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Achieving Long-Term Value of Enterprise Models

A Case Study

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Abstract

In today's increasingly agile business world, enterprises must take extensive measures in order to stay competitive. Over the last 20 years, *enterprise modelling* has become a common technique for managing the vast amounts of information and business knowledge that emerges within an organisation. Enterprise models are meant to be used and evolved over a long period of time. In order to have the wanted effect, such models must be properly managed and have the right quality.

Statoil, Norway's largest oil and gas company started using enterprise models as a part of their corporate management system ten years ago. In their experience, the introduction of enterprise models has had positive effects on operations, but evaluations have shown that there is still room for improvement. In this report, a case study focusing on the relationship between the *quality* of the Statoil enterprise model and its *use* is described. SEQUAL, a framework for evaluating model quality has been applied throughout the study in order to analyse the various aspects of the enterprise model.

The results show that the management system is extensively used in most parts of the company and that company standards and documented best practices enforce high quality on several levels. However, there is still a gap between the level of quality prescribed and what is being achieved in practice. Managing this gap through continuous improvements is crucial for the continued success of using enterprise models in Statoil.

Sammendrag

Med dagens økte satsning på smidighet må virksomheter gjennføre brede tiltak for å holde seg konkurransedyktige. I løpet av de siste 20 årene har *virksomhetsmodellering* blitt en mye brukt teknikk for å holde styr på de store mengdene med informasjon og bransjekunnskap som oppstår innad i en organisasjon. Det er meningen at virksomhetsmodeller skal utvikles og brukes over en lang tidsperiode, og for å oppnå ønsket effekt må slike modeller bli godt forvaltet og ha riktig kvalitet.

Statoil, Norges største olje- og gassfirma begynte å bruke virksomhetsmodeller som en del av sitt bedriftsstyringssystem for ti år siden. De har erfart at innføringen av virksomhetsmodeller har hatt positiv effekt på driften, men evalueringer har vist at det fortsatt er rom for forbedring. Denne rapporten beskriver en case-studie med fokus på forholdet mellom *kvaliteten* til Statoils virksomhetsmodell og *bruken* av den. SEQUAL, et rammeverk for å evaluere modellkvalitet har blitt brukt gjennom studiet til å analysere ulike aspekter ved virksomhetsmodellen.

Resultatene viser at styringssystemet er mye brukt i de fleste deler av bedriften, og at bedriftsstandarder og dokumenterte "beste praksiser" sikrer høy kvalitet på mange nivåer. Det er likevel fortsatt et avvik mellom det definerte kvalitetsnivået og det som oppnås i praksis. For å ha god nytte av virksomhetsmodeller i Statoil også i fremtiden må dette avviket håndteres gjennom stadige forbedringer.

Preface

This thesis is the result of the work done during the final year of the 2-year master's programme in Informatics at the Norwegian University of Science and Technology, under the supervision of professor John Krogstie. A case study was performed within the Norwegian oil company Statoil. Statoil have given access to and provided all necessary resources and information needed in order to complete this work. Many Statoil employees have shown interest in my work and provided documentation, demonstrations and their personal experiences and opinions. In particular, I would like to thank my main contact person in Statoil, Harald Wesenberg for spending a lot of time answering my questions and helping me to find the right people and information needed. I would also like to thank Frode Skjæveland, Terje Lie and everyone who participated in interviews and experiments. Last but not least, I would like to thank my supervisor John Krogstie for leading me in the right direction, helping me evaluate my proposed approaches and discussing the results.

Merethe Heggset
Trondheim, November 30, 2014

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Chapter 1

Introduction

Statoil, a Norwegian oil company with more than 23 000 employees, have for a decade been using enterprise modelling in order to structure their vast amounts of organisational knowledge and information. The enterprise model functions as common point of reference for the entire organisation, ensuring the quality of a large number of work processes and communicating requirements and best practices throughout the company.

A lot of research has been done in the field of enterprise modelling, as well as on the subject of how to evaluate model quality. Much work is done regarding the use and creation of models on a theoretical level, but in order to truly understand the mechanisms at work in the application of enterprise models, real-life cases can provide interesting insights. How enterprise models are actually used within an organisation will vary from case to case, so collecting as much information as possible about this from several sources will be useful for further practice.

Model quality has been discussed in several works over the years, and many frameworks and methods have been developed based on scientific theories from various fields. However, as stated by Moody [20], many of these methods suffer from a lack of adoption in practice. While the main goal of applying such frameworks in practice normally is providing a detailed evaluation of model quality in a specific case, it can also give indications of the usefulness of the framework and, based on the results, possibly enforce its position in the field which again may lead to a wider adoption in practice.

This report presents the results of a case study regarding the usage and quality of enterprise models in Statoil. The main goal of the research has been:

Goal *To examine the relationship between model quality and the use of Statoil's enterprise model, in order to make recommendations for the future*

By identifying and analysing the challenges facing the use of the enterprise model, Statoil can continue to make improvements to the enterprise model in a long-term perspective. By understanding the role of model quality in relation to use, they can improve how they create, present and maintain the models.

Three research questions have been defined to guide the work:

Research question 1 *How do Statoil employees use the enterprise model?*

Understanding how the enterprise model is used in practice, as opposed to how it is *meant* to be used, is a powerful aid in the process of creating and maintaining models.

Research question 2 *Which challenges do employees face when using the enterprise model, and how are these related to model quality?*

Statoil have already identified many of the problems related to enterprise model usage through the use of company-wide surveys. In this thesis, these and other challenges identified are structured and analysed according to how they affect the quality of the enterprise model.

Research question 3 *How should different types of model quality be balanced in order to support the goals of modelling?*

Overall model quality can be seen as a composition of different quality types, each with their own quality goals. Finding the ideal balance between these types is challenging, as they are interrelated, i.e. improvements to one quality type may negatively affect another.

1.1 Research method

This report is the result of a *single-case case study*, conducted using an *interpretive* research approach. A variety of data generation methods have been applied, including:

- **Extraction of web usage data:** For discovering patterns of use and variations in order to give context to qualitative data
- **Document study:** In order to understand various aspects of the case and analysing the quality of textual and graphic material
- **Interviews:** Providing insights into users' experiences and attitudes towards the enterprise model
- **Experiments:** For examining how users understand and read models and thus investigating quality trade-offs

The research methods used are further described in chapter 3.

1.2 Thesis Structure

Chapter 2 presents relevant background theory and defines the various themes addressed in this report. It also describes the motivation for conducting this case study.

Chapter 3 provides an overview and general discussion of the research method applied.

In **Chapter 4**, a description of Statoil and all relevant aspects of the case is given.

Chapter 5 provides a quantitative context for understanding how the enterprise model is being used by outlining the results from analysing usage data.

Chapter 6 reports the findings from analysing the quality of the Statoil enterprise model.

In **Chapter 7**, the results and experiences gained from the study are summarised and discussed.

Chapter 2

Background Theory and Motivation

This chapter presents background theory that is relevant for the case study.

2.1 Enterprise modelling

Using *enterprise models* is one step towards achieving cross-functional integration within large and complex organisations. An *enterprise* is a set of interdependent actors working together for some period of time to achieve some of their common goals [6]. A *model*, which in this context denotes a *conceptual model*, is *"a description of the phenomena in a domain at some level of abstraction, which is expressed in a semi-formal or formal diagrammatical language"* [15]. A conceptual model can represent both static (e.g. objects) or dynamic phenomena (e.g. processes) [41].

An enterprise model provides an overall representation, consisting of various sub-models outlining the design of the enterprise as seen from different perspectives, e.g. process-oriented, business-oriented or information-oriented [8] [27]. Enterprise models can be either *descriptive*, i.e. represent the current situation, or *definitional* (prescriptive), i.e. outline a future scenario [8].

Using enterprise modelling is a way of managing knowledge, and can be said to belong to the *externalisation* mode in Nonaka's knowledge creation model (figure 2.1), in which tacit knowledge is converted into explicit knowledge [24]. However, the "knowledge-as-object" view advocated by Nonaka has later been criticised, e.g. by Walsham [40], who argues that Nonaka misunderstood the notions of tacit and explicit knowledge, first introduced by Polanyi [28]. Walsham highlights the

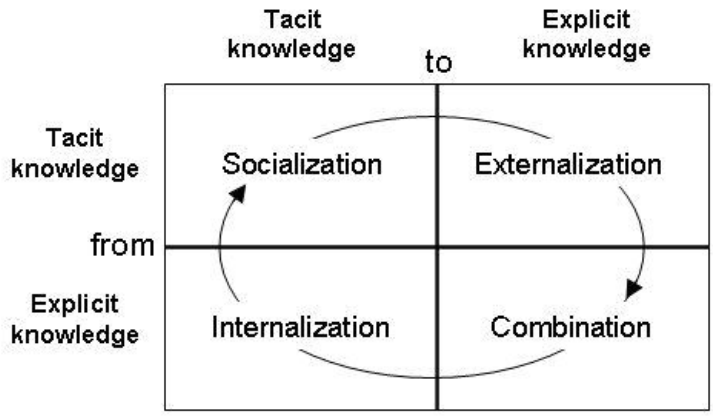


Figure 2.1: Four types of knowledge conversion

fact that Polanyi argued that there is no such thing as strictly explicit knowledge, as it is meaningless if deprived of its tacit coefficients. Christensen et al. [6] bring up something similar, namely the question of whether a *diagram* is a model in itself. In their understanding, a diagram is only a picture, and has no meaning until it is interpreted by the human mind - only then is it made dynamic (i.e. having more than one state), which is an important feature of the model.

The authors divide enterprise models into three categories, based on their purpose, in what they call "The PAKT taxonomy":

1. **Construction of reality:** Modelling as a technique for creating a common understanding among people whose cognitive models do not necessarily coincide

2. **Analysis and simulation:** Making changes to simulated enterprise models and monitoring the consequences, in order to decide if a change should be put into action

3. **Model deployment and activation:** An enterprise model being used for controlling and performing work. The operation of the enterprise is being done through and in the enterprise model

Wesenberg [42] lists some important characteristics of enterprise models, that distinguish them from other models:

- *Enterprise models are for communication through time and space* - The models are widely distributed, available from anywhere in the enterprise and not only created for a small group of actors
- *Enterprise models are abstractions* - As the domain represented by such models is large and complex, the right level of detail must be chosen for the models to be useful
- *Enterprise models are managed* - Enterprise models should be managed the same way as source code for them to be valuable
- *Enterprise models must have the right quality* - Model quality can be measured on several different levels, and it is important to balance these levels properly

2.1.1 Process modelling

As stated earlier, the notion of an enterprise model comprises different kinds of sub-models. While various aspects of the entire enterprise model will be studied in this thesis, some emphasis will be put on process models, or "workflow models" as they are termed in relation to the Statoil enterprise model (the terms will be used interchangeably in this report).

Process models are applied in several areas in practice, including information systems development, business process modelling and enterprise modelling. After BPR [1] became popular in the nineties, the importance of high quality business process models have received much attention [16].

2.1.2 Enterprise modelling in Statoil

Statoil, a large oil and gas company, decided to use enterprise models as part of their corporate management system in 2004. The introduction of models has had a positive effect on operations. The models contribute to reducing risk, from an operational, environmental and safety perspective [42]. To illustrate, the number of serious incidents per million work hours have been reduced from 6 to around 0.8 since the introduction of enterprise models. Statoil employees perform around 2 million workhours per week in total, so the reduction is significant. While other aspects certainly have contributed to this reduction, enterprise modelling have played a large role in changing the way of working in Statoil during the last decade.

[1] Business Process Reengineering, see e.g. [10]

Objectives of modelling

Enterprise modelling is used for a variety of purposes in Statoil, the main purposes are described in the governing document *"TR0002 Enterprise structure and standard notation"* [33] as:

- *Compliance management* - ensuring that all work is done in accordance with the standard set by the company
- *Competence management* - creating competency profiles related to process roles and comparing it with the competence that can be found in the company, and thus managing the competency gap
- *Portfolio management* - gaining an overview of the company's portfolio of work processes, systems and technology, for analysing the need for changes in order to meet future needs
- *Analysis for decision making* - analysing the relationship between different objects and domains in the enterprise models, to see how changes to one will impact others
- *Performance analysis* - continuously monitoring results to see if the current way of working produces the best possible result

Experiences and challenges encountered

Even though it was not until 2004 that enterprise models became widespread throughout the company as part of the corporate management system, techniques of enterprise modelling and process modelling have been used to some degree within smaller parts of the organisation prior to this. Hepsø [13] shares his experiences with mediating business process models in three different cases. In his descriptions, he emphazises the interaction between two modes of communication:

- **First-mode communication:** *Formal* and *rule-based*, views work as a prescription of temporal task sequences.
- **Second-mode communication**: *Informal* and *cultural*, deals with interpretations, sense-making and articulation of work.

Communicating work practices and requirements using process models is an example of first-mode communication. The author points out that both of the modalities are necessary. People within a group need to discuss interpretations using their cultural language, but at the same time have a common reference point in the formal representations. The first case [12] outlines the social construction of a new oil and gas organisation, namely, the oil production ship Norne,

which started its production in 1997. The example illustrates the importance of not becoming too "first-mode biased" when describing new work activities. A team consisting of people with various backgrounds were put together to plan future work activities by creating flow charts and textual descriptions. The flow charts served to increase understanding of the new operational model, but lacked detail (as they should). While being useful for describing *what* should be done, second-mode communication was needed to define *how*. The author aided the organisation in using second-mode communication to enhance and make sense of their first-mode formal representations.

The second case illustrates the opposite - the need for formalising work practices depending heavily on second-mode communication. A pilot project was started, with the aim of developing a new model of production optimisation (the process of controlling and optimising oil and gas flow). The project incorporated more collaborative work practices than before, as well as a new working environment and new information systems. The researcher's job was to describe the collaborative practices that developed during the pilot, as well as finding methods for communicating them with formal methods. The flow charts developed from this and several other pilots were simplified and became useful in a broad corporate setting.

In the third case, this new production optimisation standard was to be implemented in another, older oil field. The challenge was to be able to comply with the corporate standard while simultaneously taking local needs and limitations into account. Problems arose, due to the fact that the field was beyond its "peak production" and would eventually close down. The decrease in income meant keeping the existing old and complex infrastructure. Additionally, key production engineers with long experience were reluctant to changing their working habits. In the end, a stepwise improvement process had to be developed in order to facilitate the translation of the standards in this particular oil field. The example highlights the limitations of first-mode formal representations as they are taken out of their initial context and moved through space and time.

The three examples illustrate the need for a combination of formalism and dialog, a "double-level language". Communication on the second level provide meaning and usefulness to formal representations.

2.2 Model quality

The concept of *quality* is highly connected to *requirements*. ISO 9000 [14] defines quality as *"The degree to which a set of inherent characteristics fulfills a need or expectation that is stated, generally implied or obligatory"*. To achieve high qual-

ity, the gap between the required or expected standard and the actual standard must be minimised. Hence, to be able to evaluate quality, the expected standard must be defined in some way. The question of how to best evaluate the quality of models has been subject to some discussion. The evaluation of models can be seen as a *social* rather than *technical* process, because instead of evaluating the model against technical specifications, people's needs and expectations must be taken into account [20]. According to Christensen et al. [6], a model does not exist until it is interpreted by the human mind.

For this research, the SEQUAL framework has been applied throughout the analyses. The framework will be described in section 2.3. Various other methods and frameworks for creating and evaluating models have been proposed over the years. 7PMG is a set of specific guidelines meant to aid the creating of high-quality process models. 7PMG has its basis in quantitative research, and can be used both in the creation of models and for improving existing models. The guidelines are summarised below:

- **G1:** Use as few elements as possible
- **G2:** Minimise the number of paths from an element
- **G3:** Use only one start and one end event
- **G4:** Model as structured as possible, i.e. each split connector should have a matching join connector of the same type.
- **G5:** Avoid OR routing elements
- **G6:** Use "verb object" when labeling activities
- **G7:** If the model has more than 50 elements, it should be decomposed

Guidelines of Modelling (GoM) [29] is another model quality framework, consisting of a set of principles for improving the quality of information models. A key aim of the framework is to manage the subjectivity that is inherent in the modelling process. Six general principles are developed:

- **The Principle of Construction Adequacy:** It is impossible to judge whether a model is a correct representation of reality, but the model should reflect a consensus about the problem gained from questioning stakeholders
- **The Principle of Language Adequacy:** Concerns the interrelation between model and modelling language. The language used should be suitable for the purpose, and be correctly applied (syntactically correct)

- **The Principle of Economic Efficiency:** The cost of the modelling process should not be greater than the benefit reaped from modelling
- **The Principle of Clarity:** Covers the comprehensibility of the model system, i.e. structure, layout and information filtering should support user comprehension
- **The Principle of Systematic Design:** There should be an inter-model consistency between structure and behaviour models
- **The Principle of Comparability:** Two models should be comparable in correspondence and similarity, both on the model level and on a meta-model level

These principles form the basis for the GoM architecture, where the first three are regarded as necessary and the latter three as supplementary.

2.3 The SEQUAL quality framework

SEQUAL is a quality framework used for assessing the quality of models and modelling languages. The choice of using SEQUAL as a "theoretical lens" for studying the Statoil enterprise model is mainly based on the fact that the company has addressed aspects of the enterprise model in the context of the three core quality levels of SEQUAL (syntactic, semantic and pragmatic) in earlier work [42]. Krogstie and Arnesen [17] used a specialisation of SEQUAL to evaluate various enterprise modelling languages for use in Statoil.

The framework is based on work by Lindland et al [18], where concepts from semiotics [2] described by Morris [23] inspired the authors to make the distinction between syntactic, semantic and pragmatic quality. The framework has been further developed in accordance with research, e.g. based on research review and recommendations [20] and empirical testing of the framework [22], adding several other quality layers which will be outlined in this section. SEQUAL has three unique properties [15]:

1. It distinguishes between quality characteristics (goals) and means to achieve these goals
2. It is based on a constructivistic world-view, i.e. it recognises that a stakeholder's knowledge about the domain changes during the modelling process
3. It is closely linked to linguistic and semiotic concepts

[2] The theory of signs

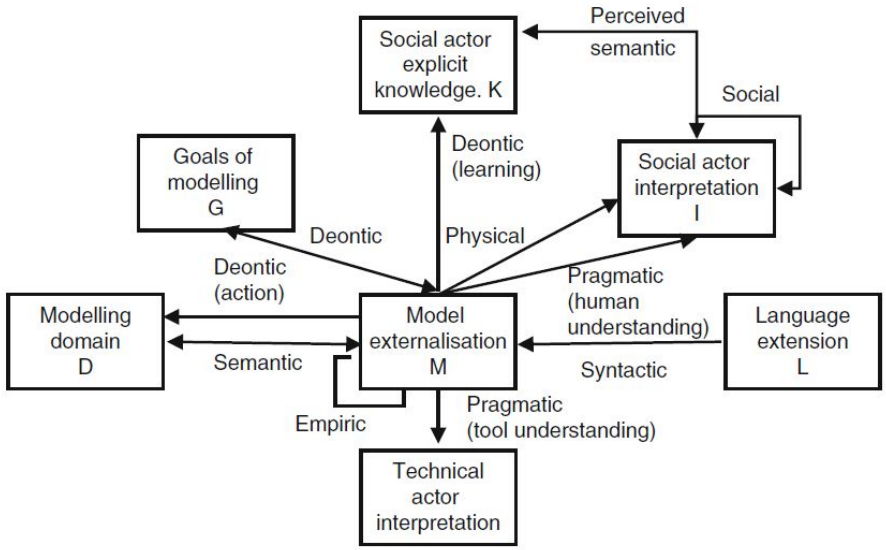


Figure 2.2: SEQUAL concepts and relationships

The framework can be useful in various ways, e.g. for [15]:

- Guiding the modelling process
- Evaluating existing models
- Evaluating modelling languages [25][17] (also ontology languages [39])
- Evaluating tool appropriateness

2.3.1 Framework concepts

The main concepts included in the SEQUAL framework and the relationship between them are shown in figure 2.2 and summarised (based on [15]) in the upcoming sections.

