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Collaborative Port Allocation - An Experiment with Collective Intelligence in a Modern Supply Chain

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ABSTRACT

Supply vessels are a crucial part of the supply chain for offshore oil and gas installations - the supply vessels carry almost all physical items to and from the installations offshore.

The supply vessels make calls to supply bases where they do loading and unloading. In general the ships doing calls to a supply base get their orders on demand or by schedules generated by the rig operators. The practical scheduling of calls is organized by the supply bases. However - the information flow and negotiations associated with scheduling a ship and assigning it to a specific quay is far from optimal. Supply vessels are expensive to operate and the incurred costs associated with delays can be very high - hence a good methodology to handle the information flow and negations prior to calls can result in savings. Expanding port facilities are one - albeit expensive – solution.

In other supply chains, information visibility and collaborative models have proved their viability – especially based on new internet based technologies. The present master thesis explores how to employ technology assisted collaborative models for practical port allocation. The present work includes discussions regarding information visibility, cooperative models and flexibility.

As a result of the discussions it has been described a system that can be used by all the participating actors. The principle of a system doing only one thing – and gather data from other sources has been used.

The expected benefits of implementing and using such a system are better information visibility and decision capabilities. Other benefits will be improved logging of all information related to port calls as well as the ability to do benchmarking and run simulations for training purposes.

ACHNOWLEDGMENT

This project was conducted as a master thesis in the 10th semester of my MSc. degree at Molde University College in collaboration with Vestbase. Vestbase and NorSeaGroup have for a period of time been looking for a new method to organize port calls at their port facilities in Norway. I was fortunate enough to be presented with this topic through Nils Jacob Berland, who later became my supervisor. I would like to thank him for guiding me through this project, and for giving me valuable insights and knowledge enough to come up with a proposition to a solution to the problem.

I would also extend my sincere gratitude to Vestbase and the people working there, especially Tommy Taknes, for devoting a countless number of hours in visits and discussions at Vestbase. It has been really great to be met with such generosity and openness towards my project.

Based on the research done in this thesis I have come up with a proposition for a new method of thinking in connection with port calls. A system based on a new set of principals has also been developed and been presented in this thesis.

25th May 2010

Frederik Knoblauch Urke

TABLE OF CONTENTS

Figures

Tables

1. INTRODUCTION

The Norwegian oil and gas sector is faced with an increasing unit production cost, driven by higher costs and an ongoing drop in production (Kon-Kraft, 2004). This has created a need to cut costs and find more efficient ways to extract these resources. Looking into a cost breakdown for the Norwegian oil and gas sector shows that approximately 6 %[1] of the operating expenses is related to logistical activities such as boats and conduct of onshore supply bases (Kon-Kraft, 2004).

This situation invites every participant involved in oil and gas exploration in Norway to take part in finding ways to reduce costs for a continuous operation on the Norwegian continental shelf. According to a study done by Kon-Kraft in 2004 a central cost driver for logistics and supply operations in Norway is utilization of offshore supply vessels, the Norwegian onshore base structure and to what extent integrated logistical concepts are being exercised.

The Norwegian supply base structure is spread out over the entire Norwegian coast and counts somewhere between 10-20 different ports, where 7 of them stands for 98 % of the total volume share (Kon-Kraft, 2004). This infrastructure is a result of a political decision where the entire country should enjoy a rightful share of the petroleum wealth. The decentralized structure gives closeness to the offshore installations but demands more out of the supply bases in terms of efficiency since they do not enjoy the full potential of economies of scale.

NorSeaGroup AS is the leading supply base operator in Norway, which today owns and operates a total of 10 different onshore supply bases along the coast of Norway (NorSeaGroup a, 2010). The following Figure 1 gives an overview over the supply base structure in Norway. NorSeaGroup bases are marked in red, and some other supply bases are marked in yellow[2]. As can be seen, the widespread structure contributes to closeness to the petroleum fields. This paper will focus on the activity in the central part of Norway, and use Vestbase AS and NorSeaGroup as a focal point.

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[1] Figures are from 2003, and are representing operating costs. Search and investments costs are approximately the same.

[2] It is hard to give an exact overview on the number of supply bases due to the fact that smaller ports can be used from time to time in addition to the normally established bases.

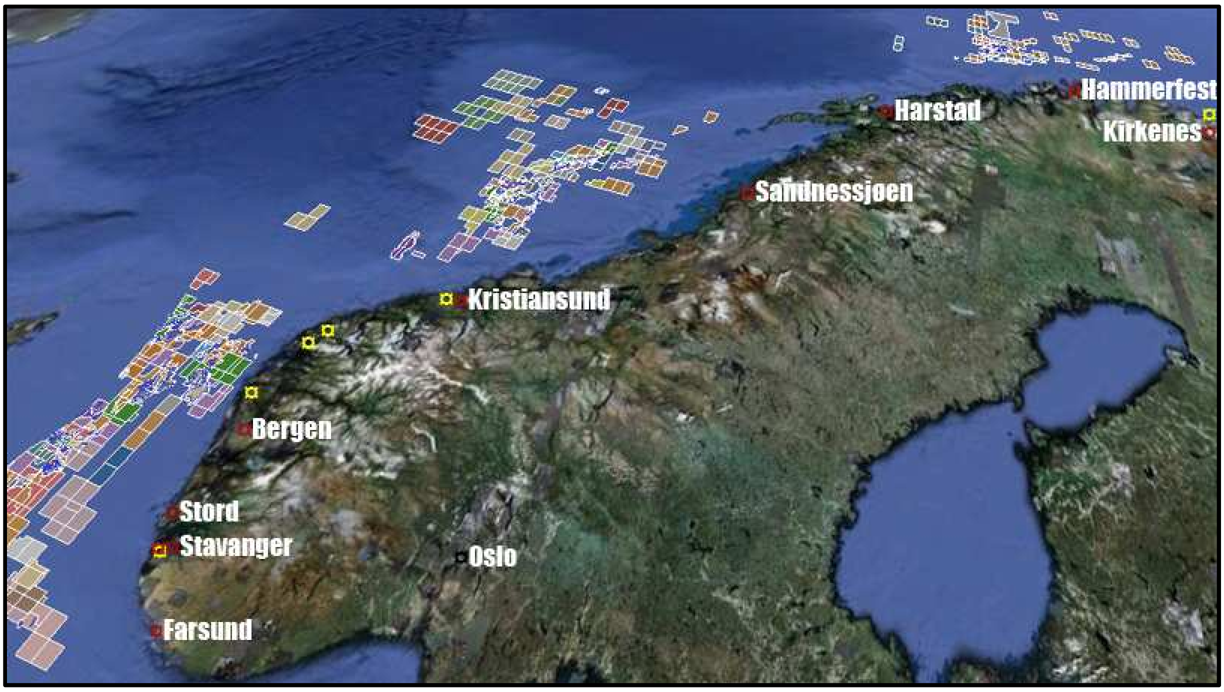


Figure 1 an overview over Norwegian Supply bases and petroleum fields.

Vestbase AS is situated on the north-western coast of Norway, as shown in Figure 2, and is a fully owned subsidiary of NorSeaGroup. Vestbase normally supplies 5 surface platforms and a various number of drilling rigs and ships that might be in the area (Vestbase a, 2010).

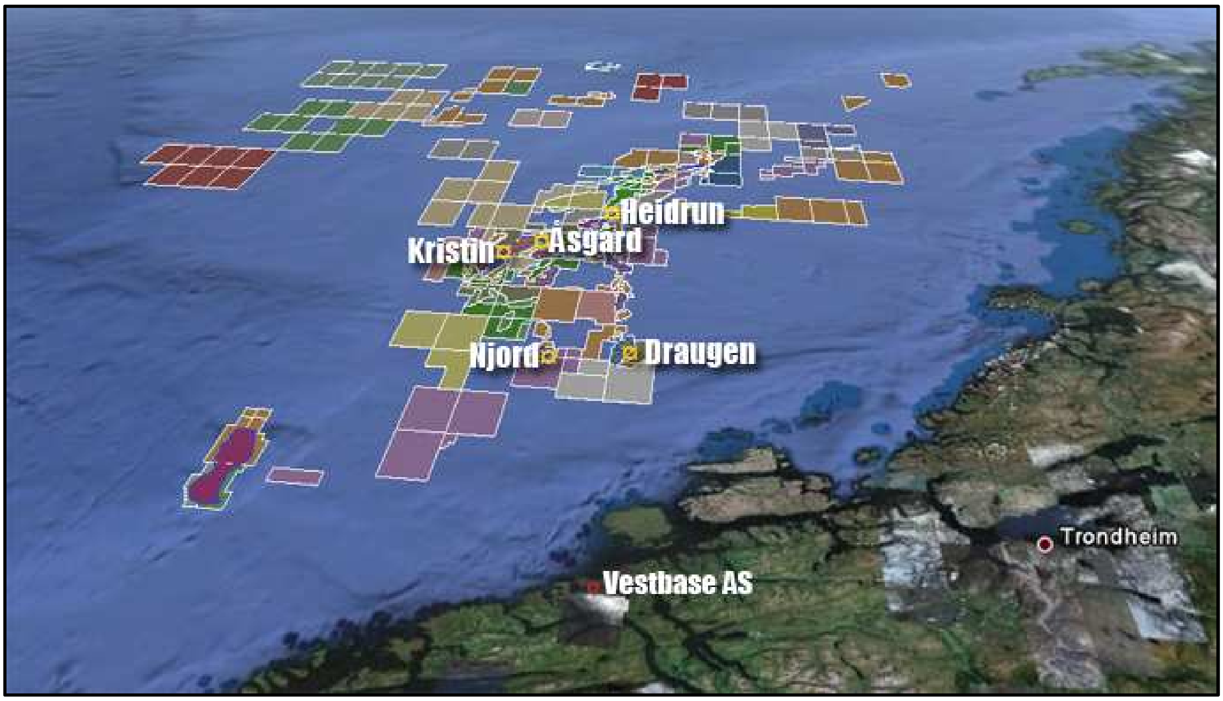


Figure 2 Vestbase and the surface construction it supplies.

Vestbase has its roots back to the 1970's when exploration of the Norwegian seabed was in its early stages. The first construction stage was finished in 1980 (Vestbase b, 2010). It has been in a constant development and expansion process up to this date and further enlargements are still being carried out. The number of companies that are established or being represented on the base is somewhere between 50-60 (Vestbase a, 2010). The logistical system has been developed along with its expansion. This might have created a logistical situation that is complex, less integrated and less efficient than required.

The logistical situation in and around Vestbase's operations consists today of a broad range of participants; platforms, drilling rigs, ships, agents, operators, suppliers, Vestbase itself and all the various types of freight. To make this operation work requires a certain amount of coordination and interaction between all the participants. One of the areas that require a lot of coordination, and what this thesis is about, is port allocation. This is about coordinating all the required resources, actions, supplies, desires and requirements, and making them happen at the right time in a satisfactory way.

Because the installations used to exploit oil and gas is located offshore, transportation of personnel and goods is not easy. As a consequence of this, careful planning and coordination is essential. Furthermore the costs of not being able to deliver could be enormous.

Collaboration is an essential tool in logistical systems, and to give a short introduction to collaborative game theory by the American mathematician John Nash it would be interesting to know a few lines from one of the scenes in the movie "A Beautiful Mind[3]" (IMDB, 2001); "*At a bar, he and his friends begin to compete for a beautiful blonde in a group of five women. "If we all go for the blonde," Nash says, "we block each other, not a single one of us is going to get her …and we insult the other girls. But, what if no one goes for the blonde. We don't get in each other's way; we don't insult the other girls. It's the only way to win….the best result comes from everyone in the room doing what's best for himself and the group"* (Garrison, 2002). The point here is that if they all collaborated and were flexible in order to improve their position, compared to the situation where they all chased the blonde, the sum of satisfaction would increase.

A port allocation process is also subject to limitations and restrictions. It is not achievable that everybody gets what they want, when they want all the time. This thesis will look at how

[3] Movie about John Nash's life, directed by Ron Howard from 2001.

collaboration could be organized and implemented as a work process and system in port allocation.

This research will look at how collaboration could make port allocation at Vestbase more efficient and flexible. It will explore how information exchange and collaborative systems can be used to allocate the necessary means in order to achieve a satisfactory logistical system that can supply the Norwegian offshore petroleum exploration. The purpose is to come up with a new tool for collaborative work, which integrates with external data to support decision making. An important feature is that it also could work as a basis for billing.

