on areas where a digitalization could help reduce costs or add greater value.

While such a survey is useful in setting the scope for a digitalization project, it does not give any information on specific goals. Therefore, additional surveys from workers in these different areas must be conducted to see which functions they would like to be digitized, automated or changed by digitalization.

Areas with a lesser added value should also be surveyed, as significant attention should also be given to small, yet manageable initiatives. These by themselves may not contribute a great deal of value, however in a large enough quantity can generate a significant value. Laczkowski et al. (2019) states that 50% of the value in successful transformations came from small initiatives, which individually contributed less than 0,5% of the total value.

6.2.2 Utilize Agile PMLC

According to Wysocki (2014), the most effective way to estimate the timeline of your project is by choosing the right approach. Choosing an approach is to an extent dependent on the project's nature. Aker Solutions carries out projects using a Stage-Gate model as a standard which is a typical Linear PMLC. A Linear PMLC may provide good estimations on the development timeline in a project with a clear scope. Aker Solutions has developed their linear model to ensure predictable delivery on requirements, scope, time and cost (Internal Documents, 2022). Their model is generally suited for projects that require physical constructions or in repetitive projects as described in Section 3.2.4.

The NOAKA field-development as a whole is seemingly well suited for a TPM approach. Yet, when the contributing projects such as the NOA Digital project are considered, some challenges related to the use of this approach are encountered. As mentioned in Section 1.2 the missions in the NOA Digital project are developed by the use of an APM approach, but is constrained by deadlines and schedules as it is tied to the NOAKA Project.

In a software development project involving uncertainty about goals and solutions, a TPM approach may not be optimal. The scope and complete solutions should be clearly defined from the start of a project when using the Linear PMLC (Wysocki, 2014). When using the Linear PMLC, major changes to scope are not expected midway through the project. Therefore, a major challenge with its use in software development is related to scope changes.

As previously mentioned, 13% of the average cost overruns in large IT projects is attributed to unclear objectives and 9% to shifting requirements and technical complexity (Bloch et al., 2012). In this case an APM approach can help reduce some of the risks and costs, illustrated by the NOA Digital project.

The Agile PMLC of the NOA Digital project allowed Aker Solutions to develop more tangible and clear goals for the individual missions, despite the vagueness and imprecise goals initially set for the project as a whole. In the early stages, major consequences from scope changes were also avoided by through the use of an Agile approach. In the idea phase of the NOA Digital project, there were 20 missions, however several were discarded or integrated with other missions, reducing the number to 11 initial missions. These missions were once again then reduced to only 8 missions midway in the project.

However, the inflexible deadlines from being tied to the NOAKA project caused one of the largest missions, the Digital Vendor Data, to not deliver according to its expectations {6}. Further diminishing the missions to only 7 missions and reducing the estimated value of the NOA Digital project by 37,5%.

In large IT projects, Bloch et al. (2012) shows that software related projects have an average schedule overrun of 33% and an average cost overrun of 66%. Despite this, such projects only have an average benefit shortfall of 17%, as opposed to non-software related IT projects with an average shortfall of 133% (Bloch et al., 2012). This shows that focusing on software delivery should be a priority as it can generate additional value despite cost overruns and delays.

With more flexible deadlines, possibly by using a more Agile approach on the NOAKA field development, the Digital Vendor Data could have been delivered according to it's functional expectations. Though delayed it would still generate value from being used in the project.

6.2.3 Early End-User Onboarding

An integral part of working with an Agile PMLC is the constant involvement of the end-users and stakeholders (Brhel et al., 2015). However, a distinction must be made between the customer and end-user. It is very common for a client of software development to assign a person, generally a domain expert or product manager, to fill the role of both customer and end-user (Brhel et al., 2015). This has also been the case for Aker Solutions, where they have assigned different experts among their workers as Mission Leads for each of the missions in the NOA Digital project (Section 1.2).

User-centric software development requires direct and unmediated contact with end-users and the aforementioned roles do not fully represent all end-users, as they may not have a grasp on the end-users' full range of tasks (Brhel et al., 2015). To secure that the missions in the NOA Digital project would adequately reflect the requirements of the end-users, Aker Solutions made sure to involve the end-users since the early stages of development {9}.