G: The goals of modelling

The goals of modelling are many, and may vary greatly. Nysetvold and Krogstie outlines five main usage areas of enterprise models [25] (partly inspired by the PAKT taxonomy [6]):

- *Human sense-making and communication:* Actors can use the enterprise model to make sense of various aspects of the enterprise, and best practices and requirements can be communicated throughout the organisation to create a common understanding (relative to PAKT category 1)

- *Computer-assisted analysis:* Models can be used e.g. for simulation of process changes (relative to the second PAKT category)

- *Business process management and quality assurance:* Models used for quality assurance of work processes

- *Model deployment and activation:* As described in the third PAKT category, the model can be used for controlling and performing work either manually, automatically or interactively

- *To give context:* Supporting system development projects

The prime advantage of enterprise modelling as observed by Berio and Vernadat [4] is the ability to create a common understanding shared by different actors which will help enforcing the enterprise culture. Modelling can also be used to achieve a greater understanding of a process or case, e.g. in order to understand why something went wrong (as in the Barings Bank case [7]).

The theoretically possible and intended (e.g. by creators of enterprise modelling methods) purposes of enterprise models do not necessarily reflect how such models are used in practice. Persson and Stirna investigated *actual* use of enterprise models, and found two main branches of objectives [27]:

1. *Developing the business*: e.g. developing strategies, redesigning operations and developing information systems

2. *Ensuring the quality of the business*: i.e. sharing business knowledge and ensuring acceptance of business decisions

From their findings, they created a goal hierarchy, shown in figure 2.3.

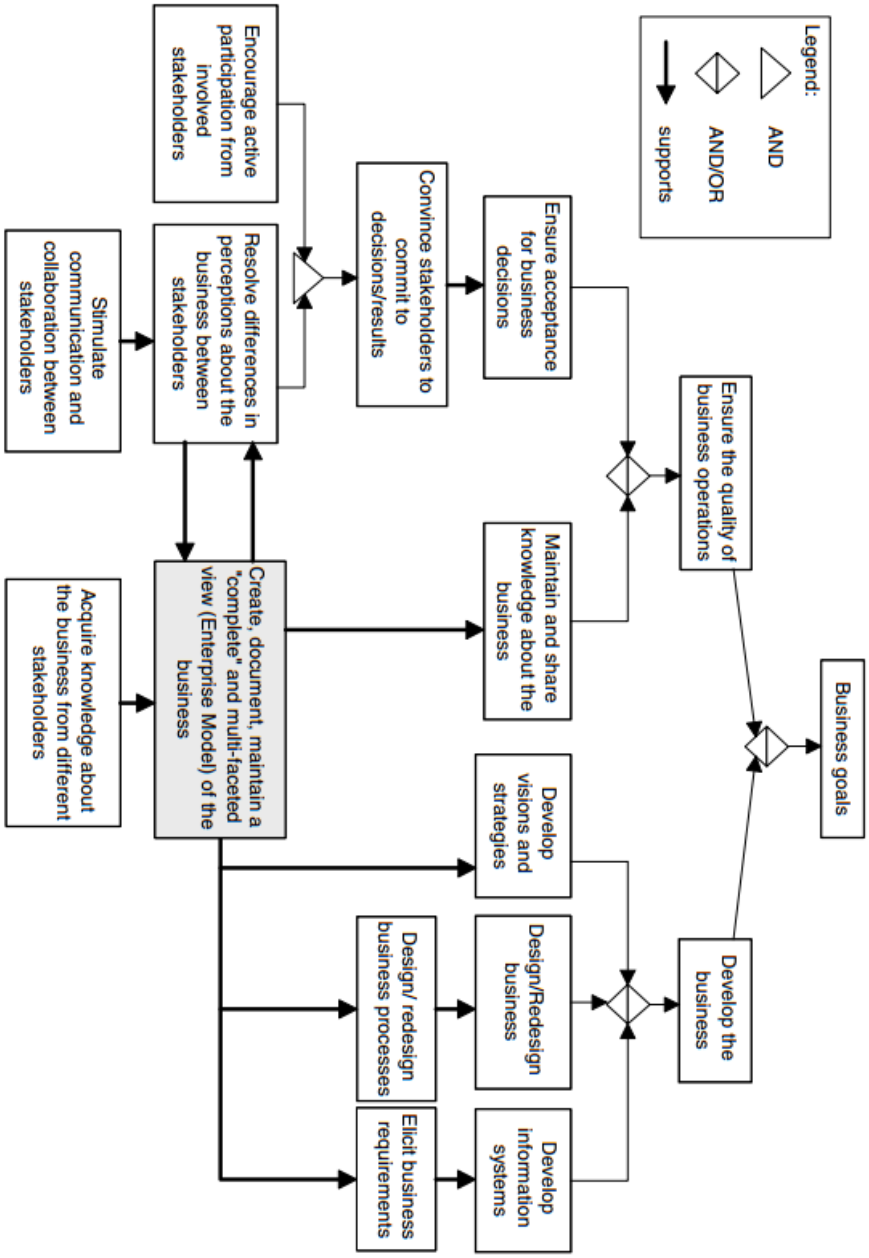


Figure 2.3: Persson and Stirna's two branches of objectives for enterprise modelling

A: The audience

The audience ***A*** denotes the users of the model, and can be comprised of individual actors, organisational actors and technical actors. The audience may change during the lifetime of the model, e.g. in an organisational setting as employees quit their jobs and new ones are hired. The audience is not shown in figure 2.2, but are indirectly represented through their knowledge ***K*** and interpretation ***I***.

L: The language extension

The language extension ***L*** is the set of all possible statements that can be made using the chosen modelling language(s).

D: The modelling domain

The modelling domain ***D*** is the set of all statements that are possible to make about the situation. There are two dimensions to a modelling domain:

1. *Temporal* - The model can represent a past, current or future (wanted or unwanted) situation

2. *Scope* - The part(s) of the world that are relevant to the model, e.g. an organisation or an information system

M: The externalised model

The model ***M*** comprises all statements about the domain made in the model. The set of all explicit statements made in the model is denoted $\mathbf{M}_E$. Statements can also be implicitly implied in the model, typically derived from logical deduction.

K: The relevant explicit knowledge of the audience

The relevant explicit knowledge ***K*** is the union of the knowledge of all participants (the audience) about the domain. The knowledge of the different participants may be different and inconsistent, and can change during the course of the modelling process as the participants' understanding develops.

I: The social audience interpretation

I is the set of all statements interpreted by relevant social actors from the externalised model ***M***. The disagreement between interpretations made by different actors can be large, and may lead to misunderstandings and faults.

T: The technical audience interpretation

The technical audience interpretation $\boldsymbol{T}$ is the set of all statements interpreted by technical actors from the externalised model $\boldsymbol{M}$.

2.3.2 Quality categories

The different types of quality will be summarised here. A thorough explanation can be found in [15].

Physical quality

Krogstie [15] lists three features that should be taken into account when discussing the physical quality of an externalised model $\boldsymbol{M}$. A model of high physical quality should be *available*, i.e. easily accessible to the intended audience, *current*, i.e. as newly created or validated as the domain requires and *persistent*, i.e. protected against loss or damage. Issues that could be discussed in relation to physical quality include e.g. search functionality, server architecture and versioning.

Empirical quality

Visual and textual choices should be made in order to promote *comprehensibility*. The quality type related to this is called *empirical*, because it takes into account means of communicating models that has been empirically shown to increase the comprehension of models. Communication consists of *encoding* and *decoding*. In relation to modelling, *encoding* means representing information in a visual form, while *decoding* means interpreting the visual representation. It is important to consider both of these processes when making design choices, to support high *comprehensibility* (empirical quality) of the model. A workflow or process model has a *visual notation*. A visual notation comprises *graphical symbols*, *compositional rules* and *semantics* that describe the meaning of symbols [21].

Shneiderman [30] notes that while many guides for designing a user interface recommend limiting the number of colours in a single display to four, the optimal usage of colour coding depend on how experienced the users are. Too many colour codes may cause confusion with novice users. One should also remember that common expectations to colour codes exist, e.g. red usually means "danger" or "stop" in western societies.

About eight percent of the male population and (less than) one percent of women experience some degree of colour blindness [30]. Also, it is likely that some people prefer printing the models on paper before using them. Not all printers will represent the colours correctly, and some might not even support colour prints. Therefore, using *only* colour to distinguish symbols with a different meaning from each other is normally a bad idea.

The 7PMG framework described in section 2.2 could also be considered at this level, as the guidelines are intended to guide the model design process.

Syntactic quality

Syntactic quality denotes how well the model $\boldsymbol{M}$ corresponds to the language extension $\boldsymbol{L}$, i.e. how many syntactical errors are present in the model. *Syntactical correctness* is the only syntactic quality characteristic, and a model is syntactically correct if there are no syntax errors in the model, i.e. all symbols are used correctly in accordance with the chosen language.

Semantic and perceived semantic quality

Semantic quality pertains to how well the model $\boldsymbol{M}$ represents the domain $\boldsymbol{D}$. Are there any invalid or missing statements needed to represent the domain correctly? However, the goal of correspondence between model and domain can not be directly measured, as a model is an abstraction, and can never fully represent every detailed aspect of the real world. Instead, what must be taken into account is the correspondence between the modelling participants' knowledge $\boldsymbol{K}$ about the domain and the audience's interpretation $\boldsymbol{I}$ of the model (*perceived* semantic quality).

Pragmatic quality

Not to be confused with empirical quality, which deals with *comprehensibility* in an objective, scientifically grounded sense, pragmatic quality deals with *comprehension*, which is how the social actors' interpretation $\boldsymbol{I}$ corresponds to the intended meaning of the model $\boldsymbol{M}$, i.e. the extent to which the model has been correctly understood by the audience.

Social quality

A model is normally used by several (often many) different actors, and each will have their own interpretation of the model. The goal of social quality is *agreement* between these interpretations.

Deontic quality

Deontic quality denotes how well the statements in the model $\boldsymbol{M}$ contribute towards achieving the goals of modelling, $\boldsymbol{G}$.

Chapter 3

Research Method

A case study has been conducted, including quantitative as well as qualitative methods. As described by Oates [26], a case study focuses on one particular instance of the subject to be investigated, studied in depth using a variety of data generation methods with the aim of getting detailed insights into the case studied. Yin [43] defines the scope of a case study as *"...an empirical inquiry that investigates a contemporary phenomenon in depth within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident"*.

Case studies are characterised by [26]:

- Emphasis on depth rather than breadth
- Natural setting
- Holistic study
- Multiple sources and methods

A case study can be either [43] [26]:

- **Exploratory:** A case study conducted as a prelude for a possible subsequent study, e.g. to see if a topic is worthy of further investigation.
- **Descriptive:** A case study with the aim of giving a detailed description of how a phenomenon occurs in a real-life context. The aim of the analysis is to tell a story.
- **Explanatory:** The objective of an explanatory case study is to explain why something occurred, and identifying factors that may have affected an outcome.

The case study reported in this thesis is mostly a combination of the latter two. While the aim has been telling a detailed story about experiences with enterprise model use in Statoil, it also investigates how different aspects of model quality can affect the use and understanding of models.

3.1 Research paradigm

The underlying philosophical paradigm influences how research is approached and evaluated. For instance, an ethnographic study can not be evaluated in the same way as an experiment, as they are each built upon a different set of *assumptions* about how we think about aspects of the world [26]. Case study research is often associated with an *interpretive* paradigm, and this is also true for the study reported in this thesis. The world-view associated with interpretivism is characterised by [26]:

- **Multiple subjective realities:** Knowledge is a construction of the mind, and no single truth exist
- **Dynamic, socially constructed meaning:** Reality can only be transmitted between individuals through the use of social mechanisms such as language and shared meanings, which are constantly changing
- **Researcher reflexivity:** Researchers must acknowledge and reflect on how their beliefs, values and actions influence the situation
- **Study of people in a natural setting:** The research takes place in a natural context, as opposed to in a laboratory or other artificial settings
- **Qualitative data analysis:** The research is mostly based on collected qualitative data
- **Multiple interpretations:** Finding one single explanation for a phenomena is not expected in interpretive research. Instead, several possible explanations are discussed

Due to its nature, interpretive research can not be evaluated in the same way as positivist research. Positivist research is the most traditional paradigm applied in natural science, underlying "The scientific method", where the world is seen as ordered and regular, and possible to investigate in an objective manner. This type of research is normally evaluated according to its *objectivity* (lack of bias and researcher influence), *reliability* (neutrality and accuracy of research instruments and repeatability of results) , *internal validity* (appropriateness of research design, quality of results) and *external validity* (generalizability of the results). Oates

[26], citing Guba [9] outlines some criteria for interpretivist research that are parallel to the criteria used for evaluating positivist research. The correspondence between these criteria is shown in table 3.1.

- **Trustworthiness:** How much trust can be put in the results?
- **Confirmability:** Is the information given about the study extensive enough to judge whether the findings are well grounded?
- **Dependability:** Is the process sufficiently documented and recorded? Tracing the whole process should be possible
- **Credibility:** Is the research carried out in a way that is likely to produce credible results? For instance, method triangulation, i.e. using more than one data generation method promotes credibility (see [26], chapter 3)
- **Transferability:** While interpretivism is not too strict about the ability of making generalisations from the results, the description of the case should be detailed enough to allow the reader to conclude whether the findings are relevant to their own situation of interest

Positivism	**Interpretivism**
Validity	Trustworthiness
Objectivity	Confirmability
Reliability	Dependability
Internal validity	Credibility
External validity	Transferability

Table 3.1: Evaluating interpretive research

3.2 Limitations of case studies

Case study research is sometimes criticised for lacking rigour and thus leading to generalisations with low credibility. There are also some practical issues that may hinder sufficient research, e.g. it can be difficult negotiating access to necessary sources, be it people, documents or other things. Gaining access to written material has not been difficult in this case, but as people in the company generally are very busy doing their day-to-day tasks, this has lead to some trouble. In case

studies as in other research strategies data generation methods, the researcher can affect the behaviour of other people during e.g. meetings, interviews and observations [26].

When conducting case study research, the choice of data generation methods is crucial to the result. Using both qualitative and quantitive methods and a wide range of sources and people from different parts of the company, each with their own perspective on things have been important to be able to see the "bigger picture" in this research. Below, the various data generation methods used are described and discussed.

3.3 Web usage data

The last couple of years, Statoil have been using Splunk Enterprise [2] for monitoring the usage of their management system. Splunk Enterprise is a platform for collecting and indexing machine-generated data. The data collected by Splunk is indexed as events, and can be searched using a query language developed by Splunk, the Search Processing Language (SPL) [5]. The results provide information about how Statoil employees use the enterprise model, e.g. about how often a certain page or model is accessed and how users navigate through the enterprise model. Throughout the quality analysis, the numbers are used for giving context.

3.4 Document study

This section describes the use of *found documents*, i.e. documents that existed prior to the research. The term "document" here refers to textual sources (documentation and descriptions), visual sources (diagrams and models) and electronic sources (systems and websites) [26].

A great deal of time has been spent on getting to know and understand the Statoil corporate management system and the associated software applications, which are further described in section 4.2, as well as important technical documents and descriptions, mainly governing documentation providing requirements and methods to modelling, as well as the intended purpose and use of the enterprise model. Other sources of information include reports, presentations and experience papers regarding the management system and/or use of modelling in Statoil, as well as charts and statistics, such as personell reports.

A summary and analysis of an internal user survey [35], conducted during the end of 2013 has been extensively consulted and referenced in the discussion of challenges facing the use of the management system. The survey results have served as a basis for further investigations, e.g. in interviews. When discussing data generation methods, this kind of data, comprising e.g. *"internal organisa-*

tional research, for example, job-satisfaction surveys and suggestion schemes", is termed *secondary data* [26].

3.5 Interviews and conversations

An *interview* differs from a "normal" conversation in that it has a set of (normally unspoken) assumptions. The discussion has been planned by the researcher, with the aim of gaining information by talking to the subject [26]. Interviews are suitable for data generation when [26]:

- detailed information is needed
- there is a need for asking open-ended, complex questions (as opposed to survey questions)
- exploring feelings or experiences is needed
- the issue to be investigated is sensitive, so that respondents are not comfortable writing about it on paper without knowing who the researcher is

The choice of including interviews in this case study is based on the first three reasons, with emphasis on the second and third. Interviews can be [26]:

- *structured*, i.e. use pre-defined, identical questions for every subject
- *semi-structured*, where the researcher has created a list of themes and questions in advance, but is willing to exclude questions, change the order to fit the flow of the conversation and ask additional questions where needed
- *unstructured*, which is more like an informal conversation where the researcher introduces themes and lets the subject decide what they want to address

Some advantages of using interviews as a data generation method include the possibility of collecting in-depth, detailed information, little need for equipment and flexibility. However, they are also time-consuming and can be unreliable. Objectivity is hard to achieve due to the researcher and context affecting the responses [26].

The interviews conducted in this research have been *semi-structured*. The interview guide is given in appendix B. The interviews were recorded using a recorder app on a digital tablet (two interviews) or cellphone (one interview), and later transcribed. Three interviews were conducted, lasting around 20 minutes each. One of the interviews was conducted using Skype, one by telephone and

one face to face. While the number of interviews was quite small, many informal conversations and meetings was had over the course of the year, discussing the management system as a whole, as well as certain aspects and particular models. Together, these interviews and conversations have helped in forming an overview of the opinions, experiences and feelings of employees in different positions and work environments regarding the enterprise model. Hence, the interviews will not be reported separately, but will be included in various discussions throughout the analysis.

3.6 Model quality experiment

An experiment has been used in this research as a strategy for investigating the effect of one quality aspect on another. The experiment design will be described in section 6.2. Experiments are often seen as the most "scientific" approach, and is the only research strategy with the ability of proving causal relationships. Experiements allow for high levels of precision when measuring outcomes. However, controlling all relevant variables is often difficult. Some measures that can be taken to control variables are e.g. eliminating factors, holding factors constant and using a random selection of subjects [26]. Common threats to validity in experiments include using too few, or non-representative participants (e.g. students do not represent the general population) or using non-representative test cases [26] (chapter 9).

Chapter 4

Description of the case

The content in this case description is based on the author's understanding of internal systems (all parts of the management system) and governing documentation, as well as conversations and discussions with users and creators of governing documentation in the management system.

4.1 The company

Statoil is a Norwegian oil company operating in 36 different countries spread throughout the world. Its largest activities are located in Norway, and the company is the largest operator on the Norwegian continental shelf. The Norwegian state is the main shareholder in Statoil with a holding of 67%. The company headquarters are located in Stavanger, and there are around 23 000 employees in total all over the world [3]. Figure 4.1 show how the permanent employees are divided between organisational units. In addition, Statoil has at all times a high number of external employees working in different areas (figure 4.2). The five largest organisational units (as of November 2014) are listed in table 4.1 [1].

4.2 The Management System

The enterprise model is realized through the Statoil management system. *The Statoil Book* [32], which is the foundation the management system is built upon, describes it as *"the set of principles, policies, processes and requirements which support our organisation in fulfilling the tasks required to achieve our goals"*. It defines how work is done within the company, and all employees are required to act according to relevant governing documentation.