Important goals for this research will be to improve utilization of resources, and create a better flow of information. Hopefully this might involve happy users and large cost savings.

2. BACKGROUND

2.1 Port allocation

The processes that make a port call happen and the reasons behind it are extensive. From a demand has come into being at one of the offshore installations, to a ship leaving port at Vestbase with the necessary cargo onboard, there has been a comprehensive coordination process to make resources meet demand. The process of making the necessary measures to meet demand at the port facilities is called port allocation. In simple terms this means to locate a ship to a given quay at a given time to serve its needs.

This process mainly involves finding the appropriate quay that can serve the necessary requirements for each operation. It might however sometimes seem that demand exceed resources on hand. This might be rooted in a less efficient use of available resources.

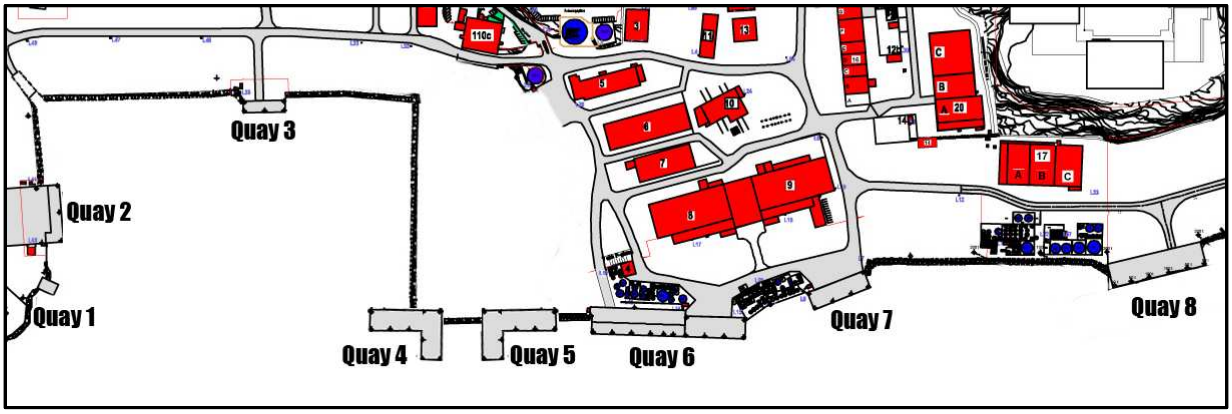


Figure 3 Overview over Vestbase area and quays. Quay 4 and 5 is still under construction (2010).

Figure 3 gives an overview over the central part of Vestbase, and shows the different quays[4] and port infrastructure. The main constraint in terms of quay resources is handling of bulk loads[5] at the different quays. Each quay is only equipped to deliver a given selection of bulk loads. This gives challenges in terms of port allocation as pressure lies on the quays that can deliver these bulk goods.

General cargo can be delivered by crane at any given quay. It is however a question of convenience and time, in terms of internal travelling distances inside the port facility, which might influence on the choice of quay.

[4] Quay 4 and 5 is still under construction in 2010.

[5] Liquid and dry bulk. Cargo that is loaded through pipes. For instance cement and water.

2.1.1 Historical data

It could be interesting to have a look at some historical data on ship movements from Vestbase to get an overview over the situation. The data is automatically generated through AIS raw-data and are unfortunately subject for some inaccuracy.

Table 1 basic traffic data from Vestbase 2009. Source: AIS traffic data from Shiplog.

Different vessels:	348
Average laytime per ship (in Hours):	13,5
Percentage port call per Quay:	
1	4 %
2	9 %
3	11 %
6	37 %
7	19 %
8	11 %
9	9 %
Utilization per Quay:	
1	11 %
2	43 %
3	44 %
6	64 %
7	63 %
8	58 %
9	N/A
Number of Shifting Operations	400
In percentage of port calls	16 %

As can be seen from the table above, there is a high number of different vessels entering Vestbase. This gives challenges in terms of necessary information about each individual vessel such as owner, charter agreement, vessel specification etc.

Quay number 6 and 7 takes most of the port calls. This is also where most of the bulk load is available. As seen in Figure 3 these quays are centrally situated at the port facilities.

There is an extensive use of shifting operations, which is the process of moving a ship from one quay to another. The ship moves with the use of own engines during this process. In 2009 there were as much as 400 time consuming shifting operations. Approximately 16 % of all port calls required a shifting operation. On average a shifting operation can take 1 hour from start to finish, and requires a lot of fuel.

2.1.2 Work Flow

The participants in a port allocation process can be divided into three main categories; operators (mostly oil companies), suppliers and the port operator (Vestbase) as shown in Figure 4. To work out a proper work flow for each of the three categories is difficult as there are no well defined methods on how requests and communication are channelled through the system. In practice there is an extensive use of mail, phones and fax back and forth in order to settle an agreement. This brings complexity to the system, and makes traceability hard.

Another uncertainty factor, in terms of work flow, is the number of different participants in the system. How things are done might vary from project to project, depending on whose involved.

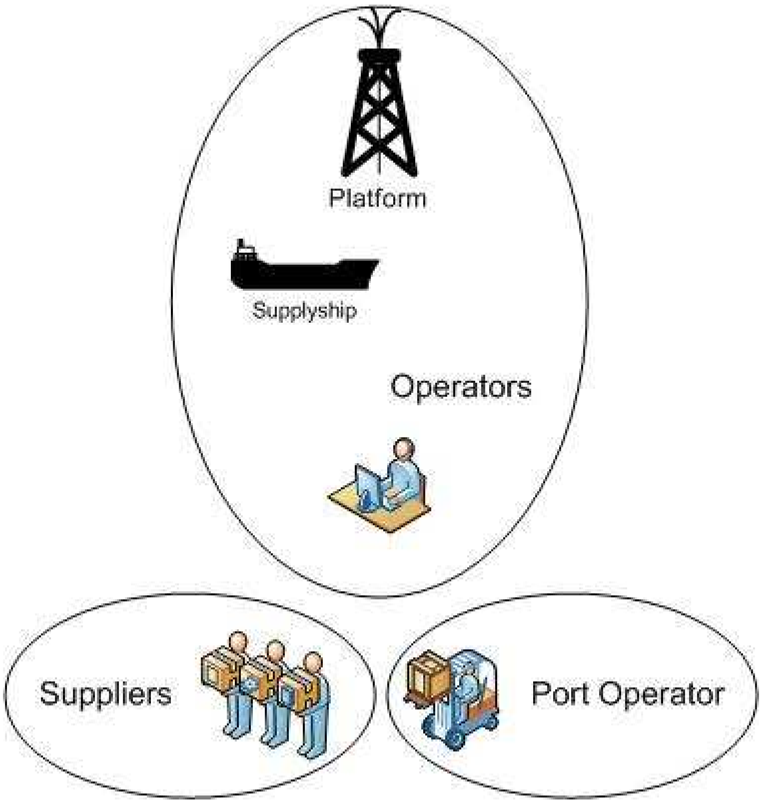


Figure 4 Participants in port allocation

The following headings will look closer at the three different categories presented in Figure 4.

2.1.2.1 Operators

An operator in the oil and gas sector is traditionally looked upon as the company that stands for the conduct of the field. The two large operators at Vestbase are A/S Norske Shell and StatoilHydro ASA. They operate the offshore oil and gas fields that are assigned to Vestbase and are as such responsible for a considerably portion of the traffic at Vestbase.

In terms of operator in this research, it makes sense to expand the meaning of the word operator. There are ships arriving at Vestbase that not necessarily are under direct operational control from Norske Shell or StatoilHydro. Ships might work on behalf of Norske Shell or StatoilHydro, but are operated through agents, suppliers or even the ships itself (Øien, 2010). Thus the term operator should include all participants in the system that operates a ship, and/or are able to book a port call.

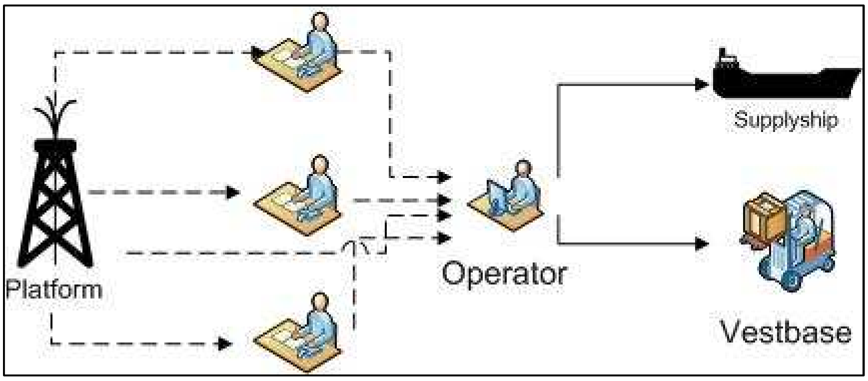


Figure 5 Operator work flow chart

Figure 5 tries to give a simplified look at reality for port allocation from the operator side. From beginning to end, communication passes through several segments, and requirements is subject to change more than once during this process. In reality the figure could be filled with arrows back and forth between the different segments. However, for StatoilHydro, the final communication between them and Vestbase goes through their logistical base operation centre at Vestbase (Rolland, 2010). This is the most important link and communication point between operator and Vestbase. Similar work flow charts are to be expected from other participants as well, with one[6] connecting links to Vestbase. The number of participants creates challenges in terms of roles within a port allocation system.

[6] There might be operations which require more than one link. However, the number of links is not numerous.

2.1.2.2 Suppliers

Firms that deliver goods and/or services to the operators and the ships at Vestbase are defined as suppliers in this research. At Vestbase there are about 45 different firms that constitutes the suppliers (Vestbase c, 2010).

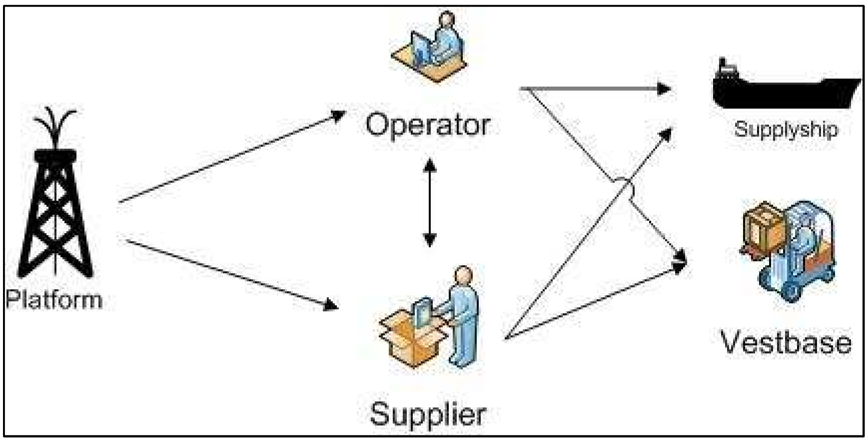


Figure 6 Suppliers and operator work flow chart

Figure 6 shows how communication of demands passes between the different participants when suppliers also enter the picture in the port allocation. Some of the suppliers have own representatives at the offshore installations that are responsible for logistical operations of their own products (Sundsøy, 2010). They coordinate necessary supplies to the onshore office, which coordinates with the operator and Vestbase.

There is also, as mentioned above, situations where suppliers may act as operators of own ships (Hansen, 2010).

Table 2 Suppliers of bulk loads at Vestbase

Supplier	Products
Vestbase	Water, cement, Gas Oil
Statoil	Gas Oil
Halliburton	Bentonite, Barite, Brine, Mud, Base Oil, Slop
MI Norway	Bentonite, Barite, Brine, Meg, Mud
SAR	Slop
Swire	Meg
Norcem	Cement
Baker	Barite, Brine, Mud, Base Oil
Petrochem	Base oil
XY	Gas Oil
MWM	Slop
Veolia	Slop

The table above presents an overview of the different suppliers and which bulk cargo they deliver. As mentioned, these bulk products are not delivered on every quay facility.

The bulk products are delivered by pipes from the onshore tank facility to the vessel. The time it takes to load the product depends on several factors;

- The length from the pump station to the ship.
- The effect of the pump.
- How many bends the piping has.
- The ships capacity to receive.

