



Norwegian University of
Science and Technology

Exploring Model Quality in Enterprise Modeling

A Case Study

Knut Sie Andersen

Master of Science in Computer Science

Submission date: June 2016

Supervisor: John Krogstie, IDI

Co-supervisor: Harald Wesenberg, Statoil

Norwegian University of Science and Technology
Department of Computer and Information Science

Abstract

The popularity for enterprise modelling has increased rapidly over the last decades. This demand has created a need for analysing and evaluation enterprise models to determine their quality. Having the right set of qualities results in a model that is useful and bringing value to the organisation.

Statoil is Norway's largest oil and gas company with over 20 000 employees spread all over the world. They have successfully implemented the use of enterprise models in marketing, midstream, and processing (MMP) to document what IT-systems they have and what functions they support.

This architecture is now going to be implemented in other business areas, and therefore it is, necessary to uncover the quality of the model and discover room for improvements. SEQUAL, a framework for model evaluation quality has been used throughout the study. It is a flexible framework, where all the different aspects of the enterprise model are evaluated.

The result of this study has revealed that the enterprise model has a high level of quality. It is a good representation of the enterprise and used for both communication and documentation. The modelling process is thorough and involves the end users from the start, resulting in semantic correct models that are understood by the users. There are however aspects of the model which are not perfect and have room for improvements.

0.1 Preface

This report is submitted to the Norwegian University of Science and Technology (NTNU) as the final part of the 5-year master program in computer science, for the degree of Master of Science. This work has been done under the supervision of Professor John Krogstie at the Department of Computer and Information Science.

This report presents a case study done at Statoil, Norway's largest oil and gas company, under the supervision of Harald Wesenberg. Statoil has given access to documents, models, employees, and facilities needed to perform this research.

0.2 Acknowledgments

During this research, I have been in contact with many Statoil employees which more or less have helped me in doing the research. A special thanks to Harald Wesenberg for guiding me through the Statoil and helping me finding relevant people and documentation. He has also been a great conservationist, and he has provided me with support and comments along the entire way. Harald has also spent an enormous amount of time in discussing the findings of my research among other things. Would also like to extend special thanks to the modellers, who have been available for interviews and questions throughout the study. Lastly, I would like to thank John Krogstie for the help in guiding me through the darkness and into the light. He has provided me with valuable sources of information and given me feedback on my work.

Contents

0.1	Preface	I
0.2	Acknowledgments	II
1	Introduction	1
1.1	Background and motivation	1
1.2	Research question	1
1.3	Report structure	2
2	Background and Theory	3
2.1	Enterprise Modeling - EM	3
2.1.1	Model	3
2.1.2	Enterprise Model	4
2.2	Model Quality	5
2.3	SEQUAL	7
2.3.1	Sets	7
2.3.2	Qualities	10
3	Research Method	15
3.1	Case Study	15
3.2	Research paradigm	16
3.3	Assumptions	18
3.4	Data Generation Method	18
3.4.1	Literature review	18
3.4.2	Interview	18
3.4.3	Survey	19
4	Description of the case	21
4.1	Statoil	21
4.1.1	Marketing, Midstream, and Processing - MMP	21
4.2	Enterprise modeling in MMP	22
4.2.1	Qualiware Lifecycle Manager - QLM	23
4.2.2	Sub-model Types	25
4.2.3	Other areas of modelling	32
4.3	Survey	33
4.4	Challenges with the case	33

5	Model Quality in Statoil	35
5.1	SEQUAL analysis of MMP’s model and modelling process	36
5.1.1	Physical quality	37
5.1.2	Empirical quality	39
5.1.3	Syntactic quality	41
5.1.4	Semantic quality	42
5.1.5	Pragmatic quality	43
5.1.6	Social quality	44
5.1.7	Deontic quality	45
6	Discussion	47
6.1	Right quality	47
6.2	Process adaptation	48
6.3	Tool	48
6.4	SEQUAL as a theoretical lens	49
7	Conclusion and Future Work	51
7.1	Data generation methods	51
7.1.1	Literature review	51
7.1.2	Interviews	51
7.1.3	Survey	52
7.2	Conclusion	52
7.2.1	Research questions	53
7.3	Contributions	54
7.4	Future Work	54
	References	58
A	Survey - Understanding of modeling notations	59
A.1	Survey	59

List of Figures

2.1	SEQUAL - Sets and relations	7
4.1	QLM - Statoil Homepage	23
4.2	QLM - Layout	24
4.3	QLM - Info box	25
4.4	System Landscape - Endur	27
4.5	Information Flow - Endur to energyBoss	28
4.6	Function Model - MMP Marketing portfolio	30
4.7	Function Model - Settlement handling as-is	31
5.1	QLM - Function model in both colors and black and white	38
5.2	System landscape - System SAP Scira	40
5.3	Survey - Sub-model in question	44
A.1	Survey - Answer Table	59
A.2	Survey - 1. Answers Orange	60
A.3	Survey - 2. Answers Blue	60
A.4	Survey - 3. Answers Brown	61

List of Tables

3.1	Trustworthiness in interpretivism vs. positivism	17
-----	--	----

Chapter 1

Introduction

This chapter will provide an introduction to the project. Firstly, it will touch upon my motivation for doing the project. Secondly, it will present the research questions. Finally, the structure of the report will be outlined.

1.1 Background and motivation

Statoil is Norway's largest oil and gas company, with more than 20 000 employees spread all over the world. They started to work on a cooperate management system for ensuring safety, security, and increase efficiency. There have been done a case study looking at how this management system was performing, showing it was heavily used [5].

Marketing, Midstream and preprocessing, MMP, is a business area in Statoil, with the responsibility of marketing and trade of oil products and gas. In MMP there is a small group of solution architects that have developed an enterprise architecture to document some aspects of the department. This architecture is not designed in a top-down approach, but with cost vs. benefit and it is starting to spread in Statoil to other departments.

The popularity for enterprise modelling has increased rapidly over the last decades. Creating a demand for better solutions for enterprise models, architecture, and frameworks. SEQUAL is a framework for analysing and determine the model quality. The framework is both extensive and flexible to support answering many different questions about the enterprise model.

To support Statoil in achieving high-quality enterprise models, SEQUAL will be applied to identify their use of it and challenges in today's practice.

1.2 Research question

To help this research some questions are asked to guide the work:

RQ1: How do the goals for enterprise modelling in MMP affect the model quality?

RQ2: How does the modelling process in MMP affect model quality?

RQ3: What changes can be made to improve model quality?

These questions will be answered in the last chapter of this report.

1.3 Report structure

- **Chapter 2: Background and theory** Contains theory on enterprise modelling, model quality, and SEQUAL.
- **Chapter 3: Research method** Presents the author's research method, assumptions made and describes the different data generation methods used in this report.
- **Chapter 4: Description of the case** This is the case description, presenting Statoil, MMP, QLM, and some of the sub-model types.
- **Chapter 5: Model quality in Statoil** Is where the analysis of MMP's enterprise model will be shown; SEQUAL will be used.
- **Chapter 6: Discussion** Contains the discussion part of this report, combining theory with the analysis.
- **Chapter 7: Conclusion and future work** will provide an evaluation of the data generation methods, together with a conclusion on the research questions. At the end, future works will be mentioned.

Chapter 2

Background and Theory

2.1 Enterprise Modeling - EM

"An enterprise can be defined as a set of interdependent actors, with at least partially overlapping goals, working together for a period of time to achieve some of their goals."[\[2\]](#)

The environment in which enterprises operates today is ever changing, requiring enterprises to change their way of conducting business. Technological innovation, new regulations, and customer behaviour are some examples of change that an enterprise can experience.

To adapt to the situations, sometimes a more in-depth view is needed, and the whole enterprise needs to be examined. EM is a proven instrument for addressing these kinds of organisational challenges [\[14\]](#).

2.1.1 Model

There is some confusion around the word model. Michael Jackson talks about two meanings of the word in [\[7\]](#):

- **Analytic models:** A model can just be a useful description. Being everything from a shopping list and a diagram of a university campus, to a database model which are describing all the different objects, attributes, and values. As long as the model is useful for analysing the behaviour of the object it represents, it is an analytic model.
- **Analogic model:** This kind of model is not a description, but another reality with some similar properties. For instance, GPS-tracking on a map, where the dot on the map is where the GPS-tracker is and the map represents the world. Here the map and dot form an analogic model. By continuing to update the map with the location of the GPS-tracker we have a representation of where the GPS-tracker is in the real world in real time.

The general goal of modelling is to capture the relevant aspects of reality in a model, which in turn can be used for its intended purpose. This may be to get an overview of a situation or organisation, share domain knowledge, or analyse it to increase efficiency. In this context, we are talking about a conceptual model.

”Conceptual models are used to represent both static phenomena (e.g., things and their properties) and dynamic phenomena (e.g., events and processes) in some domain.”

In software development they have at least four purposes [20]:

- Support communication between developers and users
- Helping analysts understand a domain
- Providing input for the design process
- Documenting the original requirements for future reference

2.1.2 Enterprise Model

”An enterprise model is a computational representation of the structure, activities, processes, information, resources, peoples, behaviour, goals, and constraints of a business, government, or other enterprise. It can be both descriptive and definitional, spanning what is and what should be.”[10]

Christensen and the other authors of [2] are categorising enterprise models into three groups according to their purpose. They call it ”The Pakt Taxonomy” and these categories are:

- **Construction of reality:** Models that are used as a foundation to create a shared world-view. As-Is and To-Be models exist for precisely this purpose, painting a picture of how an organisation is now and how it is planned to look in the future. This helps for communication and coordination since people with the same world-view typically share the same goals and understanding of the organisation.
- **Analysis and simulation:** Running simulations on a model can be done with no risk to the enterprise and still give the rewards of showing the results of a decision. Analysing a model of high quality helps in understanding the model and in turn the enterprise.
- **Model deployment and activation:** Models which are used for controlling and performing work. These models give an overview over what is and how it is done within the enterprise. The result of changing a model from this category is often that the enterprise change as well.

Not all models that describe a part of an enterprise are enterprise models. Wesenberg [21] lists some characteristics that are required for a model to be an enterprise model. Not all enterprise models have all of them, but they are used to separate enterprise models from other models.

- **Enterprise models are for communication through time and space.** Enterprise models are expected to exist for a long amount of time and used by the whole enterprise. They must be relevant after a project is done, and to other people than just the members of the development team. All of this should be reflected in the models.
- **Enterprise models are abstractions.** An enterprise is complex, so an enterprise model needs to be simplified to be efficiently used. A complex enterprise needs abstractions to achieve this, and it is important that the right abstractions are used, if not the model is not very useful.
- **Enterprise models are managed.** Enterprise models need to be consistent to be used correctly. Therefore, they need to be managed to be trusted and used.
- **Enterprise models must have the right quality.** Wesenberg talks about three qualities of an enterprise model. 1. Syntactic, to what degree does the model use the modelling language. 2. Semantic, how good the model reflects the real world. 3. Pragmatic, how well is the model understood by the target audience.

2.2 Model Quality

Quality is defined by ISO 9000 [1] as;

“the degree to which a set of inherent characteristics of an object fulfils requirements.”

The quality of an object is determined by how well it meets the requirements set for that object. High quality is when an object fulfils or exceeds the requirements, while low quality is when it does not.

Research done by Moody [11] have shown that mistakes are more expensive to correct the longer it takes to detect them. High-quality models can help in early detections and correction of errors, reducing the cost and time used.

Sandkuhl and the other authors have in their work outlined some quality criteria for enterprise modelling, and calling them the basic principles of modelling [9]. Depending on the purpose or goal of the modelling, different criteria are more relevant and carry more weight than other. The quality criteria are:

- **Completeness:** The degree to which all relevant facts from the domain are included in the model.

- **Correctness:** How well the model conforms to the rules of the modelling technique.
- **Flexibility:** The degree to which the model can adapt to changes in the modelling domain.
- **Integration:** To which degree of consistency between the different sub-models that constitute the model.
- **Simplicity:** The degree of minimal use of modelling constructs for the presenting knowledge in the model.
- **Understandability:** The extent to which the concepts and structures of the model understood by the stakeholder.
- **Usability:** The ability of the model to be used for its intended purpose.

In this report, SEQUAL is used to determine the model quality, but other frameworks exist such as Guidelines of Modeling, GoM [11]. This framework contains general principles, guidelines, on how to improve the quality of information models. In GoM, higher quality is obtained through reducing the subjectivity in the process. The principles are:

- **The Principle of Construction Adequacy:** Nobody, is capable of judging if a model is correct compared to reality. Instead, it creates a consensus of the real world, which can only be proven in questioning the stakeholders. The challenge of this principle is to create the consensus between the modeller and the user.
- **The Principle of Language Adequacy:** Modeling languages are tools used to represent systems. It is important to use the right tool for the job and use the tool right, language suitability and language correctness.
- **The Principle of Economic Efficiency:** Cost-value, the cost of creating and maintaining a model should not exceed the value gained from it.
- **The Principle of Clarity:** Deals with comprehensibility and explicitness of model systems.
- **The Principle of Systematic Design:** Every view should be connected to the model and not create disagreements between other views.
- **The Principle of Comparability:** Two models should be comparable both on model and meta-model level. content...