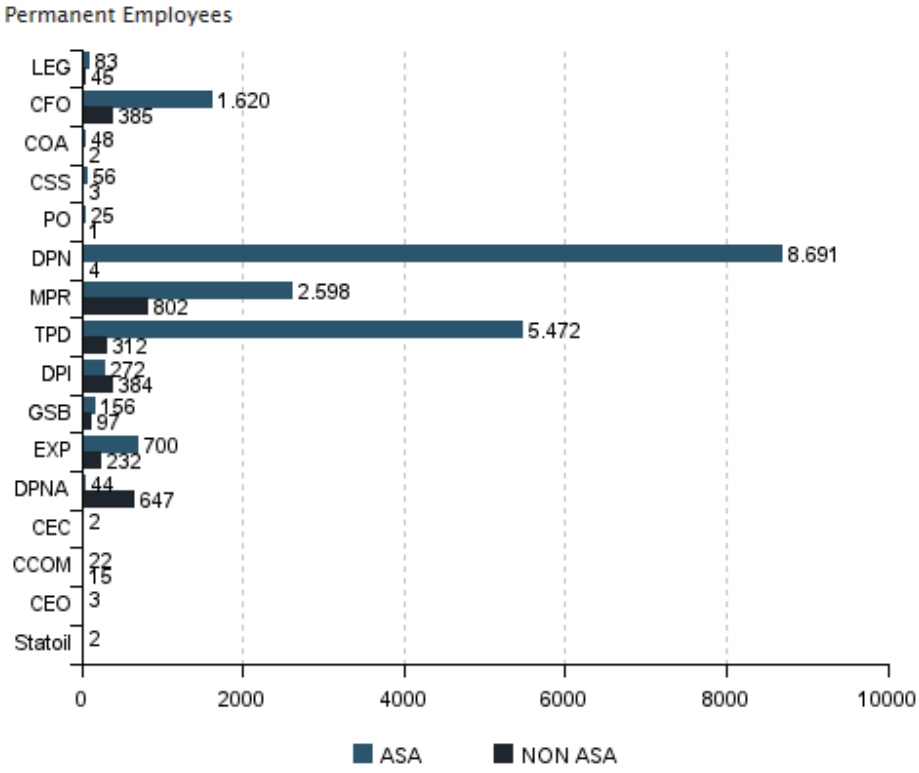


Figure 4.1: Headcount by organisation, November 2014

Unit	Permanent employees
Development and Production Norway (DPN)	8695
Technology, Projects and Drilling (TPD)	5784
Marketing, Processing and Renewable energy (MPR)	3400
Chief Financial Officer (CFO)	2005
Exploration (EXP)	932

Table 4.1: Largest organisational units

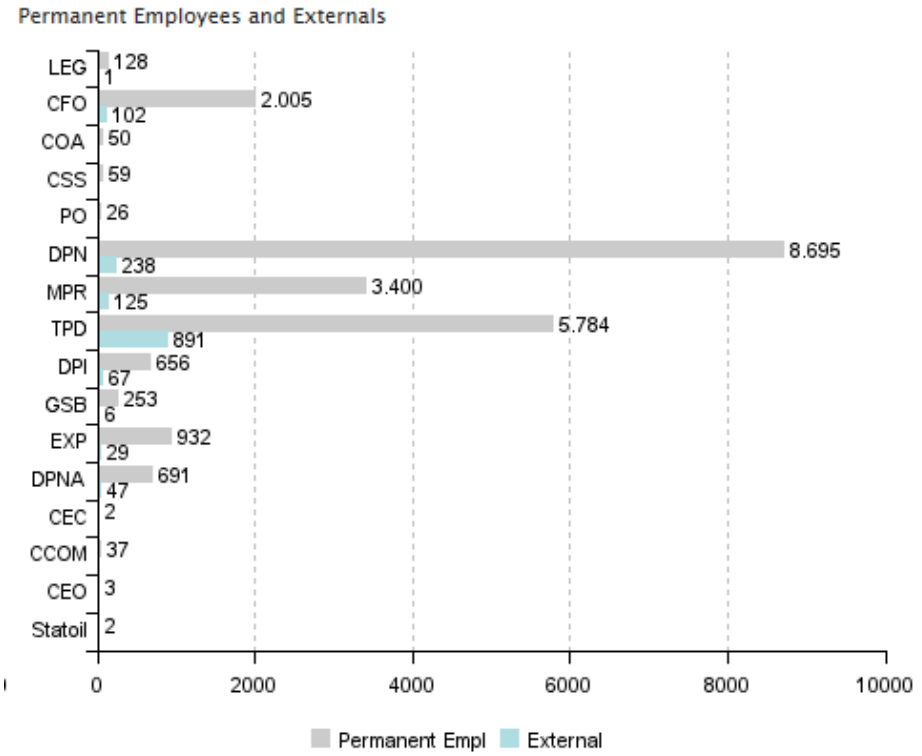


Figure 4.2: Headcount by organisation (including externals), November 2014

4.2.1 Structuring and purpose

The Management System consists of three main parts:

- **ARIS**, the IT solution from which all governing documentation is accessed by the end users.
- **Docmap**, used for handling and publishing textual governing documentation
- **Disp**, a tool which supports the process of handling applications for deviation permits in cases where compliance with a requirement is difficult or impossible to achieve.

The three main objectives of the Statoil management system are given in the Statoil Book [32] as:

1. *Contributing to safe, reliable and efficient operations and enabling compliance with external and internal requirements*
2. *Helping the company incorporating their values, people and leadership principles into everything they do*
3. *Supporting business performance through high-quality decision-making, fast and precise execution and continuous learning*

4.3 Governing documentation

Governing documentation (GD) describes what is to be achieved, how to execute tasks, and ensures standardisation. Each process area has governing documentation in the form of documents and/or process models, accessible from the ARIS start page. There are several types of governing documentation, as listed in table 4.2.

Function requirements (FR)	Describes what shall be achieved as global requirements
Work requirements (WR)	Describes requirements to work processes and how to execute tasks, as well as responsible roles
Emergency response plans (ERP)	Describes requirements to emergency response and how to execute tasks
Key controls (KC)	Gives and overview of the Key Controls for a work process
Organisation, management and control (OMC)	An overview of organisation, operating model, mandates and decision authorities
Technical and professional requirements (TR)	Describes the requirements for design of equipment, systems or functions. These documents are published in DocMap
System and operation documentation (SO)	Descriptions of systems and how to operate them.

Table 4.2: Types of governing documentation

4.4 The Management System function

The management system function is responsible for creating and improving the management system based on business needs and ensuring that the governing documentation is understood and used, as well as monitoring compliance with work requirements. The work of the function follows a five-step cycle, as shown in figure 4.3. The steps are described in the document *"FR20 Management System"* [34], as well as in workflow models.

Assess and plan changes to governing documentation

When a change or update to governing documentation is needed, a lead nominated by the owner of the governing documentation is responsible for performing a stakeholder analysis in order to identify all involved roles. A work group is established in order to perform the planning and scoping of the work to be done. The plan is then evaluated, and when agreed upon the design step can begin.

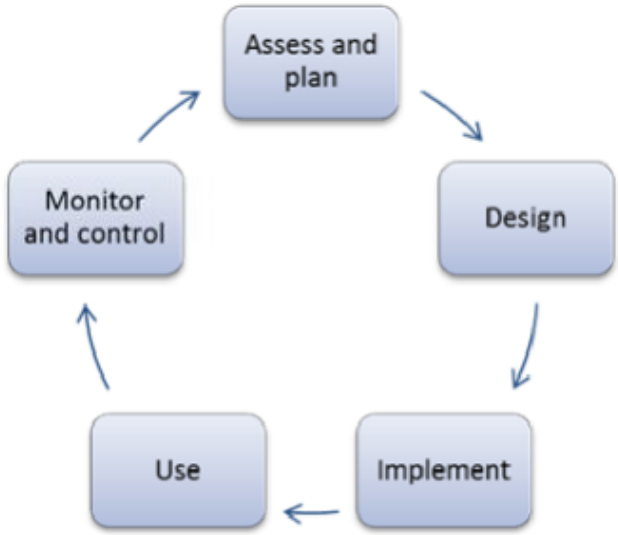


Figure 4.3: The MS function work cycle

Design governing documentation

In this step a workflow model (or governing document) is created. This work is carried out as described in a predefined workflow, and includes describing process purpose and triggers, identifying activities, checking business value, assigning roles and identifying risks.

Implement governing documentation

When the governing documentation is ready, the implementation is planned and executed. The local process manager acts as a facilitator, the scope of the implementation is assessed and a plan for the implementation is established. The local process manager then performs the activities needed in order to prepare for the implementation of the new governing documentation in his area. If needed, training of employees is prepared and conducted. When ready, he sends his confirmation to the lead of the implementation planning, who passes the confirmation on to the owner of the governing documentation. The GD is then ready for publishing at an appropriate time.

Use governing documentation

Governing documentation is intended to be used by its target group according to purpose and validity. Employees can apply for a permission to deviate from a requirement in the governing documentation. When such an application is registered, an initial consideration is performed, where comments and advise are given by the line manager and local process manager, and relevant contributors propose further actions. If the application is submitted, a professional decision is made by the process owner. Depending on this decision, the application is then either submitted for implementation approval or terminated. The line manager can reject or approve the implementation. Information on the result is then sent to the applicant, and if approved, the deviation permit is ready for use.

Monitor and control

The purpose of monitoring governing documentation is reducing risk, driving performance and ensuring compliance. Monitoring can be carried out by internal or external parties. Activities performed in internal monitoring activities include [32]:

- **Follow-up:** Ensuring that strategies and tasks are executed according to plan
- **Verification:** Confirming through objective evidence that work has been done in compliance with requirements
- **Internal audit:** Evaluating and improving the effectiveness of performance with formal mandate from the board of directors, e.g. assuring that projects are properly organised and managed

4.5 The Enterprise Model

The enterprise model is created according to a set of rules for structuring and notation, and can be used for a variety of purposes, such as compliance management, competence management, portfolio management, decision making and performance analysis. There are three levels of abstraction in the enterprise model: The *contextual level*, the *conceptual level* and the *logical level*. When designing diagrams in the enterprise model, requirements in "TR0002 - *Enterprise structure and standard notation*" shall be met [33].

4.5.1 The Contextual Level

The contextual level consists of a top level diagram and navigation diagrams, and gives a high-level overview of the enterprise.

Top level diagram

The top level diagram is mandatory, and contains a model of the enterprise in terms of process areas and function areas. The management system start page, shown in figure 4.4 is a top level diagram.

Navigation diagram

The navigation diagrams are optional, and the purpose of these diagrams is to help the user navigate to the correct model by structuring and detailing the content within a process area. The navigation diagram can contain symbols representing closed content groups, document model groups and document models. A stippled rectangle can be used to group a set of closed content groups. An example of a navigation diagram is given in figure 4.5.

4.5.2 The Conceptual Level

The conceptual level gives a conceptual view of the enterprise as model diagrams and process navigation diagrams, and the main purpose of this level is to show relationships between or within models.

Model diagram

The model diagram, as shown in figure 4.6 is a mandatory diagram that shows the content of a closed content group or a process area. It may contain collapsed workflow models, process models and document models. A rectangle can be used to group a set of collapsed process models. For quicker navigation, collapsed workflow diagrams can be placed inside a collapsed process model symbol.

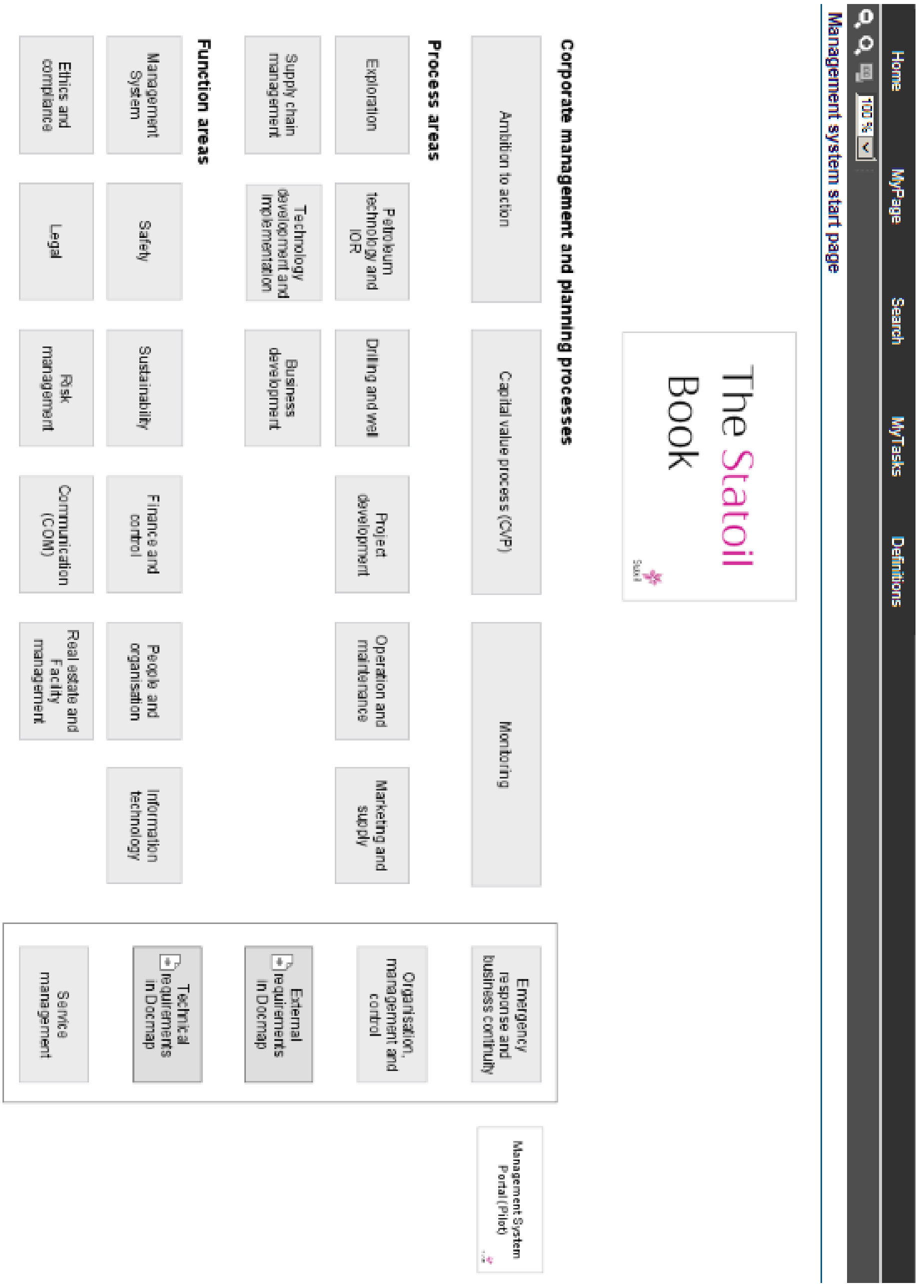


Figure 4.4: Top level diagram

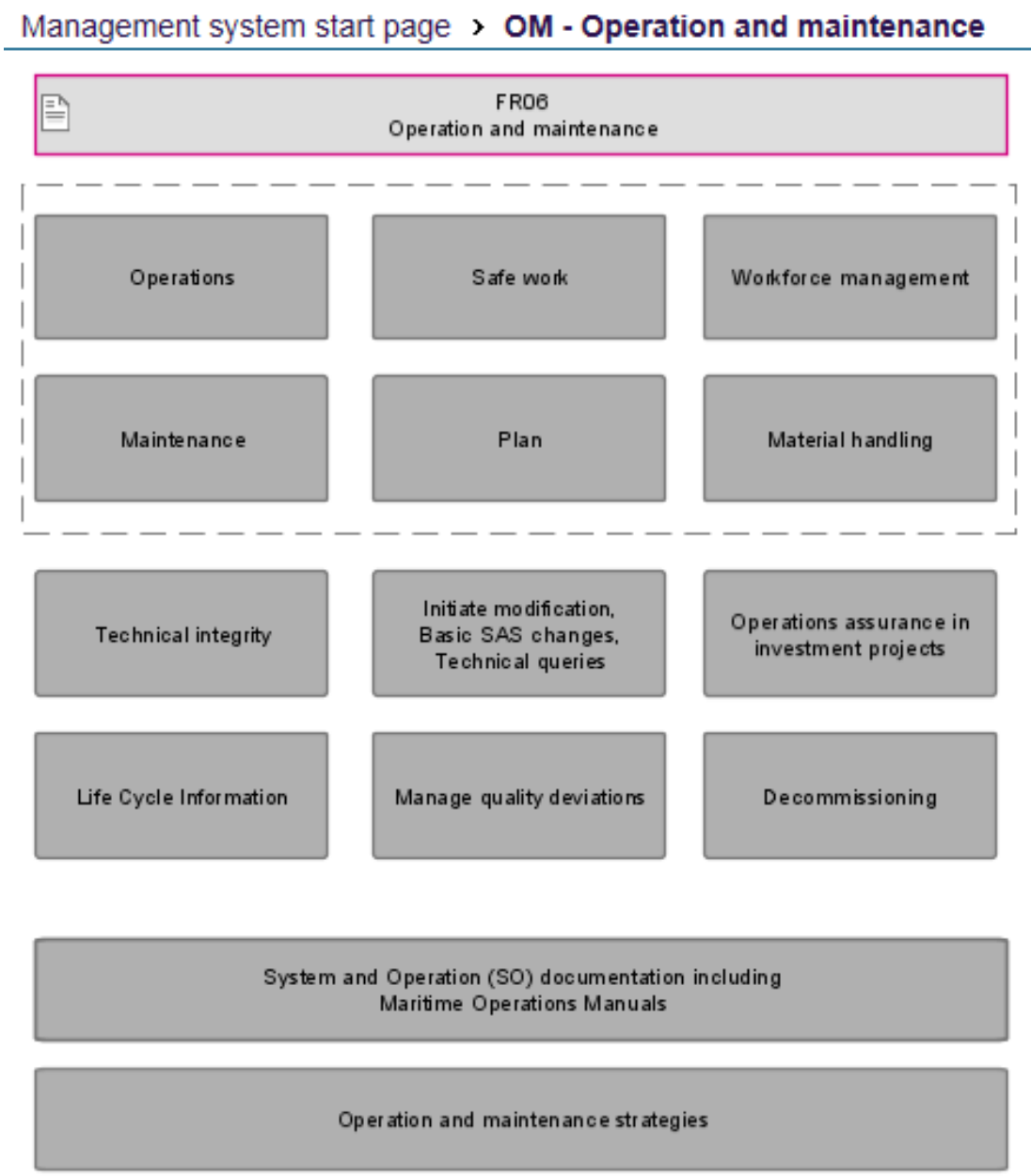


Figure 4.5: Navigation diagram

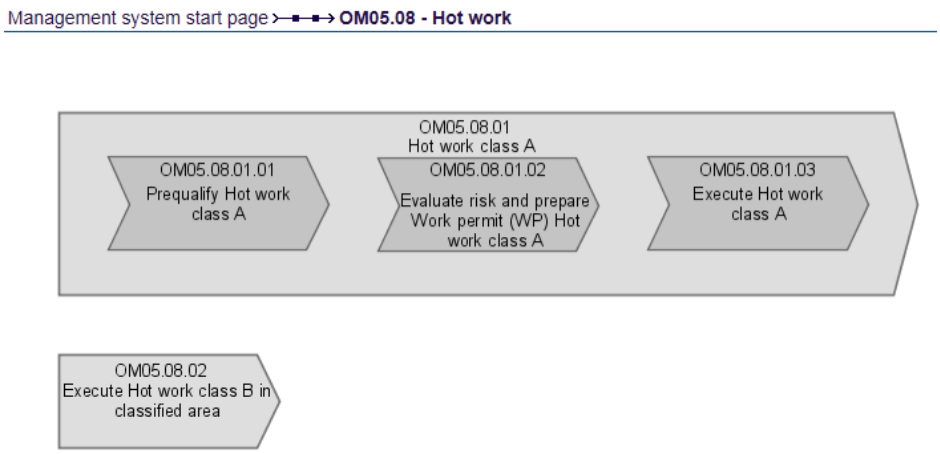


Figure 4.6: Model diagram

Process navigation diagram

The process navigation diagram (figure 4.7) is optional. It is used to show how workflow models are related to each other, and makes use of collapsed workflow models, start events, end events and intermediate events. A sequence flow in the form of an arrow visualises the order in which the workflow models shall be executed.

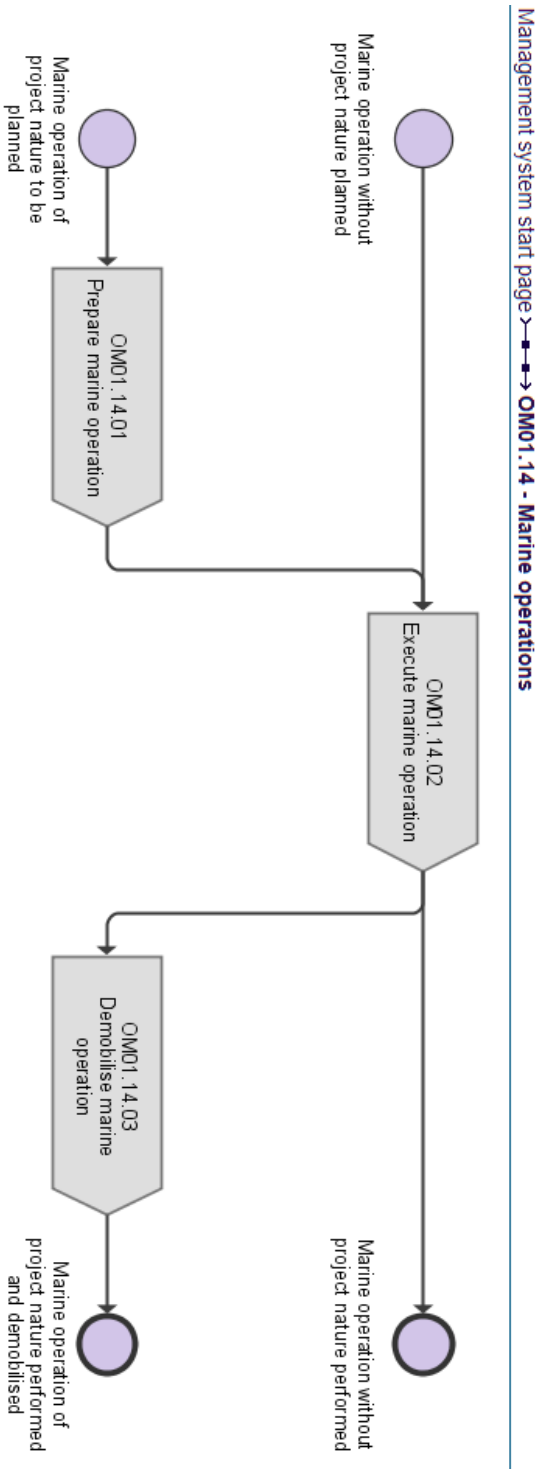


Figure 4.7: Process navigation diagram

4.5.3 The Logical Level

The logical level shows the breakdown of the enterprise model into generic elements. The only diagram visualising the logical level of the enterprise model is the workflow diagram.

