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Master's Thesis
Industrial Economics

Digitalizing Operations Management

Real-Time Opex System Design for the Ivar Aasen Asset

Universitetet i Stavanger

Kristian Solem

Universitetet i Stavanger

December 15, 2018

To my parents,

for your everlasting support

Abstract

After a drop in the oil price in 2014 – 2016, the oil and gas industry renewed their focus on cost reduction. The use of real–time data has become commonplace, but one area lagging behind is financial data. Financial data are still mostly measured, treated, allocated and bundled together before being presented weeks later.

The purpose of this thesis is to research how to make a real–time operating expenditure (opex) measurement system and its implications. The system is made for the offshore asset Ivar Aasen, which is a production platform located off the West Coast of Norway, bordering to the UK sector in the North Sea.

Opex–analysis has shown that the selected focus elements of air transport, operations manning and maintenance manning accounts for 35% of the operating expenditure that are possible to influence on a daily basis on the Ivar Aasen production platform in 2018.

Data is gathered from operating expenditure reports, input from subject matter experts and the process of creating such a system within Aker BP.

Through the information gathered, and an iterative process with the data warehouse professionals, opex visualizations are made for increasing awareness of cost, with the possibility to drill down in data. The views are split in snapshots of today's opex, historical opex and short–term forecast of about seven days. The drill–down capabilities are created for time, employment types, associated companies and organizational units.

It is too early to say how much the oil and gas industry can benefit from such visualizations, but based on similar approaches in other industries the possibility for opex reduction through awareness, interactive visualizations and analytical opex–tools are substantial.

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Abbreviations

BA	Business Analytics
BI	Business Intelligence
CRA	Constructive Research Approach
EDW	Enterprise Data Warehouse
ETL	Extract, Transform and Load
FTE	Full-Time Equivalent
GDPR	General Data Protection Regulation
JOA	Joint Operating Agreement
LOB	Large Object
OLTP	Online Transaction Processing
OPEX	Operating Expenditure
PO	Purchase Order
POB	Personnel On Board

1 Introduction

When the Brent Crude Oil price plummeted from 125 $/bbl in 2014 to 28 $/bbl at its lowest point in 2016, a reduction of 77.6%, the industry was forced to renew its focus on cost control in order to stay competitive in the global energy market. Several oil fields were operating at negative profit margins due to the low oil prices. Cost–cutting has to a large degree happened by negotiating new contracts with drilling companies, rig companies, and other vendors (Beck, 2017). This eventually came to a breaking point where the margins for the vendors could not be decreased further, forcing the continued reduction in production price per barrel to come from other sources. Effectively, this acted as the catalyst for kicking off the digitalization initiatives in virtually all major oil companies. An important foundation for the digitalization work is the quality and availability of data, because of how data can be utilized to improve efficiency, digitize, improve decision quality and safety.

Morgan Stanley (2018) see three main areas where digitalization can help reduce cost: drilling efficiency, opex and reduced headcount. They speculate that the period with lower oil prices could make oil majors re–enact the "golden decade" from 1987 to 1997 where they delivered 5–6% real-term cost savings annually.

The health sector and aviation industry, are examples of industries that have benefited greatly from using business intelligence (BI) to visualize cost connected with operations, real time (Burros, Brown, Thom, King, & Frearson, 2001; Wadsworth et al., 2009; Watson, Wixom, Hoffer, Anderson-Lehman, &

Reynolds, 2006). This is the idea behind this thesis where real–time operating expenditure visualizations are theorized to raise decision makers awareness of the costs related to the operational decisions and to provide a tool for making improved and quicker cost–reward analysis. Combining real–time data of operating expenditure and headcount can be an enabler to decrease cost substantially.

1.1 Research Questions

This thesis undertakes the evaluation of how operating expenditure (opex) can be visualized in real time, and its implications. A focus will be put on the processes of making such a system, with the available technology and data. In addition, it undertakes the evaluation of how to digitalize operations management of the offshore asset Ivar Aasen, shown in Figure 1.1. The Ivar Aasen asset was chosen as the point of study because it is the frontrunner for digitalization and remote operations in Aker BP, a major Norwegian exploration and production company. Aker BP, the department of Technology and Digitalization Projects, is the collaborative company in this thesis.

The product will be a system for measuring, visualizing and evaluating selected operating expenditures, real time. The system can be expanded to build a complete portfolio of metrics concerning the operating expenditure level of the asset. Another focus of the thesis is to study how to actively utilize real-time data to manage cost. The background for this was twofold.

Firstly, financial management of an offshore asset is dependent on information that arrive four to six weeks after the operation occurs. When

Figure 1.1: The Ivar Aasen Platform (Photo: Aker BP)

the cost is measured, treated, bundled and allocated, it is hard to grasp where one could make operational changes to reduce operating expenditure. The hypothesis was that providing operational expenditure data real time would create awareness about what drives cost on an asset, enabling decision–makers to be more agile on opex reduction. In addition, it would be a measurement tool for detecting trends in the opex as a result of digitalization.

Secondly, digitalizing existing fields came with clear expectations toward what is going to be achieved. With digitalization initiatives like predicative maintenance, digital workers, remote operations and smart contracts with vendors it is expected to see a reduction in offshore hours, because work will either be removed or done offshore (Cramer, Hofsteenge, Moroney, Gobel, & Murthy, 2011; van den Berg, Goh, van Donkelaar, & Parchewsky, 2010). A system providing continuous feedback on how much are spent on maintenance and other work areas, as well as flights to the asset could be a central part to evaluate and reward behaviour leading towards reduced opex.

The term "real time" is not very precise, and open for subjectivity. As described in the article "Real-Time Business Intelligence: Best Practices at Continental Airlines" (Watson et al., 2006, p. 8), for most people, "real time" is synonymous with "instantaneous". In the case of business intelligence and data warehousing, "real time" often means "right time". In this lies the implication that the data are only available when they are put into the systems connected to the data warehouse, and data only needs to be as fresh as the business requirements. In this thesis, the term real time will be used meaning that it is available on a daily basis. Compared to current practices this makes it visible for decision–makers, managers, cost controllers and other stakeholders maybe as much as 4-6 weeks earlier than usual.

The research questions were selected with two things in mind: what value can be created from this research for the cooperating company, Aker BP, and how can this study contribute to fill gaps in current academic knowledge and literature on the subject.

The methodology used for this research is a constructive research approach (CRA), which tries to bridge the gap between theoretical and practical contributions. There will be a product developed for Aker BP, namely the real-time measurement system for operating expenditure on the Ivar Aasen asset, shown in Figure 1.1. The results and knowledge acquired will be evaluated so that it can be re-used in similar instances and potentially fill gaps in current academic knowledge.

A thorough literature review was carried out and some gaps in knowledge were identified; of particular interest were those identified by Trieu (2016) as this was a relatively new literature review that comprised a lot of research articles on the subject. The research questions are linked to the framework, shown in Figure 1.2, of how business intelligence creates value. The Framework shows how a company goes from BI investments to increasing organizational performance and how these are linked. The theory is that business value is created in three processes: the conversion process, BI use process and the competitive process. The research questions for this thesis will cover all the cross sections covered in the framework, to delve deeper into how BI–management tools can be made, what drives its effective use and what will be the implication of it.

The research questions identified as most relevant are listed on the next page.

Industry Research Questions (company viewpoint)

- How can a real–time opex measurement system be developed efficiently?
- What kind of opex–related data is possible to measure in real time today?
- How can existing systems be modified to facilitate real–time opex measurements?
- How will digitalization impact real–time opex measurements?
- How can real–time measurement systems be successfully implemented?

Academic Research Questions (academic viewpoint)

- How can we make decisions on "the focus of BI development and maintenance" to improve operational efficiencies and competitive advantage?

  This is related to the issue of the "BI Conversion Process" in Figure 1.2.
- How do latency effects influence the effective use of BI and firm performance?

  This is related to the issue of the "BI Use Process" in Figure 1.2.
- What drives the effective use of BI systems?

  This is related to the issue of the "BI Competitive Process" in Figure 1.2.

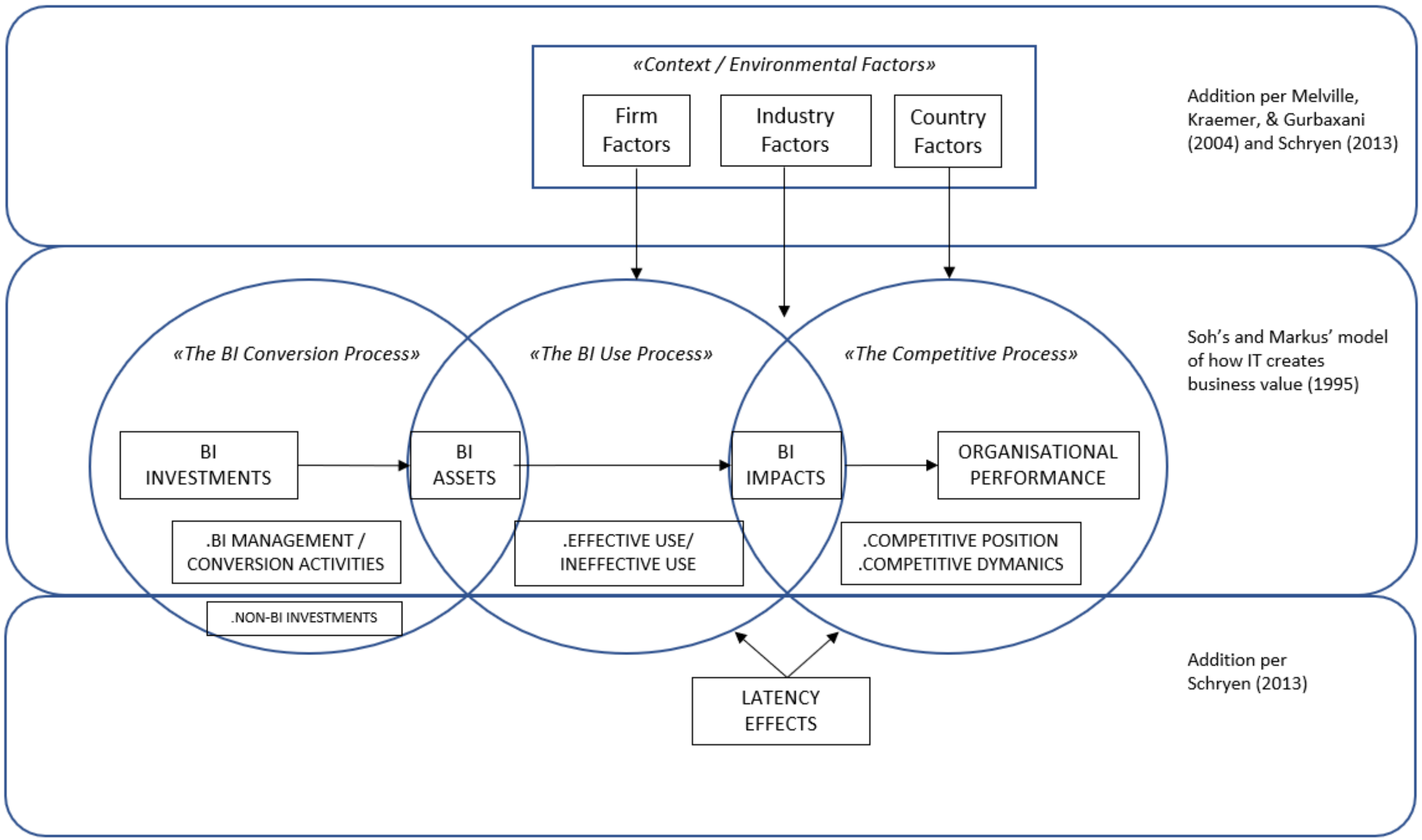

Figure 1.2: Framework of How Business Intelligence Creates Business Value, adapted from Trieu (2016, p. 113) (Melville, Kraemer, & Gurbaxani, 2004; Schryen, 2013; Soh & Markus, 1995)

2 Theory

2.1 Data Warehousing

The data warehouse is a central part of any business intelligence system. A data warehouse system supply information to the decision-makers, so that they can act based on data and analysis. There are two perspectives on data warehousing. From an organizational point of view, a data warehouse provides business intelligence. From a technical point of view, a data warehouse is a subject-oriented, integrated, time variant, non volatile collection of data (Prakash & Prakash, 2018, p. 19).

The data architecture includes the key steps of acquiring, modelling, cleansing, preprocessing and integrating data from the source to the enterprise data warehouse (Krishnan, 2013, p. 129). The steps could be the following:

1. Business requirements analysis
   Gather business requirement, figure out what kind of data are needed for an analysis and outline the requirement for data availability, accessibility and security.

2. Data analysis
   Data from the online transaction processing (OLTP) is analysed for data type, business rules, quality and granularity[1]. This is the step in which data are discovered and documented.

[1] Level of detail

3. Data modelling

   Data from OLTP models are converted to relational models. A choice of modelling approach needs to be taken in this step. Hierarchies are defined, physical database design is made and the enterprise data warehouse (EDW) schema is created.

4. Data movement

   A process of extracting, loading and transforming data is designed, developed and implemented. The process developed are in general:

   - Source extract
   - Staging loading
   - Staging extract and EDW loading

   This transforms the data from OLTP to the EDW model. Afterwards, data movement and processing needs to be verified by tracking the data from the original source until it is stored in data marts and analytical data stores, shown in Figure 2.2.

5. Data quality

   Data from the source database is scrubbed to remove data quality issues, preventing corruption and integrity issues. Issues such as those mentioned are critical to discover quickly, so that the data can be reprocessed.

6. Data transformation

   Key staging to EDW transformation rules are processed. Data aggregations and summarizations are applied and data encryptions are ensured.

7. Data presentation

   The final step concerns data presentation layers. This enables the user to actively use the data e.g by making visualizations, key performance indicators, reporting tools.

Aker BPs conceptual model of their data architecture is shown in Figures 2.1 and 2.2 (provided by the in-house department of Data & Information Management). This is the system that was used to visualize the real-time opex data.