As quays that provide bulk loads are a limited resources in the system, it would be preferable to shorten the time it takes to load the products.

2.1.2.3 Vestbase

Vestbase is the port operator which provides port and warehouse facilities. They are responsible for coordinating the port allocation and have the final saying in terms of allocation.

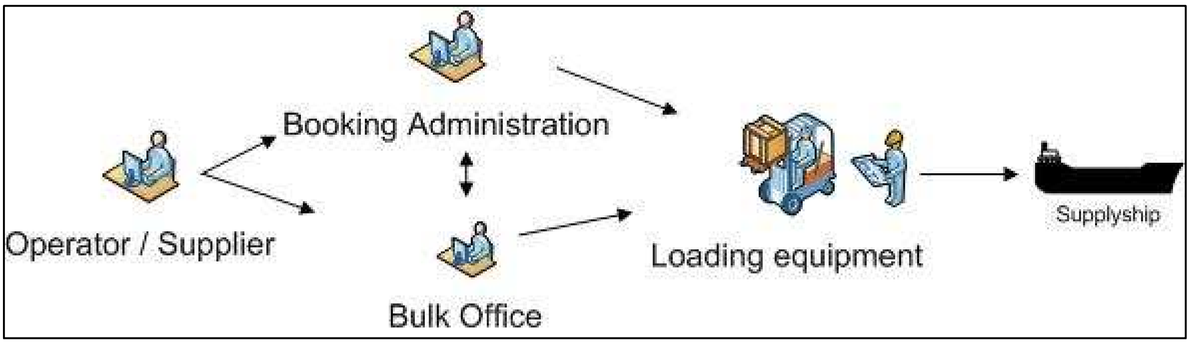


Figure 7 Vestbase work flow chart

Orders are entering through Vestbase's booking administration as shown in Figure 7. They allocate the necessary resources in terms of loading equipment and quays. Today this information is gathered and organized through the use of office outlook calendars. Each quay has its own calendar. This has its limits in terms of collaboration, as the calendars are not shared with any of the suppliers or operators. It is also limited in terms of having an automatic response to available bulk resources.

Vestbase also act as a supplier through their own bulk sales.

2.1.2.4 Other complexities

The reality is however complex and might make it difficult to shorten the loading time; a vessel might only take bulk loads at the back end of the ship. To load the ship, the supplier might have to lay more bends in order to reach the intake and thus makes loading time longer. The vessel on the other hand is unable to lie the other way as it might lose its communication with satellites.

This example was just to illustrate the complexity of the reality faced in a port allocation process in terms of optimization. This also speaks in favour for a collaborative port allocation system as there is almost no chance for Vestbase to know all about these variations.

2.1.3 Information sharing in the supply chain

An important element in port allocation is information sharing to make coordination of activities work properly. With the existing information model there is an extensive, but insufficient amount of information passing between the different participants. It's actually desirable to increase the flow of information. Doing this in the existing system could increase the workload close to the impossible. The requirements are also subject to change several times during a port allocation.

Some main operators have created a Shipping pool to be able to utilize shipping resources in a more efficient way than with normal conduct. Internal communication between different departments on the offshore installations is however not always satisfactory and leads to separate supply chains with little or next to no coordination (Kon-Kraft, 2004). This lack of communication between departments might hamper the intentions of a shipping pool

As offshore employees in charge often are free to procure supplies and equipment themselves, it often generates frequent orders and several transport hauls. Orders might also be placed directly with the supplier without informing the central warehouse administration (Kon-Kraft, 2004). This lack of integration between the departments leads to fragmented supply chains with little coordination. When someone within the system is in need of something they make an all-out effort in order to get it.

Although the intention to create a streamlined supply chain is present, it might be hampered by existing routines and a culture of information sharing that might not be suitable for the next generation of integrated supply chains.

Communication in port allocation is not easy to map in concrete terms as there is a lot of communication back and forth between different participants with the use of different communication methods as displayed in Figure 8. Orders might be received by fax, confirmed by mail or phone or vice versa. The information is coordinated by Vestbase. In practice the actual allocation is presented as schedules in Microsoft Office Outlook calendars - one calendar for each quay.

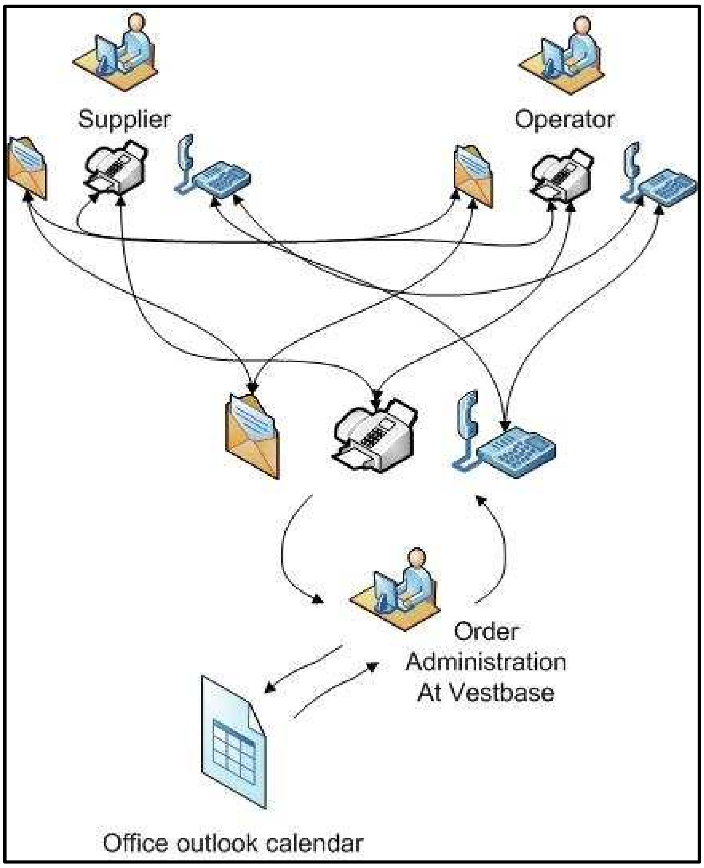


Figure 8 modes of communication between participants.

2.1.3.1 ERP systems

There is an extensive use of different ERP systems among the different participants. Each operator or supplier has their own integrated ERP[7] system. They might not be willing to make the systems communicate with each other - or it might not be technical possible for various reasons.

[7]Enterprise Resource Planning – Software that integrates various area of activity within a firm

2.1.4 Economical aspects

The oil industry is a business where both costs and earnings are high. This means that almost all activities that take place within the supply chain generate high costs – and hence small changes can have big savings, and has a potential for large savings.

The port allocation process is in some ways the rallying point for all logistical operations to the offshore installations. Mistakes and delays at this point could cause costly ripple effects throughout the system. When it comes to costs directly tied to the port allocation process it might be natural to assume that the ships are the most expensive resources per time unit, although there are no numbers to confirm this at this point.

2.1.4.1 Costs of not meeting requirements

There is spiral effect that could develop as a consequence of delays or mistakes in the port allocation process. If necessary parts do not make it to the installations in time there is a risk of having to shut down the processes offshore. This could either be a shut down in drilling activity or having to stop production of oil and gas at the installations.

If production has to be stopped at one of the offshore production facilities, high costs run by the hour in terms of loss of sale, operating expenses and so on. There is also a cost attended with the process of having to restart the production.

Having to stop a drilling activity could cause new ripple effects in terms of delaying an entire development phase. There are costs of ships, equipment and processes that have to be moved in time or charter agreements that have to be extended. One day of delay in construction also means one day loss of sales in terms of production.

Table 3 Production capacity and potential earnings at different fields. (offshore-technology.com b, 2010, offshore-technology.com a, 2010, offshore.no, 2010, Shell, 2010, energilink.tu.no, 2010, statoil.com, 2010)

Installation	Produce	Production / day	Potential Earnings /day	
Åsgård B	Natural Gas	33 million m3	USD	9 900 000
	Oil	200 000 barrels	USD	16 800 000
Åsgård A	Oil	200 000 barrels	USD	16 800 000
Njord	Oil	70 000 barrels	USD	5 880 000
Draugen	Oil	90 000 barrels	USD	7 560 000
	Natural Gas	1,5 million m3	USD	450 000
Heidrun	Oil	250 000 barrels	USD	21 000 000
	Natural Gas	6 million m3	USD	1 800 000
Kristin	Natural Gas	10 Million m3	USD	3 000 000

Table 3 above gives an overview over the different production facilities that are served from Vestbase. The potential earnings per day would, in the event of a stop in production, be the same as loss of sales per day. The cost multiplies per day and can reach considerably portions of investment costs for the field.

2.1.4.2 Costs of shifting

The cost of shifting constitutes a considerably direct cost tied to the process of port allocation. To simplify the calculations it makes sense to look solely on the bunker consumption during a shifting operation. It might be taken into consideration that an increase in crew expenses might occur for several reasons, this is however different from each individual charter agreement between operator and shipping company.

When looking at the costs for shifting there are two factors that might affect this; time and consumption. Both are subject to change from vessel to vessel. It is however possible to see from statistics (Shiplog, 2010) that the time from a ship disappeared from one quay and reappeared at another one took approximately 15 minutes. Summing up the time from engine start to engine shut down at the vessel takes by experience approximately 1 hour (Rovik, 2010, Barmen, 2010).

Table 4 bunker consumption during shifting operations (Barmen, 2010, Rovik, 2010).

Construction:		
	Electric	
Consumption	1,5	m3
density 1,1	1100	kg/m3
Consumption in Mt	1,65	ton
Fuel Oil Price	650	$ / Ton
	1072	**$ USD**

AHTS:				
	Electric		Main Engine	
Consumption	1	m3	2	m3
density 1,1	1100	kg/m3	1100	kg/m3
Consumption in Mt	1,1	ton	2,2	ton
Fuel Oil Price	650	$ / Ton	650	$ / ton
	715	**$ USD**	**1430**	**$ USD**

The table above shows the cost of shifting for a typical construction vessel and one anchor handler vessel, which typically frequent Vestbase. The cost might vary depending on different conditions such as distance and weather. However a typical shifting operation in terms of bunker operation costs seems to be about 1000 USD. If this is added up with 400 shifting operations in 2009; it counts 400 000 USD in total.

2.2 Supporting data for invoices

Today Vestbase spend a lot of time gathering information for billing purposes. Information are gathered in spreadsheets (Excel), revised, sent to customer for approval and back to Vestbase (Taknæs, 2010). There is a potential for time savings and less omissions in this information if the system could be used to gather the necessary information to be used as supporting data for invoices.

Ships entering Vestbase are to pay harbour charges. The amount to pay, and also whether to pay or not, may depend on several varying factors. Depending on contracts they might not be obligated to pay. Another factor is what kind of service they operate; for instance if a ship operates as an anchor handler it might be obligated for another tax than if it services as a supply vessel. These variations are hard for Vestbase to track down.

2.3 How to measure improvements

To measure the systems performance is important in order to be able to track improvements in a new port allocation system. It might also be interesting to be able to identify good and bad participants of the system in order to give incentives for the participants to behave well and contribute to a functional system.

2.3.1.1 KPI

Key performance indicators are commonly used in organizations and supply chains to define and evaluate how successful it is. For port allocation purposes it will be necessary to define a few points that are measurable in terms of improvements. To do this it might be helpful to look at the goals of the system and how these can be achieved. In terms of utilization of resources, greater predictability would be a key factor. Better predictability could be achieved through a greater time horizon.

KPI's for port allocation:

1. Time before an allocation is approved upon arrival of vessel.
2. The number of shifting operation during an allocation.

3. The ratio between makespan[8] and cargo loaded.

2.4 Collaboration

Collaboration is an interesting work method that can be applied in a port allocation process. Collaboration is a behaviour that is being utilized by living creatures both to survive and to gain benefits in the daily life. The simplest definition of the word collaboration is perhaps “to work together” (London, 1995). A search on Google gives more than 15 different definitions and compounds of the word. The most fitting definition in this context seems to be *“a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible”* (Gray, 2001).

Collaboration is an effective method to bring together knowledge, experience and skills from different specialisations and participants within a system (Crow, 2002). Collaborative endeavours generally share a number of basic characteristics that can be indentified with port allocation (London, 1995): ”

[...]