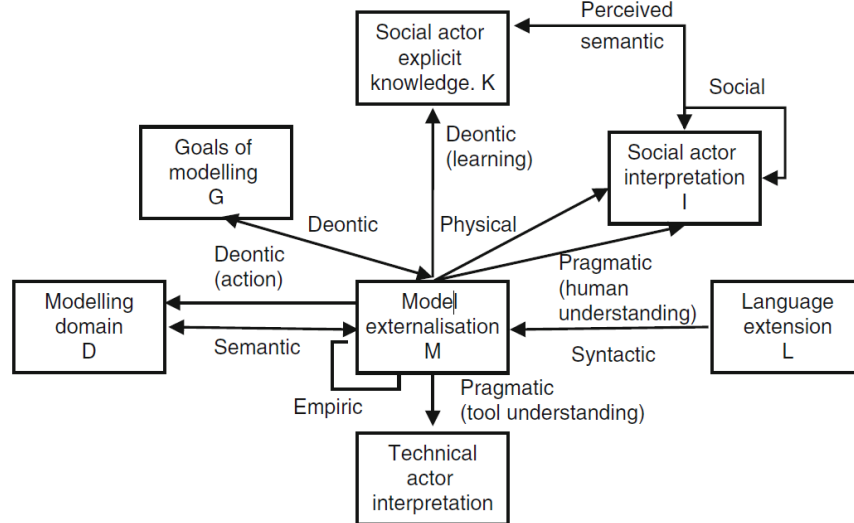
The three first principles are mandatory and create the basis of the framework; the last three are optional. The framework is flexible since the guidelines can be used independently of each other and to different degrees, depending on what problem area to address.

2.3 SEQUAL

SEQUAL is a framework for evaluating qualities in conceptual models. It consists of eight groups or sets, enveloping different aspects of the model, and looks at the relationship between them. SEQUAL is a flexible framework where each part can be used in a number of ways[8]. This include:

- Guiding modelling processes to achieve high-quality models.
- Evaluating qualities of existing models.
- Evaluating qualities of modelling languages, to assist in choosing the appropriate language for the modelling process as well as to further develop the language.
- Guiding meta-modeling in situations where a new language is needed to support specific situations.
- Evaluating tools used to support the development process.

Figure 2.1: SEQUAL - Sets and relations



2.3.1 Sets

The SEQUAL framework is made up of eight sets, with each set dealing with a different aspect of the model. The sets are Goals, Audience, Model, Language, Domain, Knowledge, Interpretation, Technical actor.

G - Goals

This set contains the reasons for modelling and range from easily understandable to quite complex. The goals (G) helps to keep focus on what is important for the model, especially when it gets more complex with many stakeholders or situations. It can answer the question of "what is supposed to be made and why?".

The main categories proposed for enterprise modeling according to the authors are [8]:

- **Communication and sens-making around models of the current state;** helping to refine the processes and sharing best practice within the organisation.
- **Communication around models of the future state;** new processes should be documented and increase the connections of the current processes and the organisation. They should also help teach the stakeholders about the domain.
- **Computer-assisted analysis;** the models should be helpful in analysing the current work processes.
- **Model deployment;** into use as a procedural tool for everyday use, and being there for the stakeholders as process-support.
- **Context;** for defining the scope of the software application.

G is often defined at the start of a modelling process and takes place mostly before the modelling starts. However, it is not a static set and can change later in the process if the domain changes or new knowledge is uncovered.

A - Audience

Audience (A) is not found in fig. 2.1, but is included in both explicit knowledge (K) and interpretation (I). A is a collective of all the different actors that are involved in the modelling process.

- **Stakeholders** are all of those who are affected by the system, e.g. financial interest, modeller, or user.
- **Participants** are a subset of Stakeholders, who are influencing the process and/or the product.
- **Technical actor** are the computer programs that interact with the model, through tasks like code generation or model layout.

A is also subject to change throughout the process. This can be due to a number of reasons, such as a change in the scope of G, employees changing jobs, new technology being introduced, or organisational changes taking place.

M - Model

This set includes all statements which are in the model. The statements are put into two subsets of the model (M), M_e represents the statements that are explicitly drawn from the model, whilst M_i represents those that are implicitly drawn from the model. M_i also includes statements that are a consequence of the modelling language logic.

Views are also covered in this set, where a view is a subset of M and ideally contains only what is relevant for a particular A. There can be many different views for many different participants, but they do not contradict each other as they only show M from different sides and sizes.

L - Modeling Language

The modelling language (L) is what the language can explain through its syntax. It contains all possible statements that can be expressed with language. There are no limits to how many different languages and sub-languages there can be.

D - Modeling Domain

Every statement that can be stated about the enterprise is included in the modelling domain (D). These statements are divided into domains, which are again split into two categories:

- **Temporal:** Past, current (as-is) or future (to-be). All of these domains are time sensitive, for instance; Used in a project and only relevant during the project's time-frame. While the past and current are usually descriptive, the future, as a desirable future state, represent the ambition of the modellers when thinking developing their model.
- **Scope:** A subset of the physical world, an organisation, or an information system are all examples of different scopes.

During development the domain shifts or evolves along with the modelling. This can be caused by the modelling itself, as well as by the domain itself, but also by external changes, e.g., the environment.

K - Explicit Knowledge

This is the relevant and explicit knowledge (K) of A. It is limited by what A knows, and therefore does not necessarily cover the entire domain. K can change through the modelling process as both individuals and the organisation learns more about the domain.

Participants may be grouped as an organisation for the purpose of knowledge coverage since individuals will always have a more limited base of knowledge.

I - Social Interpretation

Social Interpretation (I) contains all the statements that social actors can make by looking at an externalised model. Each actor has its set of statements, like the case was with K, as individuals do not always see things the same way.

T - Technical Actor Interpretation

Technical actor interpretation (T) is similar to I, but with technical actors instead. T contains statements on how each technical actor individually interprets M.

2.3.2 Qualities

The relationships between the sets are the qualities that the model possesses. Each quality can be evaluated independently of each other, which is a good feature since they are also quite extensive. Every quality is not always equal in importance, and it is up to the modellers to decide which qualities that are important for their models. This is one of the strong points of SEQUAL, making it a flexible framework for model quality.

Physical Quality

Physical quality is the relationship between M and A. Every model has to be a physical object, either stored on a disc or drawn on a piece of paper. There are three main aspects of physical quality:

- **Persistence:** How well is M protected against loss or damage and what are the risk of that happening? How is it stored? M should be safe independently of the chosen storage medium.
- **Currency:** Can the information given by M be trusted, and how long ago was the data added or changed? The domain set some requirements depending on the rate of change, with higher volatility increasing its importance. The ability to check when the data was added, modified, or validated, increases the quality.
- **Availability:** How available is M for A? M firstly needs to be externalized and information on how to access it must be known to A. This cover distributability, especially crucial for a geographically disperse A. Faster and easier access results in higher quality, e.g. having M available online is better than needing to request it by mail. What formate it is distributed in also affects the quality, with the ability to edit or comment increases it.

The quality does not include how the physical model is viewed, only that it is there to be viewed at a time that is reasonable and that a user can trust the data presented. A model repository is a common way to ensure most of this. The more rules that are followed, the higher is the quality.

Empirical Quality

Empirical quality is about how easy is it to read the model; all from size of fonts to color usage, and how many bends the edges have. Consistency in use of color, fonts, shapes, and the use of naming conventions are common ways to increase the readability of M.

For most of these aspects, there are not a correct way, but some traits have been identified empirically to make models easier to understand. These include things such as fewer elements, short edges, and less use of bends on the edges.

Syntactical Quality

Syntactical quality is the relationship between M and L and is evaluated on syntactical correctness. Meaning that all statements in the model should be in compliance with the syntax of the chosen modelling language. There are two kinds of syntax errors:

- **Syntactical invalidity:** The incorrect use of notation, words, or graphemes, with the result being a statement that cannot exist within the language.
- **Syntactical incompleteness:** To not state or declare all that is needed to complete a statement, creating room for interpretations that can create a different statement than intended.

There is a formula to determine the degree of syntactic quality in M, which is one minus the rate of missing statements from M.

$$\text{Syntactic quality} = 1 - (\#M_E/L + M_{missing})/\#M_E$$

$M_{missing}$ is the amount of statements needed to make M syntactically complete.

Syntax checks are needed to ensure syntactical quality, and should be supported in the modelling tool and modelling techniques.

- **Error prevention** is mainly controlled by a modelling tool, which checks if the statement can exist within the language. The modelling session should be stopped and feedback given to the user, to prevent continuing with an invalid model.
- **Error detection:** Not all errors are critical, e.g. syntactical incompleteness, and should be allowed during a modelling session. These errors should be marked and made known to the user, but the modelling should be allowed to continue in the hope that they will be corrected later on.
- **Error correction** will be more complicated to automate in a tool, however, there should be a way for the user to check all their errors and correct them themselves.

Semantic Quality

Semantic Quality is about how well M represent D and is measured in two ways:

- **Validity:** M is semantic valid if all the statements within M, also are within D.

$$M \setminus D = \emptyset$$

- **Completeness:** M is semantic complete if all the statements within D, also are within M.

$$D \setminus M = \emptyset$$

Both validity and completeness are not as straight forward as they appear to be. For instance, a person can have the attribute favourite color, but that attribute is in most cases irrelevant for an employee. For completeness, the domain must be small or well-defined to be of any use, which in effect means checking this quality is close to impossible.

Perceived Semantic Quality

Instead, one can look at it with the eyes of A, using their knowledge (K), and interpretation (I) of M.

- **Perceived validity:** M is perceived as semantic valid if all the statements within a participant's interpretation of M (I), also are within its knowledge (K).

$$I \setminus K = \emptyset$$

- **Perceived completeness:** M is perceived as semantic complete if all the statements within a participants knowledge (K), also are within its interpretation of M (I).

$$K \setminus I = \emptyset$$

Every aspect of the modelling process involving participants can not be absolute. Depending on what the different participants knows and how they interpret, one may have a model that is not understood by all its participants. These things can also change during the lifetime of the model, again changing the degree of perceived semantic quality. To ensure increased quality, A should be educated on both M and D to increase its understanding.

Pragmatic Quality

Pragmatic quality is the relationship between M and I; how is the externalised model interpreted by the audience? It is important to differentiate between interpretation by humans and tools. The degree of quality is determined by how correctly M has been understood by A.

For technical actors (T) the meaning of comprehension is that all statements relevant for its task are understood. A high degree of syntactical and semantical quality usually makes it easier to utilise technical actors. Examples of high syntactical and semantical qualities is a formal language and a small, well-defined domain.

Social Quality

All the social actors have their own I and K about both M and D. The goal for social quality is to make them agree on the same interpretations. There are two types of agreements:

- **Relative:** All their interpretations are consistent, e.g., security is an important quality attribute.
- **Absolute:** All their interpretations are equal, e.g., security is the most important quality attribute.

It is important to know who made changes in the model, i.e. know who made a change can make a user trust the information more.

Deontic Quality

Deontic quality is the relationship between M and G; how well does the model fulfil the goals? All goals for modelling should be addressed by M. This also includes when to stop modelling. Everything can not be represented in one model or models; it is important to know what should be contained in each sub-model. This knowledge needs to be made clear before the modelling starts.

Chapter 3

Research Method

This is a continuation of an earlier case study that the author conducted at Statoil. There have been some case studies focused on Statoil and how they use enterprise modelling. One looked at process modelling as a way to communicate work processes and requirements [6].

3.1 Case Study

An often used definition of case study is Robert K. Yin's [22]:

" A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."

Furthermore, Oates argues that there are four characteristics that defines case studies [12]:

- **Focus on depth rather than breadth:** Looking at one instance of the phenomenon in question, to get as much information about it as possible.
- **Natural setting:** Studying the case in its natural setting, not in a laboratory, with the researcher focusing on getting as close to the natural setting of the case as possible without interfering with it.
- **Holistic study:** Investigating everything as a whole and not trying to isolate individual factors. The focus of the researcher is on studying the complexity of relationships and processes and how they are connected and relate to each other.
- **Multiple sources and methods:** The researcher is using a wide range of data sources. Both quantitative and qualitative data can be used, obtained by many different data generation methods.

Even though all case studies are defined by these characteristics, there are different types of case studies. According to Yin, there are three different types of case studies[22]:

- **Exploratory:** This type of case study is used to explore those situations in which the intervention being evaluated has no clear, single set of outcomes.
- **Descriptive:** This type of case study is used to describe an intervention or phenomenon and the real-life context in which it occurred.
- **Explanatory:** This type of case study would be used if you were seeking to answer a question that sought to explain the presumed causal links in real-life interventions that are too complex for the survey or experimental strategies. In evaluation language, the explanations would link program implementation with program effects.