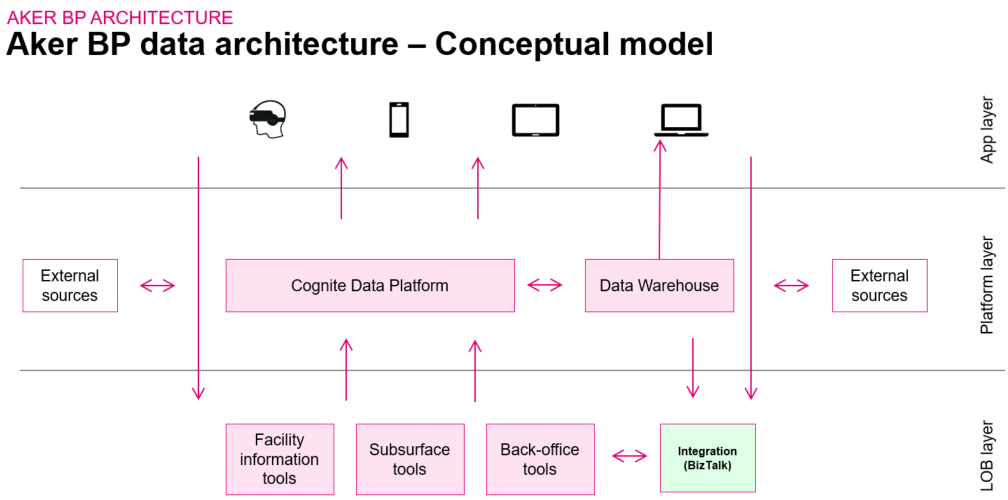

Figure 2.1: Aker BP Data Architecture

Figure 2.1 is the conceptual model of the data warehouse, showing high level detail of the structure. It is divided in three parts, the first one being the large object (LOB) layer where the data is stored. The Platform layer is where the data is going through the extract, transform, load (ETL) process and being readied for the end user. The last layer is the "App layer", where the data is used to make applications.

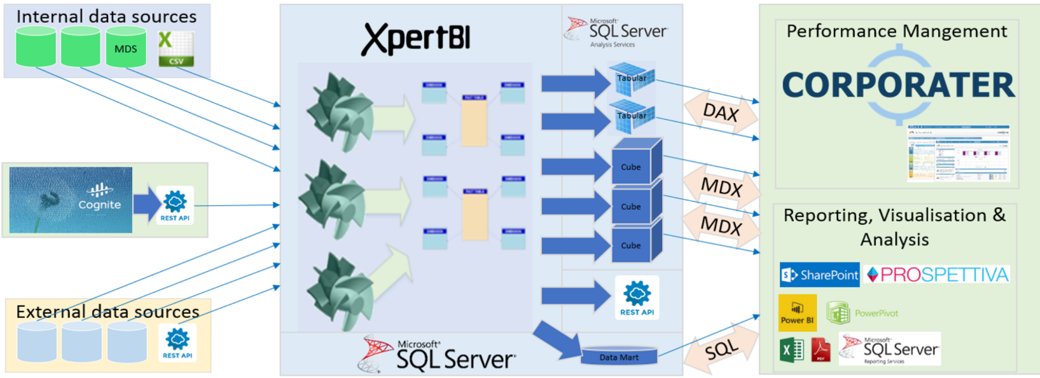

Figure 2.2: Aker BP Data Flow Architecture

Figure 2.2 shows the data flow architecture. While the conceptual model showed the flow vertically, this figure shows the same steps horizontally and with more detail. Relating to this thesis, data will be taken from external data sources and be put into a cube in the data warehouse. From there, the business analytics tool *Power BI* will be used to visualize the data in real-time opex measurements. Thus, the data will be transformed from being in silos in external software, to being visualized with other data sources in an application.

2.2 Business- and Operational Intelligence

Business intelligence has traditionally been used as an umbrella term to describe concepts and methods for improving business decision making. It includes the underlying architecture, tools, databases, applications and methodologies. As a data centric approach, BI relies on advanced data collection, extraction and analysis technologies, which are known as business analytics (BA). Data warehousing, as described in Section 2.1, is often considered the foundation of BI. Design of data marts, where a subset of data connected to a business unit is stored, and tools for extraction, transformation and loading are essential for converting and combining data (Lim, Chen, & Chen, 2013, pp. 1–2). BI is used to drive and optimize operations on a daily basis and even intraday decision-making. As business environments are becoming increasingly dynamic, companies are simply forced to react faster to changing conditions. This type of BI is usually called operational business intelligence and real-time business intelligence (Coffin, Florez, & Salim, 2016; Sandu, 2008). The oil and gas industry is an example of such a dynamic business environment. The data are available in the different systems within a given company, but the problem is that it is hard to combine data across different systems. Most is gathered in silos (Shimbo, 2008).

For strategic purposes, it is sufficient to have historical data in a time frame of months to years to create value. For tactical use, you need historical data in a time frame of days to weeks to months. For operational business intelligence used for optimizing day to day operations it is necessary to have real-time, low latency and historical data shown intra-day (Davis, 2007).

Data latency is a very important concept when it comes to making a real-time system. Data latency is the time between when the raw data are collected, prepared for analysis and stored. If this latency gets too large, it makes it not possible to use the system for operational intelligence.

The key elements for succeeding with data and BI are discussed in "Five Ways Your Data Strategy Can Fail" (Redman, 2018), shown in Figure 2.3. These elements will be discussed later in the text, as the available data are gathered and analysed.

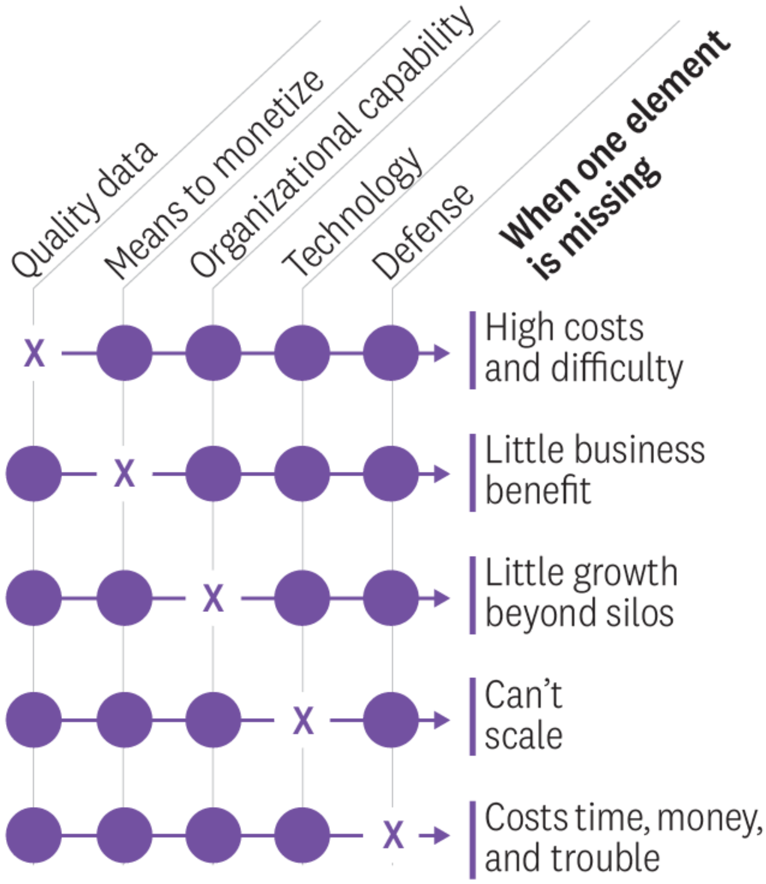

Figure 2.3: Five Essential Elements for Succeeding with Data (Redman, 2018)

Organizational capability is having talented people who can see the possibilities of using the data at hand. These possibilities must be based on a business case where taking advantage of data results in an improvement, adding value to the company. For this to be possible, the data must be of high enough quality that it can be trusted to show the intended information consistently and the technologies must be in place for the employees to do so. Finally, the data must be protected from theft and also follow the rules and regulations. When all of these elements are present, the company will start gaining significant value from their data.

Table 2.1: Description of the Five Essential Elements (Redman, 2018)

Element	**Description**
Quality data	Properly defined, relevant to the task at hand, structured and with high trustworthiness
Means to Monetize	Use the data as input for analytics, making better decisions, but most importantly define how the analytics will provide a business advantage.
Organizational Capability	Talented people must handle and use the, data and there must be an organizational structure and culture for using relevant data to improve the business model.
Technology	Technology to deliver at scale and low cost. This includes basic storage, processing and communications technologies as well as IT-architectures, analysis tools and cognitive technologies.
Defence	Follow laws and regulations, keep valued data safe from loss and theft, meet privacy requirements.

2.3 Operating Expenditure on Offshore Assets

Operating expenditure, operating expense, operational expense, operational expenditure or opex has many names and definitions but are all related to cost of normal business operations. A few of these wordings will be used interchangeably in this thesis. One definition, provided by Investopedia (2018), is:

> An operating expense is an expense a business incurs through its normal business operations. Often abbreviated as OPEX, operating expenses include rent, equipment, inventory costs, marketing, payroll, insurance, and funds allocated for research and development. One of the typical responsibilities that management must contend with is determining how to reduce operating expenses without significantly affecting a firm's ability to compete with its competitors.

The oil and gas industry in Norway, however, has its own standard of structure and content regarding budget items. As given from the "Agreement for petroleum activities and model production licenses" and the "Joint Operating Agreement and Accounting Agreement" (Ministry of Petroleum and Energy, 2017). The operating expenditure, named operating cost in the "Joint Operating Agreement and Accounting Agreement", is given in Section A. These definitions of operating expenditure will be revisited in Section 4.2: Pre-understanding, where a snapshot of the operating expenditure for 2018 was analysed for the Ivar Aasen asset, according to the Joint Operating Agreement

(JOA). This was done to get a high level overview of the economic reasoning behind the topic for this thesis. Although the real-time system for measuring operating expenditure is made with agile operational management on cost cutting in mind, and not budgeting, it is still beneficial to use this structure for the assessment.

Operating expenditure vary through the different phases of field development. For existing offshore installations, often referred to as brownfields, operating expenses can potentially be reduced through integrated operations and implementing changes in work structure for moving towards unmanned facilities. To realize the potential there is a need for sound planning at an early stage, monitoring equipment failure, remote controlled systems, multidisciplinary operations team for handling different challenges, excellent information availability and more. Although there is a definite opex reduction potential by remote control and integrated operations, most development projects fail to realize the potential during the initial phases. Experience shows that this is largely because people are reluctant to change and therefore prefer to deliver traditional concepts. Project teams and operations teams have experienced a lack of alignment because of this reluctance, and the key performance indicators used may have been dissonant with what they wanted to achieve, driving up maintenance man-hours, amongst others. (Arciero & Ismail, 2017; Dickson, 2014; Edwards & Gordon, 2015).

3 Methodology

For the research to be useful for the cooperative company, there was a necessity to combine both theory and practice. Three different methodologies were recognized as being promising for this purpose. These were: Realist Research (Fisher, 2007, p. 18), Action Research (2007, p. 22) and Constructive Research Approach (Lehtiranta, Junnonen, Kärnä, & Pekuri, 2016, pp. 95–106). Of those three, the constructive research approach was chosen because it bridges theoretical research with practical problem solving. It was developed especially for project management challenges, but is also suitable for economic and operational challenges as well. This is because of the structure of researching practical challenges and the research philosophy behind it. To provide some context of the methodological choice, the three methodologies are detailed in the following subsections.

3.1 Realist Research

Identifies and evaluates options for action. The approach aims to be scientific, but also acknowledges that not everything can be measured and studied in the same way as physical and chemical processes. This approach can contain both quantitative and qualitative methods. Theories proposed by realist research often comes with the warning that both the researchers and cases studied are subjective. However, because studies done in similar fashion will be discussed and reviewed, inadequate explanations will eventually be removed. In the end, this makes the realist research approach fit for research on subjective matters.

Regarding making a real-time measurement system for operating expenditure on an offshore asset, there will always be subjectivity in such a system, and realist research is fit for purpose.

3.2 Action Research

A further development of interpretive research that regards truth as subjective and hidden. The major theme of action research is to implement something new and study the consequences of the action. This can lead to better understanding of the underlying preconceptions and procedures about the subject matter. The problem, however, for students doing action research is that they often do not have the time to implement and observe the changes because of time limitations. This is the case for this thesis as well, so action research was not deemed the best research methodology for the thesis.

3.3 Constructive Research Approach

The philosophical stance of constructive research approach is pragmatism, where the core idea is that the meaning of knowledge is determined by its practical consequence (Hammersley, 2004).

This methodology is case- or field research parallel to ethnographic research, grounded theory, illustrative case research, theory testing case research and action research, from Lukka (2000) as cited by Pasian (2016). The distinction from other types of research is that it focuses on the construct as an outcome. The constructs can be e.g processes, practices, tools or organisational charts. For the purpose of this thesis, it can also be viewed in parallel with

Design Science Research, a seemingly similar approach (Vaishnavi, Kuechler, & Petter, 2017).

The aim is to solve practical problems, while producing an academically appreciated theoretical contribution. This makes it a good fit for studies done in cooperation with companies, that often want to have tangible deliverables from the study. The result should express a set of rules or processes on how to act in a certain situation to achieve the desired state.

Regarding the logic reasoning of the research, both deductive and inductive logic are used. Deductive logic is used for applying general theories to a particular situation, whereas inductive logic proceeds from a particular situation to say something about the general applicability of the result. Thus, the CRA can be regarded as following the abductive logic of reasoning, involving a cyclical alternation between inductive and deductive processes. Because of this, the results are not as certain as those in purely deductive studies, or as probable as those in inductive studies, but are nonetheless plausible. The steps involved in the constructive research approach, together with the reasoning used, are shown in Figure 3.1. This is the basis for the next section, Section 4, where the methodology and research methods are combined in the research itself.