- *Several stakeholders have a vested interest in the problems and are interdependent.*
- *These stakeholders are not necessarily identified a priori or organized in any systematic way.*
- *There may be a disparity of power and/or resources for dealing with the problems among the stakeholders.*
- *Stakeholders may have different levels of expertise and different access to information about the problems.*
- *The problems are often characterized by technical complexity and scientific uncertainty*
- *Differing perspectives on the problems often lead to adversarial relationships among the stakeholders*
- *Incremental or unilateral efforts to deal with the problems typically produce less than satisfactory solutions*
- *Existing processes for addressing the problems have proved insufficient*“

[8] In manufacturing, the time difference between the start and finish of a sequence of jobs or tasks. Port allocation: The time a ship spends in port.

Dr. Charles Green, a psychologist has said that; "The Idea that if you just get people together they'll start liking each other is naive. But if they are working together for shared goals, it breaks down the negative stereotype they had for each other"(Weisbord, 1992).

2.4.1 Preconditions and Principles

Table 5 the table below illustrates the differences between collaborative ways of working and more formal approaches. (Four Groups, 2008)

	Examples	Perceived Strengths	Perceived Weaknesses
Informal collaboration	Innovation, ad hoc projects, informal influencing, improvisation	Better use of resources, greater spontaneity, recognition and enjoyment	It is hard to control measure and manage. Could be seen to undermine the status quo
Formal process and structure	Customer service, business process reengineering, auditing, surveys	Can be measured, systematically optimised and enhanced	Can be restrictive, too easily satisfied with the status quo. Could be seen to undermine efforts to change

As can be seen in Table 5 above there is a tension between informal collaboration and a formal process. It is necessary to identify what type of method that is desirable for port allocation. The table shows that it is a trade-off between control, spontaneity and adoption to change. Port allocation can in one end of the scale be structured and put under a restrictive control that can be measured and optimized for best possible results. On the other hand it might invite for collaborative solutions where restrictive control is absent and conduct is left to the users. Port allocation today might be found somewhere in between. It is not very well defined in terms of giving it a collaborative or a formal classification. It is missing some qualities from both collaborative and formal classification which makes a classification hard to identify.

Each port allocation has its unique layout. The present allocation differs from the one before and the one after. Different ship, needs and requirements, people, agents, operators and so on. Ad hoc is the Latin word for special, or for this particular purpose (Wikipedia a, 2010). It normally signifies a solution that has been designed for a specific problem. As each port allocation in reality requires a different set of solutions it would make sense to define a port allocation as an Ad hoc activity.

This invites port allocation to be a collaborative work process according to Table 5. This will enable a better use of resources, greater spontaneity and recognition.

There have been several discussions among academics what preconditions for an effective collaboration is. According to Scott London (1995) there are some main points that most seem to agree upon; *"it must be democratic and inclusive; that is, it must be free of hierarchies of any kind and it must include all parties who have a stake in the problem"*. Hierarchical organization could be dangerous in terms of collaborations; *"People begin to identify with their unit — their turf.* [In hierarchies] *... communication across units and between layers becomes difficult" (Osborne and Gaebler, 1992).*

It has been mentioned several points that needs to be fulfilled for collaboration to be successful. It must gain support and involvement by prominent leaders in the organization (London, 1995). Leaders who do not approve for such a solution can with ease disturb and disrupt a collaborative system.

Collaboration must be inclusive, include all leadership and participants of the system to be legitimate. "*The level of participation required, however, is partly a function of what type of collaboration is being sought. Clearly, some forms* [...] *require only that the relevant stakeholders be included"(London, 1995).* This means that it will not be necessary for all participants to agree on solutions that they do not actually take part in. This would just be a waste of time, resource and focus, and slow the operation down. Those who know and have proven to give useful solutions can decide. This is a matter of trust.

There are some points mentioned by Scott London that needs to be answered before launching a collaborative venture;

- What are the structural relationships between the parties and the possible power issues inherent in the collaborative arrangement?
- Is there a clear understanding among all the parties of the respective goals of the other participants?
- What form of leadership is required to facilitate the process?
- Does the project have some form of integrating structure, such as a cross-section of steering committees, to facilitate and coordinate decision-making and implementation?

It is necessary to be aware of the situation that some participants in the system might possess more power than others. This is important to be aware of both for the superior part and the subservient part, so that there will not be an improper use of power. It is however hard to regulate as some participants might be in positions where they have priority due to ownership, investments and grandfather rights[9]. It is a recurring theme of working together towards a common goal.

All participants need to understand and be aware of a common goal of the system. It is on the other side also important for each participant in the system to understand the respective objectives of the other participants, and if possible work up an understanding for how the others might achieve their objectives. "*Collaboration establishes a give and take among the stakeholders that is designed to produce solutions that none of them working independently could achieve"(Gray, 2001).* This give and take action requires a great deal of understanding for the other participant's needs and requirements.

A collaborative process is like most other processes in need of some sort of leadership. Even if collaboration is supposed to be a process where the participants must be self governing, and all should take part in the process of making a joint decision. The leadership of such a system should be more in terms of guidance and coordination, rather than the traditional top-down leadership. There has been mentioned some points for collaborative leadership (Richard S Wellins et al., 1991 p. 132-133) ;

- Ability to learn
- Communication (oral and written)
- Delegation of authority and responsibility
- Follow-up
- Identification of problems
- Information monitoring
- Initiative
- Judgment
- Maximizing performance
- Motivation to empower others
- Operational planning
- Rapport building

[9] A term often used in aviation when one airline has the right to a certain time slot since they have always operated it.

These points are of interest in terms of how such a system shall be run, and what qualities and characteristics it should have. The system operator should have an overview over the situation that makes him able to identify problems, take initiative, delegate through communication, follow up and monitor, and have the ability to learn through historical data.

The project will need to have some form for committee that is able to implement the system in a satisfactory way. Key personnel from each participant should come together and act as a link and catalysts to get the system working.

2.4.2 People and Trust

The technology has now come as far that collaboration and collaborative system can easily be developed and put into practice. People seem however out to be the most important element, and bottleneck, in achieving a proper and functional collaboration. Without having people that are willing to collaborate, it is no use in having a perfect collaborative instrument. There must be an openness for team-work and open communication where input from other participants are respected and accepted (Crow, 2002). Conflicting goals could easily disturb a collaborative system, therefore the decision making process must be based on a collaborative approach, as shown in Figure 9 below.

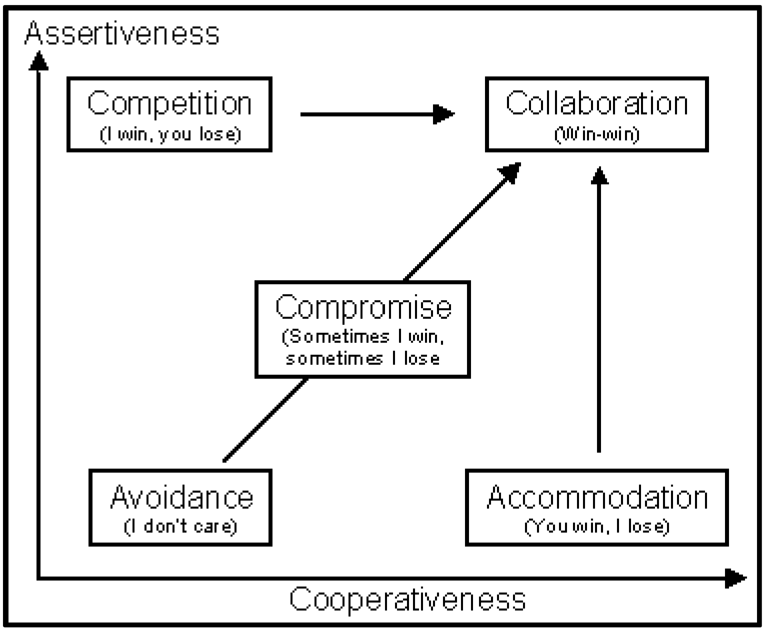


Figure 9 Cooperativeness and Assertiveness (Crow, 2002).

Compromise is by many people seen upon as the ideal, this is however not always the ideal (Crow, 2002). This is a matter of understanding long term mutual interests, and short term benefits.

A good cooperation is achieved when people are able to act professionally and committed to the case, and are able to look further than their own narrow discipline. *“The key to the win-win approach is to creatively search for solutions that can mutually satisfy the needs of the team rather than focusing on just two competing solutions that involve trade-off’s or are mutually exclusive”(Crow, 2002).*

There have been mentioned three conditions for successful collaboration(Four Groups, 2008);

- Training around collaboration will raise people’s awareness. Genuine collaboration however, is often spurred of the moment and highly context specific.
- People need to value collaboration; they have to want to put it into practice.
- Sustaining collaboration both requires and generates trust. It’s also important to gain alignment of behaviours, relationships and culture.

Perhaps the most interesting and challenging points in this case would be the last two points. People need to value collaboration. It is necessary to make people understand why this is done, and make them understand the incentives for collaborating. It might also be of value to consider creating small incentives to make people want to participate.

Understanding and mapping shared interests is of the utmost importance. Without a common interest collaboration can falter (Four Groups, 2008).

This might require that a system in the beginning is only added a small, but essential number of features. This can help in building trust and collaborative behaviour over time.

2.4.3 Collaborative Systems

Collaborative systems have had a large prosperity in the last decade as internet has become a part of daily life. Facebook might be mentioned as a great example of a collaborative system where trust has been build over time. People work together to create an up-to-date system that a person or a small group never singlehandedly could have been able to do. Wikipedia and Linux can be mentioned as a result of collaboration.

Wikipedia act as a free of charge encyclopaedia where everybody is welcome to write and make changes. It is not unexpectedly a victim for some unserious activity where people have written false information for various reasons. It is also a danger that information could be of poor quality and little credibility. This is however detected by honest people who change it back or rewrite the articles. People who are dishonest are being banned from the system and cannot contribute to any more disturbances. The system is self governing, and shows that if people are given the possibility to contribute towards a shared interest, chances are that most people will take it seriously and do what is necessary to achieve this goal.

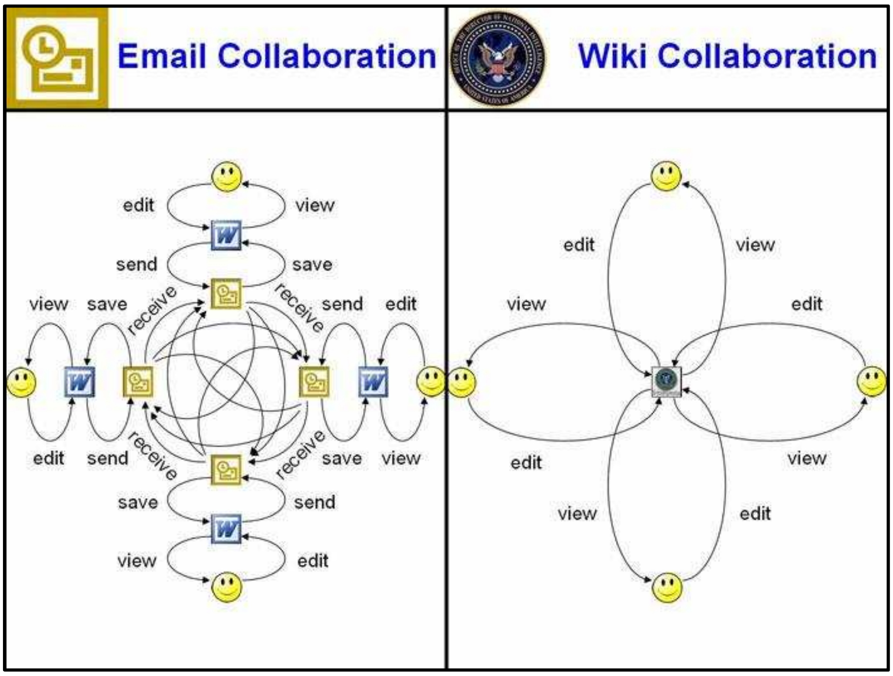


Figure 10 How wiki collaboration works as opposed to email collaboration. Source: (wikinomics, 2008)

Figure 10 above shows how wiki collaboration works as opposed to email collaboration. The figure to the left could easily have been an overview over port allocation, where there is a lot of information exchange going back and forth. Port allocation has also in addition several other means of communication such as fax, phones and radios which adds to the complexity.