Workflow diagram

The workflow diagram is a mandatory diagram, modelled using an adapted subset of BPMN 2.0[1], with several activities and possibly decision gateways arranged in a sequence within lanes representing the process role responsible for the activities. The activities are carried out by an actor representing the process role. An overview of possible symbols in a workflow model is given in Appendix A. An activity is represented by a task symbol, and can be mandatory or optional. A task symbol with a stippled line is used to represent a collaboration activity. The diagram can also contain collapsed sub-processes which lead to another workflow diagram detailing the sub-process, or call task symbols representing a reference to a workflow model in a different process model. The workflow diagram also contains start and end events and different types of gateways. An example of a small workflow diagram is given in figure 4.8.

4.5.4 Navigation

There are several ways for users to access governing documentation.

Navigating through process areas

When accessing the ARIS start page, the user gets an overview of all process areas. He/she can click on a process area to get an overview of the content belonging to this process area. From here, work processes, documents, workflow models and other relevant information can be accessed.

Using the navigation history

The user has the opportunity of accessing their navigation history from anywhere in ARIS using the dropdown menu in the upper right corner. This menu displays previously visited pages in the management system.

Using "breadcrumbs"

From all levels in the hierarchy except for the top level, users can navigate to the above levels using the "breadcrumbs" at the top of the page, as shown in figure

[1] Business Process Modelling Notation, see e.g. [31]

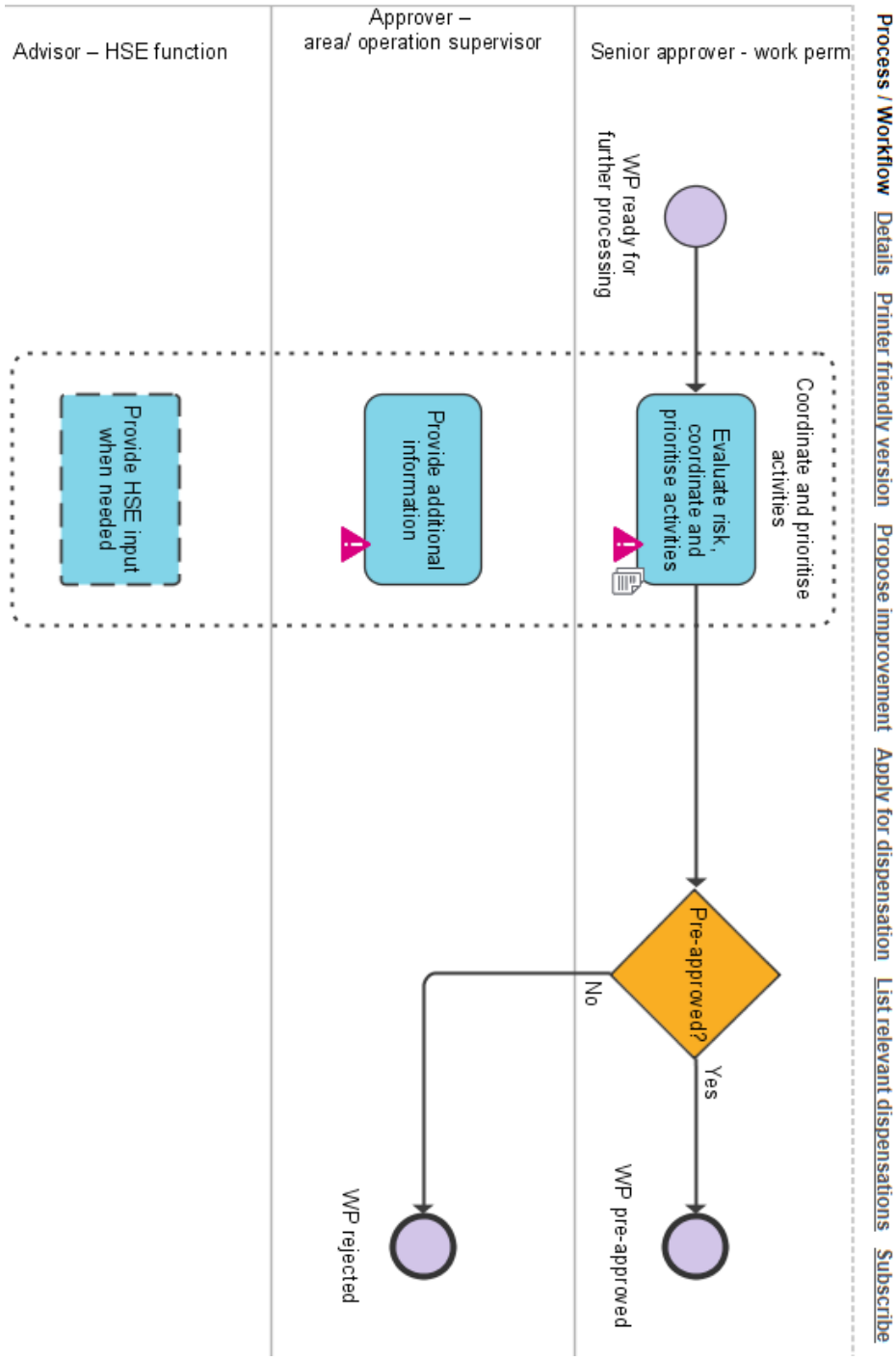


Figure 4.8: Workflow diagram

4.9. The breadcrumbs also help users keep track of where they currently are in the process hierarchy.

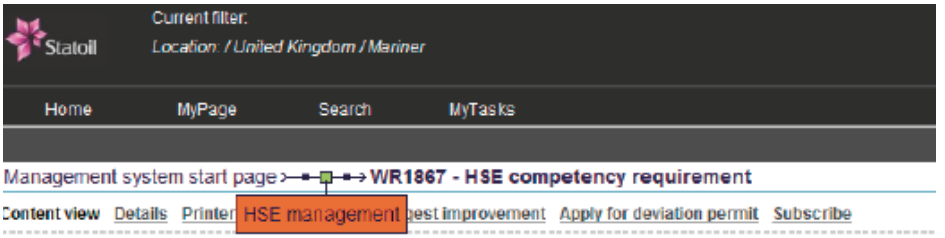


Figure 4.9: Navigational breadcrumbs

Searching

ARIS search is a simple search interface where the user can input search words in a text field, and choose the type of governing documentation they are looking for using a drop-down menu. The results appears as a list of full or partial hits which is dynamically updated as the user types.

Using "MyPage"

Each user has a personal space called "MyPage", accessible from the menu at the top left of each page. From a workflow model page, users can click the "Subscribe" tab, and confirm that they want to subscribe to this particular model. A direct link to the model will after a short while be available in their "MyPage", in the "Subscriptions" section.

4.6 The Management System user survey

During the end of 2013 and the beginning of 2014, a large-scale user survey [35] was conducted in Statoil in order to better understand users' experiences and opinions related to the management system and governing documentation. A similar survey was also conducted in 2012, and on some levels they were therefore able to measure improvements. 4828 employees took part in the survey, which equals to about half of those invited. The survey was designed with a basis in the model reflected in figure 4.10. Many challenges were identified from the survey, related to the management system itself, learning processes and work practice, all of which contribute in some way to the management system goals of safety, reliability and efficiency (relative to objective 1 described in section 4.2). The

survey is seen as very useful, due to the large amount of quantitative data as well as the amount of detailed feedback given by the participants. Statoil is using the survey results as a basis when planning and implementing changes this year, and will use a similar survey next year to hopefully be able to see a measurable improvement. Many of the issues discovered can be connected to model quality, and below the most important findings are summarised and aligned with various levels of SEQUAL.

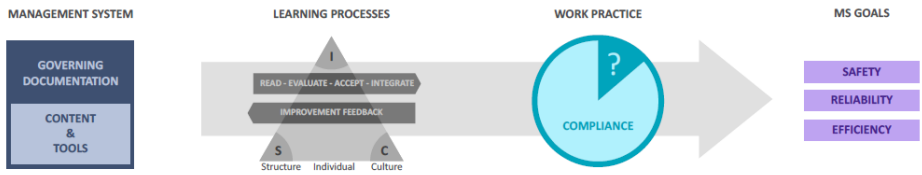


Figure 4.10: The underlying model for the user survey

4.6.1 Physical quality

The survey showed that a significant number of employees have trouble finding what they need when they look for governing documentation. Moreover, when they do find the relevant documentation, more than half of the respondents are unsure that they have found *all* relevant documentation. Some describe ARIS as a "maze", in which it is hard to keep track of where the displayed page is situated in the hierarchy. According to the respondents, the search function often does not produce the desired result. Familiarity with "MyPage" is low. Many are not satisfied with the way changes to GD affecting their work are communicated, which makes it difficult to know if the information they possess is sufficiently current. Employees are not aware of the possibility for staying updated on changes, and when they do, they experience that the reasoning behind the changes are not clearly communicated. As many as 14% of the respondents report using paper copies to access GD, so unless employees are clearly notified of changes they might keep using old versions.

4.6.2 Empirical quality

Users feel that governing documentation suffer from lack of clarity, and 42% of the survey respondents often do not understand abbreviations used in text and models.

4.6.3 Semantic quality

The possibility for users with hands-on experience with the process at hand to add improvement suggestions could improve the semantic quality of workflow models, as it could impose a greater correspondence between model and domain. However, the process of handling improvement proposals appear to be too slow and inconsistent, as most users experience waiting a long time to get feedback on their suggestions, and often the reasoning behind the outcome is not clear. Almost half of the respondents have experienced not receiving any feedback at all. This could lead to lack of motivation for posting suggestions in the first place, even though they might be needed. In addition, even though 68% feel that governing documentation has the right amount of detail, it is also often seen as too rigid and general to account for local needs and variations, which leads to a lot of deviations as the models do not fit the domain properly. 17% of survey respondents report often seeing gaps between what is described in GD and what is being done in practice.

4.6.4 Pragmatic and social quality

The survey uncovered challenges regarding understanding and processing. About half of the respondents feel that governing documentation is easy to understand. By others, governing documentation is perceived as vague and ambiguous, especially when it comes to authorities and responsibilities. This ambiguouity often causes interpretations by different users to differ from each other. One in five of the respondents often or always experience this within their department or unit.

A good support system for learning could improve users' understanding of the models and the system in general, but only 44% report being satisfied with the support they are given. About half of the respondents have participated in organised training related to use of GD. These have a higher score for confidence in, use of and compliance with GD than the ones who have not participated in a training program. The survey showed that good leadership support has a strong positive effect on use, but in general, leaders do not sufficiently encourage better use of governing documentation, and are often not able to answer questions related to the management system that they receive from their employees.

4.6.5 Deontic quality

Considering how governing documentation contribute to the goals of the management system, the results from the survey indicate that it contributes a lot to high safety (75% of respondents) and moderately to high reliability, but not to high efficiency (37%). One in five of the respondents feel that safety and efficiency is not properly balanced. Reasons for this imbalance are given as:

- GD is too focused on safety, and this slows down execution of tasks
- Requirements are too rigid and complying with them is time-consuming
- Low userfriendliness. GD can be hard to find
- Differing interpretations lead to time-consuming discussions
- Local best practice is not always reflected in GD
- Lack of cost awareness
- Competitiveness is not addressed, the emphasis is put on meeting formal requirements

Chapter 5

Use of the enterprise model

This chapter presents quantitative data on user behaviour collected using the Splunk tool [2]. Queries were executed to investigate the existing variations in and patterns of use.

5.1 Variations in use

In this section, the discovered main variations in use will be described. Knowing who the users *really* are, and which parts of the system they mostly use is of critical importance when designing and maintaining information systems.

5.1.1 Process area

According to the user survey [35], *Operation and maintenance* is the management system process area that is used most frequently. This is confirmed by results collected from Splunk [1] , visualised in figure 5.1 and table 5.1, which show that this process area is by far the most used. The number of navigational elemts and levels in ARIS vary greatly from process area to process area. Hence, if all clicks were to be included in the search, the process areas with many navigational pages would seem to have a very high usage. Because of this, only clicks on workflow models on the bottom level were included in the search. The search also excludes events that lack the *processArea* field, which means that the calculated percentage for each process area is the percentage of the total number of events that do contain the field. The query performed was

[1] numbers collected October 17, 2014

```
sourcetype="modelAccess*" type="Workflow model" processArea=*
| top 10 processArea
```

Process area	**Percentage**
Operation and maintenance	44,0
Project development	15,7
Supply chain management	11,0
Safety	8,5
Drilling and well	6,8
Petroleum technology and IOR	2,8
Management system	2,1
Exploration	1,7
People and organisation	1,6
Marketing and supply	1,5

Table 5.1: Use by process area

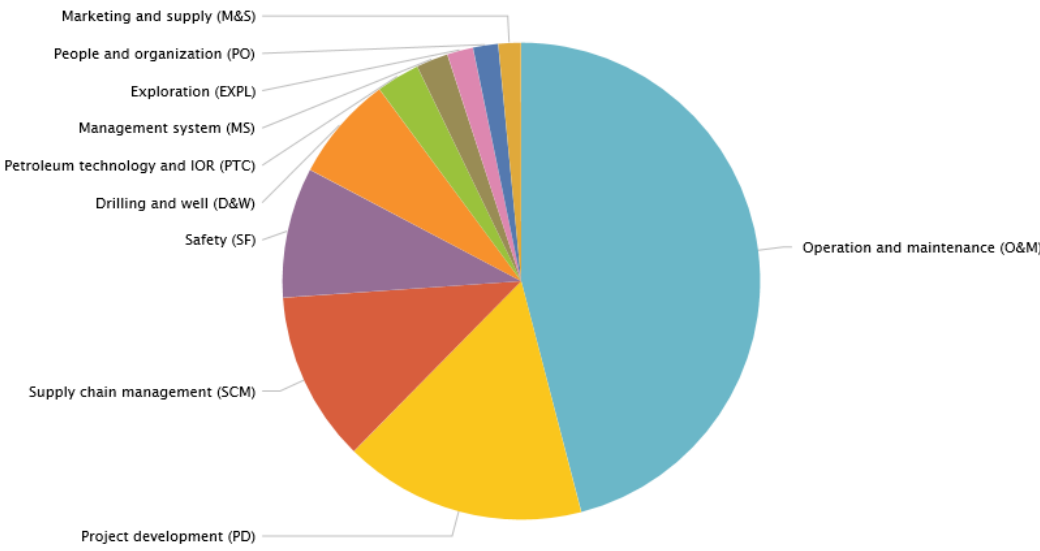


Figure 5.1: The most frequently used process area

5.1.2 Workflow models

Table 5.2 lists the ten most frequently used workflow models [2]. Out of the 20 most used workflow models, 13 belong to the *Operation and maintenance* process area. 12 out of the 20 models represent safety critical processes, i.e. they are either classified as *Safe work* (a sub-category of *Operation and Maintenance*) or belong to the *Safety* process area. The search performed was:

```
sourcetype="modelAccess*" type="Workflow model"
| chart dc(userId), count(modelName) by modelName
| sort -count(modelName)
| head 10
```

Workflow model	**Count**	**Distinct users**	**Hits per user**
Prepare isolation plan	34 580	4 054	8,5
Apply for and evaluate work permit (WP)	24 471	4 145	5,9
Initiate modification	22 975	2 342	9,8
Perform work at height	20 041	3 953	5,1
Commissioning and handover of systems	18 285	2 308	7,9
Checklist for safe work	16 349	3 572	4,6
Safety incident	15 649	1 628	9,6
Prepare for activity that weakens safety system	15 340	3 438	
Execute mechanical completion	13 560	1 993	4,5
Perform bolt tightening	13 013	2 076	6,3

Table 5.2: Top 10 workflow models

[2] numbers collected October 20th - 2014

In addition to looking at the total usage of a workflow model, it is interesting to take a look at how many distinct users a model has. Some of the models on the top 10 list have a relatively small amount of hits per user, while others have fewer distinct users and hence more hits per user. There are many factors to consider, e.g. how often do the work process occur in real life? Is the model complicated, so that the user will have to look at it every time he/she performs the task, or is the model very simple and easily remembered? Is the process safety critical? Table 5.3 lists the workflow models that have the highest number of average hits per user, generated from the search:

```
sourcetype="modelAccess*" type="Workflow model"
| chart eval(count(modelName)/dc(userId))
as ratio, count(modelName) by modelName
| sort -ratio
| head 5
```

Workflow model	**Total hits**	**Hits per user**
Prequalify potential tenderers	9 886	16,4
Perform trade	1 473	13,8
Prepare - Subsea Operations - Handling of Equipment and tools	1 972	12,8
Prepare specific strategy	9 294	11,8
Complete - Subsea Operations - Handling of Equipment and tools	1 151	11,0

Table 5.3: Average hits per user

5.1.3 Organisational unit

Figure 5.2 visualises how workflow model hits are divided between the top ten organisational units [3]. The details are given in table 5.4. These results were collected using a simple search:

```
sourcetype=modelAccess type="Workflow model org=*
| top 10 org
```

Please note that the search only includes clicks on models of type "Workflow model", and not all clicks in the management system. It also excludes all events that do not contain an "org" field, but this is a minority. Table 5.4 lists the total number of clicks for each organisational unit, as well as the average number of clicks per user (this was only calculated for organisational units with more than a thousand clicks in total). As shown in the table, DPN is the organisation responsible for the largest number of workflow hits. However, DPN does not have the highest number of average hits per employee, both COA and CSS both have a much higher number, i.e. 186,8 and 138, respectively. This is easily explained, as one of COA's main responsibilities is to evaluate and improve the effectiveness of the management system. As for CSS, this unit contains a sub-unit CSS CMS (Corporate Management System) which is responsible for the corporate function related to the management system. Hence, employees in these units work directly with the management system, but do not really represent the end users of the management system.