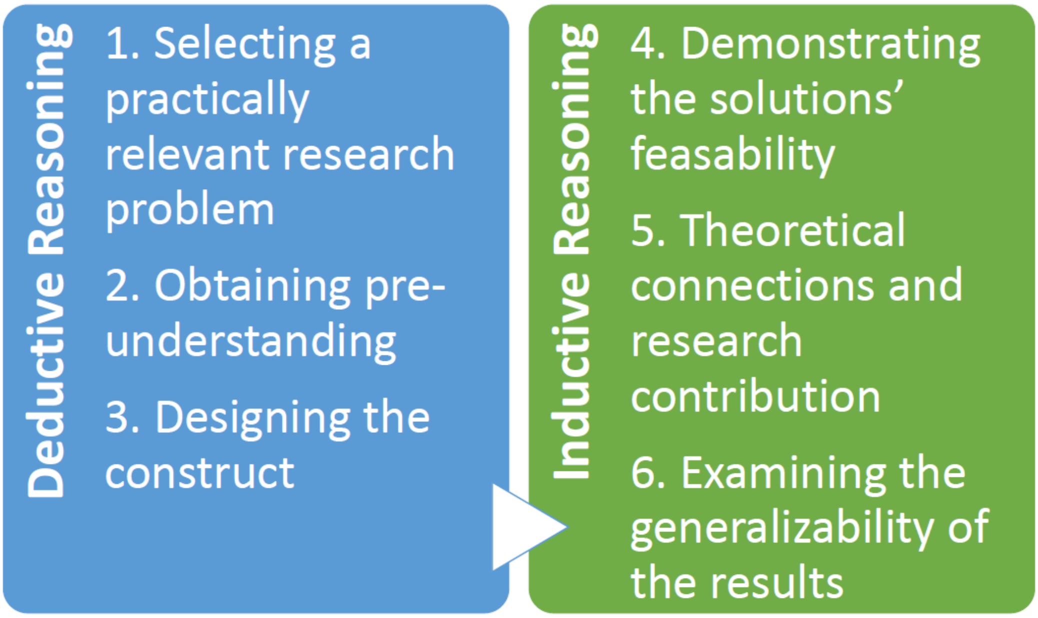

Figure 3.1: Core Processes in the Constructive Research Approach. Adapted from Kasanen, Lukka & Siitonen (1993, p. 246)

Figure 3.2 shows the research onion diagram (CS Odessa Corporation, n.d), detailing the different layers of the research design. Until now it has been stated that the constructive research approach leans on the research philosophy of pragmatism, as it uses both deductive and inductive reasoning and is a study close to etnography, grounded theory, action research and case study. Regarding the mono method, mixed method or multi-method, it can be found that this research is based on the multi-method, which is explained in Table 3.1 (UKEssays, 2017). The reason being that there will be data collected for designing the system, and afterwards data will be collected on the feasibility and implementation. Both of these data sets are individually analysed, but contribute equally to the research as a whole.

Table 3.1: Choices in Research Onion Diagram

Mono Method	One research approach for the study
Mixed methods	Use of two or more methods of research, usually both qualitative and quantitative.
Multi-method	Research divided into separate segments, each producing specific dataset and individually analysed

Continuing the dissection of the onion, the time horizon is the framework of when the research is intended for completion. Cross-sectional time horizon takes a snapshot of the current situation and evaluates the pros or cons, or two different cases against each other. Longitudinal time horizon refers to data collection over an extended period of time, and is used where an important factor of the research is the study of change over time. The time horizon is not dependent on the research approach or methodology, but on how and when the data is analysed and collected. It can be argued that the research done in this thesis follows the cross-sectional time horizon for the first part and the longitudinal for the latter part. The data gathering is happening at a specific point in time, and provides a snapshot of the "now" situation in technologies, data available and methods for collecting them. The latter part is studying how the product impacts the organization. Thus, the result might be out-dated when new software and solutions arrives. However, the methods of data collection and the discussions about the relevance of the results will still be relevant in the future.

The data collection and analysis consists of both primary and secondary data. The primary data are collected from data systems, operating expenditure for the Ivar Aasen asset and feedback from personnel in various departments in Aker BP. Secondary data are collected mainly through journal articles and books, as well as some technical websites, where access to the research material in databases and journals are provided by the University of Stavanger.

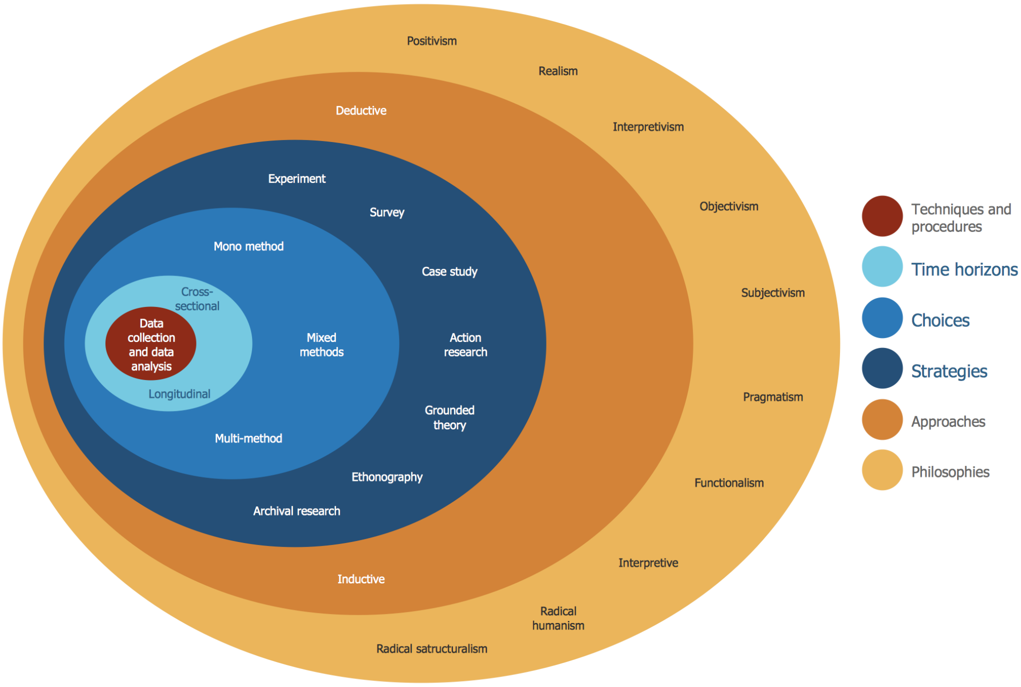

Figure 3.2: Research Onion Diagram (CS Odessa Corporation, n.d)

To test the relevance of the product in a constructive research approach, Rautiainen, Sippola & Mättö (2016) have suggested a new tool, the Relevance Diamond, to facilitate the relevance test and testing the relevance from multiple perspectives. Relevance is divided in four categories:

1. Practical value relevance

   Basically the weak market test. If the system is used in the organization, the weak market test has been passed. In addition, it is relevant if value is added to the organization.

2. Legitimative[2] decision relevance

   Information is relevant and capable of making a difference for the decisions of stakeholders and societal support for the organization.

3. Academic value relevance

   New research insights can resolve societal problems.

4. Instrumental decision relevance

   If the information is relevant and capable of making a difference for short term improvements.

Relevance tests with respect to these categories should then be done after step 3 in the CRA and after step 6. Because of the time constraint of the thesis, the relevance test will executed as part of step 4. Testing the relevance can be done using The Relevance Diamond, shown in Figure 3.3. The horizontal dimension is decision relevance and the vertical dimension is value relevance.

[2]The creators of the relevance diamond may have used an incorrect form of the word legitimate here, nevertheless the phrasing will be left unchanged in this thesis

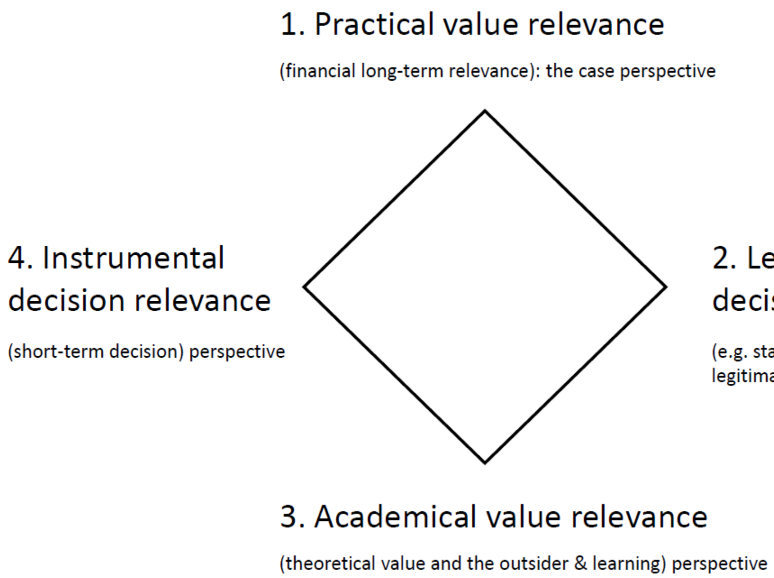

Figure 3.3: Relevance Diamond, adapted from Rautiainen, Sippola, & Mättö (2016)

4 Constructive Research Steps

This section provides the framework for the research, combining the methodology with the research methods. In addition, information of how the system is designed, data is harvested and the results will be presented.

4.1 Research Topic Selection

The idea behind the research topic selection is that to make good decisions for reducing operating expenditure, there needs to be a visual real-time representation of opex. When the cost can be correlated more directly with operational decisions it becomes easier to identify potential sources of opex reduction, and decide the best solution from a cost-reward point of view. Currently, every transaction is usually measured, treated and visualized 4–6 weeks after the operations happened. This makes it very challenging to see cost elements in relation to decisions directly.

Managing personal data over the last few years has become increasingly quicker and easier. Smartphones have apps connected directly to our bank account where we get real-time data when we spend money, what we spend them on, and the remaining account balance. If we want to allocate money, we can immediately transfer funds from one account to another. Transportation is another example which has seen drastic changes. If we want to get somewhere, we can download apps connected to taxis, buses and trains and the app suggests the most suffient route to the place we want, and how long it will take to reach the destination. The digital revolution has not yet made a proper foray on the oil and gas business. Often the data is siloed and very hard to transfer across software. One possible entry is to have a common data platform with available, structured data, where applications could be built and be available from. In that way, the person responsible for his or her part in the operations can check the data they want to manage and see if this is economically a good choice, instantly. This might have been the idea when Cognite was hired to make a data platform, but there is still a long way to go (Cognite, 2018). Specifying which data is going into the platform and then do the actual work afterwards is very time consuming.

In an industry like the upstream oil and gas business, that is highly dependent on the oil price, which is volatile, it is imperative to decrease the operating expenditure to be able to handle periods of low oil prices. Visualizations of running operating expenditure combined with operational data makes it possible to give instant decision support and enables proactive management instead of reactive.

Elements of operating expenditure to track was highlighted early on as:

- Overtime worked
- Contractors on– and offshore based on actual hourly rate and presence
- Helicopter expenses for personnel offshore based on capacity
- Logistics cost based on activity
- CO_2–taxes and other emission based expenses
- Amounts of different chemical used in operations
- Purchase orders committed versus actual spend

Since a master thesis in Industrial Economics at the University of Stavanger is written over the course of 4.5 months, the scope needed to be narrowed. It would not be possible to create a prototype system that included all the suggested metrics. It was decided to work with use cases concerning personnel on board (POB), as this appeared to be data that were possible to analyse in real-time measurement system developed within a short time frame. The elements embedded into the real-time operating expenditure system were narrowed down to:

- Overtime worked
- Contractors on– and offshore based on actual hourly rate and presence
- Helicopter expenses for personnel offshore based on capacity

After dealing with time constraint, a further narrowing of the focus elements were done. The reason for this was the lack of data availability and high latency. This is discussed in Section 4.3.2 and the final focus elements are:

- Helicopter expenses for personnel offshore per person
- Contractors and permanently employed personnel offshore

4.2 Pre-understanding

The Ivar Aasen cost controller provided operating expenses for the asset, and these were analysed to get a high level overview. The report, handed over during the summer of 2018, consisted of some actuals, but mostly forecasted opex data. It made a good basis for the analysis, as the data were used mainly to get a high level overview of the different costs per Joint Operating Agreement code. The cost data were extracted from the report according to the JOA codes.

The visualization of the data was developed using the business analytics tool *Power BI*. With this tool it is possible to drill down in the data, from high level cost into finer details. The result is shown in Figures 4.1 and 4.3 to 4.6.

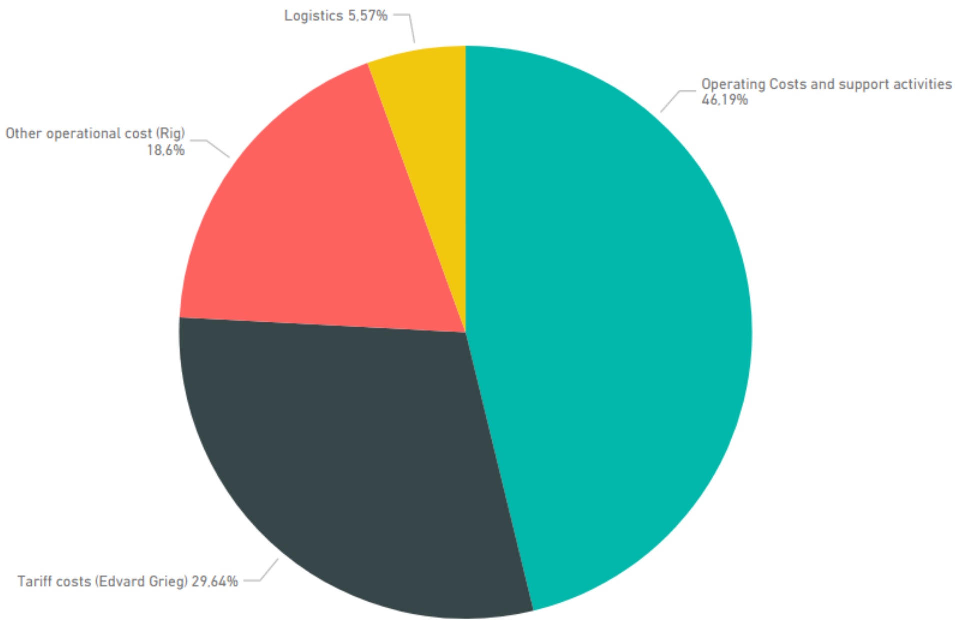

Figure 4.1: Operating Expenditure 6 - Total

Figure 4.1 shows the total operating cost for the Ivar Aasen offshore production platform, as per the joint operating agreement. In the following figures, we will drill down into "Logistics" and "Operating Costs and Support Activities". To avoid risking to publish sensitive cost information, the numbers are given as percentages. The relationship between the pie charts is shown in Figure 4.2.