As can be seen the wiki collaboration has a very simple design. Everyone is working on the same system or file that gives live and up to date information about the current state. This saves time and reduces the possibility that some information get lost along the way, or that some people for some reason did not get the information at all.

Email, fax and phone systems are not collaborative systems (O'Reilly, 1998). The email client for instance does not care about the other client's state; it only cares about getting the email to the correct server. A Collaborative system is *"where multiple users or agents engage in a shared activity, usually from remote locations* [...] [c]*ollaborative systems are distinguished by the fact that the agents in the system are working together towards a common goal and* *have a critical need to interact closely with each other: sharing information, exchanging requests with each other, and checking in with each other on their status"(O'Reilly, 1998).*

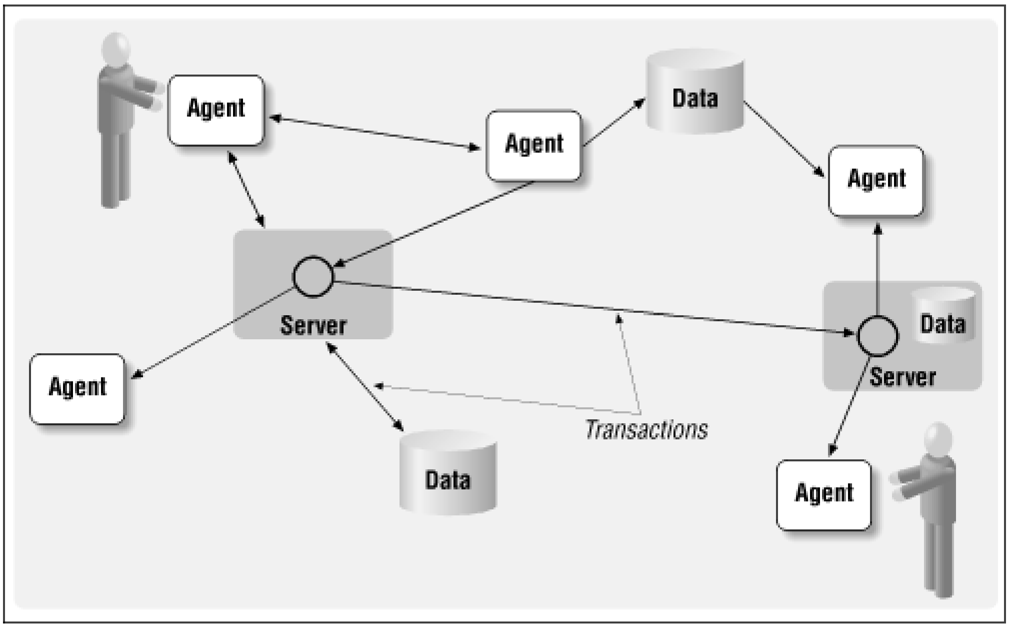


Figure 11 A Collaborative System. Source: (O'Reilly, 1998)

Figure 11 above shows an example of a collaborative system. The system contains of four different elements;

- Agents.
- Servers
- External data sources
- Transactions between the different units.

Agents are the actual users or participants of the system. Servers are used to store and hold the actual collaborative portal, historical data and so on. Data sources can be used to gather 3rd party information such as weather, and information about the whereabouts of ships and resources. Transactions between them are about how they communicate. There are different languages in use in modern ERP and information exchange systems today. They need to be able to communicate to be able to share information. XML[10] is a universal and extensible language that makes exchange of structured data between information systems possible (Wikipedia b, 2010). XML is supported by most software programs that support sharing of information on internet today, and would be the natural choice of language in this setting.

[10] Extensible Mark-up Language

2.4.4 Limitations

Collaboration might under certain circumstances not be the best work method. To understand whether or not collaboration should be applied it is necessary for all participants to be familiarized the limitations of a collaborative process (London, 1995);

- Collaboration could be a time consuming process that might not be suitable for situations that requires quick and decisive actions.
- Power inequalities between the participants can deter the process.
- Collaboration often works best in small groups and could break down in groups that are too large.
- Collaboration is meaningless without the power to implement final decisions.
- Consensus and joint decision-making sometimes require that common good take precedence over the interests of a few.

That collaboration could be a time consuming process is abhorrent to the goals of this research. Collaboration could end up in being a time consuming process if the correct work tool in terms of a proper functional portal is not there. The information exchange needs to be quick and effective, and relies on people using it effectively and consequent. It is not enough, nor meant to be, a place where one check in every now and then. Collaboration is a more time consuming process as opposed to a top down command structure. What needs to be taken into consideration is that by having a proper communication/collaborative tool, the benefits won by having a collaborative system could overcome the loss of time in the decision making process.

The system coordinator shall have the ability to make final decisions. Without it one would risk that the process of trying to reach consensus could delay the entire course of action.

It is necessary to understand that common good in some cases needs to be prioritized over the interest of few. If a participant is willing to except that his wish have been overruled to benefit the entire system, a collaborative system will have good foundation for growth. However, there might be a possibility to promote clever user of the system.

Scott London mentions some circumstances under which it is best not to collaborate; *"1) when one party has unchallenged power to influence the final outcome; 2) when the conflict is rooted in deep-seated ideological differences; 3) when power is unevenly distributed; 4) when constitutional issues are involved or legal precedents are sought* [...]"

As mentioned above, collaboration is being advised against when it could meet obstacles as law (in this setting in terms of contracts). The oil and gas sector in Norway consists unfortunately by a tangle of contracts that binds almost every part of the conduct. This aspect could give certain challenges in terms of implementing a collaborative system.

2.4.5 Criteria for collaboration in port allocation

For a collaborative port allocation system to be functional there might be several criteria's that needs to be in place. It might be interesting to enlighten a few but important criteria's;

1. All regular users of Vestbase's facilities need to take part. If not, the collaborative system will only be a parallel subsidiary to the normal operation, and might actually double the work load. Collaboration is also meaningless without all participants.
2. A common goal and understanding of why this is done. Participants need to understand the incentives.
3. A software that is easy to use and easy to access. Without it, collaboration could easily be met with unwillingness.

In other words - collaboration needs to be simple; everyone has to take part and understand why they do it.

2.5 Game theory and prisoners dilemma in port allocation

Game theory is a branch of applied mathematics that is used in various fields in an attempt to mathematically capture behaviours in strategic situations (Wikipedia e, 2010). One individual's success in making choices depends on the choices of others. Mathematicians like John Nash have tried to describe in mathematical terms the rational mentality behind certain behaviours. His theories are used in fields ranging from economics, computing to biology. Some of his thoughts and theories can help in understanding some of the methodology and behaviours behind a collaborative port allocation.

The Nash equilibrium itself describes a solution of a game that involves two or more players, where each player is assumed to know the equilibrium strategy of the other players, and no player has anything to gain by changing only his own strategy unilaterally (Wikipedia f, 2010). This setting constitutes Nash equilibrium. The concept of Nash equilibrium can be applied in many settings; like in the prisoner's dilemma, which is most applicable in the setting of collaborative port allocation.

The introduction (p. 11) mentioned a scene where a group of men were to collaborate in order to improve their position compared to the situation where they all chased the blonde. The outcome of this situation rests solely on how the cooperation is being enforced. If one goes for the blond and win her affection, he could risk the loss of friendship. For such cooperation to work in economic situations, the enforceable action has to be enforceable (Bized.co.uk, 2010), or given the right incentives not to cheat. This could be done through legal agreements, agreed punishment, fine or reward. There is a chance that where such incentives cannot be enforced the cooperation will falter and break down (Bized.co.uk, 2010).

If however the friendship was not destroyed and they were to meet over again and do the same thing again, the outcome could change. There is a chance that they will discover that each time they are betrayed; the evening is destroyed and no one is getting what they want. This shows that cooperation can be the best option in the long term.

Table 6 Prisoner's dilemma payoff matrix

	Cooperate	Defect
Cooperate	Win - Win	Lose Much – Win Much
Defect	Win Much – Lose Much	Lose - Lose

In the first situation, where they were to play the game only once, there was no apparent Nash equilibrium. Thus it made sense for one of the participants to cheat. Taking into account that they were to play the game several times, and the chance that others would defect the plan the next time increased, it made sense be cooperative. Table 6 above shows a prisoner's dilemma payoff matrix that illustrates how the outcome of four different scenarios would be.

In a port allocation process, the different participants are more or less stuck with each other, due to government decisions(Kon-Kraft, 2004), and the process is to be done over and over again. Thus it makes sense to play cooperatively and do the best out of it.

This means that each participant should strive not to benefit only themselves, and help others by not blocking for each other.

2.6 Use of Collective intelligence

Collaboration and collaborative systems is part of a phenomenon called collective intelligence. There are different definitions of this property in various fields of study. It has been linked to everything from bacteria's, animals, humans, and computer networks, and might just as well be applied to business as in sociology. The basic idea is that through collaboration and/or competition of many individuals, shared group intelligence emerges, to help consensus decision making. In simple terms - "many are smarter than few" and the challenge is to utilize these resources.

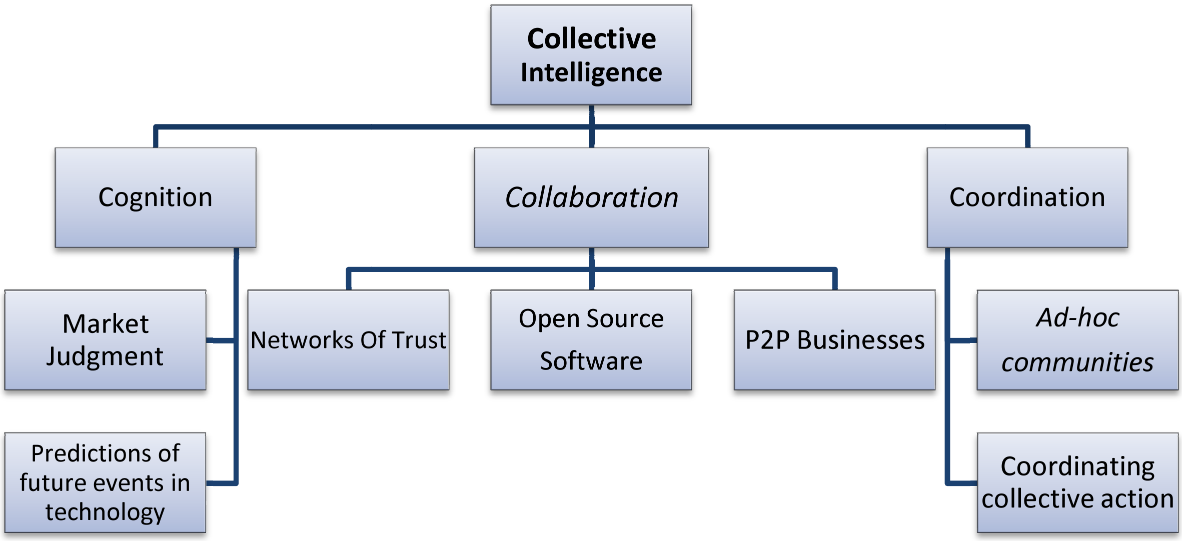


Figure 12 Types and examples of collective intelligence. Inspired by Generozova (2009).

Figure 12 gives an insight to collective intelligence, and its different elements. They all have interesting features that can be applied in collaborative port allocation.

According to Don Tapscott and Anthony D. William (2008), collective intelligence is mass collaboration, and this is based on four principles;

Openness: "[…] *openness is associated with candor, transparency, freedom, flexibility, expansiveness, engagement, and access. Open, however, is not an adjective often used to describe the traditional firm* […] *Recently, smart companies have been rethinking openness* […] *Rapid scientific and technological advances are among the key reasons why this new openness is surfacing as a new imperative for managers*"(Don Tapscott and Williams, 2008 p.21). As he points out here; openness is not a traditional way of thinking within firms. However, openness and transparency within the supply chain is now being more and more recognized and appreciated among firms. The concept of openness in form of transparency is discussed in section 2.7.

Sharing:"*Conventional wisdom says you should control and protect proprietary resources and innovations—especially intellectual property—through patents, copyright, and trademarks.*[…] *Of course companies need to protect critical intellectual property. They should always protect their crown jewels, for example. But companies can't collaborate effectively if all of their IP is hidden. Contributing to the commons is not altruism; it's the best way to build vibrant business ecosystems that harness a shared foundation of technology and knowledge to accelerate growth and innovation"*(Don Tapscott and Williams, 2008 p.26). It seems that companies are starting to understand the power of information sharing. The key is to understand which information that is vital or necessary to share. This thesis will give a better understanding, and provide guidance in identifying the correct information.