[3] numbers collected October 17th - 2014

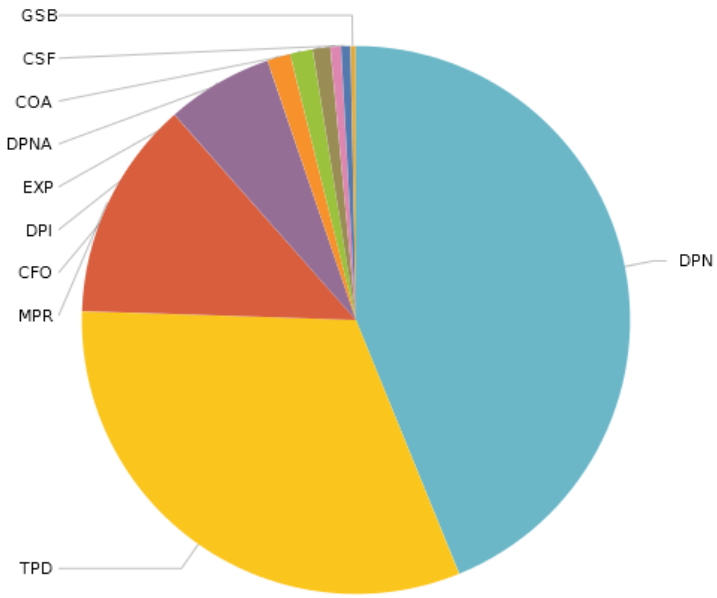


Figure 5.2: Top 10 organisational units

Organisation	**Workflow hits**	**Percentage of hits**	**Employees (permanent and external)**	**Hits per employee**
Development and Production Norway (DPN)	653 791	44,8	8 954	73
Technology, Projects and Drilling (TPD)	471 055	32,27	6 778	69,5
Marketing, Processing and Renewable energy (MPR)	193 160	13,23	3 536	54,6
Chief Financial Officer (CFO)	93 552	6,41	2 124	44
Development and Production International (DPI)	20 500	1,40	736	27,9
Exploration (EXP)	19 778	1,36	969	20,4
Development and Production North America (DPNA)	15 577	1,07	757	20,6
Corporate Audit (COA)	9 152	0,63	49	186,8
Corporate Security and Safety (CSS)	8 277	0,57	60	138
Global Strategy and Business development (GSB)	4 668	0,32	262	17,8

Table 5.4: Workflow hits per organisational unit

5.2 Clickstream analysis

In order to understand how users normally access the workflow models in ARIS, a simple clickstream analysis was performed, identifying the most frequent paths taken to access selected workflow models. The web log data collected by the Splunk tool was utilized for this purpose. A full statistical analysis of frequent paths is beyond the scope of this work, and therefore the frequent path analysis

is only carried out for a limited number of workflow models. The results are provided as a background for discussing and reasoning about the various possible ways of accessing workflow models.

According to Markov and Larose [19] (chapter 7), raw web log data must go through preprocessing before it can be properly analyzed. More specifically, this preprocessing includes:

- *Cleaning up the data*, i.e. removing automatic page requests not made by the user (e.g. requests for graphic files).
- *Getting rid of non-human access behaviour*, i.e. requests made by spiders and web crawlers.
- *Identifying distinct users* by combining IP address with other available information such as cookies and registration information.
- *Identifying user sessions*, i.e. the collection of viewed pages in a visit, as well as duration and order of the views.
- *Performing path completion*, by "filling in the gaps" in the log when the user clicks the "back" button. This requires knowledge about the site topology.

Most of these steps had at the time of analysis already been performed by Statoil using Splunk, and the only step remaining was the identification of user sessions. Markov and Larose [19] suggest the following procedure for session identification:

1. For each distinct user, assign a unique session ID
2. Define the timeout threshold t
3. For each user, do:
   (a) Calculate the time different between two consecutive log entries
   (b) If the difference exceeds t, assign a new session ID to the later entry
4. Sort the entries by session ID

This procedure was carried out using the Search Processing Language (SPL) in Splunk. Log entries were grouped according to their **userId** field using the **transaction** command, and the timeout threshold was set using **maxpause**. Since the desired result of the analysis in this case was an indication of how easily users are able to find the models they are looking for, a rather small timeout threshold was used. In most cases, users will be able to conclude whether they have found the model they are looking for within two minutes.

After grouping all log entries into distinct sessions (transactions), the relevant sessions could be extracted by adding additional search criteria to the query. The resulting SPL query was:

```
sourcetype=modelAccess*
| dedup userId name dt
| transaction mvlist=t userId maxpause=120s
| where mvindex(id, -1) == "X"
| table id
```

where the variable X was replaced with the ID of the desired workflow model. When the search job was finished, a CSV-file containing the groups of page IDs from each of the resulting sessions was exported.

It was tested and found that in ARIS, the pages are structured in such a way that e.g. clicking on the "details" tab on a workflow model page will lead to a new log entry with the same page ID. A small Java program was created, taking the CSV-file as input and removing such consecutive duplicate entries, creating a set of all actual paths taken by users to access the page specified in the search query. Clicks on the management system start page at the beginning of a path were also removed from the data set before counting, since it lead to two variants of most paths: one *with* the start page at the beginning and one *without*. The only real difference between these two variants is how long ago the user opened ARIS in their browser, hence it made sense to count these two variants as identical paths. The program then went though all of the distinct paths to count the most frequent. As an example, table 5.5 displays the path analysis results for the most frequently used workflow model, "Prepare isolation plan".

Investigation of these paths in ARIS shows that the most common path corresponds to navigating from the start page and directly down through all layers above the model page. This indicates that 38,8% know exactly what they are looking for and where to find it. The fact that so many go directly to the model via the navigational pages is not surprising, considering that this model is the most used workflow model. Most of the users probably use it frequently, and have learnt where it is located. Despite the fact that they use it often, they are not using "My Page" or bookmarks to access it directly. However, 15,1% do either this or access the model through the search function, as the second most popular path contains only one click - to the model itself. The fifth most common path found is the only one in the top five that implies that the user looks for the model in different places before locating it.

Page id	**Page name**	%
1152921521786755257 1152921521786758009 1152921526083331127 1152921526082717650	Operation and maintenance Safe Work Normally pressurised system and equipment Prepare isolation plan	38,8
1152921526082717650	Prepare isolation plan	15,1
1152921526083331127 1152921526082717650	Normally pressurised system and equipment Prepare isolation plan	4,7
1152921693585477626 1152921526082717650	Plan, set and reset isolation Prepare isolation plan	3,9
1152921521786755257 1152921521786756078 1152921521786755257 1152921521786758009 1152921526083331127 1152921526082717650	Operation and maintenance Operations Operation and maintenance Safe Work Normally pressurised system and equipment Prepare isolation plan	2,3

Table 5.5: Most common paths taken to reach model "Prepare isolation plan"

Page id	**Page name**	**%**
1152921526083068184	Chemical management	42,4
1152921521786754313 1152921526083244774 1152921526083068184	Safety Health and working environment Chemical management	14,4
1152921526081894862 1152921526082881853 1152921526083068184	Sustainability Environmental management Chemical management	5,5
1152921521786754313 1152921526082881853 1152921526083068184	Safety Environmental management Chemical management	2,8
1152921521786755257 1152921521786758009 1152921526082922702 1152921526083068184	Operation and maintenance Safe work Hazardous material Chemical management	1,9

Table 5.6: Most common paths taken to reach model "Chemical management"

Workflow model	**Number of hits**	**Direct accesses**
Prepare isolation plan	11 753	15,1 %
Initiate modification	6 721	31,2 %
Apply for and evaluate work permit	6 555	15,6%
Chemical management	2 096	42,4 %
Prepare specific strategy	1 885	25,9 %

Table 5.7: Proportion of workflow models that are directly accessed

While 11 753 sessions were found that ended with a view of "Prepare isolation plan", only 2 096 ended on "Chemical management". The most common paths to reach the workflow model "Chemical management" are given in table 5.6. Comparing the sessions for these two workflow models, the most prominent difference is the amount of users who go directly to the workflow model page. As

many as 42,4% go directly to "Chemical management", while only 15,1% access "Prepare isolation plan" in the same way. Table 5.7 shows that the amount of sessions where the workflow model is accessed directly varies a lot from model to model. There are many possible explanations for this. One likely explanation is that the awareness of "MyPage" functionality might be higher in one part of the organisation than in another. Whether the placement of the model in the hierarchy is reasonable is another. Users probably use the search function in cases where they feel that it is not easy to locate the model through the use of intuition and knowledge about the process area. These are all aspects that could be interesting to take a closer look at in future work.

Chapter 6

Model quality in Statoil

In this section, the SEQUAL framework is used as a basis for evaluating the quality of the enterprise model. The evaluation is mainly based on the following:

1. How the quality types are addressed and accounted for in TR0002 [33]

2. Issues identified through semi-structured interviews, informal conversations and other sources

3. Observations and analysis of models and other objects in the management system

TR0002 [33] explicitly states that the quality of any governing documentation is a combination of *semantic* and *syntactic* quality. However, most of the quality layers are addressed implicitly in requirements and guidelines. Some of the aspects addressed here are also described in an experience paper written in relation to this case study and presented at PoEM 2014 [1] earlier this year [11]. While the paper also focused on the evolution of quality guidelines from previous versions of TR0002 up to the current version, this report is mainly focused on the current version, as well as an upcoming version which will be discussed in a later section.

[1] 7th IFIP WG 8.1 working conference on the Practice of Enterprise Modelling, www.poem2014.org

6.1 Assessing the quality of process models in Statoil

Before addressing the different quality dimensions, the various sets included in SEQUAL must be specialized in terms of the Statoil enterprise model:

- **G, the goals of modelling**: The main (most important) goal of modelling in Statoil is compliance management. Other purposes include competence management, portfolio management, decision making and performance analysis
- **A, the target audience**: The models are meant to be used by all Statoil employees who need to comply with requirements in their daily work. The models are also used for reference by external contractors
- **L, the modelling language**: An adapted subset of BPMN 2.0 is used for workflow models. Additional objects are used for modelling e.g. organisational aspects, systems and documents. All language requirements are described in TR0002 [33].
- **D, the modelling domain**: The modelling domain encompasses all work processes performed in Statoil where compliance with requirements is necessary, both offshore and onshore.
- **M, the externalised model**: Although the entire enterprise model will be of importance when looking at some of the quality dimensions, the workflow models on the bottom level are of particular interest, as the higher levels are mostly used for navigation.
- **K, the relevant explicit knowledge**: The knowledge different actors throughout the organisation possess about the relevant work processes in the domain
- **I, the social actor interpretation**: The way social actors in the target audience, e.g. Statoil employees and externals interpret and understand the models
- **T, the technical actor interpretation**: The tool currently used for modelling in Statoil is ARIS

6.1.1 Physical quality

As described in section 2.3.2, physical quality deals with availability, currency and persistence, i.e. the model should be available to all relevant actors (and not others) at any time, up to date and safely stored.

Availability

The content in ARIS is stored on a central server system, and accessible for Statoil employees through a corporate web portal. Access to ARIS is restricted, hence the content is readily available only to individuals who possess a Statoil username and password. Thus, in theory, it is available for all relevant actors at all times. However, high availability also require that users actually can find what they are looking for, hence a well-functioning search function is crucial. The current version of ARIS search returns quite unstructured results, and is quite dependent on correct spelling. An employee interviewed feels that the current search functionality is not sufficient (all interview quotes are translated from Norwegian):

"Poor search functionality. [...] You have to be extremely specific on the syntax if you are to find what you are looking for. It is like, upper-case or lower-case letters, it is unbelievably bad"

Persistence

The system uses a load-balanced set-up with three front-end servers, in order to avoid downtime. Both servers and application are monitored. If all three front-end servers goes down at the same time, the application goes down, but this rarely happens, and according to people working with it, the system has an overall uptime of 99%.

Currency

The enterprise model is subject to periodic releases, normally four times a year at predefined deadlines. The releases are represented by the "implement" step shown in figure 4.3. The enterprise model is available to employees all over the world at any time. All governing documentation is required to contain information about validity area, a version number and changes from the previous version. The "details" tab on each workflow model page provides access to this information, so that all users can be aware of when the model or associated requirements were last updated. There are two validity types:

1. **Location,** based on geography
2. **Organization,** based on business area

Only one type of validity can be set, i.e. if organisation validity is set, the location validity remains unspecified and vice versa. In ARIS, the user can choose to set a location filter based on their current workplace so that only information

relevant to their area is shown as active. As of today, doing this does not restructure the elements in any way to make navigation easier, it merely marks the irrelevant information as "not valid". Figure 6.1 shows the model diagram for "OM05.08 - Hot work" with location filter set to *Johan Sverdrup*. Even though all of the elements in this model diagram are invalid, the navigational diagram on the above level did not show the "Hot Work" object as invalid, and so the user might visit the model diagram page in search of information before realizing that it does not apply to their area. Statoil are already in the process of making changes to the management system to mitigate these challenges, which may help to increase the overall physical quality of the enterprise model. We will take a closer look at some of these initiatives in section 7.2.4.

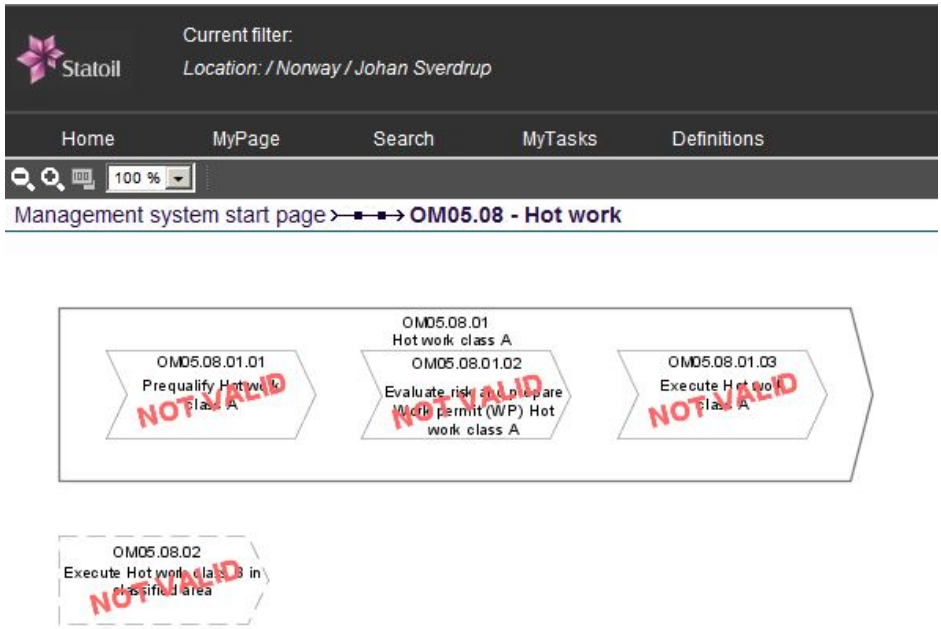


Figure 6.1: Location filter

Another important aspect of currency is *versioning*. TR0002 [33] states that each model shall have only one valid and published version, and it must be properly versioned. Two types of updates are defined: *regular* and *minor*. For a minor update, 0.1 should be added to the previous version number, e.g. 3.9 becomes 3.10. If the update is defined as regular, the integral part of the number is increased by one, e.g. 3.2 becomes 4.0. Earlier versions of technical requirement documents are easily accessible through DocMap, but earlier versions of workflow models are not readily available. All versions are kept though, and users can access them by making a request so that back-office personell can fetch them.

6.1.2 Empirical quality

Empirical quality deals with the *comprehensibility* of a model, i.e. the ability of being understood by the target audience.

Language and textual considerations

Process models and workflow models in the management system are connected to a large amount of textual requirements and descriptions. The presence of one or more requirements connected to a symbol is shown as a red triangle with an exclamation mark, placed in the bottom right corner of the symbol. Similarly, the presence of additional information is shown as an image of a paper sheet. By resting the mouse pointer on the symbol, the user will be presented with a pop-up window in the upper right corner, listing the present information and/or requirements. Requirements and information can also be accessed by clicking a symbol to open a full page. As this textual information often provides crucial information that the modelling symbols alone may not be able to convey, it is important that these descriptions are understood by the target audience. TR0002 [33] provides some language recommendations to guide the author when writing:

- *Address the reader* - e.g. use the pronoun *you* instead of *someone*
- *Use words and phrasings familiar to all users* - Use common and simple alternatives when choosing words. Mindfully use abbreviations.
- *Mindfully use the word* **focus** - Use more specific words when possible.
- *Use negative confirmation* - When expected content is not present, use terms such as "not applicable" or "none" instead of leaving it empty
- *Ensure content is sufficiently explained* - Elaborate and/or use examples
- *Use active sentences* - Avoid passive sentences that make the text seem stiff and impersonal. Using imperative or infinitive form is preferred

- *Use verbs* - Avoid using heavy nouns that make the sentence seem abstract
- *Organise your message content* - e.g. by dividing the content into suitable pieces
- *Use lists*

Use of shape and colour

The visual notation for workflow and process models in ARIS is defined in TR0002 [33]. Statoil uses a designated colour scheme in the workflow models. Rules for colouring are not directly expressed in the document, but captured implicitly in the symbol overview as each symbol has a distinct colour. In addition to black, white and grey, the standard notation uses five colours, i.e. *blue* (task and optional task), *yellow* (call task and collapsed sub-process), *grey/purple* (event-related symbols), *red* (requirements) and *orange* (gateway symbols). Considering the recommendations given by Shneiderman [30], this number of colours used might not be optimal, but as the yellow colour is used relatively rarely it should not be a considerable problem. Using a red triangle for telling users stop and read requirements seems appropriate. The high importance of reading a requirement is also highlighted by the use of a triangle shape.

14% of employees sometimes use printed paper copies when reading governing documentation [35]. All the different symbol groups listed in the standard notation [33] are also distinguishable by shape, so the models should be readable even when printed with an unusual colour scheme or without colour. They can also be read by people with some degree of colour blindness.

There is still some room for improvement in colour usage, and this might be a tool-related issue. The symbol for a "collapsed sub-process" is very similar in shape to a normal activity, with the exception of having a "plus" symbol attached to it (prescribed in the standard notation). This is problematic because the requirement of using a "plus" symbol is somehow overlooked in practice, and so it is rarely used (if ever). When printed in black and grey, there is no distinction between a normal activity and a collapsed sub-process.

The 7PMG

While the 7PMG [29] described in section 2.2 can be related to several of the SEQUAL layers, most of the guidelines support empirical quality in some way. Below, an overview of how these guidelines are followed in the Statoil enterprise model are given.

G1: Use as few elements as possible
There is no specific requirements given to the size or complexity of models in TR0002 [33].

G2: Minimize the number of paths from an element
This guideline is well supported. TR0002 [33] states that *"You shall not use more than one sequence flow arrow from an activity"*.

G3: Use only one start and one end event
The standard notation does not restrict the use of multiple start and end events, and states that if a gateway symbol with exclusive flows are used, each flow may have different end events. It is also found in practice that most workflow models *do* use several start and end events representing different conditions that may trigger the process.

G4: Model as structured as possible
This guideline states that each split connector should have a matching join connector of the same type. This is partly accounted for in TR0002 [33]. Split parallel flows resulting from a diverging parallel gateway must be merged again using a converging gateway symbol. However, as discussed in relation to G3, each flow from a diverging *exclusive* gateway can have separate end events, hence the flows are never merged.

G5: Avoid "OR" routing elements
The current Statoil modelling standard only allows for parallel or exclusive gateways, i.e. "OR" routing elements which allows for both *one* or *all* flows to be taken are not used.

G6: Use "verb object" when labelling activities
This naming convention, which is also according to the BPMN standard [31] is used in Statoil.

G7: If the model has more than 50 elements, it should be decomposed
This is not explicitly addressed in TR0002 [33]. However, in the investigations carried out in relation to syntactic quality which will be described in the upcoming section, none of the 100 most used workflow models had more than 46 elements when counting both nodes and edges (sequence flows).

6.1.3 Syntactic quality

One of the main purposes of the document TR0002 [33] is to ensure a high syntactic quality when modelling. The document provides an overview of the allowed symbols and naming conventions, both symbol specific and general, as described in the above section.

Syntactic quality can be evaluated by looking at the number of syntactical errors in the model in relation to the size of the model. There are two main types of syntax errors, *invalidity* errors, where symbols and words that are not valid according to the syntax of the chosen language are included in the model, and *incompleteness* errors, where statements necessary for making the model syntactically correct are missing [15]. A metric for syntactic quality is given by Krogstie [15] as:

$$1 - (\#\mathbf{M}_E \backslash L + \mathbf{M}_{missing})/\#\mathbf{M}$$

Where $\mathbf{M}_E$ denotes all explicit statements made in the model, and $\mathbf{M}_{missing}$ represents all statements that would be necessary to add to make the model syntactically complete. As missing statements (incompleteness) are very rare (or non-existent) in the case studied, the formula is simplified to

$$1 - (\#\mathbf{M}_E \backslash L)/\#\mathbf{M}$$

In the following evaluation, the degree of syntactical correctness was first measured on seven workflow models. In the MS user survey [35], respondents were asked to give examples of processes that were interpreted differently within their department/unit. This list of processes was used as a basis when selecting models for evaluation. Due to a high number of models listed, not all could be evaluated. The following criteria were applied when selecting models:

1. The process is directly mentioned by respondents in the user survey [35] as a cause for misunderstandings and different interpretations, and implicitly mentioned at least twice

2. The total number of nodes and edges in the model is larger than 20

3. The model is one of the 100 most used workflow models

Implicit mentions could for instance be references to a process chain that the workflow is part of, or the process or parts of the process being described with a sentence without explicitly naming the process or its identifier. References to specific requirements were not counted, as they usually pertain to vague textual descriptions and not model elements. The relevant requirements given in TR0002 [33] are here summarised as a list of rules with identifiers in table 6.2, to make the identification and annotation of breaches easier. Note that some syntactical

rules/guidelines are left out of the summary as they were not relevant for the models studied. In the table, the rules are annotated according to the symbol or aspect they are related to, i.e.:

- **N:** Naming conventions
- **T:** Task
- **OT:** Optional Task
- **G:** All types of Gateways
- **SP:** Collapsed Sub-Process
- **CA:** Collaboration Activity
- **SF:** Sequence Flow
- **W:** Wrongly used concept

As different types of errors differ in impact, "normal" errors (e.g. labelling mistakes) were given a score of one and "severe" errors (e.g. using the wrong symbol - denoted 'W') were given a score of two. In addition, breaches of "General naming conventions" were given the value 0,5. The latter type was not evaluated too strictly, for instance when applying rule *N2: Avoid names with more than four words if possible*, conjunctions and prepositions were not counted, and for rule *N7: Abbreviations should be avoided*, very well-known abbreviations (e.g. "HSE") were not counted.