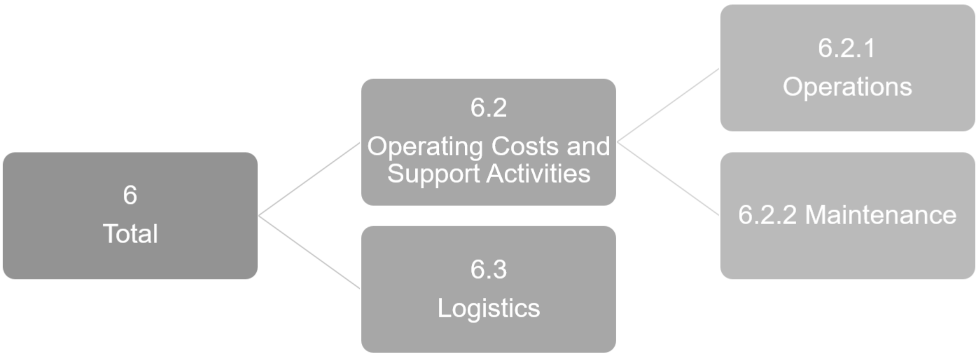

Figure 4.2: Data Drill Down Structure

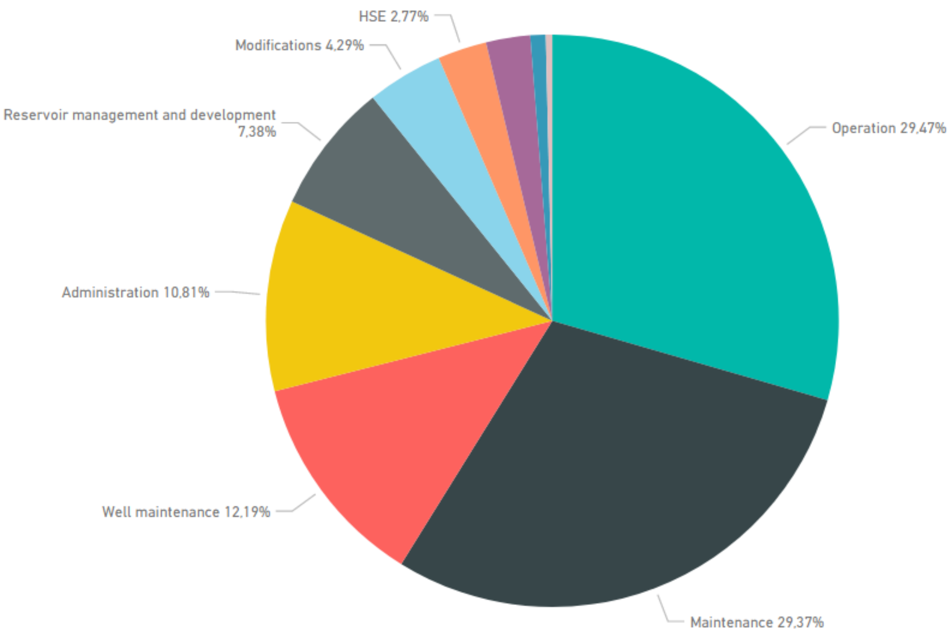

Figure 4.3: Operating Expenditure 6.2 - Operating Costs and Support Activities

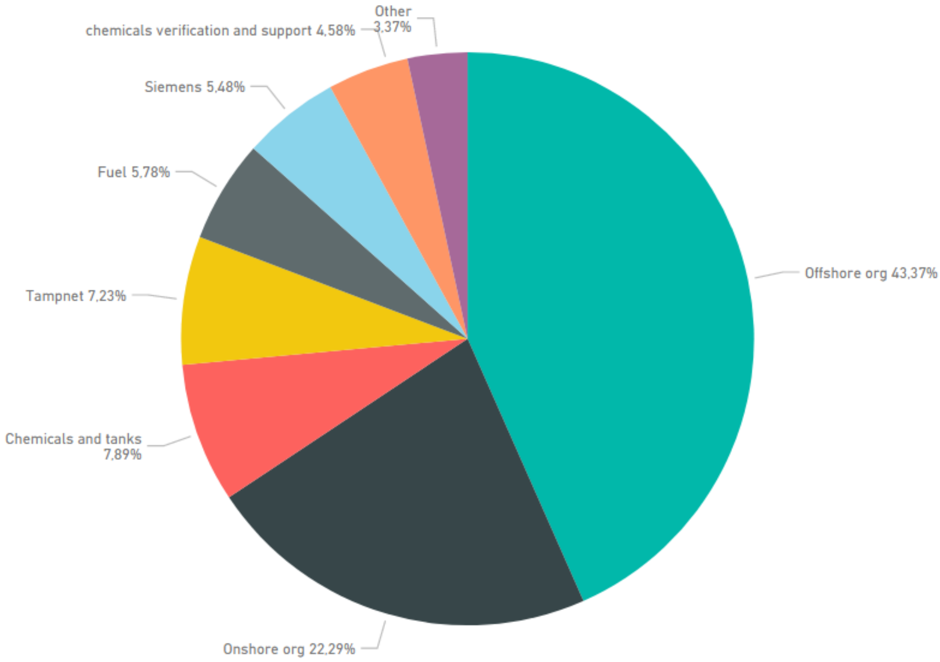

Figure 4.4: Operating Expenditure 6.2.1 - Operations

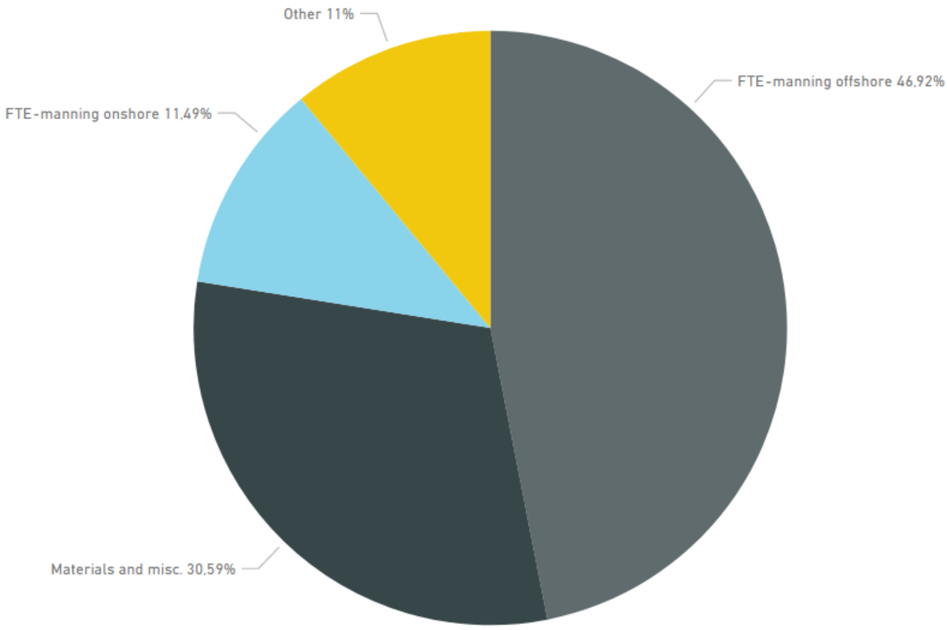

Figure 4.5: Operating Expenditure 6.2.2 - Maintenance

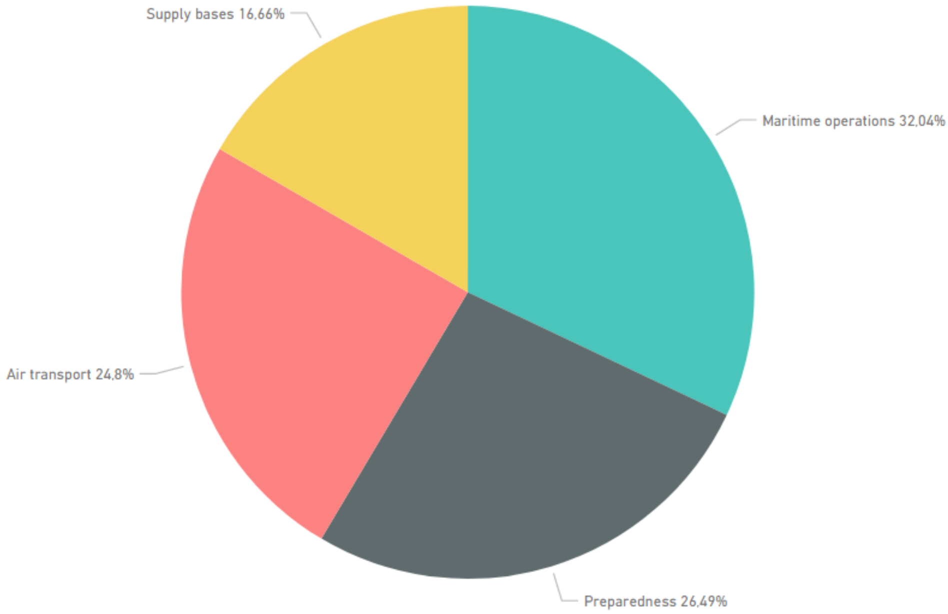

Figure 4.6: Operating Expenditure 6.3 - Logistics

The contributions to total opex of each chosen focus element were then calculated.

Air transport (part of logistics):

$$\begin{aligned} &\text{Logistics [\%]} * \text{Air transport [\%]} \\ &= 5.57\,[\%] * 24.8\,[\%] = 1.38\ \%\ \text{of total} \end{aligned} \tag{4.1}$$

Operations Manning (part of operating cost and support activities):

$$\begin{aligned} &\text{Manning Offshore } [\%] + \text{Manning Onshore } [\%] \\ &= 46.19\ [\%] * 29.47\ [\%] * 43.37\ [\%] \\ &+ 46.19\ [\%] * 29.47\ [\%] * 22.29\ [\%] \\ &= 5.90\ [\%] + 3.03\ [\%] \\ &= 8.93\ \%\text{ of total} \end{aligned} \tag{4.2}$$

Maintenance Manning (part of operating cost and support activities):

$$\begin{aligned} &\text{Manning Offshore } [\%] + \text{Manning Onshore } [\%] \\ &= 46.19\ [\%] * 29.37\ [\%] * 46.92\ [\%] \\ &+ 46.19\ [\%] * 29.37\ [\%] * 11.49\ [\%] \\ &= 6.37\ [\%] + 1.56\ [\%] \\ &= 7.93\ \%\text{ of total} \end{aligned} \tag{4.3}$$

The results are listed in Table 4.1.

Table 4.1: Operating Expenditure on Research Focus Elements

Activity	Percentage of total	
Air transport	1.38 %	
Operations Manning	8.93 %	
Offshore		5.90 %
Onshore		3.03 %
Maintenance Manning	7.93 %	
Offshore		6.37 %
Onshore		1.56 %
Subtotal	18.24 %	

The opex incurred by the focus elements, related to the overall operating expenditure for the asset, is approximately one fifth of the total. The total also takes into account opex not associated with the platform itself, namely rig cost, and the tariff cost for the Edvard Grieg platform, where Ivar Aasen flows produced volumes for further processing. From an economic point of view, these are costs that can not be reduced short term, since these are based on long term contracts and difficult to alter. If the focus is to be hands on in opex reduction and see what can be done on a daily basis, these can be taken out of the equation. The distribution of operating expenditure will then be quite different, listed in Table 4.2.

Table 4.2: Operating Expenditure on Research Focus Elements, Rig- and Tariff Cost Removed

Activity	**Percentage of total**	
Air transport	2.67 %	
Operations Manning	17.3 %	
Offshore		11.4 %
Onshore		5.9 %
Maintenance Manning	15.3 %	
Offshore		12.3 %
Onshore		3.0 %
Subtotal	35.3 %	

This exercise has shown both that the focus elements are relevant, and that there probably exists potential for cost improvement in these areas. It is necessary to look at cost as something not just to reduce, but to optimize. As personnel both offshore and onshore work towards producing more oil and gas, either directly or indirectly, cutting the cost for the sake of cost cutting might affect production goals mid-term and long-term. The goal is also to see this in the light of digitalization, removing abundant work tasks or moving work from offshore to onshore by the means of remote operations and predictive maintenance, among others.

In conclusion, there seems to be a great potential for cost improvement in these focus elements, since the subtotal of operating expenditure that are available for short term reduction is as large as 35%.

4.2.1 Literature Review Cases

The article "Using business intelligence to improve performance" by Wadsworth et al. (2009), studied financial management of the Cleveland Clinics, which is an academic medical center consisting of 11 hospitals, 16 family health centers and 5 ambulatory surgery centers. The study found that going from monthly measurements of operating expenditure to real–time dashboards with operating expenditure and operational information enabled the Cleveland Clinics to reduce expenses on a contractor nursing agency by 90% and overtime cost amongst in–house personnel, cutting costs by USD 5 million annually. They did this by focusing on, amongst others:

- Quality metrics
- Drill–down capabilities into key human resources metrics, such as overtime by job code and employee

Which is similar to the original thought for the visualization to be made in this thesis. The environments on a hospital and offshore platform are of course different, but there is definitely a lesson to be learned from other companies in other industries on how to reduce operating expenditure and see this in the view of either keeping operations at the same level, or even improve it. This will first be possible when both operational expenditure and operations quality is measured and monitored.

The article "Real-time cost management of aircraft operations" by Burrows et al. (2001), studied how real-time cost management by cost-indexing and cost-minimization affected operations. The airline industry is both capital and labour intensive, and because of the rich set of management challenges they have made their own financial reporting standards. Both of these facts are also true for the oil and gas industry, and thus makes the cases comparable. The cost-indexing and cost minimization is based on the ratio of time-related non-fuel costs and fuel cost, with many associated cost drivers included. Analysing the cost drivers of flight deck crew (pilots), cabin crew (flight attendants), inspection maintenance and overhaul and fuel, they deduced that this potentially represented 35% of the operating expenditure. Coincidentally, this is the same opex fraction that was calculated for our case as well, shown in Table 4.2.

The system and visualization had already been in place in the aviation industry for many years, so this article focused on issues with the model itself. The systems tracked both operations data and the cost of fuel, maintenance, and hourly expenses on staff. The opportunities identified with the system were:

- Technical matters and data specification must be relevant to cost drivers
- The staff must have the right incentives to cut cost for the airline company, going away from getting paid by hours alone
- All systems must be seen in context, to avoid suboptimal solution

It is interesting to see that the aviation and healthcare industries have successfully tracked operating expenditure real time for many years, being able to reduce the cost per output. The oil and gas industry is lagging behind in this area, and it highlights that there may be a considerable potential to reduce expenses by focusing on real-time monitoring and cost management.

4.3 Construct Design

4.3.1 Phase 1 Visualizations

When working on the selected focus elements in the real–time operating expenditure measurement system, it was important to specify what kind of visualizations were wanted. So the first thing that was done was creating a dummy set of values, and visualizing the wanted measurements. These visualizations were made in *Power BI* and are shown in Figures 4.7 to 4.13. These form the basis for further work.