Peering: "*Participants in peer production communities have many different motivations for jumping in, from fun and altruism to achieving something that is of direct value to them. Though egalitarianism is the general rule, most peer networks have an underlying structure, where some people have more authority and influence than others*. […] *Peering succeeds because it leverages self-organization—a style of production that works more effectively than hierarchical management for certain tasks*"(Don Tapscott and Williams, 2008 p.25). The basic idea is that this form for operation is far from the usual corporate command and control hierarchy. By applying a certain level of egalitarianism to the port allocation process, it could hopefully increase its effectiveness. This is because knowledge about the port allocation is possessed by many different individuals in the process, not by a few numbers of leaders.

Acting Globally: "*The emergence of open IT standards makes it considerably easier to build a global business by integrating best-of-breed components from various geographies*" (Don Tapscott and Williams, 2008 p.30). Although this system might not be globally in a literal sense, it is a system that should gather the best possible information from various geographies. Having a decentralized system can have many advantages and will be enlightened in section 2.10.

These four principles are thought to be defining how twenty-first-century corporations will compete. This is a sharp contrast to how traditional business culture has worked, secretive, closed and hierarchical. These principles are the main bed stones for a collaborative port allocation process.

2.7 Transparency in the decision making process

2.7.1 Transparent Supply Chain

The effect of a transparent supply chain has been mentioned in many occasions in logistical literature. Even so, it might be that the potential of this issue have not been warmly greeted among all business leaders. As with most strategies it might have both a positive and a negative impact, depending on situation and intention. For some businesses, secrecy and playing with one's cards close to one' s chest might go at the expense of a agile and flexible supply chain. With no information sharing strategy and planning is hard, thus reacting to sudden changes is made difficult.

A transparent supply chain implies that vital and useful information is available to more than one participant of the supply chain. That means that decisions, strategies and changes can be dealt with on the basis of more information and better understanding among the participants. This does however not imply that all participants shall share all information at any given time. There needs to be an understanding of what information that is useful and vital for the other participants to know, in order to fulfil their obligations to the system.

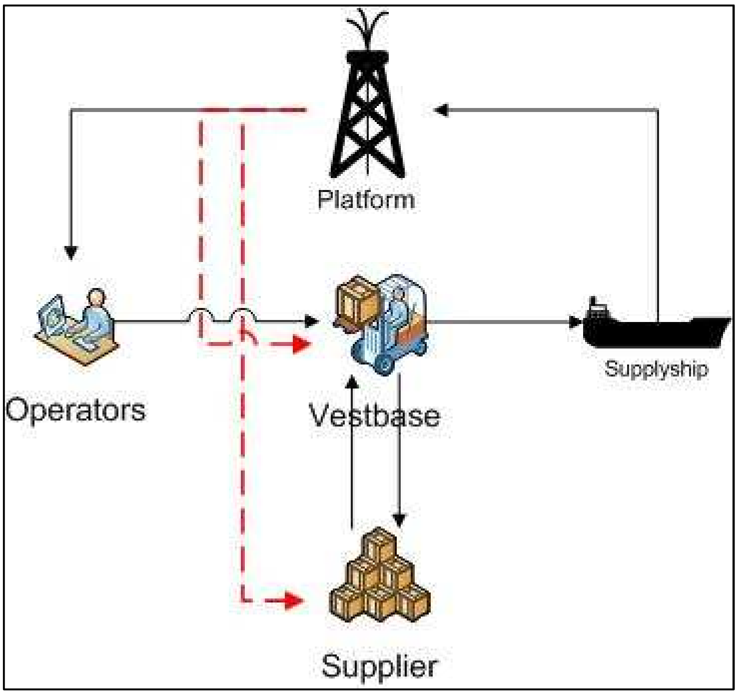


Figure 13 Simplified supply chain with and without transparency.

Figure 13 above shows an example of a simplified supply chain of port allocation at Vestbase. The platform reports its need and requirements onshore to the operators, which in turn hopefully coordinates with Vestbase. Vestbase ships it onboard the supply ship. The black arrows indicate a less effective line of communication. The different segments information has to travel through, could result in both delays and omissions in the information. If Vestbase immediately could see the information coming from the platform, they could in advance make sure that supplies were available and shorten the lead time. Although this is a simplified reality, it illustrates how transparency in terms of information exchange could help in doing the supply chain more efficient.

The time information is shared is also a critical factor. If a need as an example arise at the platform, and this requirement is not shared until the last minute, even though the need has been obvious for some time, it could result in unfortunate and insufficient actions, and ripple effects throughout the supply chain. The example from Figure 14 below shows how an unwanted situation could develop due to lack of information sharing. As the supply ship is about to start on round-trip 2, the first platform release an urgent requirement that needs attention. This results in cancelation of round-trip 2, and could cause another platform to shut down. The example might seem a bit far-fetched, but could arise if needs that has been known for a while, is not being announced until the last minute.

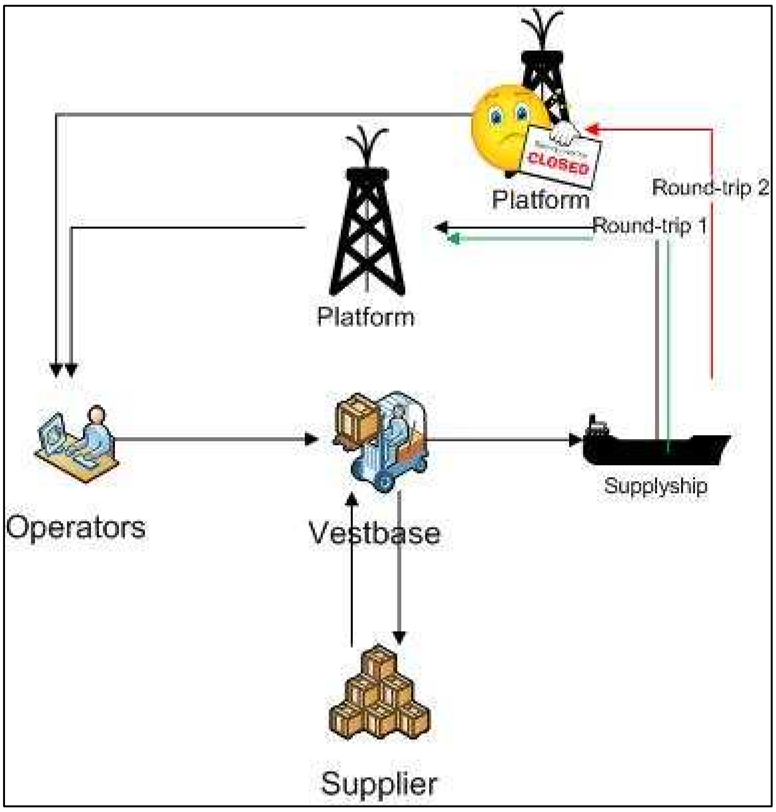


Figure 14 an unwanted situation due to lack of information exchange.

The just in time approach that could appear from the offshore installations causes challenges upstream in the supply chain. The sudden rise in demand[11] could be managed by increasing the number of supply ships, whether or not this is profitable is outside the scope of this research. It is however important to bring forward a common understanding for all participants on how the supply chain works, its abilities and limitations, and how the different participants influence on it. The decision making process will derive advantage from this understanding.

Table 7 Value Transparency: Its role in elements of a supply relationship. (Lamming Richard C et al., 2001)

Relationship:	Opaque	Translucent	Transparent
Geological	*Light cannot even penetrate the surface of the substance*	*Light can enter and exit the surface of the substance, but in a partial or disturbed/distorted fashion*	*Light enters and exits the surface relatively undisturbed*
Flexibility for customer and supplier	None	Maximum	Limited
Disclosure	None	Limited by both customer and supplier	The disclosure of value creation, nurture, and delivery is bilateral and mutually understood
Strategy	Very difficult to be strategic - little knowledge beyond own boundaries	Strategies become tactically delivered to allow for poor information	Permits strategy through mutual understanding; second order strategy needed for contingency
Accounting/cost focus	The transaction	Cost reduction, sometimes open-book on some items	The value created and delivered through the relationship
Dealing with change	Little provision for planning; surprises	Expectation of prior notice for changes; relies on formal, partial information	Flexibility should support "lumpy" development (quick response to changes)

[11] Demand in this case would in a figurative sense be a supply ship.

Table 7 above shows an extraction from a table done by Richard C. Lamming (2001). It shows the value of different levels of transparency within different elements in a supply chain relationship. The first geological row is three metaphors that describe the different levels of transparency. Then it gives an idea of the importance of having at least some level of transparency in the relationship. An interesting sighting is that full level of transparency might not always be optimum. It seems that the flexibility for customer and supplier of the system might be limited if the system has full transparency. On the other hand, transparency gives mutual understanding regarding disclosures and strategies. The ability to quickly react to changes is an important operational factor.

Instead of adopting transparency as a blanket policy for the entire system/supply chain, it is proposed that transparency is to be used for a specific purpose or project (Lamming Richard C et al., 2001). Thus it will be possible or beneficial to shift between the different principles of transparency in various stages of the allocation. A timely translucent system will also be beneficial for the users own flexibility. If everybody could see what everybody was doing all the time there is change that the system could get formal and watchful. Thus the freedom that generates flexibility would disappear.

Table 7 should provide enough incentives and understanding about transparency in a collaborative port allocation system. As can be seen; no transparency at all will give situations where there are very difficult to be strategic and deal with sudden changes. Port allocation is a process that has a high rate of changes, thus sharing information about actual needs and requirements could improve the allocation considerably.

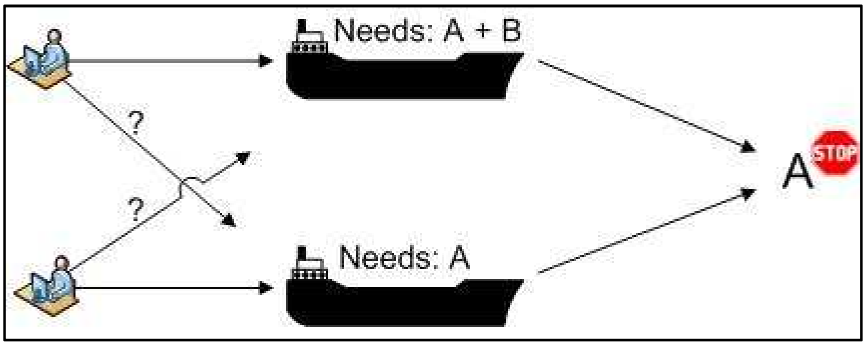


Figure 15 No transparency, no strategy to deal with congruent needs.

Figure 15 gives an idea of how port allocation without any transparency will take place. The two operators are not able to see what needs the different ships are having, consequently they both book the in on A. A is not able to serve two ships at once, thus it will either be first in first served or rejection on both[12]. No strategy for the port allocation is possible as no information is shared.

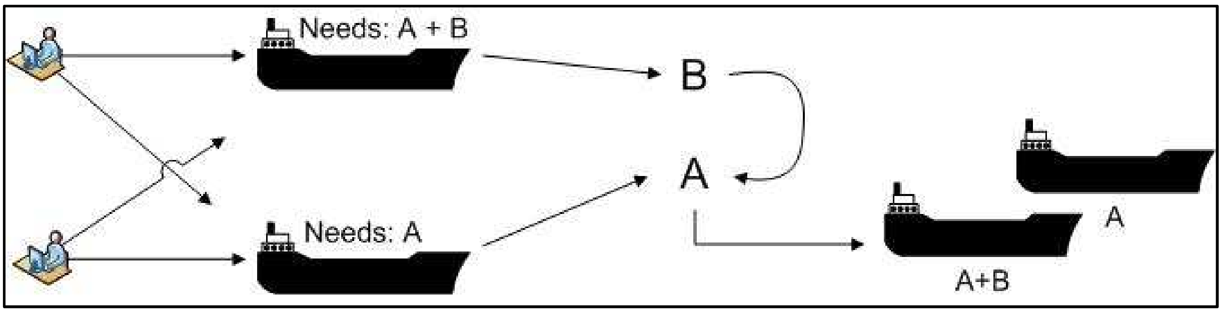


Figure 16 Transparency, able to coordinate a strategy to serve congruent needs.