This case study is of the descriptive type, as it wants to describe how MMP's enterprise models are used and how they are made. Case studies also have some types depending on time; historical, short-term, and longitudinal. This is a short-term case, describing the situation as it is now.

3.2 Research paradigm

When looking up the word paradigm in Merriam-Webster dictionary you get this definition[13]:

"a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated"

A paradigm is simply put a system for thought that guides the way we think; it is a specific way of looking at the world. A research paradigm is a way to explain how you observe the world and how this influences your research. This makes it easier to read since you get the reader to understand how you think about the world and how that has affected the way you have conducted your research.

There are many research paradigms, as the evaluation of an experiment and a case study are not done in the same way. Case studies are often used with interpretivism, with the purpose being to identify, explain, and explore how factors of a social setting are related to the case. The definition of interpretive research according to Oates is[12]:

"Interpretive research in IS and computing is concerned with understanding the social context of an information system: the social processes by which it is

developed and construed by people and through which it influences, and is influenced by, its social setting.”

The main characteristics of interpretivism is according to Oates [12]:

- **Multiple subjective realities:** There is no single big "truth". Knowledge is constructed in our minds, and that truth may not be the same as that of everyone else.
- **Dynamic, socially constructed meaning:** A person's knowledge can only be communicated through socially constructed means, like language and shared meanings.
- **Researcher reflexivity:** Researchers are not neutral. They view the world in their way, and that is bound to affect their research. Both in their understanding of the situation, but also when they present their research to others.

According to Shenton in [15] many critics are reluctant to accept the trustworthiness of qualitative research. He cites Guba's four criteria that should be considered when working towards a trustworthy study [3]. They are shown in table A in relation to their counterparts from positivism. The aspects are explained under:

- **Credibility:** The research must be done in a way to ensures credibility. Using multiple sources of data generation helps to do this.
- **Transferability:** In positivism the research needs to be detailed enough for others to understand the environment, as the case is often specific for a case and there can not be made generalisations from it.
- **Dependability:** Documenting the research sufficiently, not to be repeated to gain the same result, but to give the reader a good understanding of which methods has been used and to what effect.
- **Confirmability:** Are the findings in the research grounded in enough data? Detailed descriptions of methods should help the reader in determine if the data generation should be accepted.

Table 3.1: Trustworthiness in interpretivism vs. positivism

Interpretivism	Positivism
Internal Validity	Credibility
External Validity, Generalizability	Transferability
Reliability	Dependability
Objectivity	Confirmability

3.3 Assumptions

Before defining the case, I need to make some assumptions about my case. These are:

- **Model vs. sub-model:** When speaking and having interviews, most people speak about models. Either it is the whole model, or it is one diagram of it. In this report "the model" is referring to the entire enterprise model and all of its content. Sub-model will be used when diagrams, figures, or a part of the model is discussed. Diagrams and figures may also be used to

When talking about a diagram, figure, or a part of the model, sub-model will be used to make it clearer what is in question.

3.4 Data Generation Method

In case study research, in general, it is important to get information from different sources and methods of data generation. In this research three methods have been used; literature review, interview, and survey. In all of the three methods, different sources have been identified and used.

3.4.1 Literature review

In this research quite some time was spent on getting a good understanding of the field of enterprise modelling and model quality. This has mainly been done through a document study, including both digital and physical texts, pictures, and diagrams.

SEQUAL has been the main focus of the literature review. It was important to get a good understanding of all the aspects and uses of SEQUAL. It should also be mentioned that having the creator of SEQUAL, John Krogstie, as my supervisor has helped me a lot in my search for understanding and good documentation.

3.4.2 Interview

Interviews are not the same as conversations, but an interview is a conversation. There are also some rules to interviews that need to be followed in order for the interviews to be suitable for data generation in a scientific research[12]. The questions need to be of some complexity and reveal detailed information. They also require some open questions, creating room for the object to explore and explain feelings and experiences.

Interviews can also vary in the way they are structured. There are three types:

- **Structured:** Asking the same questions in the same order to different objects.

- **Semi-structured:** This form is not as rigid as structured interviews. The semi-structured interview provides room for new questions to come up during the interviews, as well as leave out some of the already prepared ones. However, the interview needs to stay on topic the entire time, and the topic should be well thought through by the interviewer before the interview being conducted.
- **Unstructured:** These tend to be more informal and more like a normal conversation. Questions also do arise depending on the answers of the interviewee. The questions should be probing and as open as possible to uncover more and make room for new questions.

The interviews were done in this research have been semi-structured. There have been six interviews on the topic of Statoil's modelling process and enterprise model. Two interviews were conducted during the author's earlier work on Statoil and were included as this work builds on the earlier work. There have also been done a lot of small-talk and conversations about the topic.

3.4.3 Survey

Surveys are used to gather more quantitative data than an interview. Its goal is to extract some specific data from the target audience; this can be everything from general to really specific. A survey can be done in many medias, i.e., mail, paper, phone, face-to-face, or social media. There are some factors to take into account when administrating a survey; cost, coverage of target audience, response accuracy, and respondents willingness to participate.

In a survey there are a set of questions, they are given to the target audience. If the survey is distributed to a representative sample of the target population conclusions can be drawn about that population without having everyone answer the survey. To do this it is important that the sample audience is in good correlation with the target population, or else the generalisation made by the answers may be wrong.

Chapter 4

Description of the case

In this chapter, the case study will be presented based on the author's understanding of it. The enterprise model of Statoil and the modelling practice for MMP are the focus of this chapter and used as the basis for the SEQUAL analysis presented later in this report.

4.1 Statoil

Statoil is Norway's biggest oil and gas company with more than 20 000 employees all over the world [17]. They operate under many conditions, such as different cultures and laws, as well as different common understanding, and experience. In all of this Statoil needs to focus on safety, security, and to influence their employees to follow their best-practice. To ensure this Statoil started to use enterprise models in their cooperate management system.

Previous research within Statoil has shown that their management system is heavily used throughout the whole company, resulting in high work quality and increased safety [18]. However, there is still room for improvement [6].

Some years back there was a focus in Statoil on enterprise architecture. As a result, one business area started to develop their own modelling process, not following any particular architectural framework.

4.1.1 Marketing, Midstream, and Processing - MMP

Marketing, Midstream, and Processing include marketing of and trade with oil products and gas in Statoil. This business area encompasses the responsibilities for developing the value chain for oil and gas, alongside transport, processing, distribution, and the development of business opportunities for reusable energy [19][16].

Global Business Services IT (GBS) is Statoil's IT organisation, providing the solution architects who are working on the architecture. They are the modellers working on this architecture full time, participating in projects and keeping the

model up-to-date. Some have also worked with other business areas to help them get started with the using the architecture.

The architects reasoning for the modelling practice for MMP is due to the focus on what works, something that was confirmed in all the interviews conducted by the author with the modellers:

"Everything we do is based on what works, cost vs. benefit. That is the reason we have focused on some sub-models since we can see them being used, while we have gone away from others."

They do modelling because they see the benefit from it, and not because there is a request from the top that something needs to be modelled.

4.2 Enterprise modeling in MMP

Within MMP there has been a focus for modelling for quite a while, starting with process modelling of their work processes. In one of the author's interviews, it was said that the models were too detailed, which made them impossible to maintain. So when Statoil started focusing on enterprise architecture, MMP changed focus away from process modelling and reduced their work with it.

In MMP they started with documenting their systems, to get an overview of what systems they had and how they were interacting with each other. In an interview, this was said:

"When Statoil started an initiative on enterprise architecture it was then completely natural to find out what kinds of systems we had, and how they were connected."

This uncovered some duplication of functionality, where different parts of the department used different systems for similar things. They started making their systems more generic, and not dependent on what kind of product they were selling, as it had been previously. The result was the creation of the function model.

" With connecting function model and system landscapes, we could find out which system supported which function of the department. It became an important tool for communication with planning, showing where we had gaps and where to invest or improve"

The sub-model described above here it the master plan, illustrating how well the business functions are covered.

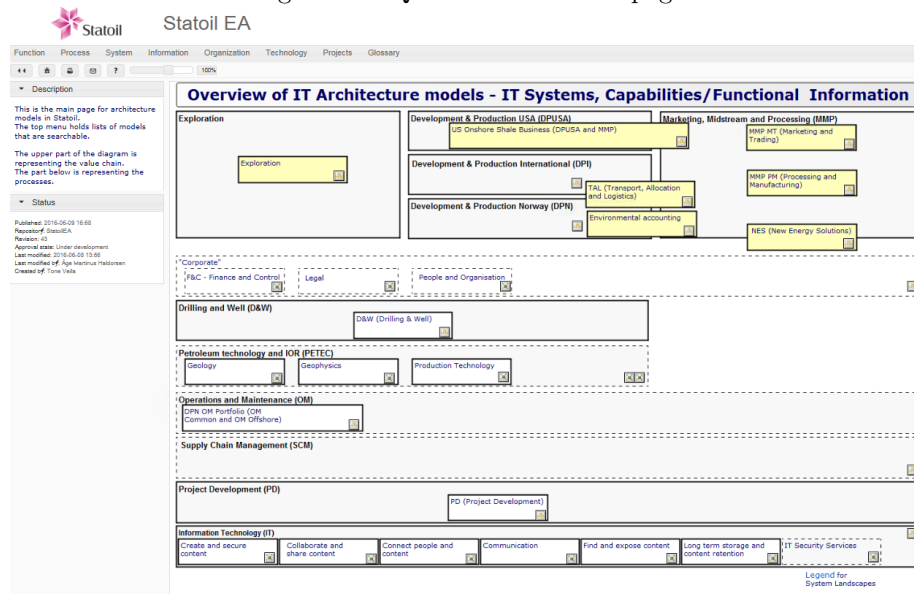
Now the architects who work with MMP are developing a system showing the information structure between systems, which information objects are handled by different systems. Big data analysis is the driving force behind this project.

4.2.1 Qualiware Lifecycle Manager - QLM

QLM is a flexible modelling tool created by Qualiware, a private Danish company with offices in more than ten countries, including Norway. Qualiware provides not only a tool but also a meta-model and a modelling language, they are also responsible for maintaining the meta-model and thus change it when Statoil needs it. In several of the author's interviews, it was mentioned that Qualiware has a good relationship with Statoil, and there is rarely a problem with facilitation changes.

Within MMP they use one common private workspace for all modellers, QLM is therefore not run locally. In this database, the whole model is stored, and all templates and diagram are available for every modeller. QLM does publish the sub-models to the web every night, the same as ARIS. These sub-models are available to every user on the Statoil network with some restrictions. There are some diagrams, to-be, that are restricted to only some certain users. This is not often the case, but the functionality to restricts diagrams are there. Most of the security in keeping the sub-models for Statoil's eyes only relies on access to the Statoil own network.

Figure 4.1: QLM - Statoil Homepage



In this case study only the HTML generated version of the tool is explained in detail. Since the author did not have access to the other part of the tool. The HTML version of the tool, the published model, is what the consumer relates to. The modellers use the modelling version when in meeting and doing modelling with users, but then the modeller are there to explain everything, the HTML

version is supposed to be stand alone.

The tool's UI is quite plain and colorless as shown in fig 4.2. The tabs contain drop-down menus of sub-category relating to the tab categories. On the left, there is space for different fields depending on what the tool is showing, but there is always a status field. The field can be hidden from view with the help of the double arrowhead right above it. The status field shows general information about the view that is showing, including last modified and last modified by 4.2.

Figure 4.2: QLM - Layout



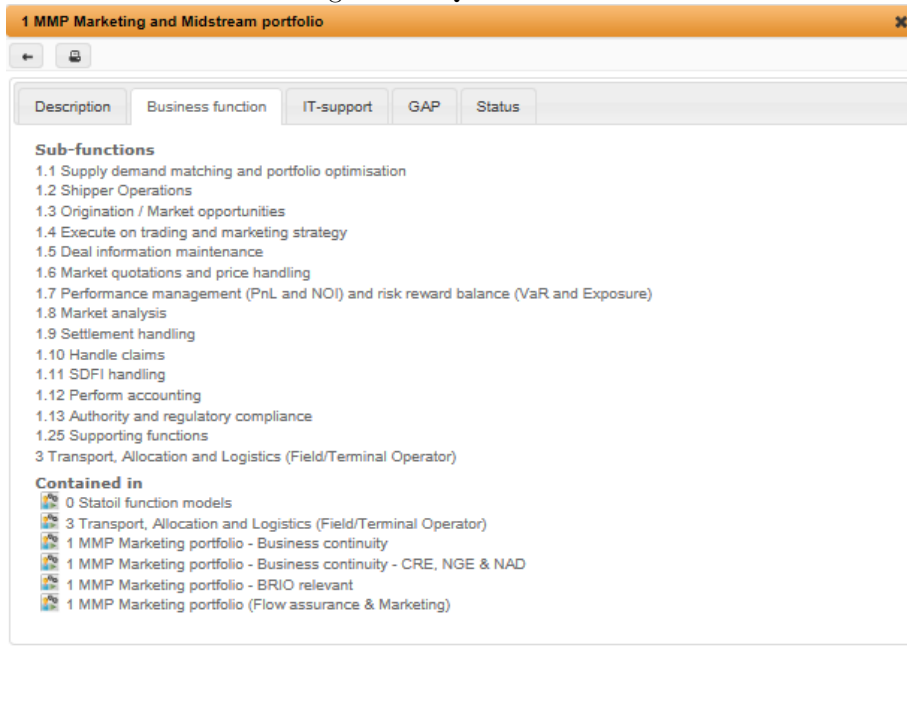
Above the field are some buttons and a slider, the buttons are; home, print, mail, and help. Home brings the user to Overview of system landscapes and functional models. The print button prints the page you are on, in a format adapted for paper. Mail opens up outlook and creates an to the architects in MMP. Help redirects you to a page that is not found, and there is no current plan for the button. The slider is for zoom, it is not smooth, but jumps to specific resolutions; 100% is standard, and the range is 25 to 150.