Furthermore, the end-users have been involved throughout the entire development of the missions. Different software was continuously tested not only by Aize and the main developers, but also by employees which were otherwise uninvolved with the NOA Digital project {6,9}. Feedback from these tests was then used to alter, correct and adjust the different features, as well as introducing new features {2,9}.

Significant effort has also been put into promoting the project and the different missions. All areas which will be affected by the digital transformation were made aware through various meetings and notices {9}. Information on the project is strongly featured on the main employee pages, both in easily digestible and in more detailed formats (Internal Documents, 2022). Moreover, weekly meetings were held during the development, to give employees involved in the project an overview of the progress and to ask questions {9}.

Through these measures, Aker Solutions significantly reduced the risk of *Lack of User Adoption* for the NOA Digital project (Section 5.1.3.1). Additionally, the strong involvement of the end-users also mitigate some aspects of the critical risk of *Inadequate Differentiation of Wants and Needs* (Figure 5.8).

6.2.4 Cybersecurity

Cyber attacks are a growing threat in the digital world and awareness of this issue needs to be raised (Sun et al., 2018). It is important for companies, organizations and individuals to have an everyday focus on security that prevents the majority of attacks (von Solms & van Niekerk, 2013).

As mentioned in the analysis of *Major Operational Attacks* (Section 5.1.5.2), there has been little direct focus on cybersecurity with people working on the NOA Digital project. Missions such as Digital Vendor Data and Digital Engineering Documentation had some considerations on information security, authorization and access. Yet, cybersecurity was generally seen as the purview of the IT-department and emphasis has not been put on cybersecurity in the development of the missions.

Cybersecurity is an issue that can affect all levels of a company, in an organization and in society (Telenor, 2022). From the top management to all the employees lower in the hierarchy, to customers, and to any other members of an organization. It is important to understand current trends in malicious threats, to have an interest in the topic, to be able to identify weaknesses and to understand how you can protect your data against these threats (Telenor, 2022).

The vulnerability of one's values and interests increases with digitalization and the growing number of attacks must be taken seriously (Telenor, 2022). In order to achieve structural and organizational resilience, there is a need for a culture where every employee takes more responsibility for cybersecurity where it is integrated into all projects and work-processes (Telenor, 2022).

6.3 Leadership and Culture

An aspect hitherto unmentioned is the impact of leadership and company culture. Blackburn et al. (2020) identified that the stall in digital progress was in 14% of the cases caused by insufficient alignment and commitment across organization, and in 18% of cases caused by misaligned culture and ways of working. The latter of which is not within an organization's near-to-medium term control (Blackburn et al., 2020). It is therefore important that a good culture, ambitions, and leadership is in place to undergo a digital transformation.

This is an area where Aker Solutions has been excelled. From the interviews it was observed that, across all levels of hierarchy, there was an unanimous opinion that digitalization is seen as a positive development in the company. The top leadership was seen as highly supportive of the digitalization efforts and allocated sufficient resources and manpower for the NOA Digital project{1,2,3,4,8}. From the software developer's perspective, it was also noted that Aker Solutions was supportive of digitalization and encouraged its workers to be so as well {5}. The only major issue noted from the interviews was the scope being vague and ambitious, as discussed previously in Sections 5.1.1.1 and 6.2.1.

A minor issue noted from the interviews, was that several employees in senior positions did not have a strong understanding of digitalization as a concept. Often conflating the terms digitization and digitalization (Section 3.1.2). However, those in charge of coordinating the NOA Digital project, those in development, and the top leadership had a good understanding of digitalization. The value of digitalization has also been well recognized by the top leadership, to the point that digitalization was made a core strategy of the company {1,4,8}.

The aspect of leadership and culture has had a large degree of say in the formation of the risk networks. Many potential risks and issues stemming from poor leadership, lacking commitment, and negative culture has not been considered. If taken into consideration, the networks could be fundamentally altered to reflect these potential factors. However, this was not done so in this thesis. As exactly which areas, and in what way, these factors would affect the different risks was not clear due to a lack of concrete examples in the NOA Digital project.