Figure 16 shows a port allocation process where the needs of the two ships are shared between the different operators. One ship is in need of A, and the other is in need of both A + B. It would then make sense that the ship with needs of both A + B would start off with B before moving to A. Transparency enables an operational strategy that serves in favour of both operators.

[12] If we disregard any possible power relationship.

2.7.2 Decision-making process

Decision-making has been described as a mental process that results in an outcome that in turn is leading to the selection of a course of action among several alternatives (Wikipedia c, 2010a). This research will not look deep into decision making theories, but rather have a look at decision-making in a port allocation context. A port allocation comes into being after a series of different decision has taken place (Figure 18).

Figure 17 below shows an illustration of effective decision-making. Port allocation could in some cases be positioned above the effective decision-making area (in the same direction as the cost arrow), and consequently be described as inappropriate, hasty and indecisive. This is where the amount of challenges exceeds the range of capabilities, and adds costs to the system.

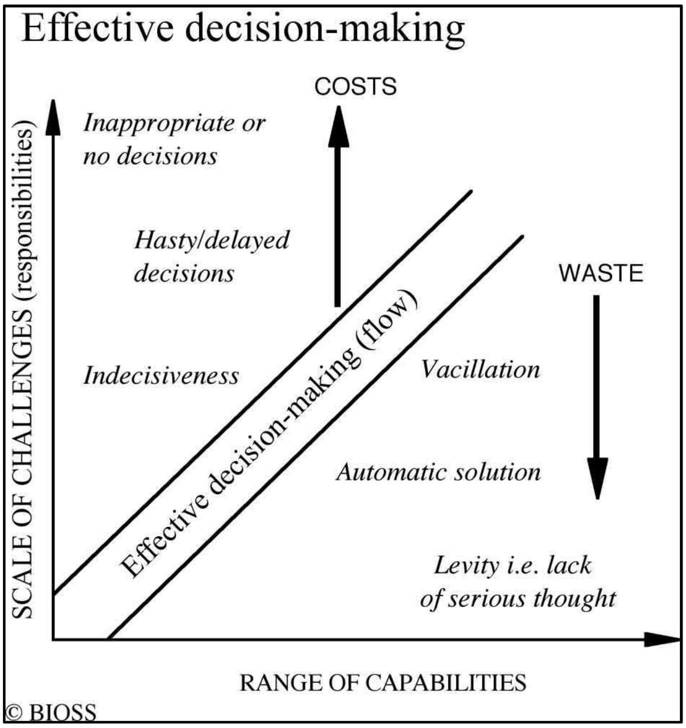


Figure 17 Effective decision-making. Source: (Stamp, 2008)

It will not make sense to alter the scale of challenges in a port allocation; the process needs to run its course. Instead it would benefit the decision-making process if the range of capabilities was increased.

Decision-making is a field of study with many different approaches and theories. There are however a set of different steps that reappear (FML, 2010, MindTools, 2010);

1. Define what you want to achieve.
2. Generate good alternatives.
    a. Consider different perspectives.
3. Explore these alternatives.
    a. Risk analysis and implication
4. Choose the best alternative.
5. Check your decision.
6. Communicate your decision, and take action.

An allocation sometimes requires several rounds of decision making processes, like the one mentioned above.

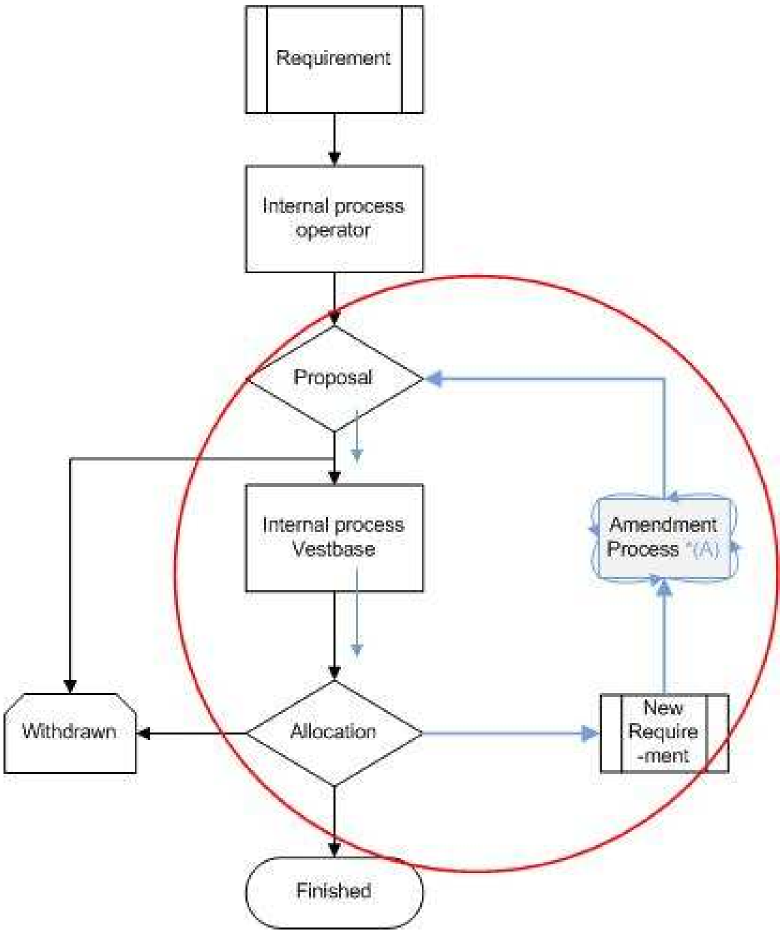


Figure 18 Port allocation process

Port allocation is an ongoing process that lasts up until the ship has left the port, heading for its destination. The final port allocation is therefore not settled before this moment. Encircled in Figure 18 is the ongoing process before a port allocation is final. This requires that an accepted port allocation is still open for changes and subsequent amendments.

2.7.3 Amendment process (A)

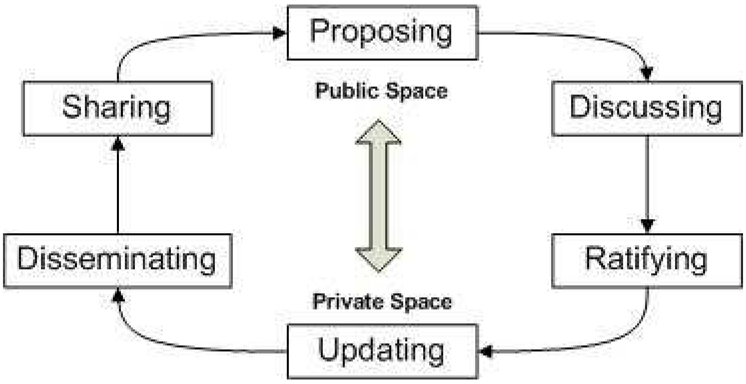


Figure 19 Internal amendment process

The amendment process is a central part and feature of a collaborative port allocation. Figure 19 displays the concepts of the amendment process from Figure 18. When a new requirement arises, the already proposed port allocation will be the starting point for a new proposal.

The amendments might be simplified and categorized as in Table 8 below. Essentially there are four types of amendments available; shifting, adding or subtracting needs and time.

Table 8 Available amendments

Amendments	Allowed	Lead to/Results:
Shifting	Only admin	Availability
Adding resource-demand	Operator/supplier	Time/Shifting
Withdraw resource-demand	Operator/supplier	Time
Time	Operator	Availability

- **Shifting:** is to be considered as a heavy duty amendment which requires time and adds costs to the system. It is desirable that only admin (Vestbase) have the option of shifting. (Note that this is only shifting itself, and not shifting as a result of another amendment). This is to prevent and raise the threshold for shifting on the basis of convenience. It is also necessary that admin has supervisory control as port operator.
- **Adding resource demand:** the act of adding any type of cargo or cargo operation falls under this category. In principle this should not constitute any large actions other than added time to load the cargo. There are however constraints concerning what type of resources each quay has available. When adding a resource that is only available on

other quays, it will be necessary to open up for shifting. For the sake of simplicity and collaboration it will make sense that an operator can propose a new quay.

This will however open up for a possibility to bypass the threshold for shifting, mentioned above. The incentive to not trick the system exists through the fact that one have to order cargo in order to enable the feature.

- **Withdraw resource demand:** this category deal with every cargo or cargo operation that is being withdrawn from the operation. Both operator and supplier should be able to perform this operation. This operation will under normal circumstances only make changes on time. It could open up for a shifting operation to a quay with fewer resources. This is however not necessary as long as there are no demand on these resources.

  Given these conditions, the system should be able to perceive that a resource is available on any given quay, even though the quay itself is occupied.
- **Time:** to change the length of a port allocation is a secondary function of adding and withdrawing resource demands. It is however necessary for operators to be able to lengthen the stay for various reasons.

  If no cargo operations are being performed it will be preferable that a quay with as few resources as possible is chosen. Shifting is however not necessary with no demand for the given quay.

2.8 Satisficing

Satisficing deal with the outcome, or the anticipated outcome of a decision making process. It is a decision making strategy that attempts to meet the criteria for adequacy, rather than working towards the optimal solution (Wikipedia c, 2010b). In this context however, there are two different versions of an optimal solution; the optimal solution for the entire supply chain, or the optimal solution for each different participant of the supply chain. To achieve the best possible solution for the entire system might require that each participant is willing to go for a solution that is, from their perspective, a less optimal solution.

A satisficing strategy might actually end up being (close to) the optimal, if the costs of the decision making process itself, such as the cost of gathering complete information, also are taken into consideration. *"In addition to all of the other alternatives we must evaluate, we can also evaluate the expected utility of finding a better option (than the best so far)"(Byron, 1998 p.6)*. This means that finding or going for the optimal solution comes with a cost. Either in the form of obtaining information or in form of costs imposed on other participants or the supply chain itself. Michael Byron, a Ph.D. in philosophy and ethics has mentioned two different terms of goals; global optimization and local satisficing. His theories are mainly about human behaviour, but could be interesting to have a brief look at, as it might be transferable to the business world;

He states that we as human beings set ourselves some life goals or achievements that we want to accomplish some time along our career. For instance the choice of buying the perfect house would be a global optimization. To get there we might on the way do with some local satisficing, as getting a job at a gas station. Not the perfect job, but it will help us achieve the global optimization. Another local satisficing could be that one is going to buy a gift for a friend. It does not need to be an expensive gift; the important thing is that the friend gets a gift, a small gesture to show attention in order to sustain the friendship, the global optimization.

The point is that the small sacrifices done on the way, in the end will pay off, and perhaps lead to a more robust solution.

In port allocation this means that participants should be willing to sacrifice, and understand the purpose of satisficing. If a particular resource it not required in order to fulfil an operation it is not necessary to acquire it. In more concrete terms this could for instance be situations where operators may want a specific quay for the sake of convenience instead of the actual requirements.

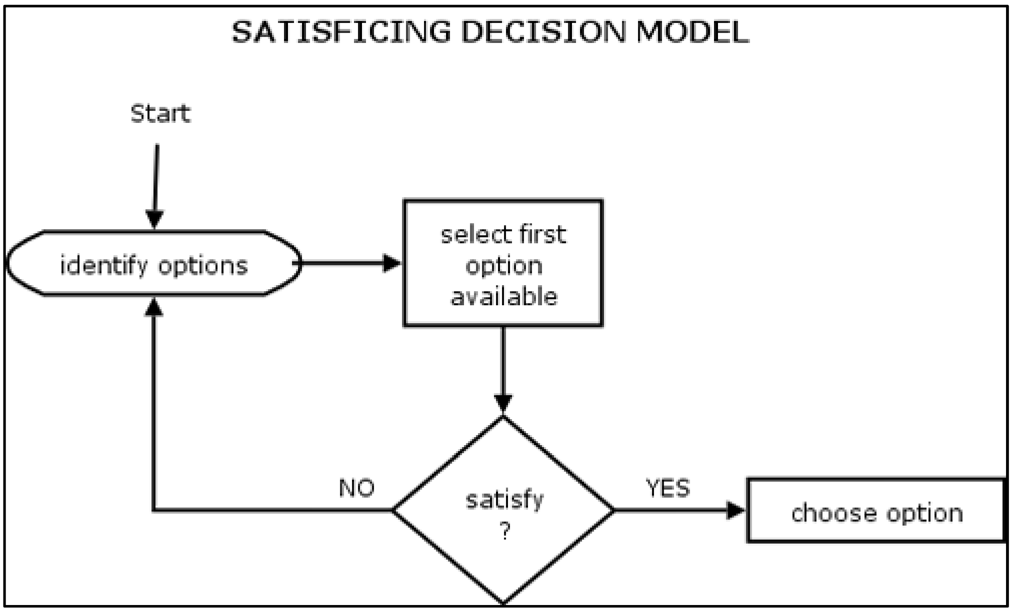


Figure 20 Satisficing decision model. Source: (Queen, 2006)

Human beings lack the cognitive resources to optimize (Simon, 1991). According to Herbert Simon, human beings are not able to know the relevant probabilities of outcomes, thus we can rarely evaluate all outcomes with enough precision. As a consequence of this, bounded rationality would be a more realistic approach which takes into account the human limitations (Simon, 1991).