When the user clicks on most items, figures, or names an info box will appear, see fig 4.3. This box contains different tabs depending on what type of object it is displaying information about and how much information is related to the object. The box from fig 4.3 is from MMP's Marketing and Midstream portfolio (fig 4.6), it displays all the sub-functions(group boxes) of the portfolio and also shows in which diagrams the portfolio is drawn. I pop up in the middle of the

screen, and the box is draggable and re-sizable, but there can only exist one box, and when opening a new one, it is back to default place and size.

The box has two buttons; back and print. The back button goes back to the previous box on that page, changing diagram or view resets it. Print prints its content in a format adapted for A4-paper.

Figure 4.3: QLM - Info box



4.2.2 Sub-model Types

In the enterprise model, there are several sub-model types. They combine objects in different ways to show a specific view or answer a specific question. Some of these sub-model types are used more than others. This case study focuses on two types; system landscape and function model. Each of these sub-model types can be presented as an as-is and to-be.

AS-IS

Every sub-model that represents how something is today are an as-is sub-model. They are used to communicate what state something is in right now, and can be used with other sub-model types.

It is used as documentation and to get an overview before beginning a new project. In the early phases of a project they are checked, to make sure they are up-to-date. In one of the interviews, it was stated that

"... ment to represent what we have. The modellers use them in projects to illustrate what we have and what we are working with."

TO-BE

A to-be sub-model is a futuristic state, most desirable state, used to communicate intentions of an area or system. In a project, this is how the architects think a system will look after the project. The to-be is constantly updated to represent the goal of the project. When the project is done, the as-is is updated and the to-be not being important any longer is usually stored in case of later use.

There are also sub-models of how the architect think an area is going to be without it being in a project. This can be a planned change, change of life-cycle status or some other event from outside of the architects control that triggers the creation of such a to-be. There are also to-be sub-models that are plans or projections, like a five-year-plan, these are routinely , every sixth month, checked to make sure the sub-model are correct or in line with new changes.

System Landscape

System landscape is one of the first sub-model types that were created for this architecture. It was created as documentation of what IT-systems where within MMP had and how they were connected to each other. It gives a logic representation of an IT-system and its information flow to other systems. Fig 4.4 is a system landscape of Endur, one of the systems that currently is involved in a project.

A centric system landscape has an IT-system in the middle and all of the systems that are connected, around it. There are also external actors represented in the diagram and the kind of interface that exists between them for communication.

The system has a color assigned to it, depending on the life cycle status of the system. There are four colors:

- **Green:** The system is in use now and safe to use in the future. The risks of this system are considered none to low from today's standpoint.
- **Yellow:** The system is in use now but has an unsure future. There are some risks the system will not be used in the future.
- **Red:** The system is going to be removed either by a running project or a planned one.

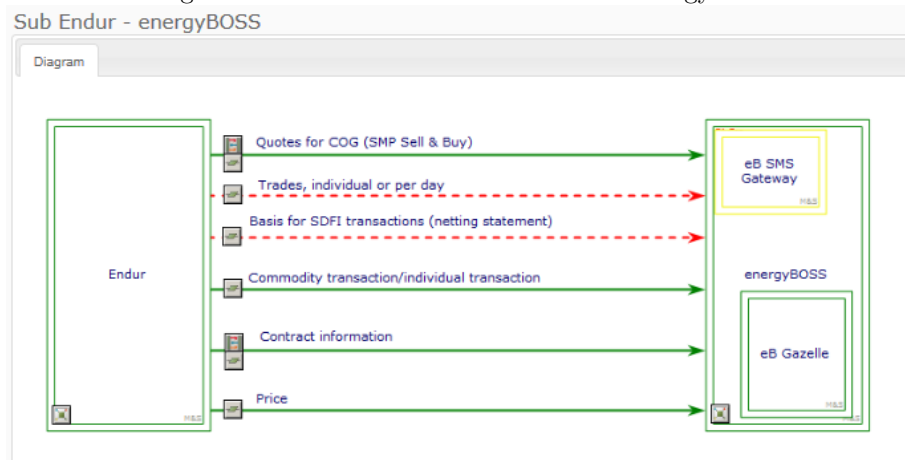
- **Purple:** The system is emerging, used in to-be diagrams, representing a new system that has not been incorporated yet.

Each color is decided by the system responsible, and reviews are triggered by events. These events can, for example, be; new technology or hardware, market change or system supplier going bankrupt.

Information flow in system landscapes is represented in the diagram as an arrow. This arrow has different shapes and colors depending on the level of automation. There are five types of information flow in this architecture:

- **Solid green:** The information flow is fully automated.
- **Dotted green:** The information flow is semi-automated. The data movement is automated, but it needs to be triggered by a user.
- **Dotted red:** The information flow is semi-manual. The information is moved digitally by the help of a user; an example is copy/paste.
- **Solid red:** The information flow is fully manual. There is no IT-support for the data, and it needs to be manually moved and entered. An example is getting a note with variables for a function to be run in a simulation.
- **Solid black:** This is just an abstraction of multiple information flows. When the user clicks on it, a new diagram will appear with all the flows i.e., fig 4.5.

Figure 4.5: Information Flow - Endur to energyBOSS



Every system has a system responsible, who is a part of all the processes of modelling his system. This is special for MMP where there are not that many IT-systems. In QLM there is a system list where all systems that are in the model is listed, with name, life cycle, and description just to mention

some columns. The system responsible has the overview of all the technical interfaces, but not necessarily all the non-automatic ones that exist. In one of the author's interviews, this was said about the gathering of information for the manual interfaces:

"We catch the manual interfaces by talking to peoples. We arrange a meeting and model-on-the-fly with them, explaining what we have and ask them if something is missing. This is connected with starting a new project, always start with as-is to get it completely updated from the people who are working with the system."

This type of sub-model is not used by a software developer for implementation documentation, as it is not detailed enough for that. It is used in projects to get all involved on the same page, and to show all dependencies for the IT-system in question.

System landscapes are used both as as-is and to-be sub-models. The as-is system landscape is a representation of how the system works today and is updated before every project. The to-be is created to communicate the destination for the project, or where the architect believes the project is going. It is during the project used as a goal and changed accordingly if the goal changes. After the project is completed the to-be is now representing the system, the old as-is is updated. All the sub-models and diagrams used in the project is then discarded.

Function Models

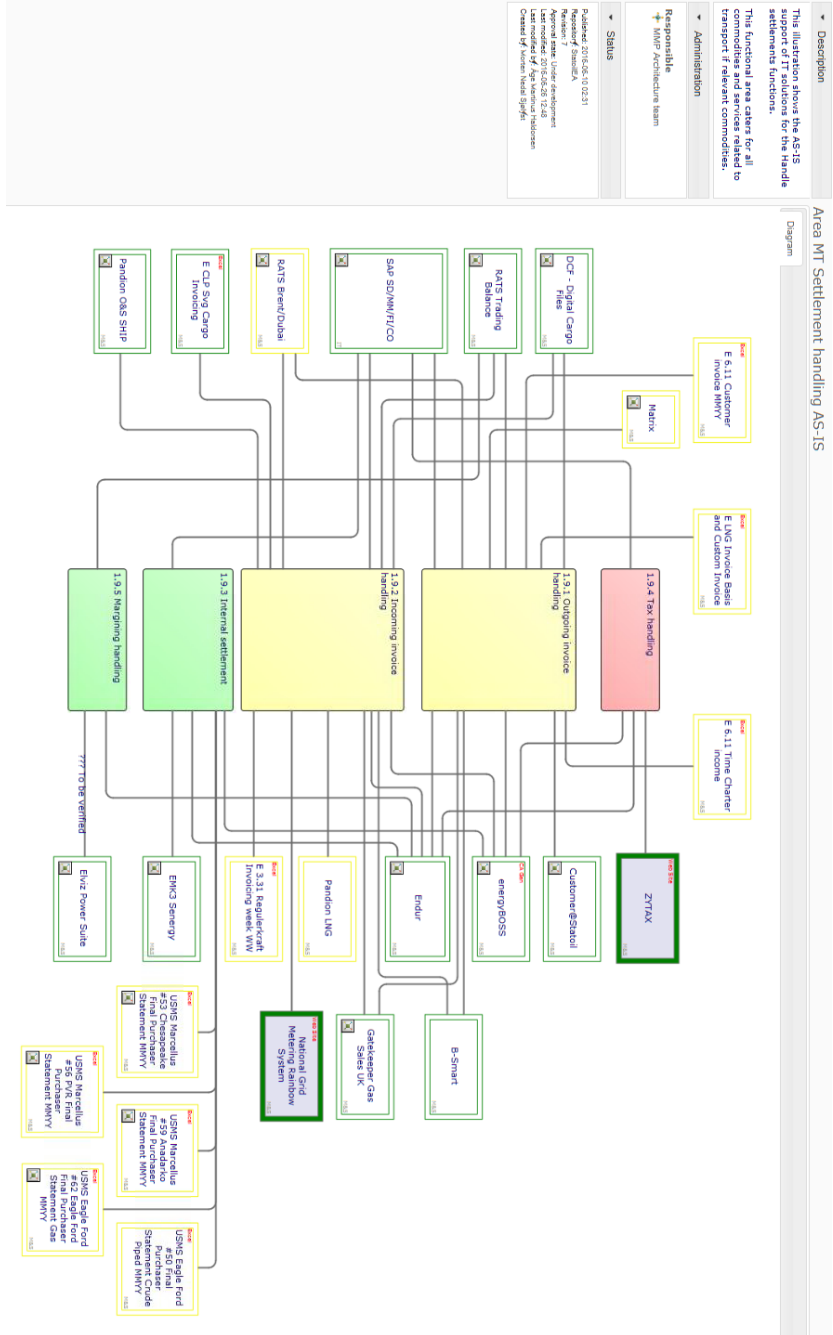
The function model shows how business functions are connected to each other and how they are supported by IT-systems. The goal is to communicate in which situation the department functions are in today. This is a high-level conceptual model.

As shown in fig 4.6 the functions of MMP Marketing are grouped in different areas. Each function is colored to reflect how well a function meets its requirements. It is important to note here that a function's color does not signify what the colors are on the IT-systems that supports it. It implies that there is a gap between how things are and how they should be. On this topic, this was said in one of the interviews:

"A function can be green even though there are gaps in the system. There should not be used money on the system, and there has been an assessment and a decision is taken to go forth with the system."

There are three colors; Green, yellow, and red. Green signifies that the requirements are satisfied. When a function is yellow it is not covered enough, the state is not desirable, and something should be done. Red signals that there is a problem that needs to be addressed. There is such a gap between how it is and how it should be that it is causing trouble.

Figure 4.7: Function Model - Settlement handling as-is



It is important that the coloring tells a correct story of the situation. Too much green gives no gaps and does not give priority when deciding where to start new projects. On the other hand, too much red indicates that the place is on fire and creates lots of projects which is costly and may not be money well spent. The coloring needs to be faithful to the state of the function, and not what someone wishes it to be.

The coloring process is done by solution architects and reviewed periodically. The whole process is used to uncover gaps, which are used to document the need for a project. There are a lot of factors that contributes to the color choice, both the user and supplier are taken into account. The user may feel that the system is no longer satisfying their needs. The supplier may go bankrupt, or discontinue a product. On this topic during the author's interviews, it was stated:

"One time we had a supplier go bankrupt. This created a lot of top-priority projects to substitute the system."

There are no official rules for the coloring process. It is done with a focus on what gives the most value, cost vs. benefit.

When going deeper into the sub-model, diagrams are showing exactly which IT-systems are supporting which function. Fig 4.7 shows all the functions for settlement handling and their supporting IT-systems. The lines between them indicate which system are supporting which function. This area is a good example for showing there are not necessarily a correlation between system color and function color.

When a gap is identified, it is registered in the model and linked to the function. The gaps for a function is shown by the info box when selecting the function and then the GAP-tab. This does not show the documentation for the gap, only that it exists and a little description of it. There is a list in QLM where all identified gaps are recorded.