The *size* of the model is equal to the total number of nodes (symbols) and edges (arrows). After measuring the syntactic quality (SYN) of these seven selected workflow models, they were compared to other models of a similar size. The criteria used when choosing models for comparison were the same as the criteria listed above, except for criteria 1 which was inverted - only models *without* direct mentions were found appropriate. For each of the "troublesome" models, the three models closest in size from the top 100 list, that also fit the set criteria were evaluated (Due to the limited amount of models to choose from, especially with sizes above 35, the same models were reused in some cases). The syntactic quality of these three were measured, and an average syntactic quality was calculated (AVG). The results are summarised in table 6.1.

As shown in the table, five of the seven chosen workflow models have a syntactic quality that is well below the calculated average, while the model "Prepare isolation plan" has an average syntactic quality. One model, namely "Set, verify and approve isolation" has a higher measured quality than the chosen similar sized models. The results may indicate that a low syntactic quality contributes

Model	**Size**	**Breaches**	**SYN**	**AVG**
Apply for and evaluate work permit	21	7xN2, 2xG2, 2xG3, 2xN2 CA3	0,55	0,87
Prepare isolation plan	23	CA3, G2, N2	0,89	0,89
Project control	24	12xN4, N2, E1, CA2, CA4, G2, G3, SF1	0,48	0,82
Execute mechanical completion	30	2xN4, 4xN7, 4xE1, 3xW, 4xN2, 2xSF1, G2, G3	0,37	0,80
Set, verify and approve isolation	30	2xN2, 2xSF1, CA4	0,87	0,80
Safety incident	39	E1, 7xN2, 3xN2, 3xG2, 2xG3, SP2, 4xW	0,58	0,78
Commissioning and handover of systems	46	2xE1, SP1, SP2, 2xSF1, 16xN4, 2xN2, 5xG2, 5xG3, 3xT1	0,39	0,78

Table 6.1: Syntactic quality

to confusion and misinterpretations of models, but clearly other aspects must also be considered. Even though all of the examined models are frequently used, "Prepare isolation plan" is the most used model of all, and so it is more likely to be mentioned by a survey respondent than a model with a lower usage.

N1	Names on symbols and expressions shall be formulated in singular form
N2	Avoid names with more than four words if possible
N3	A name shall not be a detailed description
N4	The first letter of a symbol name shall be in upper case. All other letters should be lower case
N5	Proper names shall start with upper case letters
N6	The Statoil official name of a concept shall be used when alternatives exist
N7	Abbreviations should be avoided
T1	The title of a task shall be a verb imperative (reflecting the activity performed in order to add value) followed by a noun (reflecting the asset)
OT1	The title of an optional task shall be a verb imperative (reflecting the activity performed in order to add value) followed by a noun (reflecting the asset)
OT2	The use of an optional task is only allowed within a collaboration activity
OT3	It is not allowed to connect sequence flows to the optional task symbol
SP1	The title of a collapsed sub-process shall be a verb imperative (reflecting the activity performed in order to add value), followed by a noun (reflecting the asset)
SP2	The collapsed sub-process symbol is drawn using a standard activity shape with a "+" attached
CA1	The tasks grouped by a collaboration activity symbol shall not be sequenced in time or contain dependencies
CA2	The title of a collaboration activity shall be a verb imperative (reflecting the activity performed in order to add value), followed by a noun (reflecting the asset)
CA3	The name of a collaboration activity shall be unique and you shall not name the collaboration activity with names that have been used for the tasks that have been framed by the collaboration activity symbol
CA4	Each of the tasks framed by the collaboration activity symbol must have a unique title, clarifying different type of activities performed by different roles
E1	You shall define the title of a start or end event as a noun (reflecting the asset) followed by a verb past participle (reflecting the activity performed to add value to the asset)
G1	You shall not name parallel gateways
G2	The title of a diverging exclusive gateway shall consist of the term control (can be replaced with check, verify, evaluate or clarify) followed by a noun (reflecting the object submitted to control)
G3	The exclusive flow shall be described through an adjective or a phrase describing the alternative flows. You shall not use yes or no when designing exclusive gateways
SF1	A sequence flow shall have only one source and one target
SF2	You should not use more than one sequence flow from an activity
W	Using the wrong symbol (or similar errors)

Table 6.2: Summary of rules from TR0002

6.1.4 Semantic quality

As stated earlier, the *validity* and *completeness* can not be directly measured, due to the complexity of the domain [15]. A model can not be seen independently of its interpretation by the human mind [6]. TR0002 explicitly use the notion of semantic quality, and defines the resulting quality of any governing documentation model as a combination of semantic and syntactic quality.

In ARIS, there is a possibility for users to post *improvement suggestions* to models. If this option is actively used, and the suggestions properly handled, it can improve semantic quality. The audience will give feedback if they feel that something about the process is not properly modelled. In this way, members of the audience also become participants in the ongoing modelling process, by contributing with their knowledge about the domain, and also their interpretation of the model.

An example of lack of validity was given by one of the interviewees:

"...for instance PD03.64, which is that handover... handover and commissioning of systems, one example here is "commissioning procedure approved?", there is only one way of getting out of it, and that is "yes". Some things do NOT need a commissioning procedure. Then someone has interpreted this as though they have to make it, no matter what"

This problem is probably related to the fact that many models are very general, which has been a recurring theme in conversations and interviews. They are meant to cover a large number of different projects, which vary in size and complexity. This, combined with the goal of compliance with requirements may be problematic, and lead to a large number of deviation applications or "silent deviations" - deviations from requirements that occur in practice but are not reported.

6.1.5 Pragmatic quality

The aim of pragmatic quality is comprehension, and therefore all measures taken to increase the users' understanding of a model can be said to be supporting pragmatic quality. Since one of the main goals of using workflow models are ensuring compliance with requirements, it is important that the users understand the division of responsibilities in the work process. The importance of users recognizing role names is emphasised in TR0002 [33]. The purpose of a process role is given as:

1. Securing necessary segregation of duties
2. Achieving efficient recognition and allocation of competence

A *process role* is independent of organisation and location, and categorised according to the RACI (Responsible-Accountable-Consulted-Informed) principle. In addition to type (RACI), a generic process role name is given, e.g. "verifier", "executor" or "external stakeholder".

TR0002 [33] lists several requirements for mandatory inclusion of meta-data for models and model elements, some of which may increase comprehension of the model and its elements.

Category

Each governing documentation connected to a model element must have a category. There are two main categories:

1. Requirement
2. Information

In ARIS, these categories are distinguished using symbols, as described in section 6.1.2. Identifiers are also used to make the distinction clear, documents belonging to the "Information" category are labeled I-nnnnn and documents classified as "requirement" are named R-nnnnn, where n is a digit (the number of digits is arbitrary).

Purpose

Each model shall have a defined primary purpose, and a secondary set of purposes if needed. The purpose shall as a minimum include:

- *Risk* - A description of the *risk(s)* the model is meant to mitigate
- *Objective* - A description of the intended result or output
- *Target group* - A list of the main end users

In ARIS, this information shall be displayed on the "details" page connected to a workflow model, in the "purpose" field. Out of 100 random models (process or workflow) examined, 61 had a defined purpose, and 39 contained only a blank field. While the majority of models have a defined purpose, there is clearly an opportunity for improvement here. Moreover, very few of these contained the required descriptions of risk, objective and target group. Also, some of the purpose descriptions seem rather vague and disconnected from the organisational goals of modelling. By increasing emphasis on the modelling purpose in relation to organisational goals, the pragmatic quality can be improved.

6.1.6 Social quality

For a model to be of high social quality, agreement in interpretation between relevant users of the model must be achieved. The "validity" field, described in section 6.1.1, show which organisational actors are relevant. Even more important is the agreement between the actors fulfilling the various process roles responsible for the activities in a model.

A short description of how to conduct the modelling process is provided, under *"General requirements when designing models"* in TR0002 [33]. This paragraph describe, amongst other things, the need for doing a stakeholder analysis when designing a model. It is stated that it is important to do this analysis in order to provide a suitable abstraction level, complexity, terminology and linguistic maturity as the target audience differs throughout the company. By doing this thourougly, a high social quality can be ensured in cases where the target group is quite small and uniform. For larger and more general processes that are applied throughout the company in different work environments (e.g. HSE processes), this is difficult to achieve, as what is the right complexity for one group of actors may not be ideal for another group. The results of the experiment outlined in section 6.2 show how easily the meaning of symbols and models can be interpreted differently. During interviews and conversations, many have complained that workflow models they use in their daily work are a source for misunderstandings and time-consuming discussions within their work environment.

An interview respondent confirms that people interpret models differently, and that this leads to time-consuming discussions. He/she brings up the fact that the models are very general:

"Of course, I see that ARIS is made for big projects, right, an execution project, and then if we work with small modifications which again don't have a very large scope, and spend a lot of time on various things that may be a bit unnecessary for some cases. So it is meant to encompass a broad range of situations, which is good, but..."

Another interviewee has also experienced varying interpretations, but realizes that there can never be one way of reading a model:

"There are some who think that the models can be read in a kind of biblical way, as if there is one correct way of reading them, but it is not like that. As long as we are wired differently, we'll read them differently. There are different backgrounds and different perspectives"

Statoil work with a high number of contractors in various projects, so it is not only internal Statoil employees who need to understand the process models. This can be problematic, as those representing contractors are not necessarily used to the Statoil way of working, and most important, not used to the management

system. An interview respondent, speaking about his/her experience with differing interpretations, illustrate that low social quality can be problematic when working with external contractors:

"It is especially when working against contractors, you know, that want to make sure... contractors who think we are more difficult than we really are. So it has to do with interpretation. Our interpretation and the supplier's interpretation."

6.1.7 Deontic quality

No specific guidelines are given on the relation between modelling aspects and the achievement of goals in TR0002. As described in section 4.2, the main objectives of the enterprise model are:

1. Contributing to safe, reliable and efficient operations and enabling compliance with external and internal requirements
2. Helping the company incorporating their values, people and leadership principles into everything they do
3. Supporting business performance through high-quality decision-making, fast and precise execution and continuous learning

The enterprise model emphasizes safety in all governing documentation. The results outlined in section 5.1.2 showed that safety critical workflow models are frequently used. In order to achieve safe, reliable and efficient operations, it is important that users understand who is responsible for complying with each requirement. The RACI-principle used when defining process roles as described earlier can help achieving this understanding.

6.2 Model quality experiment

Wesenberg [42] highlights the importance of achieving the right balance between *syntactic*, *semantic* and *pragmatic* quality. He also emphasizes pragmatic quality as the most important - a model is useless unless it is understood by its target audience. But how to achieve a high pragmatic quality? Finding the right level of detail is one important aspect, i.e. including enough elements to make the model understandable, without going too far and making it cluttered and too complex. Additionally, how much emphasis should be put on using correct syntax? Do syntactic correctness positively influence pragmatic quality? The results of measuring syntactic quality on "difficult" models described in section 6.1.3 make it

seem likely. A small experiment involving Statoil employees and informatics students was conducted to investigate this further. Finding volunteers for the project proved to be more challenging than expected, so due to a quite low number of participants, the results should not be taken as statistically significant. Instead they give an indication of what should be looked at and investigated further. Furthermore, due to their busy and overlapping schedules, some of the Statoil participants completed the task in a rather uncontrolled environment, e.g. alone in their own office.

6.2.1 Experiment design

In this experiment, two workflow models were selected, and changes were made to these models to increase their syntactic quality. Participants were asked to answer a range of questions related to the models in order to measure their understanding and thus the pragmatic quality of the models.

The original intention was to use Statoil employees from different departments and locations as participants, but since it proved to be difficult to find enough volunteers, a student experiment was carried out in parallel. In total, 18 students and 9 Statoil employees participated in the study. In order to avoid participants answering based on personal knowledge rather than by consulting the models, the participants from Statoil were not supposed to have first-hand experience with the modelled processes. The models selected for the experiment had a syntactic quality below average, and were found to be easily improvable by correcting mistakes according to the rules listed in TR0002 [33]. Improvements were made to several models before selecting the two, but for most of them, the necessary changes became too extensive and hard to incorporate in the experiment. After some trial and error, the two workflow models chosen were:

- SF103 - Safety incident
- OM05.07.01.03 - Reset isolation and pressurise

Key numbers for these workflow models are given in table 6.3. SF103 was also part of the syntactic quality evaluation reported in section 6.1.3 because it was highlighted in the user survey as a model subject to misinterpretations. OM05.07.01.03 was not directly mentioned, but has a many as 9 implicit mentions, mostly due to the "parent" process *OM05.07.01 - Plan, set and reset isolation* being listed.

Model	**Hits**	**Size**	**Syntactic quality**
SF103	16752	39	0,56
OM05.07.01.03	6662	29	0,72

Table 6.3: Workflow models used in the experiment

Syntactic quality was here measured on the Norwegian versions of the models, as the experiment was to be conducted in Norwegian. This was decided in order to avoid language-related misunderstandings, as all of the respondents were native Norwegian speakers. With the conventions and metric used, there might be slight differences in measured quality between versions in different languages, as some of the rules are related to naming. Sometimes errors are either lost or created in translation. The Norwegian version of *SF103* had a low original syntactic quality of **0,56**, while *OM05.07.01.03* had a moderate syntactic quality of **0,72**. When making the new versions, the models were adjusted to make the syntactic quality as close to 1 as possible. Quite major changes were made to SF103, as many the errors were significant, e.g. the wrong symbol was used in several cases. With OM05.07.01.03, the changes made were mostly corrections in naming of symbols and splitting of arrows.

The participants were each given two models to interpret - one original and one modified. The participants were split into four groups, and each group was given a different combination of models and questions, following a latin square design, outlined in table 6.4. As shown in the table, two groups were given the new SF103 and the old OM05.07.01.03. The other two were given the new OM05.07.01.03 and the old SF103. The order of presentation were also reversed for half of the groups, to avoid it affecting the results. As an example, Appendix C shows the question sheet given to group 1. In addition, all were given a symbol overview.

Group 1	SF103 (new)	OM05.07.01.03 (old)
Group 2	OM05.07.01.03 (old)	SF103 (new)
Group 3	SF103 (old)	OM05.07.01.03 (new)
Group 4	OM05.07.01.03 (new)	SF103 (old)

Table 6.4: Latin square

6.2.2 Results

The participants were each given 15 questions connected to SF103, and 10 questions connected to OM05.07.01.03. When summarising the results, each wrongly answered question was given -1 points, unanswered questions were given 0 and correct answers were given a score of 1. The total number of available points for each model is the result of (number of participants x number of questions), e.g. 9 x 15 = 135 for questions to SF103 in the student experiment.

Results from the Statoil experiment should be given some emphasis in the analysis. None of the participants from Statoil work directly with the process areas in question, but they still represent the intended users of the models more closely than the student participants. And even though 5 of the 8 respondents reported that they never use ARIS in their everyday work, they are still naturally more familiar with the Statoil way of thinking than the students.

SF103 - Safety incident

The overall results for SF103 are summarised in table 6.5. As shown, the modified version of SF103 scored significantly higher than the original version both in the Statoil experiment and the student experiment. Some specific questions are worth taking a closer look at, as they give insight into certain problem areas and normal misunderstandings. Question 2 stands out, as *all* of the Statoil participants answered wrongly when looking at the old version of the model, and half of those looking at the new:

2. True or false: The process always starts with a safety incident occurring

Taking the student respondents into consideration, the change is even bigger: as many as 7 out of 8 that were given the original version answered the question wrongly, and only two that were given the new made the same mistake. The question is related to events, and in reality there are two possible triggers to the process:

- A safety incident happens in the field
- Someone reports a case of work-related illness

In the original version, many event-related symbols are used wrongly, e.g. there are two cases of "end event" symbols with sequence flows pointing *out* from them, and event symbols are used instead of task symbols even though the process does not start or end at these points. It is therefore not surprising that the respondents have trouble distinguishing the actual process triggers.

The next critical question is number 6 (the question had three alternatives):

6. What is special about the activity "categorize, classify and decide causes"?

2 of 4 answered wrongly when looking at the old model, while everyone managed to answer correctly when looking at the new. This might be due to the fact that the sub-process symbol used in the original model does not correspond exactly to the one defined in the standard notation overview, as it lacks the "+" a collapsed sub-process is supposed to have attached to it, according to the text (this is however not depicted in the legend overview). However, this mismatch is not reflected in the students' responses - *all* of them answered the question correctly.

Question 9 also got two wrong answers with the original version, and none with the new:

9. The process ends when an accident investigation is carried out

Here, some of the students are also confused: the old version lead to three wrong answers and one unsure (unanswered), whereas the new lead to only correct answers. This question is also event-related, so the reasoning is the same as for question 2.

Experiment	**Old version**	**New version**
Statoil	33/60 p (55%)	52/60 p (87%)
Students	93/135 p (69%)	122/135 p (90%)

Table 6.5: SF103 results

OM05.07.01.03 - Reset isolation and pressurise

The results for OM05.07.01.03 are shown in table 6.6. In this case, the new versions actually got a lower score, but the difference is not very big. In the Statoil case, the difference is also evenly spread among the questions, none of the questions differ by more than two points (corresponding to one mistake less or more) between the two model versions.

The question with the lowest score for both versions was question 3:

3. Yes or no: Should the area technician always contribute to approving the execution?

A similar result can be seen in both experiments. The question is connected to an optional task. Even though it is specified in the legend that a task symbol with a stippled line is optional, many are not able to distinguish this from a regular task.

Question 6 also gave some interesting results:

6. What should be investigated when arriving at the symbol "Safety valve?" (old version) /"Check safety valve" (new version)?

All of the Statoil employees answered the question correctly for both versions, except for one who was "unsure" (old version), whereas in the student experiment, four of the respondents looking at the old version skipped the question and one gave the wrong answer. Everyone answered correctly when looking at the new. The question pertains to a gateway symbol which in the old version is labelled merely "Safety valve?" ("Sikkerhetsventil?" in Norwegian) with exits annotated with 'yes' and 'no'. The text is not very descriptive, so without any domain knowledge it could be very difficult getting the meaning of this gateway symbol. This might explain why the Statoil employees got this one right while so many students were unsure - even though the Statoil respondents did not have first-hand knowledge about the process, they have probably picked up some knowledge about the domain over the years of working in the oil industry.

Experiment	**Old version**	**New version**
Statoil	31/40 p (78%)	27/40 p (68%)
Students	64/90 p (70%)	59/90 p (66%)

Table 6.6: OM05.07.01.03 results

6.3 New version of TR0002

In May 2014, work on a new and simplified version of TR0002 [38] started. During the development of this version, the main considerations have been:

- Simplification of the content
- Improvement of the content
- Removal of unnecessary content
- Understandable language
- Application of discipline knowledge

During the last few years, the changes from version to version of TR0002 have been minor. This time, the changes are significant. Taking a look at how the different quality levels are addressed in the new version can therefore be quite valuable. At the time of analysis, several changes had been made to the original draft, but the content was still subject to change.