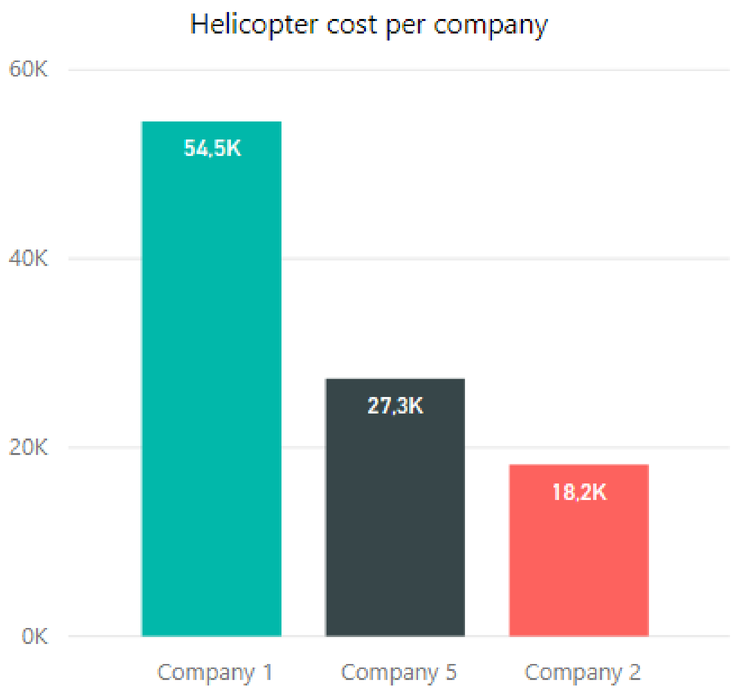

Figure 4.7: First Draft of Helicopter Cost

The idea behind Figure 4.7 was to visualize the cost of transporting people by helicopter offshore to carry out a job. Company 1, 5 and 2 are just place–holder names for actual companies transporting personnel to the asset. All similar annotations in other figures are place–holder names.

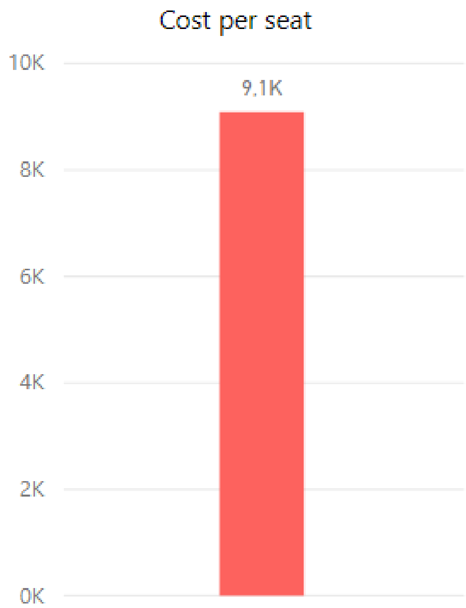

Figure 4.8: First Draft of Cost Per Seat

Figure 4.8 is visualizing the cost per seat in the helicopter, to highlight the cost per person sent offshore and to show capacity utilization.

Figure 4.9 is made with the thought in mind that there is going to be a future focus on moving work tasks from the offshore environment to the onshore environment. Based on the ideas of remote operations, experts being able to instruct offshore personnel from onshore through the means of virtual reality centres and the possibility for better audio– and video communications, and more. Having an overview of core manning numbers could then be used as a benchmark for considering sending more people offshore. The questions could then be asked if there are people offshore already capable to execute the tasks, either by themselves, after taking an e-learning course online or by receiving instruction from a subject matter expert onshore before, and while performing the task.

Figure 4.10 shows a waterfall plot of associated cost of the personnel above core manning.

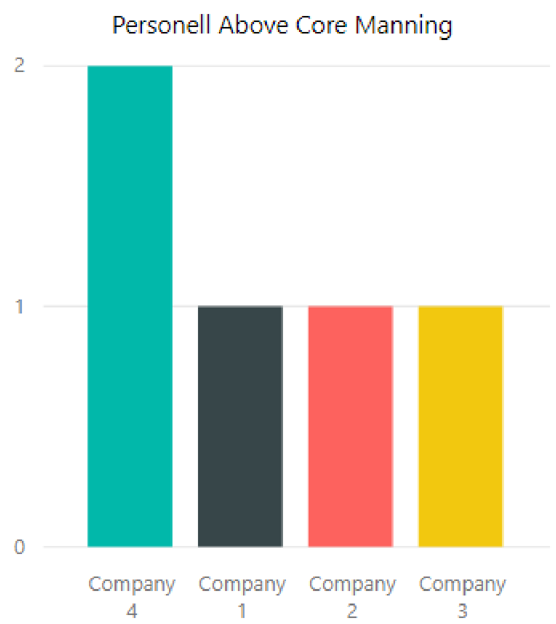

Figure 4.9: First Draft of Personnel Above Core Manning

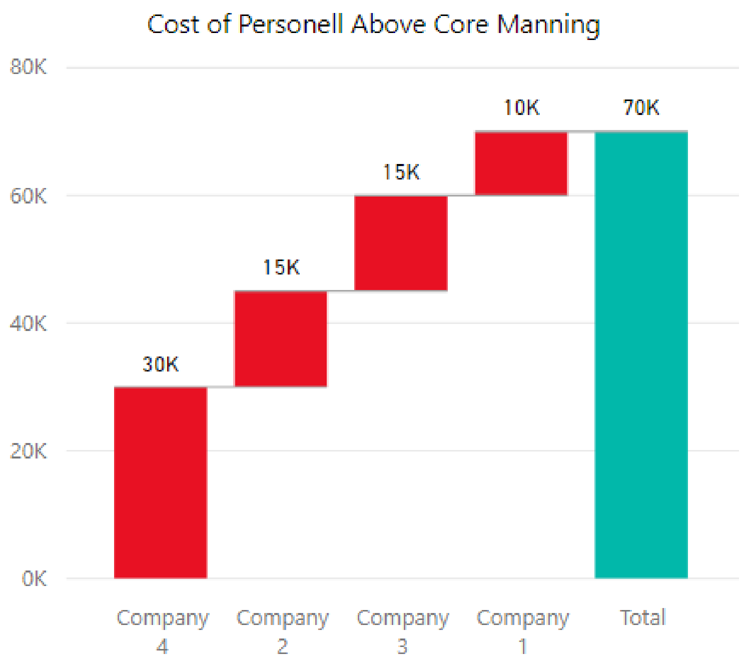

Figure 4.10: First Draft of Cost of Personnel Above Core Manning

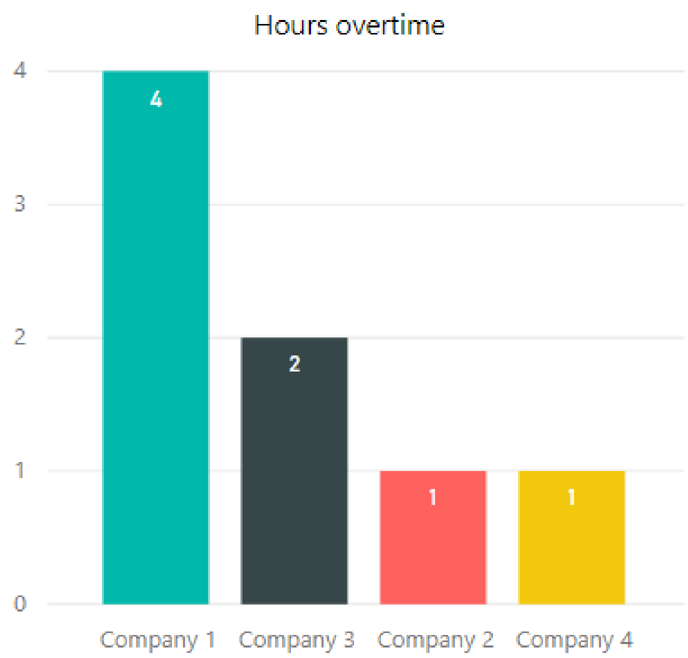

Figure 4.11: First Draft of Hours Overtime

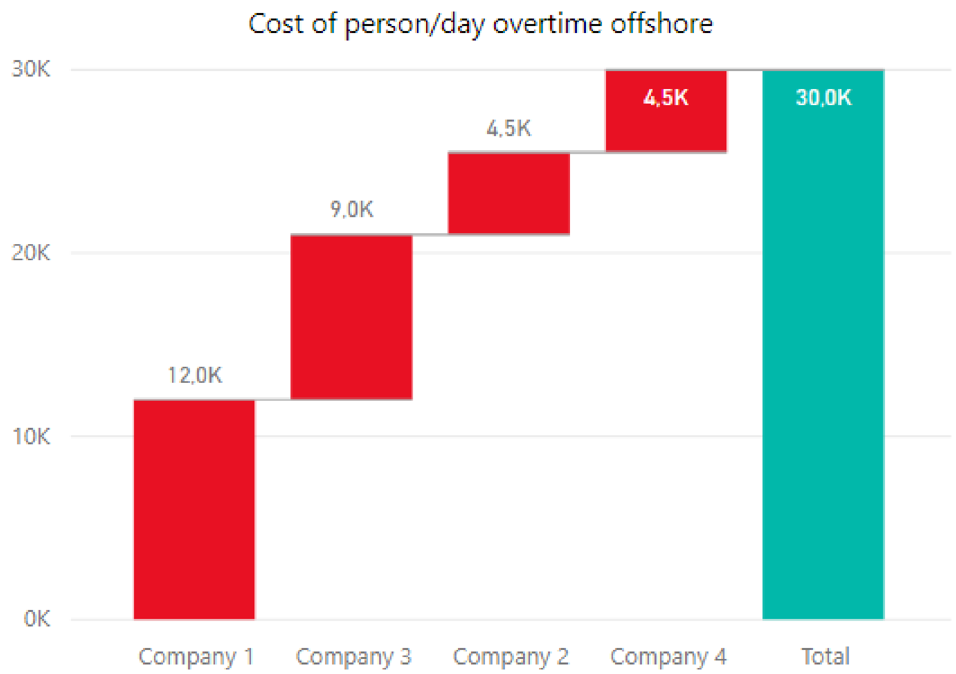

Figure 4.12: First Draft of Cost of Overtime Work

Figure 4.11 would show the hours overtime worked by the different companies. This could enable increased efficiency focus, better resource allocation in areas where there is an abundance of overtime and overall cutting expenses associated with overtime work. This is in accordance to the studies discussed in Section 4.2.1.

Figure 4.12 shows a waterfall plot of made up cost associated to Figure 4.11.

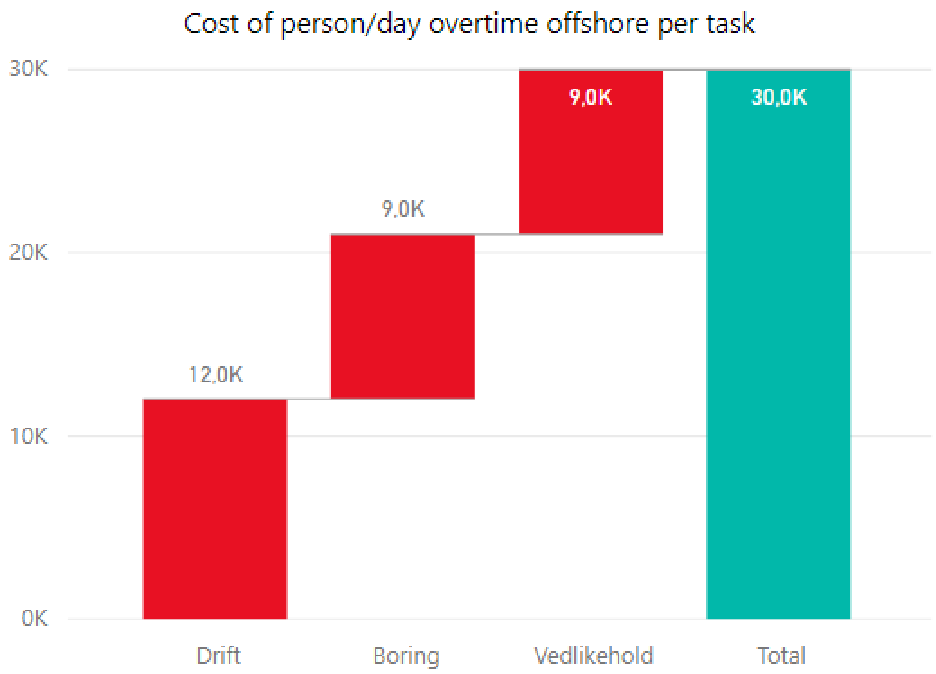

Figure 4.13: First Draft of Cost of Overtime Work Per Function

Figure 4.13 visualizes the cost associated with people staying extra days offshore. This could be broken down by task and would make for better prediction of the resources required for certain jobs. For this particular measurement, extra days could also be because of waiting on weather situations. This highlights that all visual representation connecting operations data to cost real time must be used as an operations tool. If the system itself were to do interpretation of the data, more heavily connected systems would need to be in place.

As highlighted in Section 4.4, communication and common understanding of cost are not always straightforward, as the point of view differs for different positions and goals. The tools provided by real–time opex measurements ensures that dedicated personnel have access to the data and can switch views from high–level to low–level, and vice versa. This can ensure that everyone has a common understanding of the operating cost.

4.3.2 Data Harvest

Table 4.3 was used when going around talking to people to determine where the necessary data was stored, and gather information about how the system could be developed.

Following is a list explaining the table headers:

- Status

  Green: data was readily available and possible to get real time

  Yellow: possible to acquire the data, but with a latency or quality issue

  Red: data was either very hard to get, with high latency or not fit for purpose.
- Case

  The case specified which focus element the data was related to.
- System

  This column specified which system the data could be taken from.
- Location

  Which location in the system the data was stored.
- Sheet

  Used if there was a specified sheet in the location of the data it could be collected from.
- Data type

  What kind of data that was being requested.

Table 4.3: Data for Opex Measurement System

Status	Case	System	Location	Sheet	Data type	Comment	Format	Treatment	Visualization
	Helicopter				People on board				
	Helicopter				Number of seats				
	Helicopter				Company				
	Helicopter				Tasks				
	Helicopter				Cost per helicopter				
	POB				Number on board				
	POB				Company				
	POB				Length of stay				
	POB				Tasks				
	POB				Core manning				
	POB				Hour/Daily rates				
	Overtime Onshore				Time				
	Overtime Onshore				Company				
	Overtime Onshore				Task				
	Overtime Onshore				Hourly/Daily rates				
	Overtime Offshore				Time				
	Overtime Offshore				Company				
	Overtime Offshore				Task				
	Overtime Offshore				Hourly/Daily rates				
	Contractors				Number offshore				
	Contractors				Company				
	Contractors				Tasks				
	Contractors				Hour/Daily rates				

- Comment

  Used to comment on any information regarding either the system, location, data etc.

- Format

  Specified the format of the data, for example text, numbers, date etc.

- Treatment

  What kind of calculations or editing should be appended to the data.

- Visualization

  How the visualization should look like.

After talking to personnel responsible for the various data, it was apparent that the information needed could be found in the following systems:

- DaWinci: the Norwegian North Sea's de facto industry solution for personnel logistics and POB management.
- OCS: in this case, system for registering hours worked.
- SAP: in this case used for tracking cost of helicopters, and additionally used for keeping track of Purchase Orders (POs) for the asset.