4.2.3 Other areas of modelling

There are other areas where it has been done some modelling within the enterprise architecture for MMP. The topics that are modelled, besides from system and function, are; process, information, organisation, technology, and projects. They also have a glossary containing names, type, and a small description, the list of names are quite extensive.

In one of the author's interviews the topic of what the plan was discussed:

"Now we are working on more structuring of information between the systems, which conceptual information objects are handled in each system."

They want to have a greater control of what is the real source of data and trying to angle it towards big data analysis.

4.3 Survey

During this research, a survey was conducted, to test the audience understanding of the model. This survey was done with a system landscape from the MMP's enterprise model. Using a real model instead of a made up one, or one with made up systems, was chosen to get an actual opinion of one of the sub-models. The survey can be found in Appendix A

The survey was split into two smaller surveys, both identical, but distributed differently. One was sent to Statoil employees in Global Business Service IT (GBS) which supports MMP with IT-services. The other was shared through social media, Facebook, to friends and family. This was done to get more answers, and there could also be interesting to see if the Statoil employees had a better understanding than someone who did not know the domain at all and had never seen a system landscape before.

The survey consisted of a picture of the sub-model, where three areas were marked in boxes of different colors. Then there were some statements about each of the colored boxes. The participants would choose which statements they thought were true. In the end, there is a legend explaining what the different colors and objects meant.

The survey result is lacking on the point of answers. The survey was available for two weeks and only generated 36 answers in total. Of these, only one third was within the target audience of the model, Statoil employees, the rest were from people with no experience with enterprise models. The results reflect this, where the answers from not-employees had a higher spread and given the sub-model more meaning. There are also statements that are not realistic for IT-systems, i.e. "The information flow between the systems can not be controlled", and 20% of the answers from Facebook had that option selected.

The results of the survey can also be found in Appendix A, and it will be discussed later in this report.

4.4 Challenges with the case

Lack of documentation combined with people having little time has been the main challenges in conducting this study. As said earlier the architects are working closely together and have had little need to document all of their work. Therefore, it was necessary to conduct interviews to ensure enough documentation to base this report on.

Setting up interviews have not always gone smoothly, sometimes employees simply do not have the time to make an interview. Other times it has taken time just to get in contact and then, even more time before the interview took place. This has thankfully not been the case in the majority of the interviews.

Getting Statoil employees to answer the survey was also not straight forward. First finding a group that could answer the survey and then sending it to them did not present much of a challenge. However, getting the survey recipients to reply to the survey presented more of an issue. A week after it was sent out,

nobody had replied to the survey. The author's supervisor at Statoil, called them to learn that the survey mail had been perceived as a part of Statoil's ever ongoing phishing campaign. Even though it got sorted out and the survey was sent out again and answered, there were fewer replies than expected.

A minor inconvenience has been that the author's supervisor at Statoil travels a lot and has a lot of meetings during the day. Making it hard to set meetings on a day to day basis. This has resulted in having fewer longer meetings, and weeks where he was away the entire time. He was however always available through mail and sometimes phone.

Chapter 5

Model Quality in Statoil

In this section, the SEQUAL framework will be used in some aspects of the enterprise models from MMP. The focus will be as-is and to-be of the sub-model types system landscape and function model. The basis for the evaluation is:

- **QLM architecture modelling:** This document describes best practices in working with QLM [4].
- **Semi-structured interviews:** Interviews were held, and the architecture and modelling process were discussed.
- **Informal conversations:** Over the course of this case study there have been many informal conversations regarding MMP's model and their work with it.
- **Diagrams:** The model has been studied and analysed with a focus on system landscapes and function model.
- **Survey:** A survey has been held on the topic of understanding of notation in a system landscape.

During the author's first interview the goals for system landscape and function model were discussed. Goals represent the foundation on which SEQUAL evaluates model quality.

Through conversations with my supervisor pragmatic stood out as the most important quality for Statoil. Repeatedly in all the interviews cost vs. benefit were mentioned as the main concern when making a decision. The model needs to be pragmatic, to be used and understood, to increase the benefit of creating and maintaining it.

5.1 SEQUAL analysis of MMP’s model and modelling process

MMP’s enterprise model is huge, with many sub-models that cover many different aspects of the organisation. There are several lists of different sub-models so the author has felt the need to limit his self. The focus of this research has been the system landscapes and function model. They are two very different sub-models; one focuses on IT-systems, while the other on business functions. They do however share quite many characteristics and features: Their goal is the same, just for different areas. Both are used by the same audience and created by the same tool and language.

The sub-model types have been explained in the previous chapter, but they need to be connected to the various sets of SEQUAL.

- **Goals - G:** The overall goal of modelling in MMP is to be more useful than it costs; cost vs. benefit. The main purpose for system landscapes is to communicate which systems the company has, to illustrate how the systems are connected to other systems, and to communicate the life cycle status of each system. The goal of the function model is to illustrate in the state of the business functions. As well as to communicate the needs for improvement when planning which IT-projects to start.
- **Audience - A:** The diagram should be readable for everyone, but the target group of system landscapes are; system users, portfolio administrators, project teams, and solution architects. Whilst for the function model it is; solution architects, portfolio administrators, and the management. Additionally, parts of the function models are targeted towards the system responsible.
- **Model - M:** The scope for this analysis is system landscapes and function models, both the as-is and to-be versions of them.
- **Language - L:** It is used a slightly modified version of QLM’s own language, with some changes to the meta-model. These changes have been made by Quailware on the request of Statoil, i.e. when Statoil have had the need to create a view that was not possible to make.
- **Domain - D:** The modelling domain for this analysis is the IT-system portfolio of MMP and business functions for MMP marketing and trading, although only the areas that are accessible through Statoil’s internal network.
- **Knowledge - K:** The knowledge of the different IT-systems and business functions within the modelling domain.
- **Interpretation - I:** How MMP employees and external suppliers view and interpret the sub-models.

- **Technical actor - T:** The tool that is used for both modelling and presentation, QLM.

5.1.1 Physical quality

As stated in 2.3.2 the physical quality consists of three aspects; persistence, currency, and availability. M should be protected against loss and stored safely, information in M can always be trusted, and M should be available to A and only A always.

Persistence

There is a database at the bottom which QLM stores the model repository. Every night the model is then published to the Statoil internal network.

When asked about downtime for the system it was replied that the system was almost never down, or at that, there had been no complaints suggesting downtime being an issue.

Currency

The model is under periodic review, and changes are facilitated both at the start and finish of a project. The solution architects also watch their environment closely to keep the model updated.

Also, there is support for checking who made the last changes, when they were made, and who created the diagram. There is in the HTML version of QLM a status field on the side, see fig 4.3, which displays this information.

A system landscape changes irregularly when the IT-system is involved in a project. The as-is is checked at the start of the project. While the project is on-going, there exists a to-be of the system, which is changed when needed to fit with the goals of the project. However, these changes only affect those in the project. After the project is done the as-is is updated to reflect the new system, while the to-be is discarded.

The function models are more stable and require less updating. There are on the other hand more things that affect the functions since some of its requirements can be made by external factors. If the change is big enough it will create a new requirement for a system, but not necessarily.

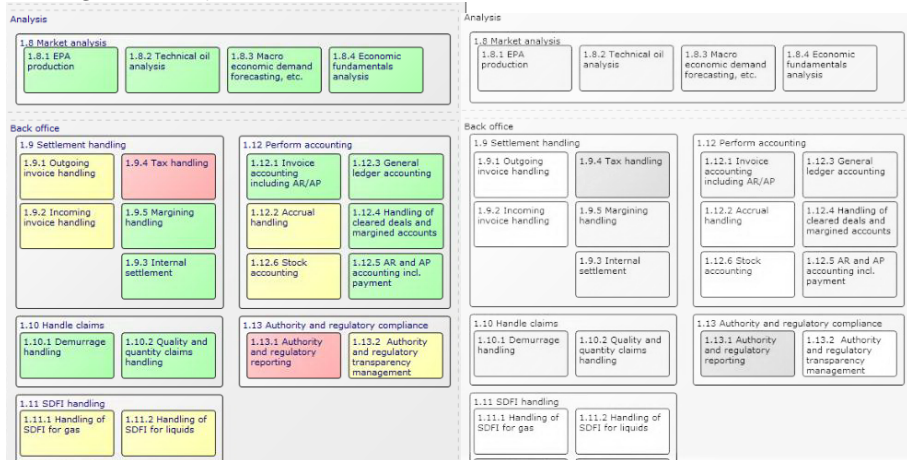
Availability

The enterprise model is available for all who have access to the Statoil's intranet. All Statoil employee has access for the most part, but there are some sub-models that are hidden. The security of the models lies in access to the Statoil internal network, excluding external supplier from gaining easy access.

MMP's areas of responsibility are dispersed across the entire country, making this an important feature for them. Statoil has support for remotely connecting to their network, providing the opportunity to access the model from everywhere with Internet.

It is also important that the users find the information they are looking for. QLM’s on-line version has an orderly layout with tabs for the major types of diagrams. Additionally, there are lists with all the different sub-model of a specific type, which is searchable, but there is no search function for the entire enterprise model. They have naming conventions to increase the accuracy of the search.

Figure 5.1: QLM - Function model in both colors and black and white



Both system landscape and function model are heavily reliant on colors. Viewing them in a medium without colors renders them almost useless. Fig 5.1 shows how a function model would look if it were only black and white, in contrast to colors. The red functions are a bit darker, but green and yellow looks too similar to each other. This creates a restriction for the physical model, i.e. it needs to be a medium that supports colors.

Meta-modelling

Meta-modeling support is explained in Krogstie’s book [8], which contains a list of requirements for good quality meta-modeling. Meta-modeling in MMP is done by Qualiware, who is the supplier of QLM, but according to one of the modellers they do not have a problem with that:

“We have continuous contact with the supplier to get the changes we want, but we have followed the recommendations from them. They have their own meta-model, which we also use, but some small changes have been made.”

They have used the meta-model that followed with the tool, but some changes have been made to accommodate MMP’s specifications. They also

have a focus on publishing when they make changes, to ensure that the published model is better looking or more correct than to the previous version.

5.1.2 Empirical quality

Empirical quality addresses how easy it is to read M, including considerations of such things as consistency in the use of colors, shapes, and sizes. All of which increases the readability for the user.

Color and shapes

The solution architects decided early on that they wanted to use the standard layout that QLM provided. They have also had many rounds of updating the look of the tool to make it more appealing to the users. This was said about the focus on empiric quality:

"It is all about getting the message out clearly, then it is important that it looks good and have a tidy and readable layout"

Fig 5.1 illustrated the importance of the coloring for function models to clearly communicate its message. Color is the only indicator of the state of the function, something that also applies for system landscapes.

The color scheme adheres to the standard representation of colors, with green indicating good and red indicating bad. This is also the same for both types of sub-models, the difference being which areas the colors are used; life cycle status in system landscape and requirement coverage in the function model. Using just three colors makes it easy to remember what each color is indicating. There are rules for what colors to use, but coloring the function model is a complex task done by a solution architect.

In system landscapes, there is more colors and shapes than in the function model. There is purple for systems, as well as lines between the systems that have their own rules for coloring. The lines mainly have red and green, but black is also used to indicate there are more information flows, and that it is just an abstraction. They follow the same convention, red is bad, manual interface, and green is good automatic interface.

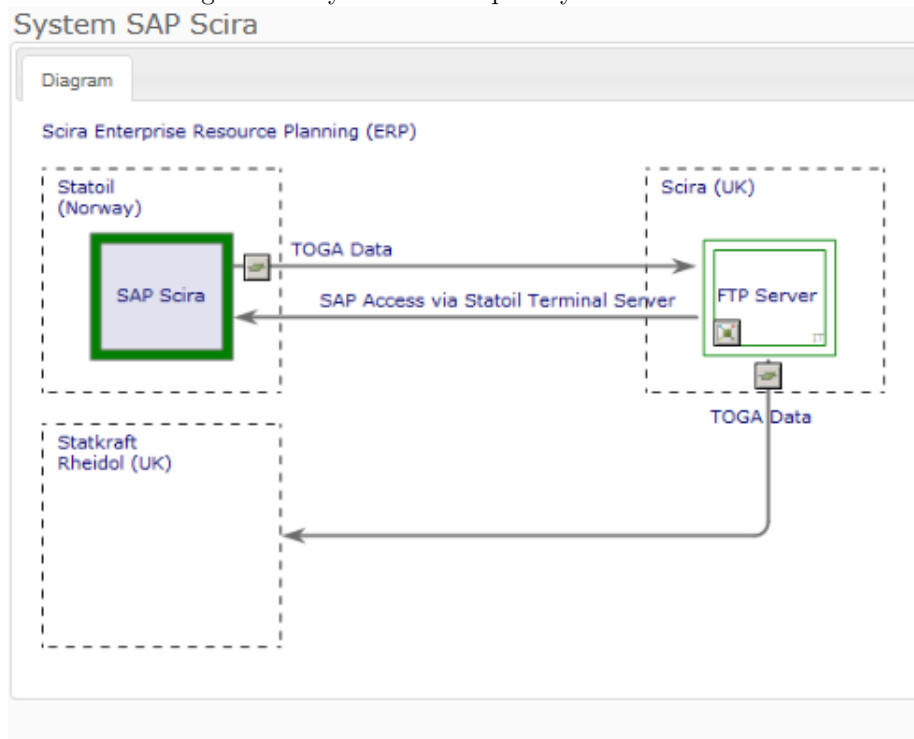
The lines and boxes in system landscapes uses the same coloring, but what they symbolise is not the same. The shapes helps, line and box, to separate them, but using the same color for different things is not particularly a good idea as it could be. It could be misinterpreted as having a fully manual system or an interface that are in use now and risk-free.