The notion of a process model

Perhaps the most significant change from previous versions of the document is the increased emphasis on the more traditional notion of a business process model, where some *input* is consumed by or transformed in the process into an *output (product)* which has value for some *customer(s)* or other stakeholder(s). This is in particular reflected in the more detailed guidelines given for the modelling process, where various information is gathered to aid the development, also to be given as metadata for the process representation in the enterprise model:

- Purpose
- Customer(s)
- Product/output
- Most important value aspect
- Possible variant criterion
- Expected frequency
- Possible special remarks

Empirical quality

Several requirements to graph layout are given in the new version, which is something that is scarcely addressed in the current version. 14 specific requirements are given, including requirements to placement of activities and starting points of sequence flows. Layout requirements are also given for process diagrams, i.e. the diagrams on the level above workflow models consisting of symbols for several processes.

In contrast with the current version, the new version allows for the inclusion of OR-conditionals. This is a breach of G5 from 7PMG: "avoid OR routing elements". Using such conditionals may lead to increased complexity of the model.

Syntactic quality

A major syntactic change in the standard notation is the opportunity of having several sequence flows from an activity. While the current standard allows for only one flow exiting from an activity symbol, the new allows for several flows. If no text is attached to the sequence flows (arrows), the activities following all arrows shall be executed in parallel. Using text, each flow can represent the result of a conditional, i.e. "if <condition>". This kind of "if" clause is the

only type of text allowed in relation to a sequence flow. The syntax covers both XOR-conditionals, i.e. where only one of the statements can be true, and regular OR-conditionals, where one or both of the statements can be true at the same time. This new way of representing conditional flows will substitute the use of gateways. Although the removal of gateways is not explicitly addressed in the document, such symbols are not included in the list of allowed symbols.

Only one start event is allowed. In cases where more than one condition can trigger the process, the start event can be a disjunction, e.g. "Equipment destroyed or inspection date reached'. The new standard introduces the notion of a *team role*. When possible, team roles can be used throughout the process instead of using collaboration activities. An example of a team role given is "technical team".

Semantic quality

The new standard contains more support for *variants* of a process. While the standardised way of executing each process reflecting company "best practice" is preferred when possible, the need for making small adjustments to the way things are done in certain cases (e.g. in countries where legal reasons may hinder certain activities in some way) is recognized. In these cases, a variant of the process can be modelled, based on some *variant criterion*. This is already sometimes done in practice, but has not been properly addressed in previous versions of TR0002. A naming convention for a process variant is set:

- The name of a variant shall inherit the name of the original process as the first part of the name. The second part shall be a value taken from the domain of the variant criteria.

E.g. if the name of the process is "Deliver product" and the variant criterion is "jurisdiction" with domain {UK, Canada}, then the name of the variant processes can be "Deliver product UK" or "Deliver product Canada". Using process variants may lower the need for performing the laboursome and slow process of applying for and approving a deviation. In general, it can lead to increased *semantic quality*, as the correspondence between the model variant and the domain in the special case will be higher than the correspondence between the original model and this domain.

Deontic quality

The new TR0002 [38] notes that activities are the most important elements of a model. A distinction is made between three types of activities:

- **Real value-adding:** Activities that are essential for meeting the customer's expectations
- **Business value-adding or necessary non-value adding:** Activities that are essential to conduct business, but add cost to the process
- **Non value-adding:** Activities that are neither real value-adding, business value-adding or necessary in any way

The new requirements to modelling state that *all* non value-adding activities shall be removed, and the number of business-value adding actitivites should be removed when possible. Removing activities that do not contribute towards achieving any of the organisational goals will increase *deontic* quality of the model.

Chapter 7

Evaluation and Discussion

This report has described approaches and results from a case study conducted in cooperation with the Norwegian oil company Statoil. The focus has been on studying the corporate management system used in Statoil, and in particular the models used in this system. The aim has been to connect various aspects of the management system to the different levels of the model quality framework SEQUAL, and do a detailed evaluation of enterprise model quality. In this chapter, the learnings and experiences gathered throughout the case study will be discussed and evaluated.

7.1 Evaluation

This section contains an evaluation of the work done and choices made in relation to the case study.

7.1.1 General

The methods chosen for data generation in this study have been chosen due to appropriateness and convenience. A mix of quantitative and qualitative methods have been used in order to investigate the case from several perspectives. In Statoil, changes and improvements are made continuously, and a great deal of work have been done within the company in relation to the management system parallel to the investigations carried out here. Studying a system that is constantly being evaluated, restructured and improved is challenging, and hence some of the information gathered might be outdated even before it has been reported here.

Web usage data

When analyzing an enterprise model, being able to know how it is actually used is potentially very helpful. However, using this data for finding a cause-effect relationship between the quality of a model and the frequency of use would have been challenging, if not impossible. Controlling all factors in such an unstructured environment is beyond the scope of this thesis, as it would be extremely time-consuming and would require knowledge very hard to gain for someone "external" to the company during the timespan given. Factors that contribute to frequency of use, include (but are not limited to):

- How often does the process occur in practice?
- How complex is the model, i.e. can the workflow be easily remembered?
- Is the process safety-critical?

Instead, the numbers collected from Splunk Enterprise have been used to add context to the other analysis done.

Document study

The study of written and graphic material was used extensively during the first phase of the research, where the aim was to get an understanding of the case. This work was relatively straightforward, except for that it involved searching through a vast jungle of material, mostly contained in the management system, but also located at team-sites. Some material had to be requested by asking various organisational actors personally. The User Survey [35] proved to be a good starting point for the analysis, and gave an overview of relevant aspects that should be considered in the study. When using found documents such as this, it is important to be aware that it has often been collected and analysed for a different purpose [26]. Some of the findings in the survey did not map well onto this research, while others proved to be highly useful, and possible to discuss in relation to the quality layers of SEQUAL.

The study of workflow models, and especially the evaluation of syntactic quality is a somewhat subjective task, and so the researcher might affect the results. For instance, the identification of errors in models is not a straightforward task, and errors might have been missed or been interpreted differently from model to model.

Interviews

Interviews, being an artificial form of conversation, may be misleading. Knowing whether the subjects actually do or think what they *say* they do or think is not

possible [26]. Due to differing geographical locations, only one of the interviews was carried out face to face. Interviewing over Skype or phone may lead to misunderstandings, and it leaves body-language out of the equation, an aspect that normally could help the interviewer interpreting the answers and understanding the intentions and feelings of the respondent.

Experiments

The main threat to validity in the model quality experiment is that the number of participants was low. Hence, all trends discovered may have been purely coincidental. Additionally, students are not part of the target group of the enterprise model, and the findings would have greater validity if all participants were Statoil employees, preferably employees who use the enterprise model frequently in their everyday work.

Although it is not possible to make generalisations about the affect of the syntactic changes on understanding, it was still useful looking at some specific questions and seeing that many, even Statoil employees *do* interpret the model wrongly - syntactically correct or not. From some of the answers, it was clear that not everyone know and understand the standard notation, so increasing awareness about models and modelling standard is important.

7.1.2 The use of SEQUAL

Using SEQUAL for analysing the Statoil enterprise model have been rewarding, as relevant aspects have been found on the core *syntactic*, *semantic* and *pragmatic* quality dimensions as well as all of the dimensions in the extended framework. The framework has been helpful for being able to connect the results from various data generation methods. The use of SEQUAL has served to structure the work itself as well as the results of the work.

7.2 Discussion

In this section, the main findings of the study are summarised.

7.2.1 The purpose and use of enterprise modelling in Statoil

The models in the Statoil management system are mainly used for communicating requirements and best practices with the aim of achieving high quality of work, i.e. ensuring that all processes are carried out in accordance with the standard set by the company. As noted earlier, the objectives of using entprise modelling

in Statoil thus fall into the *ensuring the quality of business* branch in Persson and Stirna's goal hierarchy [27]. More specifically, the main purpose is what Nysetvold and Krogstie speak of as "business process management", where models are being used for quality assurance of work processes [25]. The focus is on safety, and most workflow models contain activities and requirements that can be seen as safety measures, with the aim of avoiding accidents and serious injuries. While this is clearly important, it often negatively affects efficiency, as activities done to ensure safety can be time-consuming. Finding the correct balance is important, but difficult. Ensuring that all unnecessary activities are removed, as specified in the upcoming version of TR0002, is one important step towards finding this balance.

7.2.2 Enterprise model quality

When analysing the quality of the enterprise model, three main aspects have been investigated:

1. **Model quality as prescribed in TR0002:** How does the defined modelling standard address quality?

2. **Model quality in practice:** How are quality goals actually supported in the management system?

3. **User experience:** How do users perceive the quality of the enterprise model?

Model quality as prescribed in TR0002

Overall, the modelling standard has high support for model quality. It particularly enforces *syntactic* quality, as the main purpose of the document is defining structure and notation. Specific requirements are given to labelling and use of symbols. The terms semantic and syntactic quality are both used in the document, and the resulting quality of a model is defined as a combination of the two. *Empirical quality* is also quite well addressed, as several specific guidelines are given for how to use language to support comprehension. The use of symbols and colour is implicitly accounted for in the symbols overview. The other quality dimensions are supported in various ways. The mandatory inclusion of metadata for a model supports *physical* (validity, versioning, changes from previous version), *pragmatic* (purpose, validity) and *social* (purpose, validity) quality. Considering *deontic* quality, the main purposes of modelling are described in the document, but the relation between model and goals is not addressed.

Model quality in practice

While the requirements given in TR0002 are quite defined and structured, they are not always complied with in practice. Measurements on syntactic quality show that syntax errors are quite common in the workflow models. Inspection also revealed that some of the required meta-data fields are often left empty. Several sources working directly with certain processes have complained that the workflow models of processes they are familiar with do not fully correspond to reality as they experience it, i.e. the perceived semantic quality is sometimes low.

User experience

The user survey [35], interviews and conversations provided valuable insights into how users experience the management system. Some measures can be taken to achieve higher quality. By increasing awareness of existing functionality such as MyPage and the ability to subscribe to governing documentation, users can find what they are looking for more easily, and stay updated on changes. This will increase *availability* and *currency* of the enterprise model, and hence increase physical quality. Simplifying the user interface and improving the search functionality can also contribute to this.

Some users feel that governing documentation is hard to understand. Increased understanding should be of high priority if 100% compliance is the goal. Measures that can contribute to this include applying the language guidelines and naming conventions more strictly and tailoring the complexity of models according to the needs of its target audience.

7.2.3 Balancing the types of quality

Addressing the different levels of quality in isolation is not sufficient, as they are clearly all interrelated. As noted by Wesenberg [42], achieving the correct balance between syntactic, semantic and pragmatic quality is crucial in enterprise modelling. In TR0002 [33], semantic and syntactic quality are explicitly emphasised, but Wesenberg describes the pragmatic aspect as the most important. Measuring pragmatic quality is not straightforward, and many other quality dimensions seem to affect pragmatic quality.

Syntactic quality affecting pragmatic quality

In most cases, the models that were highlighted by users as "causes for conflict" had a low syntactic quality compared to models of similar size and with approximately the same usage frequencies. This is an interesting finding, but not surprising. The results of the experiment showed that the notation is not always

understood, even when applied correctly. Using the notation wrongly most likely leads to even more confusion.

7.2.4 Ongoing initiatives that may affect model quality

Parallel to this work, Statoil are already in the process of taking the enterprise model to the next level, through *The Management System roadmap initiative*. Extensive measures are taken to improve the quality of the management system. The user survey [35] indicated that the goals of safety, efficiency and reliability were not properly balanced. The MS roadmap initiative was started to accommodate for this imbalance. The problems addressed in the initiative are [36]:

- Low leader support
- Too many requirements
- Unclear document structure
- Too many deviations
- Limited learning
- Too complex architecture
- Poorly implemented governing documentation

Installation-dependent portals

To remedy the lack of findability discovered in the management system survey [35], Statoil are introducing alternative, installation-dependent user interfaces, called *portals*. The portals will contain only valid information, structured according to its relevance for users at a particular workplace or within an organisational unit. Such portals have already been implemented in pilot projects, and the feedback on these pilots has been good [37]. If using such portals actually do contribute to increased findability of governing documentation, physical quality will be greatly improved.

New search functionality

Another measure taken to increase findability is the development of new functionality for searching for governing documentation. Whereas the old search function returns a quite unstructured set of results, the new functionality will take advantage of harmonized and maintainable meta-data to facilitate the possibility of narrowing down the result set. The new search function allows the user to search

for keywords, and then limit the results based on meta-data related to the results. The results can e.g. be limited by *type* (e.g. document, work process), *process area*, *owner*, *validity* and *date*. The aim is to help the user navigate through search results more easily.

7.3 Contributions

As the findings presented here are the results of studying a single case, they are most valuable in the context of the particular case, and can be used as a basis for further improvement of the enterprise model in Statoil. However, certain aspects may be transferable to other, similar cases. One objective when writing this report has been providing sufficient detailed information about the case, and thus allowing the reader to evaluate if the results are transferable to his/her own situation. The main contributions of this work are:

- **An extensive analysis of the Statoil enterprise model**, which can be utilized for making improvements to the management system
- **"Sorting" of challenges and other aspects according to various quality layers**, which provides a simplified overview of enterprise model quality, and may serve as a "check-list" when executing and measuring improvements
- **A real-life example of using SEQUAL for evaluating a large and complex enterprise model**, which can be useful for applying the framework in other, similar contexts

7.4 Future Work

There are several possibilities for further work related to the Statoil enterprise model. When the new functionality developed through the MS Roadmap initiative has been implemented in full-scale, the actual effect of these changes on model quality in practice can be analysed. A new user survey, similar to the one carried out in 2013/2014 will be distributed by Statoil when these changes have been put into effect. Studying the new results and comparing them to the old may give important insight into the real value of such changes. In particular, following the implementation of the new TR0002 document in practice, and how it impacts model quality and use is an interesting possibility.

Another possibility is to carry out a more quantitative study, in which an experiment similar to the model quality experiment reported here is carried out

in a larger scale, with a more appropriate selection of candidates and in a more controlled environment.

Lastly, using SEQUAL to evaluate enterprise modelling in other large organisations can together with this work provide the basis for making generalisations useful for the practice of enterprise modelling.

Bibliography

[1] Entry. `http://www.entry.statoil.no`. Accessed: 2014-11-17.

[2] Splunk enterprise. `http://www.splunk.com/view/splunk/SP-CAAAG57`. Accessed: 2014-09-23.

[3] Statoil - a leading energy company in oil and gas production. `http://www.statoil.com`. Accessed: 2014-11-17.

[4] Giuseppe Berio and Francois Vernadat. Enterprise modelling with CIMOSA: functional and organizational aspects. *Production planning & control*, 12(2):128–136, 2001.

[5] David Carasso. *Exploring Splunk: Search Processing Language (SPL) primer and cookbook*. 2012.

[6] Lars C Christensen, BW Johansen, N Midjo, J Onarheim, T Syvertsen, and Terje Totland. Enterprise modeling-practices and perspectives. *COMPUTERS IN ENGINEERING*, pages 1071–1084, 1995.

[7] Chrysanthos Dellarocas and Mark Klein. A knowledge-based approach for designing robust business processes. In *Business Process Management*, pages 50–65. Springer, 2000.

[8] Mark S Fox and Michael Gruninger. Enterprise modeling. *AI magazine*, 19(3):109, 1998.

[9] Egon G Guba. Naturalistic inquiry. *Improving Human Performance Quarterly*, 8(4):268–76, 1979.

[10] Michael Hammer. Reengineering work: don't automate, obliterate. *Harvard business review*, 68(4):104–112, 1990.

[11] Merethe Heggset, John Krogstie, and Harald Wesenberg. Ensuring quality of large scale industrial process collections: Experiences from a case study. In *The Practice of Enterprise Modeling*, pages 11–25. Springer, 2014.

[12] Vidar Hepsø. The social construction and visualisation of a new Norwegian offshore installation. In *Proceedings of the Fifth European Conference on Computer Supported Cooperative Work*, pages 109–124. Springer, 1997.

[13] Vidar Hepsø. Mediating business process models with an anthropological voice: "double-level language" in the Norwegian oil industry. In *Handbook of Anthropology in Business*, pages 485–504. Left Coast Press Inc., 2014.

[14] David Hoyle. ISO 9000: quality systems handbook. 2001.

[15] John Krogstie. *Model-based development and evolution of information systems: A Quality Approach.* Springer, 2012.

[16] John Krogstie. Quality of business process models. In *The Practice of Enterprise Modeling*, pages 76–90. Springer, 2012.

[17] John Krogstie and Sofie de Flon Arnesen. Assessing enterprise modeling languages using a generic quality framework. *Information modeling methods and methodologies*, (1537-9299):63–79, 2005.

[18] Odd Ivar Lindland, Guttorm Sindre, and Arne Sølvberg. Understanding quality in conceptual modeling. *Software, IEEE*, 11(2):42–49, 1994.

[19] Zdravko Markov and Daniel T Larose. *Data mining the Web: uncovering patterns in Web content, structure, and usage.* John Wiley & Sons, 2007.

[20] Daniel L Moody. Theoretical and practical issues in evaluating the quality of conceptual models: current state and future directions. *Data & Knowledge Engineering*, 55(3):243–276, 2005.

[21] Daniel L Moody. The "physics" of notations: toward a scientific basis for constructing visual notations in software engineering. *Software Engineering, IEEE Transactions on*, 35(6):756–779, 2009.

[22] Daniel L Moody, Guttorm Sindre, Terje Brasethvik, and Arne Sølvberg. Evaluating the quality of process models: Empirical testing of a quality framework. *Modeling ER 2002*, page 380, 2002.

[23] Charles William Morris. *Foundations of the Theory of Signs*, volume 1. University of Chicago Press, 1938.

[24] Ikujiro Nonaka. A dynamic theory of organizational knowledge creation. *Organization science*, 5(1):14–37, 1994.

[25] Anna Gunhild Nysetvold and John Krogstie. Assessing business process modeling languages using a generic quality framework. *Advanced topics in database research*, 5:79–93, 2006.

[26] Briony J Oates. *Researching information systems and computing*. Sage, 2005.

[27] Anne Persson and Janis Stirna. Why enterprise modelling? an explorative study into current practice. In *Advanced Information Systems Engineering*, pages 465–468. Springer, 2001.

[28] M. Polanyi. *The Tacit Dimension*. Terry lectures. Anchor Books, 1967.

[29] Reinhard Schuette and Thomas Rotthowe. The guidelines of modeling–an approach to enhance the quality in information models. In *Conceptual Modeling–ER -98*, pages 240–254. Springer, 1998.

[30] Ben Shneiderman. *Designing the user interface: strategies for effective human-computer interaction*, volume 2. Addison-Wesley Reading, MA, 1992.

[31] Bruce Silver. *BPMN method and style*. Cody-Cassidy Press, 2009.

[32] Statoil. *The Statoil Book*. 2013.

[33] Statoil. TR0002 enterprise structure and standard notation, 2013.

[34] Statoil. FR20 management system, 2014.

[35] Statoil. Management system user survey U13, 2014.

[36] Statoil. MS roadmap initiative - information meeting sessions september 3rd and 4th, 2014.

[37] Statoil. MS toolbox forum for ARIS, Docmap and Disp, 2014.

[38] Statoil. TR0002 enterprise structure and standard notation version 4, 2014.

[39] Xiaomeng Su and Lars Ilebrekke. Using a semiotic framework for a comparative study of ontology languages and tools. *Information Modeling Methods and Methodologies*, (1537-9299):278–299, 2005.

[40] Geoff Walsham. Knowledge management systems: Representation and communication in context. *Systems, Signs & Actions*, 1(1):6–18, 2005.

[41] Yair Wand and Ron Weber. Research commentary: information systems and conceptual modeling - a research agenda. *Information Systems Research*, 13(4):363–376, 2002.

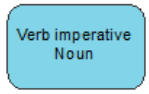
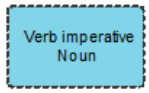
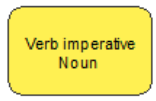
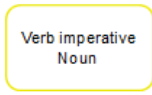
[42] Harald Wesenberg. Enterprise modeling in an agile world. In *The Practice of Enterprise Modeling*, pages 126–130. Springer, 2011.

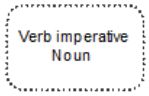
[43] Robert K Yin. *Case study research: Design and methods*. Sage publications, 2014.