7. Conclusion

7.1 Conclusion

This thesis is a case-study of Aker Solutions' NOA Digital project, functioning as inductive research on the risks and opportunities within digitalization projects and the development of new software. The thesis set out to answer 3 research questions:

> ***1. How is the risk picture of the current digitalization activities of Aker Solutions?***
>
> ***2. What are the key risks and opportunities identified from the NOA Digital project?***
>
> ***3. What are the challenges for the NOA Digital project with the Linear PMLC of Aker Solutions?***

To answer the first research question, a Bayesian Network of the risks identified in the NOA Digital project was established. The risks were then categorized into 5 categories based on their respective place in the different stages of development and areas of specialty. Each risk was then characterized and assessed. The assessment was made with information gathered through semi-structured interviews held with 9 employees relevant to the project, as well as internal documents provided by Aker Solutions.

Out of the network specific to Aker Solutions, a new generalized Bayesian Network was established. From which the most critical risks were identified and visualized through additional networks. The 3 critical risks *Underestimating Complexity*, *Inadequate Differentiation of Needs and Wants*, and *Inadequate Software Functionality* were found. Additionally, *Commercializing the Products of Digitalization* and *Reuse Unfinished Projects* were the 2 opportunities discovered from how Aker Solutions managed the NOA Digital project. Thus answering the second research question.

The generalized risk network is a framework that may apply to any digitalization project. The method of visualizing risk through a Bayesian Network provides a more comprehensive and holistic understanding of risks, showing the causality, interactivity, and interdependency of the different risks.

It can be adapted and employed throughout different industries with additional data points to create a comprehensive strategy for digitalization, development of new software, and creating digitalized work-processes, with an emphasis on the critical risks.

Answering the third research question, different aspects of project management in the NOA Digital project were discussed. It was found that the project faced difficulties with the meeting of TPM and APM. The Agile PMLC of the missions allowed Aker Solutions to reduce or avoid some of the risks, yet the overarching Linear PMLC of the NOA Digital project with its harsh deadlines lead to a central mission being canceled. Reducing the estimated value of the project by 37,5%. A central aspect creating complications for the development was found to be the lack of clear goals. Setting clearer goals in the early phases of the project and allowing more flexibility of deadlines through a more agile approach could have mitigated the key risks.

The research found that the measures Aker Solutions used to promote the project internally and to involve the end-users from the early stages of development, significantly reduces the risks in the post-developmental phase of the project. Though some issues regarding cybersecurity awareness was identified, the leadership and culture at Aker Solutions was a significant factor in how the NOA Digital project was shaped, helping them reduce risks and limit the overall risk picture. Employing similar measures and using the proposed risk framework of this thesis can likewise reduce risk for other digitalization projects across different industries.

7.2 Further Research

This thesis covers the NOA Digital project before it is finished, where the final implementation of the missions is unknown. Validating the results found in this thesis could be interesting. Additionally, each mission of the NOA Digital project could be assessed separately rather than solely investigating the overall project. Providing additional data and information to revise and expand the risk pictures.

As the method of using Bayesian Networks in this manner is new, it is proposed that further research should be done employing this method. Case studies of different projects, both related and unrelated to digitalization, could benefit from it.

The method of presenting risk through Bayesian Networks itself could be worth researching. Comparing it with other methods of risk analysis and risk assessment more commonly used across different industries. Thereby, raising awareness of the method to the broader risk society. How the method is currently used and how it can be used in conjunction with risk simulation methods to estimate the cost of risks and potential losses in projects, is an area which could be elaborated on.