Layout

The layout of the model online is pretty minimalistic and colorless. There is the top bar with multiple drop-down menus, each for a different kind of sub-model type. When selecting one of the options in the drop-down menu, usually

the user is taken to a list of all sub-models of that type. Between the list, the columns are a little inconsistent regarding what attribute it contains, however, the columns are searchable.

Figure 5.2: System landscape - System SAP Scira



System landscapes have no official rules for how to create them. When asked in the interviews this was the answer:

"In system landscapes the system are in the middle and everything that interacts with the system around."

This is a good description, but there are diagrams where this is not the case. There is diagram where it is not logical to do it, i.e., where there are just a couple of systems (see fig 5.2). The layout for function models is simpler because there are fewer elements in the diagram. Functions are grouped together in areas, but the size of them varies depending on the text inside the boxes.

5.1.3 Syntactic quality

Syntactic quality reflects the correctness in the use of the modelling language in the model. In section 2.3.2 a formula for syntactic quality was described, but that formula is not relevant for this case study. There is little focus on syntactic quality with the modellers, mainly trying to keep it simple and use as few different objects as possible.

Syntactical invalidity and incompleteness

The syntactic rules of the modelling language are loose and informal, and according to one of the persons interviewed:

"We can model anything we would like."

The model is made to support communication between humans, and not humans and tools. There are some rules regarding what objects can exist in certain types of diagrams and what kind of relation they can have with each other. One of the interviewees said this about creating a diagram that was syntactic wrong:

"It is very hard to create a diagram with illegal objects in it."

Error detection

The modelling team is a close knit group that work pretty close together. They have periodical meetings where they go through the models to correct mistakes or make changes. They also check the model before starting a project, adding a layer of detection of errors.

Error prevention

There is support for error prevention in the tool. Each diagram type is an object, with rules for which other objects that can live within it. Making it impossible to put an object into a diagram where it is not welcome.

Description

An example of an informal rule: The description is a mandatory attribute for all objects within this scope. In the QLM architectural modeling document [4] it mentions description on the first page:

"General rule: Please add proper descriptions(NOT short description) for ALL objects! Experience tells us that we tend to forget later :)"

and later in the documentation for system landscapes:

*"This is a general description of the purpose of this system landscape, and other useful information - **in business terms!**"*

It is close to impossible for a tool to determine if a description is a proper description, is written in business terms, or in a language that business people understand.

5.1.4 Semantic quality

The usefulness of creating a matrix for semantic quality is questioned, and would be only interesting in a well-defined and limited domain, according to Krogstie [8]. Since the domain for this model is not limited perceived semantic quality is measured instead.

It is important to look at how the model is created and maintained to determine its semantic quality. Firstly, domain knowledge is gathered from users and owners of the system and put directly into the model. This is done by involving users and owners in a meeting and making the sub-model together with them, giving them ownership of the sub-model. Expressing their knowledge instead of an interpretation of it. One of the modellers said it was:

"..easy to forget spreadsheets or special methods. We catch these errors by talking with the users and having a modeling-on-the-fly meeting. Typically along the lines of 'This is what we have so far, please help us in filling out the rest' "

After the sub-model is first made it is sent around to make sure it is correct according to the users and owners, this is done iterative until everyone is content with the representation. These first meetings include a small tutorial of the modelling language for those of the users or owners who are not familiar with it, or when they document a new part of the domain.

Secondly, when the sub-model is wrong, or there is a change to it, the architects are alerted of the change either by themselves or by the users. Then they adapt the model and sends the sub-model around again to make sure it is correct. This ensures that the model is kept up to date and trusted by its users. To support this, there is an email button in the HTML version of QLM. Making it easy to send an email to the correct architect with comments regarding the sub-model. There is also periodic meetings to ensure the consistency of the model.

Reuse

There is a lot of reuse within the enterprise model. There are many sub-models of different types that all use the same objects. There is also reuse of the same object, i.e. IT-system, on other domains that just MMP. The architects have

been working in other business areas with extending the enterprise model and architectural network.

5.1.5 Pragmatic quality

This quality is the most important quality for Statoil, since a model which is not understood is not used. One of the goals of the model is to support communication, they also rely heavily on user feedback, to keep the model up to date and correct.

Krogstie lists several activities that can help achieve pragmatic quality both for actors and tools in his book [8]. Some of these activities are done for actors:

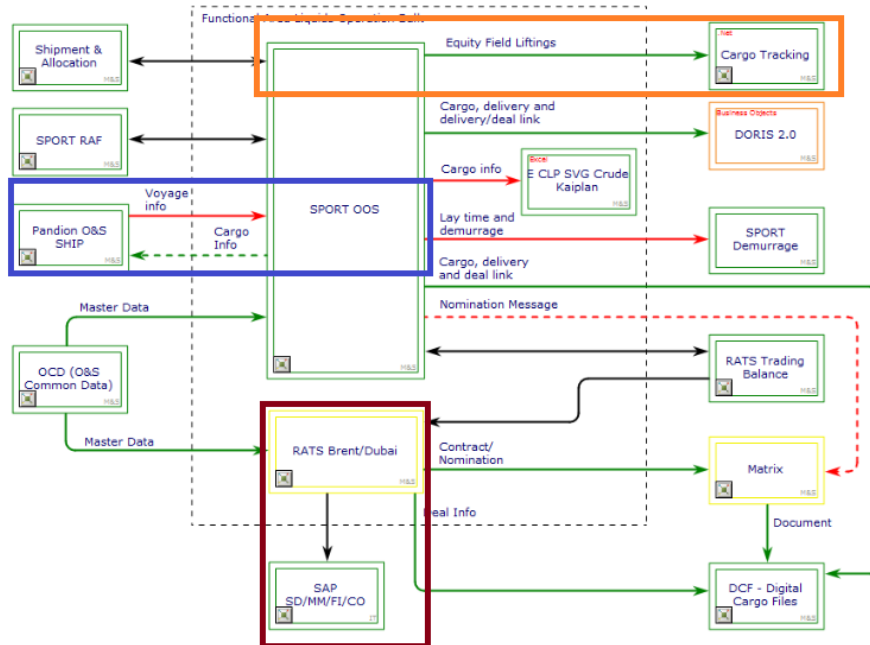
- **Participant training:** There are no formal training of the audience from the modellers, except the tutorial in the modelling meetings. Most of the education happens during projects, but there are some meetings where the architects gather users to explain the model. However, these meetings are not a regular thing.
- **Model inspections and walkthroughs:** This is done periodically for both system landscapes and function models. System landscapes have a higher frequency of inspections, due to higher volatility.
- **Model filtering:** Every sub-model has a special user in mind when it is created. Every sub-model is a smaller part of the model, but there is also sub-sub-models that in turn are even smaller and more specific part of the model. For example, Endur is a system which is documented in the model, see fig 4.4. There also exists 15 system landscapes where the title consists of both Endur and sub, being sub-sub-models of Endur, one of the being fig 4.5.
- **Query:** There are lists of all sub-model types in QLM, and these are search-able. This gives users the opportunity to make a query on all of the attributes displayed in the list.

The tool does support creations of queries, but also the automatic generation of the HTML version, which is distributed through the Statoil internal network. Every night it generates an HTML version of the model, increasing the readability for its users.

Survey

The survey shows there is good overall understanding of the notation used in system landscapes, as can be seen from the results in fig A.1. Even with few answers some of the statements are included in over 95% of all the received answers. These statements can be found in the legend in the survey, and therefore it is not very surprising that so many have gotten these right.

Figure 5.3: Survey - Sub-model in question



There have been few who understood that the systems that where green were going to be used in the future. Where in the legend in Appendix A states:

”Green: In use now - no risks in foreseeable future”

Of the 36 people who answered the survey only 5 and 4 participants said that the systems in the orange and blue boxes, see Fig 5.3, were going to be used in the future which is true. There were a lot more who understood that the systems in the brown box, see Fig 5.3, was in use now, 58%.

The Statoil employees from GBS has selected few of the false statements included in the survey, resulting in a higher precision than the Others. The Others have given the diagram more meaning than explained in the legend: 24% selected ”There have not been any errors in the information flow in the past 24 hours”. 28% selected ”Voyage info can contain incorrect information”. Even though the notation seems to be easy to understand, some domain knowledge would be appropriate and also an understanding of how an IT-system works.

5.1.6 Social quality

For a model to achieve high social quality the social actors needs to agree on how they interpret the model. The importance of this aspect for Statoil is great,

considering one of the main goals of the model is communication.

Solution architects have the main responsibility to change and maintain the model. With the model now starting to be used by more than just one business area and only one group of architects, there has been established an architectural network. This is a place to share experiences and talk about the model, making sure everyone is on the same wavelength. On the cooperation of architects across departments, this was said during one of the interviews:

"It was necessary with documentation when we got more departments using the architecture. The QLM modelling document was created, [4], and all training sessions start with going through that. Then we adapt for the specific business area. Sometimes they need to think differently, other times it is us, then we update the document."

and

"There is also meetings across of the departments to ensure that we are on the same wavelength. In our own area, we have for a time done weekly meetings, we do it more frequently at the start up for a new department."

There are meetings to ensure semantic quality and to gather information about the domain. In these meetings, they are using a public screen and desktop, where the architect is the facilitator and modeller, and the other participants are explaining and commenting. With these kinds of meetings, all the participants are in agreement on how the model should look. The selection of participants for the meeting is based on earlier meetings, choosing participants who have done it before or shown interest in the work. On the topic of meetings one of the interviewees said this:

"It is easy to set up a meeting, and people understand it fairly quickly. It is important to choose the right people and people who have done this before. We want to have end users with us and take into account that some are better than others to view the situation as a whole and not too focused on the details. Important question is: 'What do I do, and why?'"

As mentioned earlier, if there are still somethings that need to be modelled after the meeting the model is then passed around until all the participants can agree on the model. If not an absolute agreement it is at least relative.

5.1.7 Deontic quality

Enterprise modelling needs to have a reason for being done, some goal that needs to be achieved. Deontic quality is how well the model fulfil its goals. The motto for the architects are; cost vs. benefit. Using as little time and resources as possible to get the best performance. Focusing on when to stop modelling

is a part of that, knowing when they have enough statements in the model and the right statements.

For system landscapes, the goals are to document their IT-systems and what type of interface there exists between them. To what technical detail do they need to model? This question was answered during one of the interviews:

"We can model what we want, but for the most part we use a language aimed at those who use it."

The audience for system landscapes are not software developers; it is the management, end users, and project teams who uses the model. The project teams may consists of developers, but the sub-model is not for technical documentation. It is more to create user stories, which leads to functional requirements rather than being the requirements themselves.

Function models have systems at the bottom if that level exists for that particular sub-model, so they have the same level of technical info. It is the function model that determine the importance of functions, thereby systems, to indicate in what order they are supposed to be restarted in case of a reset, blackout, or other types of shutdowns, planned or not.

Another question to be asked and that was answered in the interviews were: When should the modelling stop, when is it enough? To this one of the interviewee answered:

"It does not exist any formal rules for when to stop modelling. There is a dialogue between both the users and suppliers, and between them they create a good picture.."

In system landscapes, they stop when all systems have been modelled. When creating a system landscape for an area, they stop when they have documented the systems they deem useful. For function models, there is nothing to signal an end to modelling. They are continuously updated, but since they are naturally stable updating intervals are pretty long six months.

Chapter 6

Discussion

In this chapter, some aspects of the enterprise model and architecture are discussed.

6.1 Right quality

The definition of quality [1] is the relation of characteristics and requirements. The requirements for the enterprise model of MMP is to support communication and documentation, through being useful and used by its intended users.

In section 2.1.2 some characteristics are for a model to be an enterprise model are listed. These characteristics can all be found in MMP's enterprise model:

- **Communication through time and space:** The enterprise model have existed for some year and will continue to be used and developed. The sub-models exists after the project which created them are done; then they are also used by other people than those who created them.
- **Abstractions:** System landscapes are an abstraction that is simple and used. The architects in MMP have chosen some aspects to focus on, and in the use of them, the abstractions can be said to be right.
- **Managed:** The architectural network takes care of maintaining the models and keeps the up-to-date.
- **Right quality:** In [21] three qualities were mentioned; syntactic, semantic, and pragmatic. Of those three pragmatic is the most important, also for MMP. The model needs to be understood to be useful. Semantic is second and syntactic has very little focus.