Appendix A

Modelling notation

5.6.2 Workflow diagram symbol

Symbol name	Symbol	Description and naming convention
Activity related symbols		
Task		This symbol represents an activity. You shall define the title of this symbol as a verb imperative that reflects the activity performed in order to add value to the asset. The noun shall reflect the asset.
Optional Task		This symbol describes an optional activity. You shall define the title of this symbol as a verb imperative that reflects the activity performed in order to add value to the asset. The noun shall reflect the asset.
Collapsed sub-process		This symbol represents a part of the workflow diagram that is collapsed to increase the visual quality of the workflow. The symbol is drawn using a standard-size activity shape with a [+] symbol attached. You shall define the title of this symbol as a verb imperative that reflects the activity performed in order to add value to the asset. The noun shall reflect the asset. The symbol shall be linked to the corresponding workflow diagram with an identical title.
Call task		This symbol is used to address a workflow diagram in a different work process model. The external workflow diagram is addressed with a reference or a link in the task. The title of the call task shall be identical to the workflow diagram name that it calls.

Collaboration activity		This symbol is used to group activities when they are executed in cross lanes collaboration. The activities grouped by this symbol shall not be sequenced in time or contain dependencies. The verb imperative shall reflect the activity performed in order to add value to the asset. The noun shall reflect the asset.
Event related symbols		
Start event		A start event describes the state of the asset that triggers initiating work according to the workflow diagram. You shall define the title of this symbol as a noun reflecting the asset. The verb past participle shall reflect the activity performed in order to add value to that asset.
End event		An end event describes the state that terminates conducting work according to the workflow diagram. You shall define the title of this symbol as a noun reflecting the asset. The verb past participle shall reflect the activity performed in order to add value to that asset.
Gateway related symbols		
Parallel gateway		When you have a parallel sequence in your workflow diagram you shall use a parallel gateway to visualise the parallel divergence and convergence. You shall not name parallel gateways.
Diverging exclusive gateway		An exclusive gateway visualises a control of exclusive divergence and/or convergence. The title of this symbol shall consist of 2 pieces of information: • Term: Control • noun that reflects the object submitted to control Example: Control water-pressure level
Converging exclusive gateway		The converging exclusive gateway is used if the design require a need to merge the flows from the exclusive gateway prior to a common end event. You shall not merge the flow from exclusive gateways if requirements unique to one flow apply to any of the preceeding activities after the merge. You shall not name converging exclusive gateways.

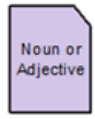
Other symbols		
Sequence flow		This symbol is used to show the sequence in which activities and conditions are performed. A sequence flow can be given a title that describes the flow. It is mandatory to add a title when exclusive split applies to the flow. Then the title shall be the adjective reflecting the result of the control. If possible, the text shall be placed on top of the symbol close to the arrow exit.
Data symbol		This symbol is used to describe a physical collection of information. The symbol can be used in workflows when it is necessary to indicate the creation or use of information in an activity. The title of this symbol shall be a noun in singular or an expression in singular starting with a noun or an adjective.
Data association		This symbol is used to link data symbols together with other symbols of this diagram.
Association		This symbol is used to link text annotation symbols together with other symbols of this diagram.
Lane		A lane horizontally frames relevant activities and conditions. A lane inherits the name of the process role of which it represents.
Presence of requirements		This symbol is used to show the presence of one or more governing elements classified as requirement. Symbols that may have requirements linked to them are: • Any type activity symbol except the collapsed sub-process. • Any type gateway symbol In addition this symbol can be visualised on workflow diagrams.
Presence of information		Used to show the presence of one or more governing elements classified as information

Table 5.5: Available symbols for workflow diagrams

5.6.3 Workflow diagram - requirements to the design

5.6.3.1 Activity

5.6.3.1.1 Task and Optional task

- A task symbol represents what actors do as “individuals” in their process roles and thus shall be limited to a specific lane only.The optional task symbol indicates that the corresponding

Appendix B

Interview guide

Intervjuguide – Bruk av ARIS

Semistrukturert intervju, spørsmål og stikkord er veiledende og kan tilpasses underveis

T1. Introduksjon

- Presenter meg selv (navn, studieretning)
- Fortell om oppgaven
- Forklar hensikt med intervjuet: Å hente meninger, erfaringer og refleksjoner rundt bruk av styringssystemet (i hovedsak ARIS)
- Forklar at svarene gis anonymt
- Få samtykke til opptak

T2. Informasjon om intervjuobjektet (kun for eget bruk, skal gjennomgås før lydopptak settes i gang av personvern-hensyn)

S1 Hva jobber du med til daglig?
- Stilling
- Avdeling
- Ansvarsområde(r)

S2 Har du utdannelse?
- Hvilken?

S3 Hvor lenge har du jobbet i Statoil?

T3. Bruk av ARIS

S4 Bruker du ARIS i din arbeidshverdag?
- Arbeidsflytmodeller og/eller andre elementer?
- Hvor ofte?

S5 Hvilke modeller bruker du jevnlig?

S6 I hvilke tilfeller/situasjoner går du inn i ARIS?
- Undersøke hvilke krav som foreligger
- Finne ut hvilke arbeidsoppgaver vedkommende skal utføre
- Søke om unntak
- Andre ting?

S7 Har du utført noen av disse handlingene?
- Lagt inn forbedringsforslag
- Søkt om unntak

T4. Utfordringer og erfaringer

S8 Er ARIS enkelt å bruke?
- Hva er enkelt/vanskelig?

S9 Hvordan hjelper ARIS deg i din arbeidshverdag?

S10 Finner du enkelt det du leter etter i ARIS?

S11 Hvordan leter du frem informasjon?
- Søk
- Bruker du/kjenner du til MyPage (abonnere på modeller)
- Bokmerker
- Følger lenker fra prosessområde til modell

S12 Synes du det er enkelt å lese arbeidsflytmodeller?
- Hva er evt vanskelig?

S13 Er du og dine kolleger vanligvis enige om hvordan modellene skal leses?
- Diskusjoner rundt tolkning?

S14 Har du fått/får du god opplæring og støtte til å bruke ARIS?

T5 Avslutning

S15 Er det noe du vil tilføre angående hvordan styringssystemet fungerer i dag?

- Takk for intervjuet

Appendix C

Model quality experiment - example question sheet

Undersøkelse om modellkvalitet, oktober 2014

I forbindelse med min masteroppgave i informatikk tar jeg en nærmere kikk på en rekke prosessmodeller som benyttes av Statoil. Et ledd i analysen er å undersøke hvor godt slike modeller blir forstått av brukere.

I undersøkelsen vil du få utdelt to ulike prosessmodeller. Til hver modell hører det en rekke spørsmål/påstander som du skal forsøke å ta stilling til ut fra den informasjonen du har fått utdelt. Svar så godt du kan ut fra det du kan lese av modellen. Dersom du har tilleggskommentarer kan disse noteres på baksiden av spørsmålsarket. Undersøkelsen er beregnet til å ta ca en time å gjennomføre.

Svar først på disse spørsmålene:

I) **Hvilket årskurs holder du på med ved NTNU?**

Svar:

II) **Hvor gammel er du?**

Svar:

III) **Kjenner du til modelleringsspråket BPMN – Business Process Model and Notation (strek under det som passer)?**

Ingen kjennskap/Noe kjennskap/God kjennskap

Evt. kommentar:

Spørsmål til modell A

For å svare på disse spørsmålene må du se på bildet merket med "Modell A". Strek under det alternativet som passer.

1. **Dersom beredskap startes er det ikke behov for å registrere HMS-hendelsen.**

   SANT/USANT

2. **Prosessen starter alltid med at en HMS-hendelse oppdages.**

   SANT/USANT

3. **Er det alltid nødvendig å utføre varsling om en inntruffet HMS-hendelse?**

   JA/NEI

4. **Dersom varsling blir utført og beredskap igangsatt er prosessen over.**

   SANT/USANT

5. **Skal en HMS-hendelse alltid registreres?**

   JA/NEI

6. **Hva er spesielt med aktiviteten «kategoriser, klassifiser og finn årsaker»?**

   a) Den representerer en underprosess
   b) Aktiviteten er frivillig
   c) Aktiviteten har ekstra høy prioritet

7. **HMS-personell er ansvarlig for å kontrollere kvaliteten på hendelsesrapporten.**

   SANT/USANT

8. **Linjeleder skal evaluere om granskning er nødvendig**

   SANT/USANT

9. **Prosessen slutter når ulykkesgranskning er gjennomført.**

   SANT/USANT

10. **En HMS-hendelse skal alltid granskes av HMS-personell.**

    SANT/USANT

11. **Når en granskning er gjennomført skal HMS-personell utføre de foreslåtte tiltakene umiddelbart**

    SANT/USANT

12. **Alle foreslåtte tiltak skal godkjennes av linjeleder før de utføres.**

    SANT/USANT

13. **Linjeorganisasjon bestemmer at det ikke er nødvendig med varsling av HMS-hendelse. Hva er da det neste som skal gjøres?**

    Svar:

14. **Hva skal representanter fra linjeorganisasjon gjøre dersom kvaliteten på hendelsesrapporten ikke er bra nok?**

    a) Oppdatere rapport på nytt
    b) Utføre planlagte tiltak
    c) Foreslå nye tiltak

15. **Hva skjer etter at HMS-personell har avgjort at kvaliteten på hendelsesrapporten er OK?**

    a) Rapporten skal oppdateres i Synergi
    b) Planlagte tiltak skal utføres
    c) Linjeleder skal godkjenne rapporten

Spørsmål til modell B

For å svare på disse spørsmålene må du se på bildet merket med "Modell B". Strek under det alternativet som passer.

1. **Hva er første aktivitet som alltid skal utføres dersom full isolering er utført?**

   a) Godkjenn iverksettelse av tilbakestilling og trykksetting
   b) Tilbakestill isolering
   c) Bidra til godkjenning av iverksettelse av tilbakestilling og trykksetting

2. **Hva er forskjellen på de to mulige starthendelsene?**

   a) Hendelsene er like, men det er to ulike roller som utfører dem
   b) Om den gjennomførte isoleringen er full eller ikke
   c) De er like, men den ene skjer før og den andre etter at iverksettelse er godkjent

3. **Skal områdetekniker alltid bidra til godkjenning av iverksettelse?**

   Ja/Nei

4. **Områdetekniker ser at type isoleringsplan ikke er full isolering. Skal *verifiserer - isoleringsplan* da verifisere tilbakestilling i felt?**

   Ja/Nei

5. **Hva angir boksen «Forbered for trykksetting»?**

   a) At det er valgfritt hvilken av de to rollene som utfører aktiviteten «sjekk system- og områdestatus»
   b) At det er en samarbeidsaktivitet
   c) At aktivitetene den omslutter er frivillige

6. **Hva skal undersøkes når man kommer til symbolet «Sikkerhetsventil?»?**

   a) Om det er behov for sikkerhetsventil eller ikke
   b) Om sikkerhetsventil inngår i systemet eller ikke
   c) Om sikkerhetsventil er satt riktig eller feil

7. **Skal *utførende – sentralkontrollrom* alltid være delaktig i prosessen?**

   Ja/Nei

8. **Finnes det tilfeller hvor *verifiserer – isoleringsplan* ikke er delaktig i prosessen?**

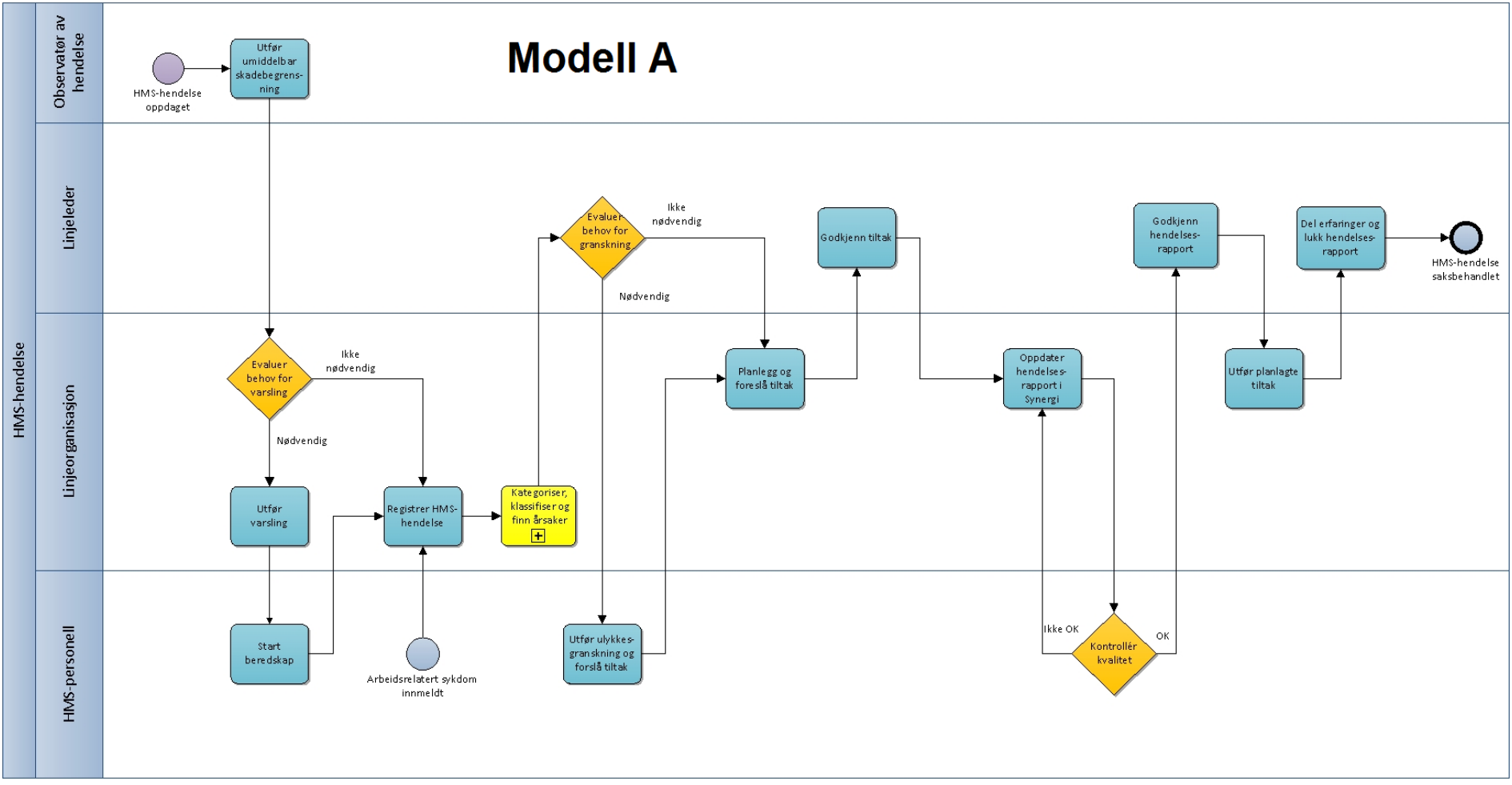
   Ja/Nei

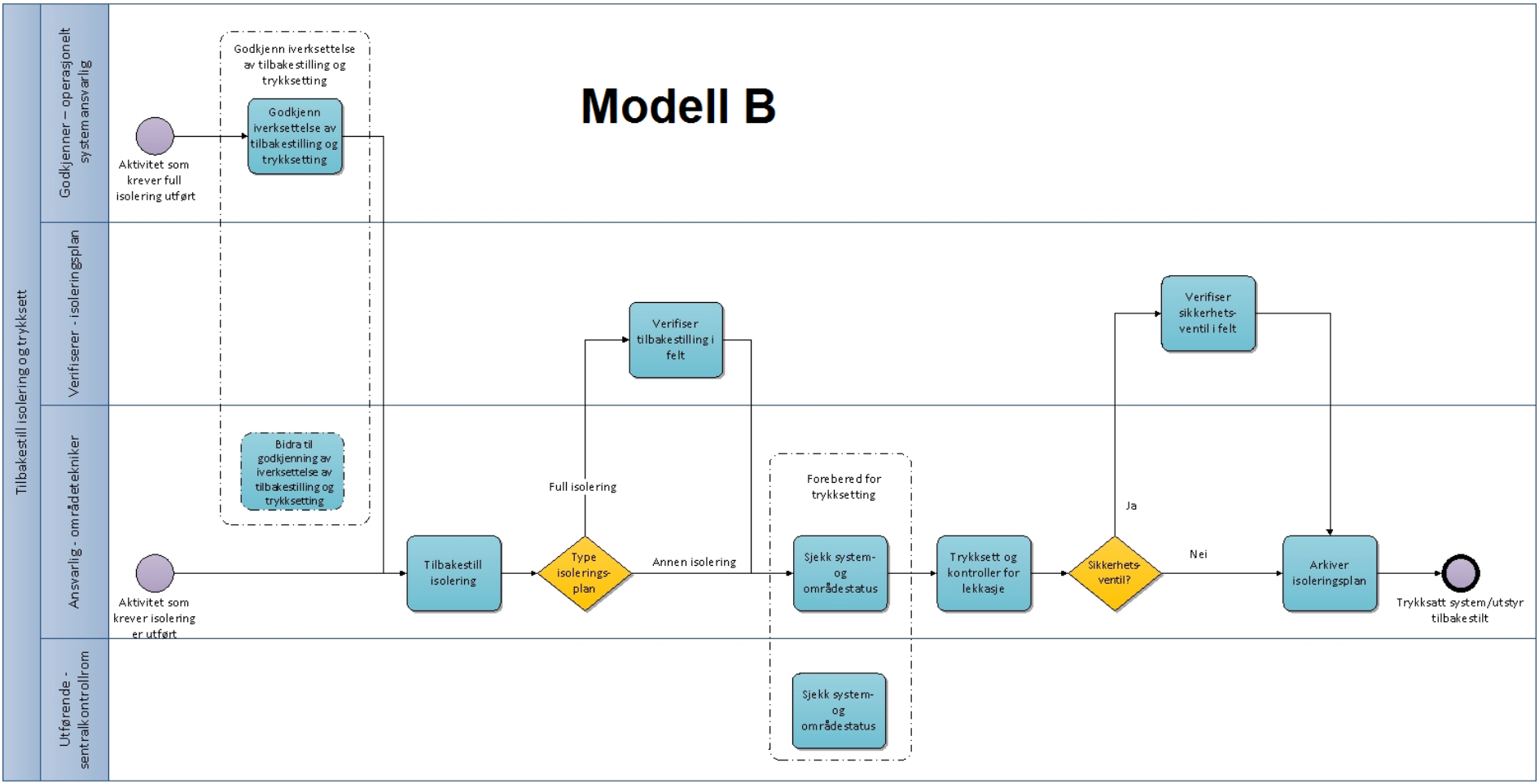
9. **Er operasjonelt systemansvarlig alltid delaktig i prosessen?**

   Ja/Nei

10. **Skal ansvarlig områdetekniker alltid kontrollere for lekkasje?**

    Ja/Nei


HMS-hendelse
Observatør av hendelse
Linjeleder
Linjeorganisasjon
HMS-personell
Modell A
HMS-hendelse oppdaget
Utfør umiddelbar skadebegrens-ning
Evaluer behov for varsling
Ikke nødvendig
Nødvendig
Utfør varsling
Start beredskap
Registrer HMS-hendelse
Arbeidsrelatert sykdom innmeldt
Kategoriser, klassifiser og finn årsaker
Evaluer behov for granskning
Ikke nødvendig
Nødvendig
Utfør ulykkes-granskning og forslå tiltak
Planlegg og foreslå tiltak
Godkjenn tiltak
Oppdater hendelses-rapport i Synergi
Ikke OK
Kontrollér kvalitet
OK
Godkjenn hendelses-rapport
Utfør planlagte tiltak
Del erfaringer og lukk hendelses-rapport
HMS-hendelse saksbehandlet


Tilbakestill isolering og trykksett
Godkjenner – operasjonelt systemansvarlig
Verifiserer - isoleringsplan
Ansvarlig - områdeteknikker
Utførende - sentralkontrollrom
Modell B
Godkjenn iverksettelse av tilbakestilling og trykksetting
Godkjenn iverksettelse av tilbakestilling og trykksetting
Aktivitet som krever full isolering utført
Bidra til godkjenning av iverksettelse av tilbakestilling og trykksetting
Aktivitet som krever isolering er utført
Tilbakestill isolering
Type isolerings-plan
Full isolering
Verifiser tilbakestilling i felt
Annen isolering
Forebered for trykksetting
Sjekk system- og områdestatus
Sjekk system- og områdestatus
Trykksett og kontroller for lekkasje
Sikkerhets-ventil?
Ja
Verifiser sikkerhets-ventil i felt
Nei
Arkiver isoleringsplan
Trykksatt system/utstyr tilbakestilt