After figuring out in which system the information could be found, expert users were contacted to give input. The eighteen people contacted work within finance, logistics, human resources, data management, information management, operations, digitalization analysis and more.

The information resulted in the following realizations:

- DaWinci: data is well structured and with low latency.
- OCS: data is available and structured, but the latency is high because a lot of people do not register their working hours in the system on a daily basis. Visualizing these data "real time" does not create much value.
- SAP: a lot of the cost data registered in SAP are unstructured, free text, PDF-files, Excel-files etc. This makes it very difficult to gather these data.

Table 4.4: Data System Information

System	**Access**	**Structured**	**Latency**
DaWinci	Good	Mostly	Low
OCS	Good	Yes	High
SAP	Good	No	High

Based on this, it was concluded that it was not possible to monitor some of the elements we wanted in real time. The remaining focus elements are:

- Helicopter expenses for offshore personnel
- Contractors and permanently employed personnel offshore, with possibility to add overhead cost

4.3.3 Phase 2 Visualizations

A new proposal for visualizations were made for the remaining focus elements, shown in Figures 4.14 to 4.17. These are examples only, but based on real data extracted from the systems. Note that Figure 4.16 is for three persons only, to save time making the visualizations.

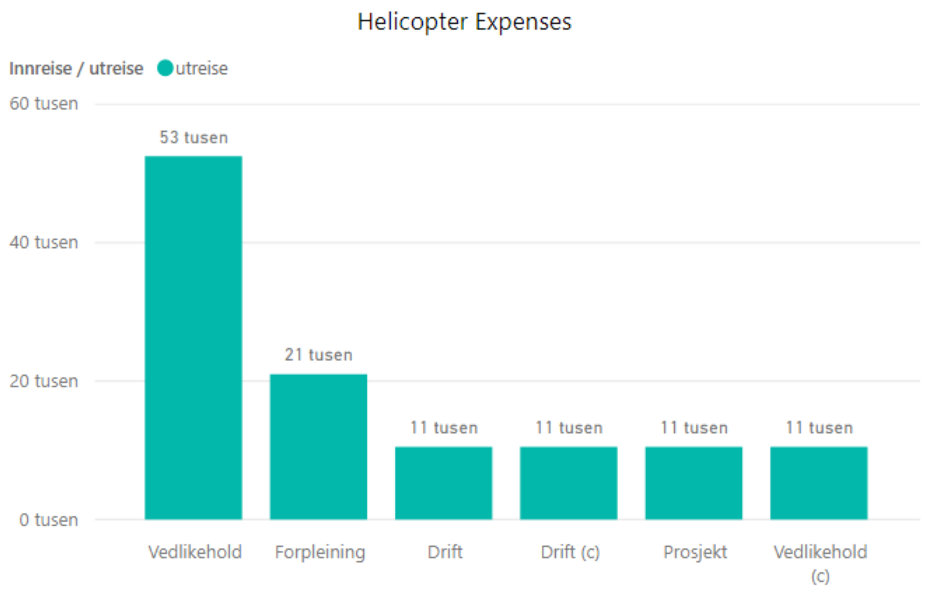

Figure 4.14: Helicopter Expenses

The expenses shown in Figure 4.14 includes the aviation cost of transporting personnel offshore per organizational unit, security at heliport, survival suit, support, assurance and software cost. It is pre-calculated by the logistics department based on an yearly average, so that it calculates a cost per person per days offshore. In the case of the Ivar Aasen Asset this cost is set to 900 NOK/person/day. When using a calculated average like this, the cost will not be visualized as it is in the cost reports, but it will give the operations cost. In Section 4.4: Testing Construct, a case is explained where this visualization could help bridge the gap between reported cost and the actual running operating cost.

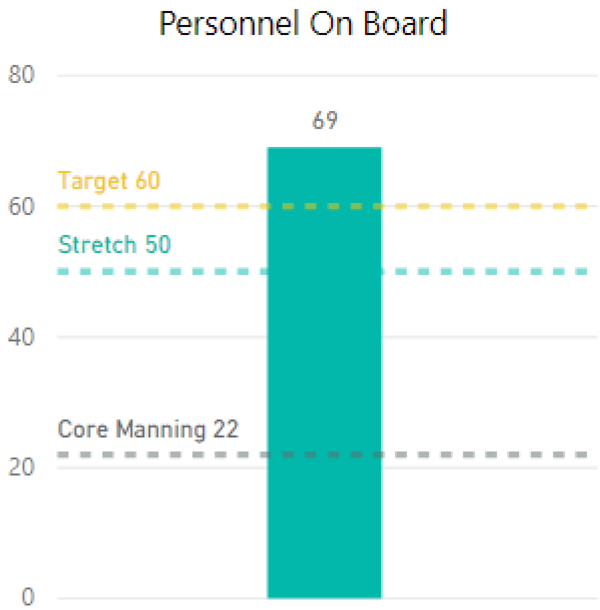

Figure 4.15: Personnel On Board

Figure 4.15 shows number of personnel on board the Ivar Aasen. The target, stretch and core manning levels are put in as example values only. The idea behind it was to show POB–targets, for helping set performance indicators for remote work. For the final visualization such targets need to be set by operations managers and people involved in the strategy for the asset, if they want to focus on this, or a similar, metric.

Figure 4.16: Employment Status of Personnel on Flight

Figure 4.16 shows the employment type of the personnel on the flight. If such measurements were shown for planned flights, it opens up the possibility to be proactive and check if the work could be done by people already on the platform, or if it was possible to do with remote assistance in stead.

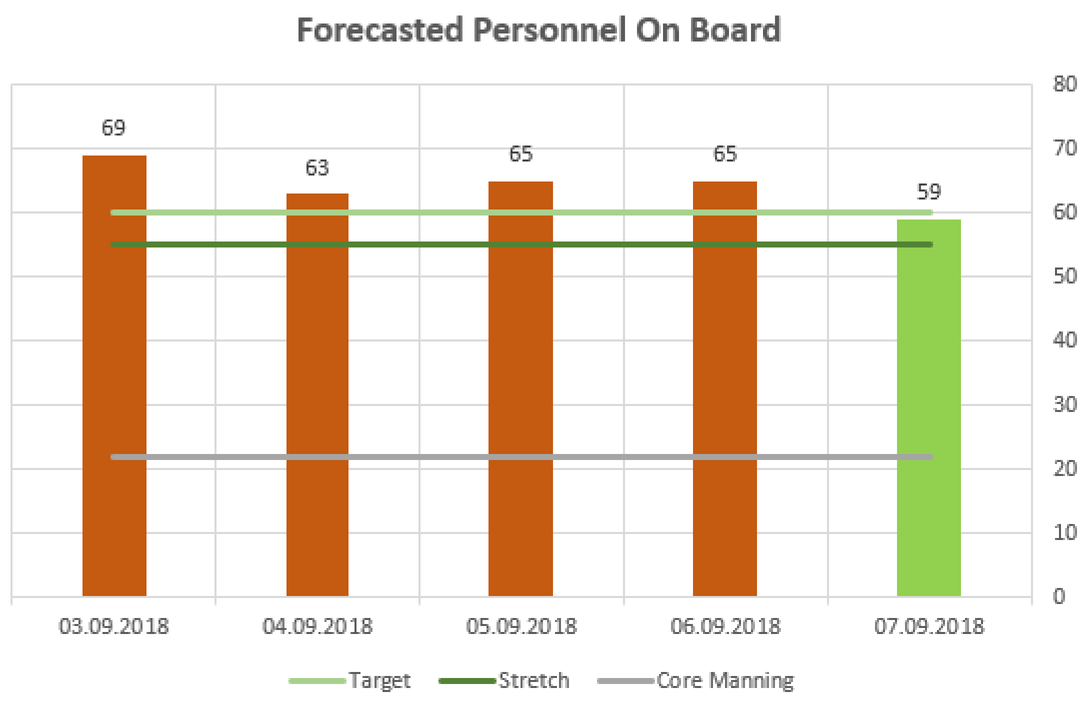

Figure 4.17: Forecasted POB Level from September 2nd

Figure 4.17 shows forecasted POB values, with example target, stretch and core manning values, as in Figure 4.15. This could be used in a similar manner as Figure 4.16, to add extra focus on keeping the POB low by doing more work remotely or by remote assistance.

4.3.4 Final Construct Design

When Figures 4.14 to 4.17 were finished, it was time to start the cooperation with the Data Warehouse. Before starting the work, an A3 was made. A3 problem solving is a tool within the lean philosophy, focusing on presenting the challenge, current state and what the future state will look like. The reason for this is to be clear on the business case and what problem will be solved, and what value will be created. The A3 is shown in Figure 4.18.

The observant reader can see that the date is set to August 15th, and the system was to be implemented in October. This was an optimistic plan, and the final product was not ready until late in November. This affected the time left for feedback and implementation, which will be discussed later in this thesis.

The job of structuring the data and making them available is outsourced to another company, BI Builders, and at the kick–off meeting November 5th they could confirm that most of the data was already structured and ready to be used. The data was later on structured in a tabular, shown in Section 2.1 Figure 2.2.

The data available to set up included:

- Time

  Year - Month - Day
- Employment type

  Permanently employed, consultant, company, department
- Personnel on board platform
- Helicopter flights and cost
- Assets

  Ivar Aasen and Skarv

This allowed for a wide variety of different dashboards to be created. To be able to use them for getting information about different situations quickly, the structure was divided into "Today", "Historical View" and "Forecasting". All of these with possible drill-down capabilities, either on time from yearly

Date: 15/08/2018

A3: Real-Time Measurement of Operating Expenditure on Ivar Aasen

Owner: Kristian Solem

Team: XX

AkerBP

Challenge

Challenge

The general trend is to use live data. Finance is one area lagging behind, still using a periodic concept. This makes it difficult to supervise daily expenses, and it is not possible to be agile on reducing operating expenditure (opex).

Link to organizational goals

- Aker BP has a long term goal of reducing opex to $6/bbl and there is also an target for each asset. Thus, a system showing real-time opex level brings the possibility to be agile in cost reduction and can in time be a major contributor to reach these goals.
- As the Ivar Aasen asset is the forerunner for digitalization in Aker BP it is a good opportunity run the first implementation of this new system.

Future state and hazards

Future state
Combine data from DaWinci, SAP and OCS to present daily operating expenditure on an asset. First focusing on helicopter logistics, personnel onboard, associated consultants and overtime. Later adding more metrics. This results in:

- Consistent operating expenditure data for the asset
- Visualization of operating expenditure as they occur, as per LEAN-principles
- Awareness, which in turn drive behavior, when being exposed to live data

Risks
- Not effectively implemented on asset
- Measuring wrong parameters

(Both of which can be improved after implementation)
- Inconsistency in data-points

Current state

Current operating expenditure

- Measured
- Treated
- Bundled
- Allocated
- Presented 4-6 weeks after occurrence

This makes it difficult to have a solid understanding of what level of operating expenditure you are on, short term.

However, it is important to specify that the real-time opex measurements will not replace any processes currently in place. It will be a new method of measurements which will add value to both the assets financial management and evaluation of digitalization initiatives.

Action Plan

Id	Milestone	Resp.	Deadline
1	A3 approved		24.08.2018
2	Dashboards ready for testing		12.09.2018
3	Implementation		01.10.2018
4	Feedback and (possible) updating 1		01.11.2018
5	Feedback and (possible) updating 2		03.12.2018

Measure - KPI

- Metrics of how the asset is doing with respect to operating expenditure level
- Possible future KPI's / KI's

Figure 4.18: A3

to monthly to daily view, or on employment type to company and associated department worked for.

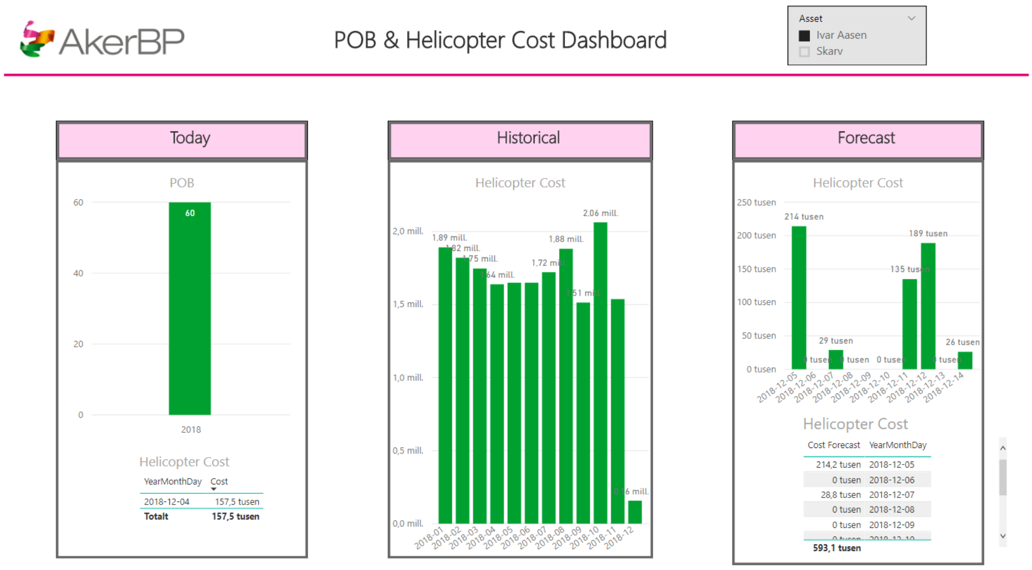

Figure 4.19: POB & Helicopter Cost Frontpage

Figure 4.19 shows the front page of the dashboard of real-time POB & helicopter cost. The current view shows forecast of 11 days, while the historical view is monthly. It gives an overview of how the levels are today, historical by months and the forecasted helicopter costs. From this view it is possible to enter a more detailed view by clicking on the frames, transporting the viewer to Figures 4.20, 4.22 and 4.23. The reason for Skarv showing, in the top right corner, is that the initiator of this thesis asked if this could be included. As the data was already structured in the data warehouse, Skarv could easily be incorporated and thus added to this system. This thesis, however, focuses only on the Ivar Aasen asset.