In this case, syntactic quality is not very high, and still the model is used and expanded to other departments. The model has existed for more than a decade and is still in use. The architects are still working on creating new contents, not just doing maintenance to keep the model usable and correct. In this report,

there is no documentation of how much the model are being used, other than the ones interviewed stating that they use them a lot.

When looking at the syntactic quality, there is not that much to say. Their error detection and prevention is done extensively because it also covers semantic correctness, and that is important for the architects. Syntactic quality dose supports pragmatic, by resulting in a more precise model with less room for interpretation. But this model is used to help communication between humans, and as long as the intended users understand each other, the model has high pragmatic quality without having high syntactic quality.

This raises some questions that could be used for future works, like How much does syntactic quality affect pragmatic quality for human actors? What would happen to the qualities and uses of this enterprise model if measures were taken to improve syntactic quality? Does the adoption of tool interpretation reduce the human interpretation?

6.2 Process adaptation

There are few IT-systems in MMP, meaning there is few system responsible for the architects to interact with. The low amount of IT-systems may prove to give the architecture more success than appropriate. With the cost going considerably up with more people involved in meetings and with keeping the models up-to-date. The increase in complexity with more people would possibly increase the requirements for some solution architects, documentation of best-practice in modelling, and the way to organise all the architects.

The increase of architects and the organisation of these have already happened. The architectural network in which all the architects communicates about models helps and the core still listens to and followed. The lack of documentation could come back to them as a problem later when new modellers start modelling new aspects that have not been documented before.

The process they have work today within MMP, but that is no guarantee for it to work outside. That does not mean it should not work outside either, just that the architects should be ready for problems to occur along those lines.

6.3 Tool

The model is easy to access and view. The tool publishes the model to an HTML version that is accessed through the Statoil network. The tool does a decent job of it; there are some functionalities that could be improved:

- **”?” button:** The help button directs the user to a page which is not found, displaying an error 404 page. This indicates that there is some help documentation out there, but the user can not get to it. The truth is that there is no help page, and when asked on of the modellers said that they were not sure what to do with it. This should be removed until they decide to utilise it.

- **Info box behaviour:** The info box, described in 4.2.1 and shown in fig 4.3, has some annoying default behaviour that should be improved on. It always appears in the same place, the middle of the browser window, and resizing to a default size that varies from system to system. This is impractical when the user has moved the info box not to be in front of the diagram, then to have it jump to the middle again when opening a new one or simply by using the back feature on the box itself.
- **Search functionality:** There is no full model search functionality, only for columns in lists. In ARIS there is a full search functionality [5], why is this not supported in the HTML version of QLM?
- **Browser functionality:** The browsers back functionality works but has at least one fault. After selecting a sub-model from a list after searching in it, when the user then wants to go back the list is without the previous search or sort. Also "open in new tab" or "open in new window" creates a new tab or window with a duplicate of what the users are viewing and not the sub-model it clicks on, also without the search or sorted list.

On the question on search functionality there can be several explanations:

- The cost vs. benefit ratio is off. Implementing a good search function has a cost, and if the benefit is low, then it is not done.
- Another reason can maybe be that the different part of the models are used by different people? Not having the need for a model wide search, because a user mostly uses sub-models of the same type. Making the already implemented search functionality good enough.
- Could also be because the users know where the sub-models they use are, independently of sub-model types.

6.4 SEQUAL as a theoretical lens

Working with SEQUAL to analyse MMP's enterprise model have been profitable. SEQUAL have helped the author to analyse the enterprise model in a structured way and structure this report. The framework has also helped to direct the interviews and asking the right questions. SEQUAL is extensive, and not all of what it covers has been put to use, but it is flexible enough to be still helpful regardless. In this chapter, some aspects of the enterprise model and architecture are discussed.

Chapter 7

Conclusion and Future Work

In this chapter, a conclusion will be presented based on the analysis and theory presented in this report.

7.1 Data generation methods

In this section, the data generation methods will be evaluated. Explaining how some of the data was gathered and some toughs that were made up during the research.

7.1.1 Literature review

For the most parts articles or books have been found on the Internet. There have been spent considerable time to locate books that were free or to find the section that was relevant. Most of this is just for the overall understanding of the theory in this case.

Also, time spent to locate useful documentation of the enterprise architecture and models from MMP have been a considerable amount. There is very little documentation of them, resulting in the need for another way of generation data on them, interviews.

Both my supervisors have been of great help in this work, providing relevant books and articles both from the field of enterprise modelling, model quality, and internal in Statoil.

7.1.2 Interviews

There were held six interviews with the solution architects and a portfolio manager in MMP. By interview multiple actors from the same group a good overview could be created. With asking the same questions to the actors, some nuances

was discovered to give more detail of the topics questioned about. Uncovering if the person being interview painted another picture than the truth.

The interviews were semi-structured, with the main topic being why and how they did enterprise modelling. The author let, for the most part, the interviewee speaks about whatever they had on their mind and used questions to trigger conversation and direct the interviewee into other sections of the topics.

For the most part, these interviews were an hour long and face-to-face, with one exception. There was one interview that was conducted over Skype due to the geographical factors. It also did last for only 30 minutes, because the participant had another meeting that had come up. When planning the interviews, a meeting needed to be scheduled at least a week into the future.

There could have been more interviews, and a more variety of subjects, but overall they gave a great basis for conducting the analysis of why and how they model.

The interviews were recorded and then quoted in this report, the quotes are translated from Norwegian, as that was the language the interviews were held in. In some cases, the result of the translation has been poor, either due to poor translation skills or to the use of Norwegian expressions. The quotes, however, are true to their meaning as perceived by the author.

7.1.3 Survey

In this research, there was conducted a survey about the use of notation in the sub-model type; system landscape. It was distributed to GBS, global IT-services for Statoil, and through social media, Facebook.

The survey had fewer answers than expected, and too few to conclude on much. But there were enough answers to say something of the notation used in system landscapes.

Most of the answers were also not from the target audience, from the survey posted on social media. These clearly showed some with a lack of even a basic understanding of how IT-systems work. Should also be a little more critical to these answers, because the user could be anyone and therefore also a person with malicious intent.

7.2 Conclusion

In one of the first interviews goals for modelling was discussed extensively for the author to get an understanding of why the architects do what they do. Cost vs. benefit was mentioned and explained as being the reason for most of their decisions. Communication and documentation are what the model should do; cost vs. benefit is the basis for how it should do it. Everything that is done is with cost vs. benefit in mind. The result is good either with high benefit or low cost; the best is, of course, a combination of both.

For getting a high benefit the model needed to be useful for not just the architects, but also for the rest of MMP or others who where working within

the domain. Instead of describing the whole of MMP in the model, so aspects was chosen out of a need for documentation. The model was an answer to a problem, getting the approval of intended users. The architects continued with this way of thinking.

The sub-models in the architecture is very simple, with few variety of objects and relations. In system landscape, there is only IT-systems, interfaces, technology platforms, and external entities. In function models, there are only functions and IT-systems that supports them. This is resulting in an easy-to-learn-system, reducing the bar for using them. Both of these types are very specific and does their jobs well, but this limits their use in other areas where a little more modelling would be required.

To reduce the costs they, as mentioned earlier, started only with some aspects. Over the course of time, the model has become big and more detailed, where a new project results in more diagrams. The architects try to only keep the vital diagrams, so at the end of a project, the diagrams and figures are looked over and sorted. Trying to keep the model compact to reduce the maintenance of it.

Also to reduce cost, some sub-model types are chosen not to be included in the model. In MMP there were process models explaining work processes, these were also created for documentation and communication. After the architects had modelled for a while the enterprise model started to become hard or even impossible to maintain. This is the reason there are not any process models in the enterprise model today and that it serves as a good motivation to keep the maintenance costs down.

The enterprise model of MMP provides useful sub-models to end users, during projects, and to upper management. This is also what the author thinks is one of the reasons it is still being used, developed, and expanded into other business areas in Statoil. The model can and is used by many, and this creates a common platform for communication between the different work areas.

7.2.1 Research questions

RQ1: How does the goals for enterprise modelling in MMP affect the model quality?

The goals affect the model quality by focusing more on some of the qualities and less on others, also the relationship between the qualities. For example; pragmatic being the most important quality for the architects, the model must be understood by the users. Syntactic being less important, the architects are not enforcing rules to increase syntactic quality if it reduces the pragmatic.

Cost vs. benefits is putting some guidelines on how much work is going to be put down into modelling. Only spending resources on tasks that the architects deem necessary for the qualities they believe matters the most.

RQ2: How does the modelling process in MMP affect model quality?

For modelling in MMP, the process is essential for the model quality obtained. The meetings for creating new sub-models or updating old ones are important for both ensuring pragmatic and semantic quality. The use of to-be system landscapes in projects supports social quality, communicating the goal for the project. The architectural network also helps the architects keeping the model quality high.

RQ3: What changes can be made to improve model quality?

The HTML version of the tool, the way the users view the model, is good, but some improvement and implementations of new features could help to increase both the physical and pragmatic quality. These features are mentioned in chapter 6.4.

7.3 Contributions

This report is a case study of enterprise modelling in a specific field within Statoil. This is a specific research which is most valuable for this field and organisation. It can be used as a basis for future works about enterprise modelling in Statoil. There are however some parts of this report that can be interesting for others, i.e. their case is similar to this one, or they have the same reasons for modelling as found in this case. These contributions are:

- **Analysis of MMP’s enterprise model:** The analysis presented in this report can be used for further development of enterprise modelling in Statoil.
- **The use of SEQUAL for evaluating model quality:** This work has been assisted by the use of SEQUAL, and can be used as an example of that. Further proving the use of SEQUAL for evaluation of model quality.

7.4 Future Work

In this report, some aspects of the enterprise modelling that are done in Statoil is outlined. There are many aspects that have not found its way into this report and could be explored by others. Some of these tasks being:

- **Specialized quality research,** in this report the relation between syntactic and pragmatic, has been talked about. There is still much more to say about this, and it could be interesting to see their relationship fully explained.

- **Implementing of search function**, the search function is discussed in chapter 6.4 and found wanting. The importance and cost of an implementation could be look at, and if deemed appropriate carried out or a plan made to do so.
- **Following the development of this enterprise architecture**. This architecture is implemented in other business areas in Statoil, and it would be interesting and valuable to look at how this is done. Discovering success factors for implementing it, and to see if it works well outside of MMP.
- **Process models and function models in Statoil**. There have been done case studies on both the process models and function models in Statoil. They are both used heavily in Statoil, but not very much together. Looking at how these models could support one another and what needs they would cover would be interesting.

Bibliography

- [1] ISO 9000:2015(en), quality management systems fundamentals and vocabulary. <https://www.iso.org/obp/ui/#iso:std:iso:9000:ed-4:v1:en2016-04-21>.
- [2] Lars C. Christensen, B. W. Johansen, N. Midjo, J. Onarheim, T. Syvertsen, and Terje Totland. Enterprise modeling-practices and perspectives. pages 1071–1084.
- [3] Guba Egon G. Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology, Vol. 29, No. 2 (Summer, 1981)*, pp. 75-91.
- [4] AAge Martinus Haldorsen. Qlm architecture modelling. 2015.
- [5] Merethe Heggset. Achieving long-term value of enterprise models - a case study. 2014.
- [6] Merethe Heggset, John Krogstie, and Harald Wesenberg. Understanding model quality concerns when using process models in an industrial company. In *Enterprise, Business-Process and Information Systems Modeling*, pages 395–409. Springer.
- [7] Michael Jackson. *Problem frames: analyzing and structuring software development problems*. Addison-Wesley Longman Publishing Co., Inc., 2001.
- [8] John Krogstie. *Model-Based Development and Evolution of Information Systems*. Springer London, 2012.
- [9] Anne Persson Matthias Wibotzki Kurt Sandkuhl, Janis Stirna. Enterprise modeling. 2014.
- [10] Michael Gruninger Mark S. Fox. Enterprise modelling. 1998. [://eil.toronto.edu/wp-content/uploads/enterprise-modelling/papers/fox-aimag98.pdf](http://eil.toronto.edu/wp-content/uploads/enterprise-modelling/papers/fox-aimag98.pdf); Accessed: 08.10.2015.
- [11] Daniel L. Moody. Conceptual modeling ER '98: 17th international conference on conceptual modeling, singapore, november 16-19, 1998. proceedings. pages 211–225. Springer Berlin Heidelberg.