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A. Interview Questions

A.1 General Questions

1. Kan du presentere deg selv og si litt om din rolle?
2. Kan du forklare hva du personlig mener med begrepet "digitalisering"?
3. Har dere hatt noen digitaliserings eller forbedringsprosesser før NOA Digital Prosjektet?
   Hvis ja, hvordan gikk det med dem?
   Hva var utfordringene da?
4. Hvordan mener du kulturen i firmaet er i forhold til digitaliseringen, støtter de det eller ikke, hva tror du er deres meninger?
5. Hva ser du som en åpenbar eller stor risiko innenfor digitaliseringen?
6. Har dere hatt noen utfordringer hittil med digitaliserings prosessen?
7. Hvordan planlegger dere å håndtere og kontrollere risiko innenfor NOA Digital Prosjektet?
8. Hva er deres mål eller ønsker med digitaliseringen?
9. Hvilke andre muligheter ser du innenfor digitaliseringen?
10. Hva mener du er suksess i forhold til NOA Digital Prosjektet?
11. Hva tror du ledelsen må gjøre for at NOA Digital Prosjektet skal bli suksessfullt?
12. Ut ifra din rolle, hva tror du at **du** må gjøre for at NOA Digital Prosjektet skal bli suksessfullt?
13. Hvordan estimeres et gevinst-bilde for digitaliseringen?

A.2 Targeted Questions

Interview #2

1. Har dere hatt noen andre digitale verktøy som ligner på Constructability Engine?
2. Hvordan har det gått med det første utkastet av Constructability Engine programmet?
3. Hvordan forgår arbeid i dag, som dere vil at Constructability Engine programmet skal erstatte?
4. Hvordan planlegger dere å håndtere og kontrollere risiko innenfor Constructability Engine programmet?

Interview #3

1. Har tidsfristene blitt nådd hittil?
2. Hvilke særlige utfordringer eller problemer har du merket med både:
   Kommunikasjon?
   Teknisk skape produktene?

Interview #6

1. Hvordan scopet ble satt for NOA Digital Prosjektet?
2. Var det gjort en intern undersøkelse blant de ansatte og hva de mener trengs for å kunne arbeide bedre?
   Eller ble det sett mer fra toppen og undersøkt hvor det er mest gunstig å digitalisere?
3. Hvordan ble budsjett satt opp for missjonene?
4. Hvorfor ble Digital Vendor Data ikke utgitt til sin tidsfrist?
   Hvordan går det med backup-planen for dette?

5. Til hvilken grad blir missjonene utviklet med Agile metode?
6. Til hvilken grad ble missjonene eller selve scopet til NOA Digital Prosjektet planlagt med en tanke på Agile utviklings metode?
7. Til hvilken grad har folk som vanligvis ikke jobber med utviklingen av missjonene fått prøve og bruke de nye programmene?
8. Hvordan håndterer dere risiko knyttet til cybersecurity?

Interview #7

1. Har dere hatt erfaring fra tidligere med ubemannete plattformer og andre objekter som styres digitalt?
2. Hva er planen hvis N-Digi ikke levere tilstrekkelig gode program, eller om flere missjoner blir avlyst, som for eksempel Digital Vendor Data ble?

Interview #8

1. Kan du fortelle litt om Eureka prosjektet? Når startet det?
2. Hva var målene, hvem satte dem og hvordan ble de satt?
3. Hvordan var det å arbeide med prosjektet?
   Var det god nok kommunikasjon?
   Var det nok kompetanse?
4. Hvilke særlige utfordringer møtte dere under prosjektet?
5. Hadde dere noe fokus på Risiko?
   I så fall hvordan håndterte dere det?
6. Hvordan ser du på NOA Digital Prosjektet?

Interview #9

1. Har sluttbrukere vært nok involvert i de forskjellige fasene av utviklingen?
   Var de med i de tidlige fasene?

2. Til hvilken grad tror du programmene er utviklet etter sluttbrukerens behov, i motsetning til hva lederskapet eller andre ønsker?