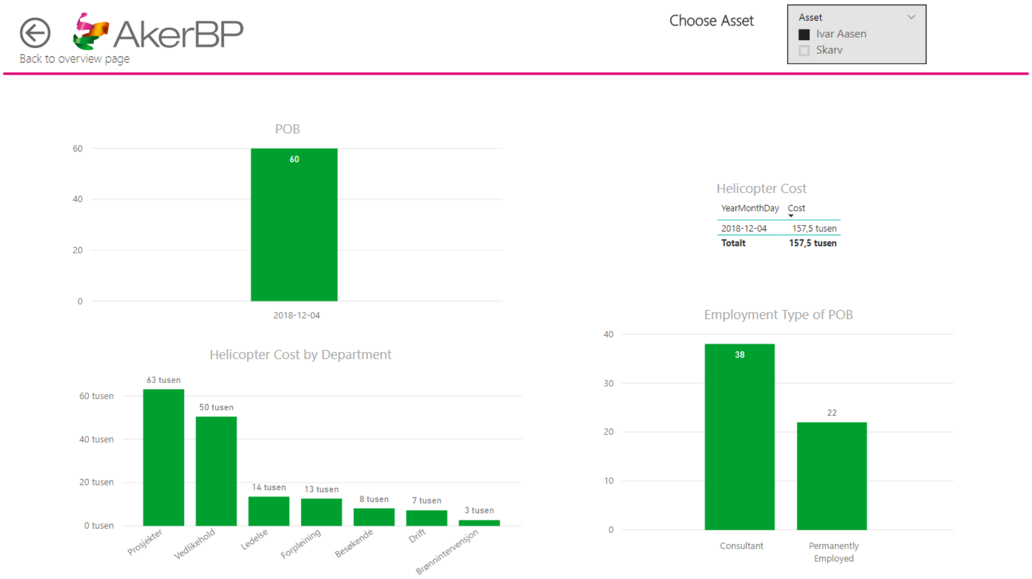

Figure 4.20: POB & Helicopter Cost - Today

Figure 4.20 shows today's values with POB, helicopter cost by organizational unit and employment type of POB. If wanted, this could be broken down into organizational units and companies present, by clicking on the specified column. As shown in Figure 4.21. Similarly, this can be done for all other charts as well.

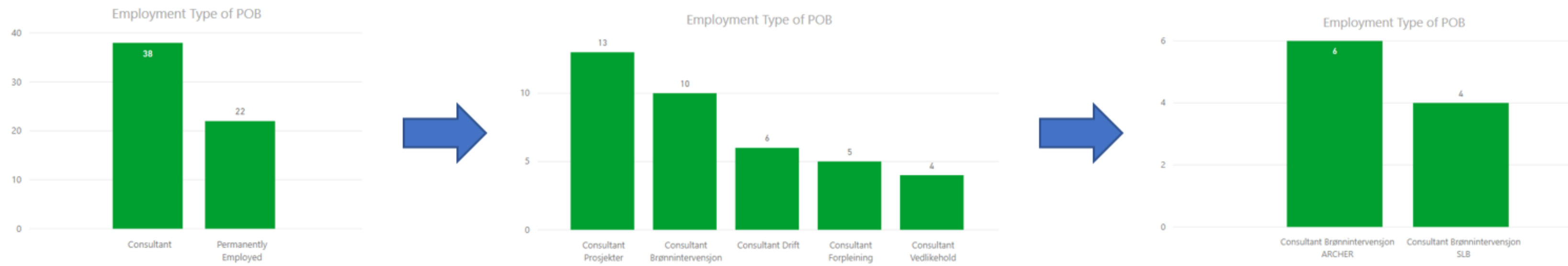

Figure 4.21: Breakdown of Employment Type

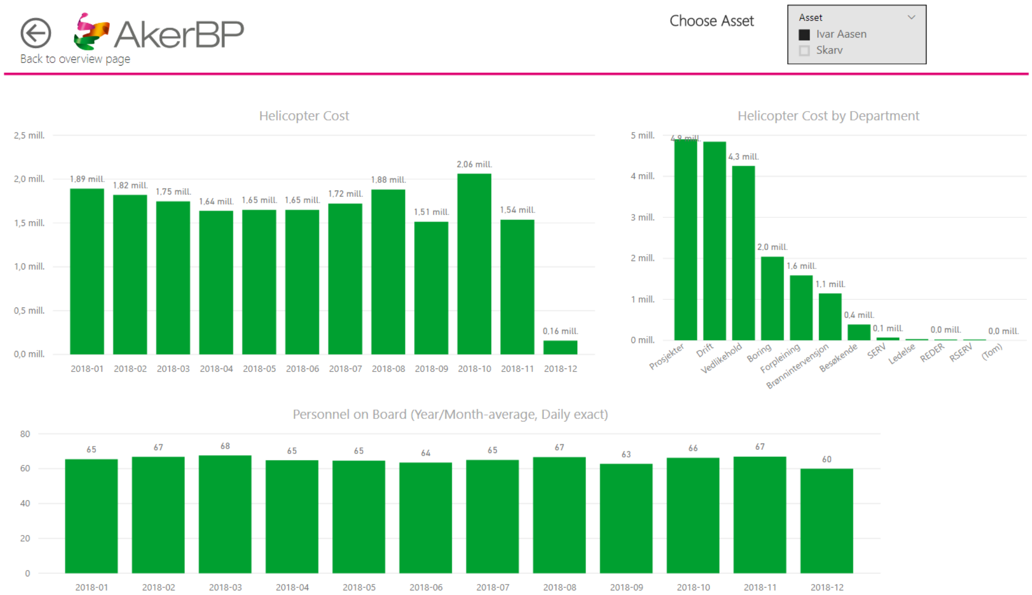

Figure 4.22: POB & Helicopter Cost - Historical

Figure 4.22 shows historical values of POB and helicopter costs. The same breakdown capabilities are present here as previously shown.

This viewpoint would be of particular interest when trying to connect reported cost, arriving with a large lag, to what has actually happened in operations. A real–life scenario for this will be discussed in a later section, Section 4.4.2.

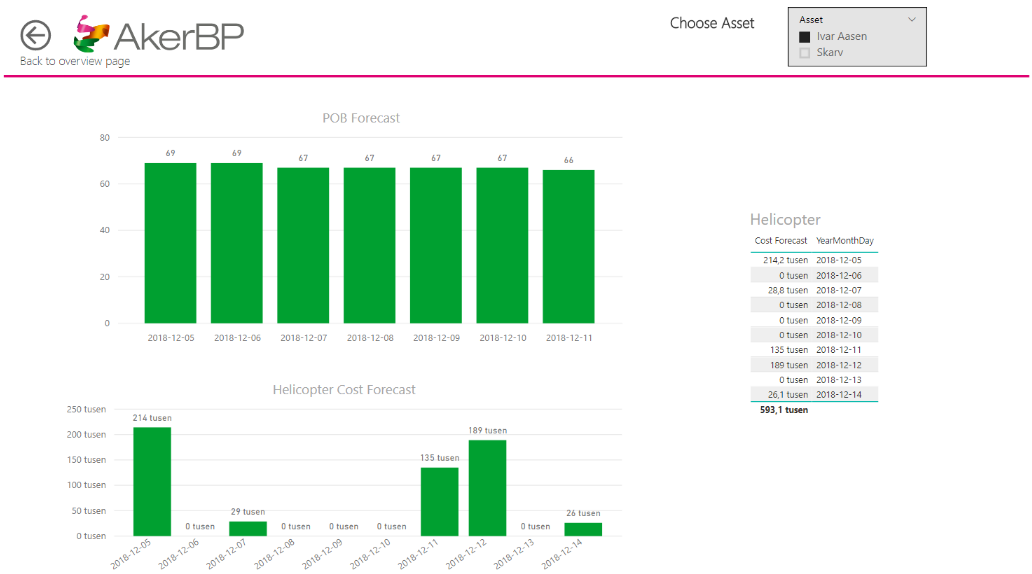

Figure 4.23: POB & Helicopter Cost - Forecast

Figure 4.23 shows a forecasted view of the POB and helicopter cost. This view changes dynamically when new data are put into DaWinci.

Being able to get a view of what is going to happen in the next days may enable for being proactive instead of reactive to changes in operations.

4.4 Testing Construct

4.4.1 Relevance Diamond

After finalizing the system design, the relevance of it is discussed using the relevance diamond from Figure 3.3. It took quite some time to make the system, due to resource constraints. Resulting in decreased time to study the implementation of it, so the relevance will mostly be discussed on a potential basis.

1. Practical value relevance

   The system is not implemented in the organization as of yet, but as will be mentioned later there is awareness of its applicability. So right now the practical value relevance is low, but it has potential to create value for the company. Firstly, by creating equal information distribution between different departments. When something happens in operations connected to POB and helicopter cost, it can be seen in the system. If more opex-measurements will be added in the future, this will also contribute to enhance the value of the system. As more of the cost picture will be shown the easier it becomes to get the whole picture, and drill down into specific areas of interest.

2. Legitimative decision relevance

   The system of opex measurements are sensitive information as it tracks performance for the asset. For this to be relevant for making a difference for stakeholders and societal support the information must be available and directly connected to the contributors. This could be a very good idea when thinking of how to incentivise vendors and other stakeholders so that everyone gets rewarded for what actually decreases cost. If it was possible to share the information on operating expenditure and make companies involved or responsible for having as low opex as possible while still providing quality support, then this could become a valuable tool.

3. Academic value relevance

   The thesis has shed some light on important and lacking areas in current academic knowledge. Especially in latency effects on BI performance, effective use of BI systems and focus of BI development. This will be highlighted more in Section 5 as well. Increasing knowledge about interconnected systems and utilization of real-time data will benefit the society by continuing the trend of benchmarking, creating key performance indicators, enable data streams for machine learning and artificial intelligence, which are not currently present in our focus elements. In the end, value will be created through increased production and resource efficiency.

4. Instrumental decision value

   The Instrumental decision value and short term improvements are not yet researched. Since this system is quite new it is difficult to foresee the short term implications. Especially since this is a new way of representing financial data, it is difficult to immediately see the possibilities. Through maturation of system, processes and mindset there is a great potential for instrumental decision value.

4.4.2 Feedback

Feedback from the logistics asset controller regarding the robustness and correctness of the visualizations and real-time data gave some valuable information about use cases for the system. When reporting cost for aviation on the Ivar Aasen asset, and assets in general, the cut off date is usually more than a few days before the month is over. The rest of the days will then be added as a forecasted cost in the report. If there are complications after the cut off date and it becomes necessary to pay for extra helicopter transports, the actual cost of the month will become much higher than what was forecasted in the report. This effect is exacerbated by the fact that adding an extra, unplanned flight costs considerably more than regular scheduled flights. Thus, the report and actual cost has a wide spread. The extra cost will be reported in the next month, and this will in turn affect the budget, which will be increased to accommodate the change in expenditure. In a thought-up, but realistic scenario, this lag in information causes the people responsible for the budget to be alarmed, because they can see an increase in cost from the report. They are, however, unable to see the direct reason behind it, as the cost is registered the month after the complications happened. There will be a mismatch between reported cost and budgeted cost, where the latter will first increase to accommodate for what is perceived as a new standard, then regulated below normal in the following months when realizing that they overestimated the cost. This instance of mismatch between report- and budget cost is referred to as the "heartbeat curve", which is shown in Figure 4.24. It is a result of lacking communication between cost controllers making the report, and the budget responsible who is concerned about both being on budget and need to connect the cost to what is happening in the operations.

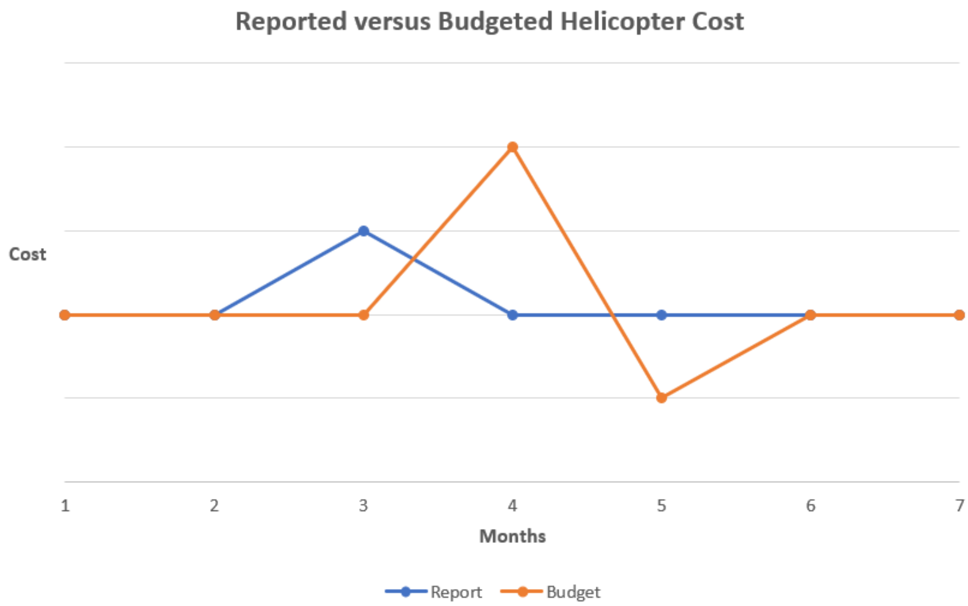

Figure 4.24: Heartbeat Curve

As an example, this happened on one occasion where the drilling crew experienced trouble with the drill string at the end of the month. This required massive operations and extra helicopter transport to fix, but did not show in the report, as it happened after the cut off date. Thus, the added cost was shown in the next month, and this affected the forecast for the month after.

Such situations can be avoided by having transparent real-time visualizations, with the possibility to switch to historical data and drill down into the details. The confusion created by looking at asymmetric data will be prevented and save hours, if not days, of work to understand what has happened.

4.5 Theoretical Connections

The theory states that sufficiently low latency is paramount in utilizing data for operational intelligence. This study confirms this, as the data becomes less valuable when the latency is high. The original problem is that the financial data has very high latency. Information from both the literature review highlighting experience from other industries, and knowledge acquired in this study, indicates that when operating expenditure are shown real–time and connected events it becomes easier to reduce cost.

With respect to Figure 2.3, where five elements that must be present for succeeding with data visualization was presented, the study found these to be true.

1. Quality data

   Without quality data, the difficulty utilizing the data increases and it becomes very costly to harvest and structure it. The cost data for the different companies and the rates for the different contractors are saved in highly unstructured formats. Use of data when it is saved in PDF's, Excel spreadsheets, word documents, picture format or similar, is very demanding. It is, of course, possible to acquire the data, but as mentioned this requires a lot of work and is costly, therefore efforts should be made to structure this data better.

2. Means to monetize

   This was a weak point in the system design as the theory is that visualizing real-time cost data is an enabler for reducing cost and increasing quality of work, but in practice it needs specific actions to make it happen. This could be said for many measures done to digitalize. However, in this day and age where changes are happening extremely quick, there might be a need to start implementing digitalization initiatives that are no clear business cases for, because otherwise would be to lag behind competitors.