- [12] Briony J. Oates. *Researching Information Systems and Computing*. SAGE, 2005.
- [13] Merriam Webster online dictionary. Definition of PARADIGM, 2016-05-25. <http://www.merriam-webster.com/dictionary/paradigm>.
- [14] Kurt Sandkuhl, Janis Stirna, Anne Persson, and Matthias Wiotzki. *Enterprise Modeling*. The Enterprise Engineering Series. Springer Berlin Heidelberg, Berlin, Heidelberg, 2014.
- [15] Andrew K. Shenton. Strategies for ensuring trustworthiness in qualitative research projects. 22(2):63–75.
- [16] Statoil. Statoil annual report 2015.
- [17] Statoil. Statoil in brief. 2009. <http://www.statoil.com/en/about/inbrief/pages/default.aspx>.
- [18] Statoil. Management system user survey u13, 2013.
- [19] Statoil. Marketing, midstream, and processing (MMP), 2016-06-20. <http://www.statoil.com/no/About/CorporateGovernance/GoverningBodies/OrgChart/Pages/MMP.aspx>.
- [20] Yair Wand and Ron Weber. Research commentary: information systems and conceptual modelinga research agenda. *Information Systems Research*, 13(4):363–376, 2002.
- [21] Harald Wesenberg. Enterprise modeling in an agile world. 2011.
- [22] Rober K. Yin. *Case Study Research: Design and Methods*. 2003. Third edition.

Appendix A

Survey - Understanding of modeling notations

A.1 Survey

In this appendix the survey and its answers is documented. There were 36 answers in total, 11 from Statoil employee and 25 who answered through social media.

Figure A.1: Survey - Answer Table

	Statoil	%	Others	%	Total	
Total answers:	11		25		36	
What does the model illustrate in the orange box?						
The information flow between the systems are very precise	1	9,1 %	4	16,0 %	5	13,9%
The information flow between the systems is automatic	10	90,9 %	25	100,0 %	35	97,2%
The systems are going to be used in the future	1	9,1 %	4	16,0 %	5	13,9%
There have not been any errors in the systems in the past 24 hours	0	0,0 %	4	16,0 %	4	11,1%
There have not been any errors in the information flow in the past 24 hours	0	0,0 %	6	24,0 %	6	16,7%
Since "SPORT OOS" is green and the information flow is green, then "Cargo Tracking" automatically be	2	18,2 %	1	4,0 %	3	8,3%
What does the model illustrate in the blue box?						
The information flow between the systems is manual and semi-automatic	11	100,0 %	24	96,0 %	35	97,2%
The systems are going to be used in the future	1	9,1 %	3	12,0 %	4	11,1%
There have not been any errors in the systems in the past 24 hours	0	0,0 %	5	20,0 %	5	13,9%
Voyage info can contain incorrect information	1	9,1 %	7	28,0 %	8	22,2%
Voyage info is red because "Cargo info" only is dotted green	0	0,0 %	1	4,0 %	1	2,8%
There can be bad connection between the systems, resulting in information sometimes not coming th	1	9,1 %	4	16,0 %	5	13,9%
What does the model illustrate in the brown box?						
The information flow between the systems are unknown	3	27,3 %	12	48,0 %	15	41,7%
The information flow between the systems can not be controlled	1	9,1 %	5	20,0 %	6	16,7%
RATS has an uncertain future	10	90,9 %	25	100,0 %	35	97,2%
The systems are in use now	4	36,4 %	17	68,0 %	21	58,3%
The systems are in use now, but "RATS" are not always on	0	0,0 %	0	0,0 %	0	0,0%
RATS is yellow, therefore the information flow to "SAP" can not be green	1	9,1 %	2	8,0 %	3	8,3%
The information flow between the systems have had many errors over the past 24 hours	1	9,1 %	0	0,0 %	1	2,8%

Figure A.2: Survey - 1. Answers Orange

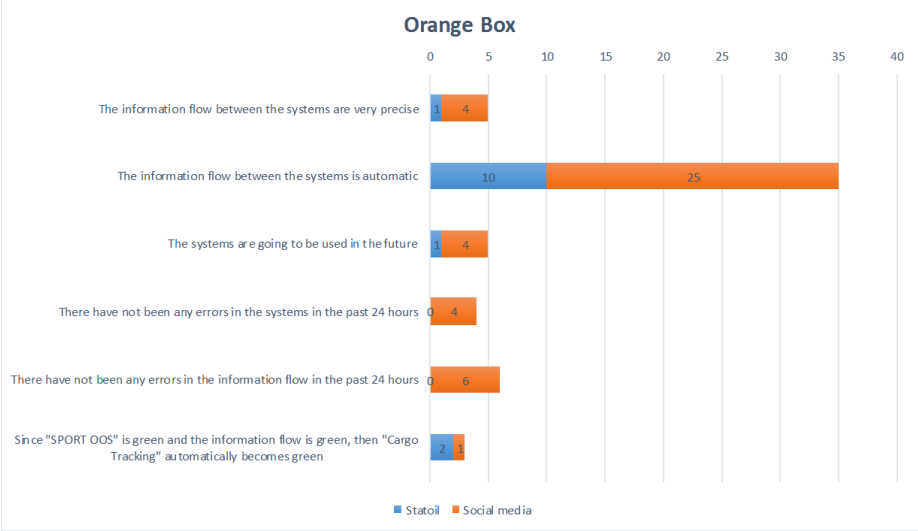


Figure A.3: Survey - 2. Answers Blue

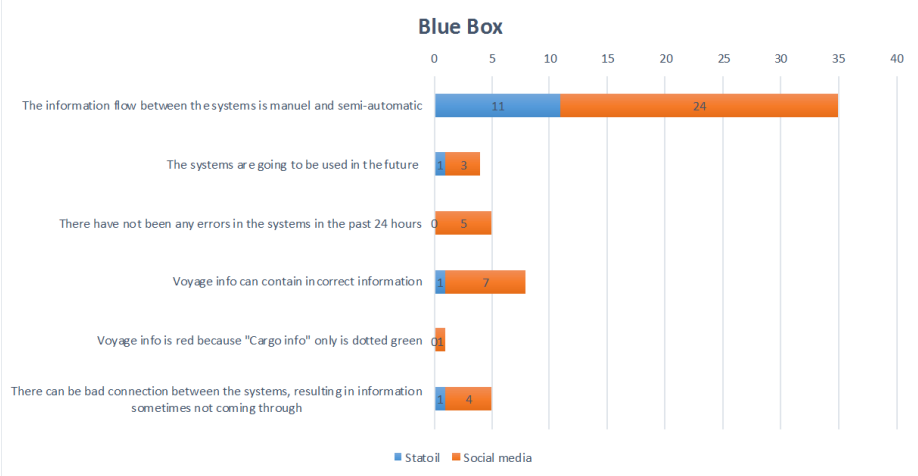
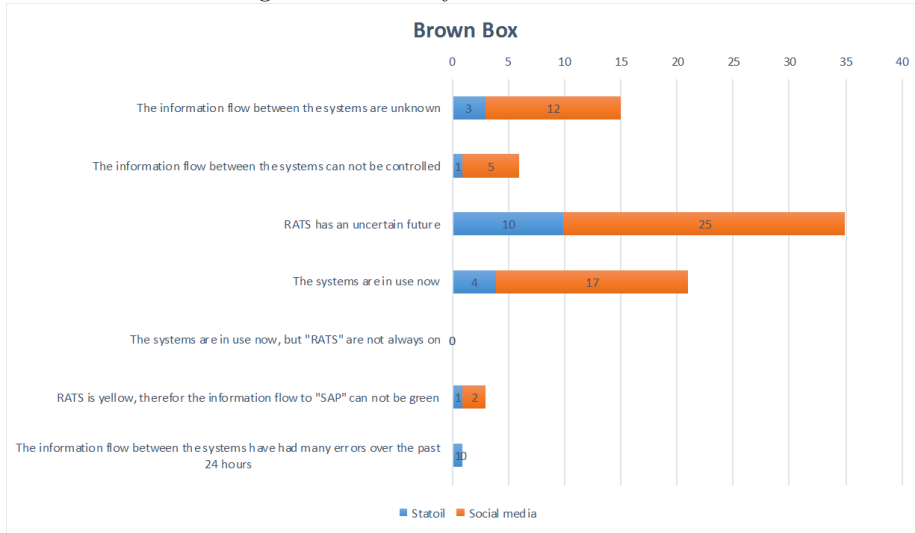


Figure A.4: Survey - 3. Answers Brown



Forståelse av notasjon i virksomhetsmodeller

Dette er en spørreundersøkelse gjort i forbindelse med min masteroppgave og skal prøve å belyse hvor godt folk forstår virksomhetsmodeller som brukes i Statoil AS.

Gjennomføring av spørreundersøkelsen tar i underkant av 5 min.

Undersøkelsen består av 3 spørsmål om hva du tror modellen viser på 3 forskjellige steder. Modellen ligger under, og de forskjellige delene er markert med fargebokser. Det følger også med en generell beskrivelse av notasjonen. Det kan være flere riktige svar alternativer per spørsmål.

***Må fylles ut**

1. Hva mener du modellen viser i den oransje ruten? *

Velg de alternativene som du tror er riktige

Merk av for alt som passer

- Informasjonsflyten mellom systemene er veldig presis
- Informasjonsflyten mellom systemene er automatisk
- Systemene skal tas i bruk i fremtiden
- Systemene har ikke hatt feil iløpet av de siste 24 timene
- Det har ikke vært feil på informasjonen mellom systemene de siste 24 timene
- Siden SPORT OOS er grønn og informasjonsflyten er grønn, blir Cargo Tracking automatisk grønn

2. Hva mener du modellen viser i den blå ruten? *

Velg de alternativene som du tror er riktige

Merk av for alt som passer

- Informasjonsflyten mellom systemene er manuell og semi-automatisk
- Systemene skal tas i bruk i fremtiden
- Systemene har ikke hatt feil iløpet av de siste 24 timene
- Voyage info kan inneholde feil informasjon
- Voyage info er rød siden Cargo info bare er stiplede grønn.
- Det kan være dårlig dekning mellom systemene, så er ikke alltid sikkert at informasjonen kommer frem

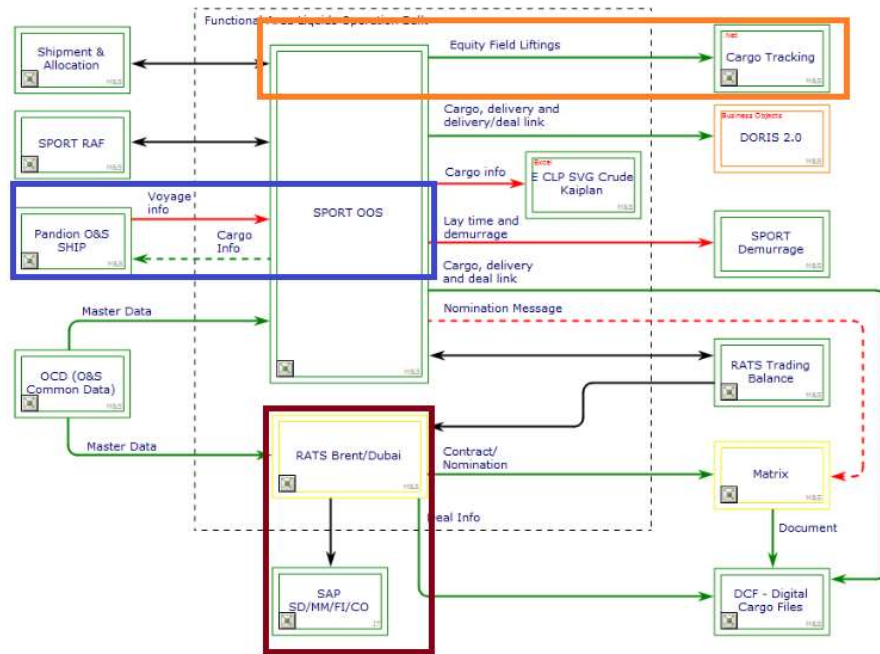
3. Hva mener du modellen viser i den brune ruten? *

Velg de alternativene som du tror er riktige

Merk av for alt som passer

- Informasjonsflyten mellom systemene er ukjent
- Informasjonsflyten mellom systemene kan ikke kontrolleres
- RATS har usikker fremtid
- Systemene er i bruk
- Systemene er i bruk, men RATS er ikke alltid på
- RATS er gult, derfor kan ikke informasjonsflyten til SAP være grønn
- Informasjonsflyten mellom systemene har hatt veldig mange feil de siste 24 timene

Modellen



Informasjon som følger med modellen

The Legend used for the IT Solution landscapes

The information flow legend is as follows:

- Solid red: Fully manual interface
- Dotted red: Copy/Paste to eliminate some typing errors
- Dotted green: Data movements automated, triggered by user
- Solid green: Fully automated information flow
- Solid Black: More information "below"
- Text is added to explain what data is flowing with description

IT Solutions are represented with rectangles. The colours represent life cycle state:

- Green: In use now - no risks in foreseeable future
- Yellow: In use now - uncertain future
- Red: On it's way out/Out
- Purple: Emerging (TO-BE solution)

Technology platform is documented in red in the left upper corner

- Excel, SharePoint, Web Site, Business Objects, QV App

External entities are represented by a special symbol