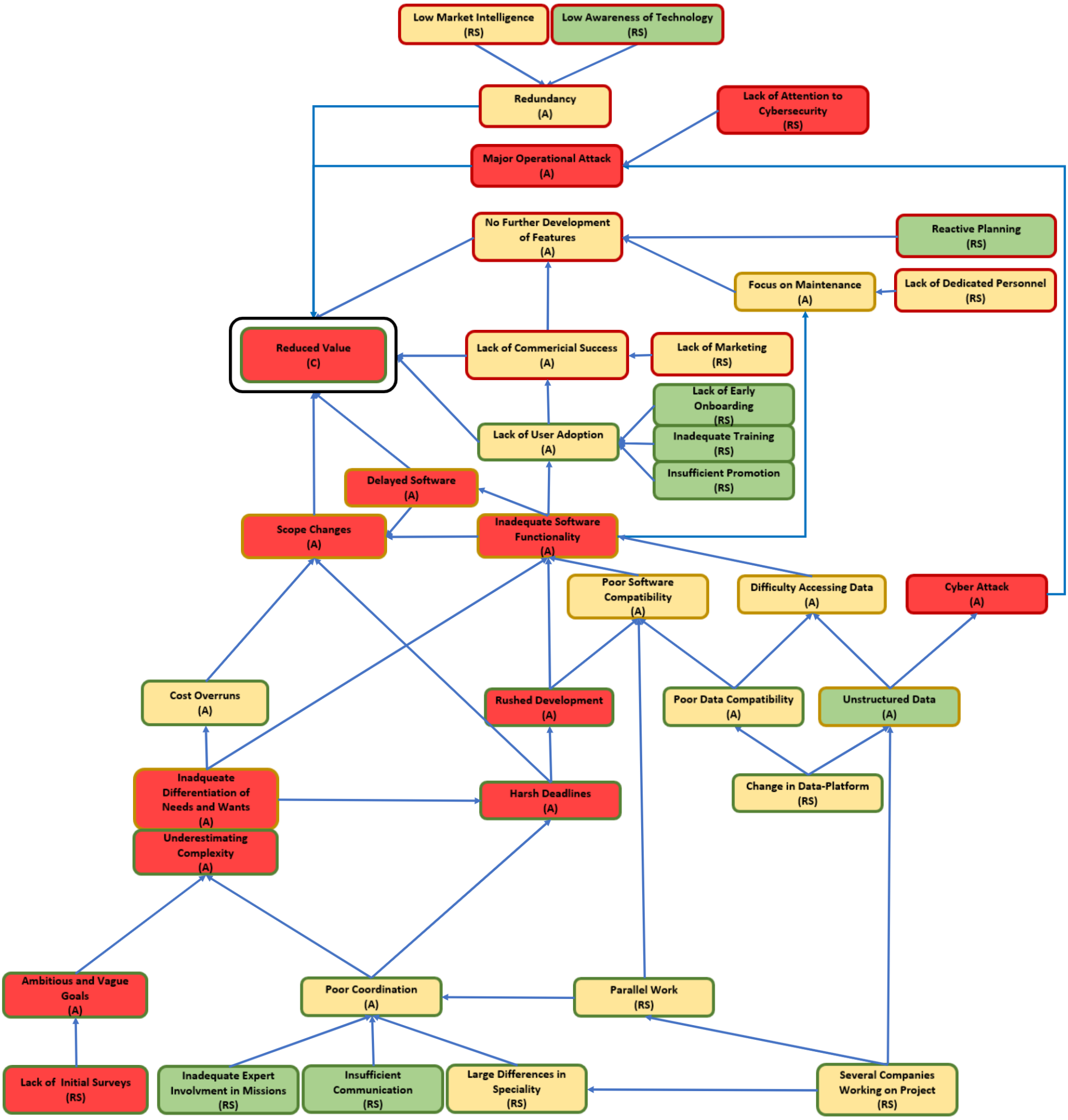
3. Hvor godt har programmene i N-Digi prosjektet blitt reklamert til vanlige arbeidere og de spesifikke sluttbrukerene?

4. Har de forskjellige avdelingene og arbeiderne som skal bruke programmet fått god nok trening på forhånd gjennom testing eller andre måter?

5. Hva mener du er de viktigste målene eller ønskene med digitaliseringen ut ifra sluttbrukerens perspektiv?

B. Risk Networks

B.1 Complete Risk Network



B.2 Generalized Risk Network