3. Organizational capability

   Utilizing systems that are cross-functional requires very good communication between departments, which is a challenge to ensure. In addition, knowledge gained from real-time data must result in changes made to the work processes, so that the company itself learns and benefits from the gained knowledge.

4. Technology

   The technology right now is adequate. The systems for both storing, capturing and distributing data are present and enable users to analyse data at hand. Aker BP have entrusted Cognite, an external company, to gather all of their data into a common data platform. When, and if, all the data are gathered it will be much easier to tap into the data and create value from it. When the data is stored in one platform, with good metadata, it will be much easier for everyone to use the data to ease their work by automation and be innovative. If personnel can start making applications to solve the problems they have in their working life, as people are doing now for their personal life which you can easily download from your smart phone, companies could benefit greatly.

5. Defense

   The defense of the system is not something that have been focused on, as this is taken care of within Aker BP. However, with the new general data protection regulation (GDPR) (European Comission, 2018) in motion, the system was checked by the in-house GDPR-responsible. However, in a world which is getting more and more connected, cyber–security is more important than ever. When connecting everything, the security is only as good as its weakest link or connection point.

Literature review findings state that operations data connected with cost in real time has been used in other industries for many years to reduce expenditure. The time might have come for the oil and gas industry as well, which needs to reduce their own cost to be competitive in the energy market. There is no doubt that there is a large unrealized potential for cost reduction in this industry. There is, however, a long way to go. Oil and gas exploration and production companies have a very large amount of vendors delivering all kinds of equipment, manning, software, systems and so forth. Combining and using these data is a challenge. It is apparent that a lot of people are not directly aware of the possibilities within real–time opex measurements. Part of the reason for this is that it is so different from how reporting is done today. Every cost has a lag connected to when operations happen and when the cost is presented. A change in mindset is necessary for people to become aware of the possibilities that lies within real-time cost visualization, but with implementation of the system this will mature with time.

4.6 Applicability

This study has been done in the business environment of a Norwegian exploration and production company in the oil and gas industry, which sets the background for the applicability. It is highly relevant for companies within this business segment, but also for other industries, since the thesis has taken inspiration from different industries, e.g health care and aviation.

The use of business intelligence and real–time data are becoming more widespread as the technology and data–availability is increasing every year. This makes the research relevant on different levels e.g how to reduce operating expenditure, develop real–time systems, implementation of new tools in an organization, and data analytics.

One weak point of the thesis is that it has studied only one offshore asset for a short period of time, and thus the results have few comparisons to back it up in the oil and gas industry. Another one is that the research methodology itself is a limiting factor. It focuses on the product as an outcome and goes through an iterative process between inductive and deductive reasoning. This makes the result not as certain as purely deductive studies, nor as probable as purely inductive studies, but the results are nonetheless plausible.

The strength of this research is that is has been done in cooperation with a company focusing on digital change, with the intention to solve industry challenges. This makes it highly relevant in the current state of business. By having taken time to do a literature review and finding research material backing up the idea behind the concept and also locating gaps in academic knowledge, it has made it possible to pin–point areas of study that contributes to fill these gaps.

5 Discussion

Going through the steps of understanding the idea and goal behind making real–time operating expenditure visualizations, locating data, talking to personnel with expert subject knowledge, and coordinating the work for putting the data together has created a lot of knowledge concerning the research questions that lay as a foundation for the study.

Making an efficient system with real-time measurements from both operations and financial data is demanding. Firstly, the business case and goal should, by principle, be well explained, so that everyone is on the same page and are working toward the same goal. Having such well predefined goals is not easy when working in a business environment that is constantly changing and actively and actively transforms their way of working through digitalization. Having well defined business cases might not be as important now as it has been in the past, because of the speed at which digital transformation is happening. Companies taking too long to adapt, risk the possibility of falling behind. Creating a common system for information sharing and visualization of operating expenditure in real time is novel and can create interesting new ways of working. However, it is necessary to have a multi–disciplinary team with knowledge of the vision and goal, financial data, operations data and how to best utilize the data through a data warehouse or other data platforms.

The focus for the opex system design was operating expenditure associated with sending people offshore, overtime hours onshore and offshore connected to the Ivar Aasen asset and cost of people working for the asset on- and offshore. All based on the actual hourly rate of both contractors, consultants and permanently employed staff. It became evident early on when working on this thesis that most of this was not feasible, because of the way data is registered in the systems. There are no regulations for writing either regular or overtime hours in OCS. People can usually do it when it suits them, with two restrictions; the hours must be registered on the last day offshore and hours must be filled in at a cut off date before quarterly presentations. The implication of this is that there is a latency in the data that is not compatible with a real–time opex system. The rates of contractors and consultants in SAP, these are stored in an unstructured fashion. The rates could be hourly, daily, a part of a deliverance package, or something else. In addition, the data is stored as PDF's, word files, excel files or even as pictures. This makes the data very hard to extract and use. The result of this was that the only acquirable data related to helicopter transport, and an associated cost that was calculated by the cost controller to make an approximation for cost per seat. To reduce latency of hours–data, new ways of registering hours must be implemented. Ideally, hours are written daily. Onshore it would be easy, for instance, only writing hours that differ from the regular 7.5 hours per day. Offshore, the hours could be registered on phones or tablets at the end of each day. These devices are potentially being used to complete work tasks on an everyday basis. This would ensure right–time data and latency would be decreased. Rates of contractors and consultants would need individual specification. When registering data into the system there must be a standard, non–ambiguous way of doing so, ensuring that the data is structured. If these points are implemented, the system of real–time opex measurements could be as initially envisioned for hours worked. In an ideal world, all the data generated from different systems would automatically be inserted into a common data platform. Each person could then tap into this data platform and get a hold of the needed data. This would enable people to make applications themselves to ease both their own work, but also possibly increase the efficiency and streamline the work of the organization as a whole. This is the vision for Aker BP through the Cognite Data Platform. It is however, a big job to structure and create a data stream for all of the data being generated, so it will take some time.

When digitalizing offshore fields for the future, it is expected that redundant or repetitive work will be removed, minimized or be done remotely. This would then be seen in the real–time opex system as a decrease in people going offshore, or it would change the frequency of it, and decrease workload on certain organizational units registered in the system. Savings would then occur by reducing flights and transport, and reducing work-hours. Maintenance is moving towards predictive and prescriptive modi, so savings correlated with this will materialize itself in reducing work-hours and spending less on material for maintenance and reducing downtime offshore.

Successful implementation of such a system is dependent on stakeholders being involved and that information about its existence is distributed in the organization. In addition, it must be easy to access. Having one data platform from where to retrieve any data, but also one platform to distribute the different applications based on the business needs, could be a game changer. It is easy to get stuck in situations where all the data and the usage of them gets isolated within the departments and sub–groups. This is apparently the present situation in the oil and gas industry, and probably other industries as well, but it is slowly changing.

The focus of business intelligence development and maintenance must lie in the previous mentioned aspect. The data must be easily accessible when you need it, and ready to use. It must be easy to create applications and visualizing what you want to achieve, and these applications must be easily shared with co-workers and other stakeholders.

Based on the knowledge gained in this thesis, more research should be done on the following themes:

- Standardization of how to save and structure data in software and systems
- Real-time knowledge sharing in organizations
- What drives effective use of BI systems

5.1 Looking Ahead

The system made in this study for visualizing operating expenditure contains only a fraction of the total expenditures. It can be utilized for a narrow section of operations management, but the value of the system increases as more elements of operating expenditure are added to the system. This will make it possible to get an overview of the cost as a whole and drill down into a more detailed view to do low–level inspection.

An enabler for this would be to have more data readily available, and not in silos as is the current state. Having the data available at hand, with good connected metadata for finding relevant data, makes it much easier to create the visualizations and applications needed.

When the data is structured and has a continuous flow, it becomes much easier to automate work processes and also use machine learning and artificial intelligence for predicting outcomes and detecting changes in variables. With this framework in place, one would have a digital twin at hand for all aspects concerning the operations. The digital twin would then be a digital representation of what is actually happening in the physical world. All personnel with access to the digital twin could then ask questions on what the situation is presently, and what could happen in the future. It would present the data and answer our questions so that we could make decisions based on instant feedback and analysis.

6 Conclusion

This thesis has researched how operating expenditure can be visualized in real time, and some of the implications this can have for the future. The operating expenditure on the offshore production platform Ivar Aasen has been investigated to find important cost–contributors and make real–time measurements of these.

The research questions listed in Section 1.1 are answered below:

- **How can a real–time opex measurement system be developed efficiently?**

  The research from this study concludes that to develop a real–time opex measurement system, it is beneficial to form multi–disciplinary teams to ensure results that are on target. To combine business intelligence with opex–measurements knowledge is needed in the fields of: operations, economy and cost controlling, and data warehousing or similar platform technologies. Rather than having one person acquiring information from different stakeholders, a dedicated team would be better suited to efficiently plan and develop such a system.

- **What kind of opex–related data is possible to measure in real time today?**

  By studying the focus elements of operating expenditure it was concluded that data concerning hour-writing and rates of contractors and personnel are currently not suited for being made into a real–time system. Readily available data were the ones registered for specific assets, such as helicopter flights and personnel.

Table 6.1: Current Real–Time Availability

Data	Available Real–Time
Aviation cost	Yes
Personnel on board	Yes
Hours worked / overtime	No
Contractor rates	No

- **How can existing systems be modified to facilitate real–time opex measurements?**

  For overtime worked, there needs to be a change in how it is registered. Hours must be written on a daily basis, and rates must be put into the system in a structured, standardized way. Another solution would be to only register hours that deviated from the regular 7.5 hours per day onshore, or 12 hours per day offshore.

  Rates for contractors onshore and offshore must be registered in such a way that it is possible to use the data for daily analysis, if applicable. This means registering a structured, hourly or daily rate in the system. If the contract specifies price per contract period, this could be registered as is, and be shown in the measurements and visualizations.

- **How will digitalization impact real–time opex measurements?**

  Because of the focus on removing abundant work offshore by remote operations, digitalization will probably impact the current available real–time operating expenditure systems by inflicting a decrease in helicopter cost and cost related to personnel on– and offshore towards assets.

- **How can real–time measurement systems be successfully implemented?**
  For successful implementation of a real–time measurement system it is important to get decision–makers involved in the process. Awareness needs to be spread in the organization of different ways to measure and react to cost, since such real–time opex measurements are not yet common in the oil and gas industry.

- **How can we make decisions on "the focus of BI development and maintenance" to improve operational efficiencies and competitive advantage?**
  The focus of business intelligence development and maintenance with respect to real–time operating expenditure should be to present low latency data and prevent vulnerability to changes in software and in systems. The oil and gas industry is dependent on many different software and systems which can be replaced, or added to, in a short time frame. The BI system, data warehouse and data platforms should be able to handle such transitions quickly. This is also an area where providers of software and systems can benefit, if they are able to provide easy data extraction.

- **How do latency effects influence the effective use of BI and firm performance?**
  It has been shown that high latency in a real–time operating expenditure system decreases the usability of the system. A focus needs to be put on

how to decrease the latency, either in the system architecture, or in work procedures providing the data at the source.

- **What drives the effective use of BI systems?**
  Since the real–time operating expenditure system was first available late in this study, the effective use of the real–time operating expenditure system could not be researched. This is a great research area for the future, as the oil and gas industry has a lot to gain from efficiently using BI systems, and especially real–time opex measurements.

As a concluding remark, literature review has shown that many industries have used operational data connected to operating expenditure to drive down cost. The oil and gas industry has not yet put a large focus on it, but the time is ripe for becoming more cost efficient to stay competitive in the future energy market. There are still some challenges with availability of structured data in many different software and systems, and some ways of registering data might have to change. That being said, the industry seems close to being able to use a large amount of these data connected together. This thesis has shown the potential for such a real–time operating expenditure system, and that it is possible to make it.

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Appendix A

Joint Operating Agreement: Operating Cost

The Joint Operating Agreements budgeting structure of operating expenditure is as follows (Ministry of Petroleum and Energy, 2017):

6 Operating Cost

This phase begins when a field enters the operating phase.

6.1 Operating Preparations

Activities related to recruiting, training and preparing the operating organization for taking over the plant and perform the operation. Start-up activities related to the testing of a facility are not included as part of preparations for operation.

6.2 Operating costs and support activities

6.2.1 Operation

All work that is directly attributable to production and operation of a facility. This mainly comprises operating activities on the offshore/onshore facilities, as well as costs such as support activities from land and production chemicals.

6.2.2 Maintenance

All maintenance activities related to an offshore facility, land plant and associated pipes. These mainly comprise inspection, status check, preventive and corrective maintenance, surface maintenance, maintenance drilling module as well as maintenance support.

6.2.3 Well maintenance

All costs related to down-hole work up to the choke, and which do not form part of a drilling project.

6.2.4 Modifications

Activities related to extension or modification of existing equipment and facilities requiring amended technical documentation. Change projects and reconstruction that are neither maintenance nor an operating investment are included.

6.2.5 Subsea operations and maintenance

All operating and maintenance activities related to subsea facilities, including inspection and contingency costs for the subsea facilities.

6.2.6 Platform services

Costs related to the accommodation/catering on the platform and any other support services on the platform, as appropriate.

6.2.7 Administration

Costs related to management, direct and indirect administration of operative organization, e.g. field manager, economy, personnel and IT.

6.2.8 HSE

Activities related to HSE work as well as licence specific HSE projects.

6.2.9 Reservoir management and development

Costs in connection with long-term planning, quality assurance, reservoir management, production optimizing, modelling and enhanced oil recovery.

6.2.10 Business development

Commercial activities in connection with evaluating business opportunities for a licence in operation.

6.3 Logistics

6.3.1 Maritime operations

Operating activities related to vessel operations, with the exception of standby vessels which are attributed to item 6.3.4. Vessel costs included in the report will comprise supply vessels, storage vessels, special assignment/support vessels and anchor handling, as well as consequential costs and administration of vessels.

6.3.2 Air transport

Transport services between helicopter bases and the installation as well as shuttling between facilities on the fields. Costs relating to SAR (Research and Rescue) and ambulance transport are attributed to item 6.3.4.

6.3.3 Supply bases

Costs related to the operation of bases such as area, rents, personnel, etc., as well as any transport to and from bases.

6.3.4 Preparedness

Vessel and helicopter costs related to operative preparedness on the fields. Installation specific standby vessels, any share of area standby vessels and consequential costs related to such vessels. SAR helicopter (Search and Rescue) and ambulance transport.

6.4 Tariff cost

Costs related to field external processing and transportation of oil and gas between fields.

6.5 Other operating costs

Costs that cannot be attributed to other operative items, e.g. write-down of stocks, obsolete stocks, previous years' costs, excess field times, gas purchases in connection with injection, insurance/guarantee matters related to operations, etc.