The concept is fairly simple. Since the human mind cannot process all possible options, taking into account that there is a limited time to make decisions, one should one the basis of available information identify the options and select first option available as shown in Figure 20 above. If the chosen option does satisfy the needs, choose the option. When identifying the available options they should be assessed on the basis of minimum requirements. In simplified terms that means; if requirement is sleep, choose bed. If house is chosen it would be a waste of resources.

For port allocation purposes; a ship requiring a quay structure with water facilities does not need to occupy a quay structure with both water and fuel facilities. To push things to the extreme; it will not be possible, and require too much time and resources to foresee that the ship also might require fuel.

2.9 Flexibility

In the light of this research, flexibility refers to the ability for something to be changed. Foremost the ability to make changes on short term operational matters, but also on a larger and strategically scale.

In this setting it makes sense to divide flexibility into two different main categories;

- **Strategically flexibility**: This refers to the organizations capability to identify major changes in the external environment (Katsuhiko Shimizu and Hitt, 2004). This is flexibility on a management level and is not the focal point of this research. Implementation of a collaborative port allocation system could however be signs of strategically flexibility.
- **Operational flexibility**: This describes flexibility that is related to the core activity on a daily basis. Collaborative port allocation is dependent on a high level of operational flexibility. However there are some elements that divides the different levels of operational flexibility into two different segments;
    - **Hard constraint →Low flexibility**: Elements that are not easily changed without larger investments costs, or takes a long time to change.
    - **Soft constraint →High flexibility**: Elements that are easy changeable without larger costs, and does not consume a lot of time.

Table 9 Flexibility types and their initiator.

Flexibility	Type	Participant
Resource flexibility	Soft	Operator / Supplier
Quay allocation flexibility	Soft	All
Time flexibility	Soft	Operator / Supplier
Ship flexibility	Hard	Operator
Machine flexibility	Hard	Vestbase / Supplier
Equipment flexibility	Hard	Vestbase / Supplier
Labour flexibility	Hard	Vestbase / Supplier
Operation flexibility	*Soft/Hard*	*All*
Expansion flexibility	Hard	Vestbase
Draught flexibility	Hard	Vestbase
Quay flexibility	Hard	Vestbase

Table 9 above gives an overview over flexibilities within a port allocation process. As can be seen, most of the flexibilities are bounded by hard type constraints. Expansion of quay facilities and machines could solely be seen as an effective method to increase capabilities and avoid allocation problems in the future. This is however a heavy investment, which in turn, the customers would have to bear the cost of in the future. The concept of satisficing, discussed in chapter 2.8, will also manifest itself here.

Thus it makes sense to concentrate on the soft constraints; Resource, Quay allocation and time flexibility, as shown in Table 10 below. The table shows the three main flexibilities, additional flexibility (if any), and how all the flexibilities are interlinked. Secondary action describes what changes in this row will lead to.

Table 10 flexibilities, secondary actions and limitations.

Resource Flexibility (z)	Secondary action	Limitation
Volume flexibility	Time flexibility	Time flexibility
Type flexibility	Quay flexibility	Quay
Quay Allocation Flexibility (y)	**Secondary action**	**Limitation**
Quay flexibility	Resource flexibility	Ship/Allocation
Time Flexibility (x)	**Secondary action**	**Limitation**
Time Flexibility	Volume flexibility	Ship/Allocation

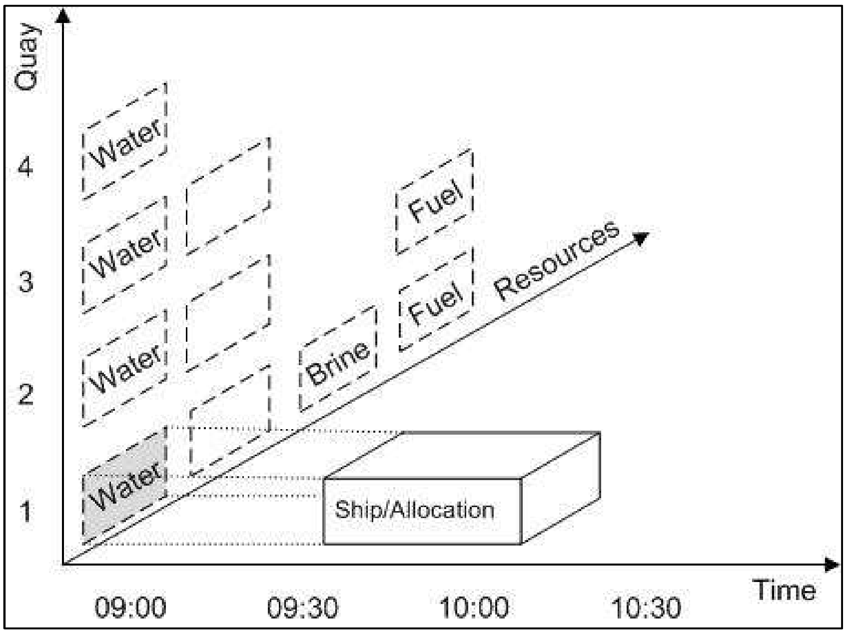


Figure 21 the flexibility concept in a XYZ diagram.

In Figure 21 above, the different flexibilities from Table 10 have been put into a XYZ diagram to visualise how the different entities are linked together. The allocation consists of time, quay and resources. As long as the allocation is alone in the picture, it can move around as it like.

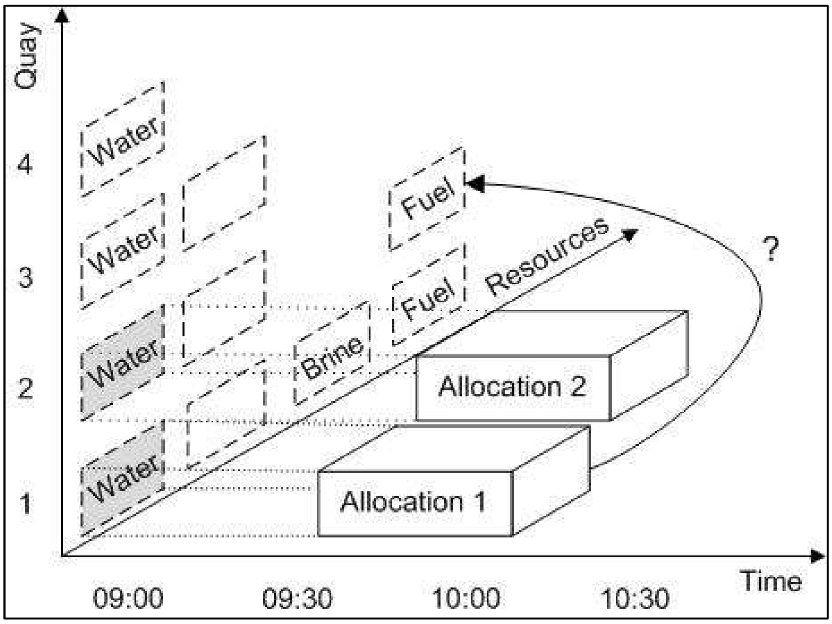


Figure 22 the flexibility concept with two allocations.

In Figure 22, a second allocation has been added to quay 2. “Allocation 1” is now unable to move into the same resource and time slot as “Allocation 2”. This system does however raise a possibility for “Allocation 1” to move into another resource at Quay 2, as this is not blocked in any form. In reality the entire quay is occupied but not being picked up by the system.

Figure 23 shows a further development of the system that deals with this problem. “Allocation 1” has now occupied Quay 1 with resources; Water and Fuel. The colour labelling indicates that the quay is occupied, but the green resources are available. If “Allocation 2” is in need of Brine, the only resource in this case would be at Quay 1. “Allocation 1” could then move to Quay 3, which is free, and has the required resources. Another option would be to swap quay with “Allocation 2”. Matching grey boxes are possible to swap.

There is a challenge with allocations such as “Allocation 1”, which consists of more than one block; “Allocation 1a” and “Allocation 1b”. They are without doubt interlinked in terms of being the same ship, but each operation could start and end at different times. Say both “Allocation 1a/1b” starts at 09:30; “Allocation 1a” is finished at 10:00; “Allocation 1b” is finished at 10:30. This means that 10:30 would be a milestone for “Allocation 1”; it will not be finished until all operations are done, meaning that they are dependent on each other.

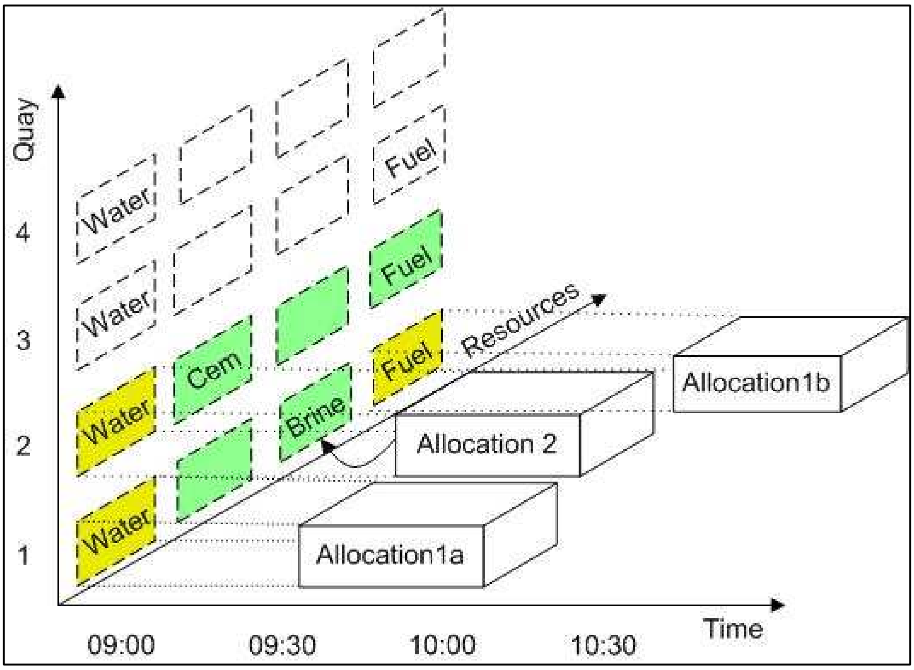


Figure 23 the flexibility concept in action.

In real life scenarios a shifting operation or swap of quays would not take place during a cargo operation. A cargo operation would not be stopped in order to bring another ship in, other than with extreme situations. Thus it would be preferable to have a status of resource/quay saying that there is an ongoing cargo operation, and requests of swapping would automatically be dismissed. Table 11 shows the different operational statuses resources can have.

Table 11 the operational status for resources.

Operational Status	Meaning
Free	All are free to make allocations
Occupied, open for Request	Request for resource can be made
Occupied	Request for resources can be made, given that applicant can make an identical swap
Locked	No request can be made

2.9.1 Time flexibility

There are flexibility features that might be added to time, in order to give a time frame to work on. A ship might arrive at a given time, or it might arrive within a given time period. The same goes for departures. If it's possible to assign a gray zone at the beginning and end of a port call it might be possible for others to request access to the time slot if it's not locked.

2.10 Work shop scheduling

A port allocation process might remind of a factory floor process, where materials flow through the work shop from one station to another while being assembled into a finished product. The same principle works for port allocation. When a ship comes into Vestbase it might need to be processed at several quays in order to become a finished product.

2.10.1 Gantt chart

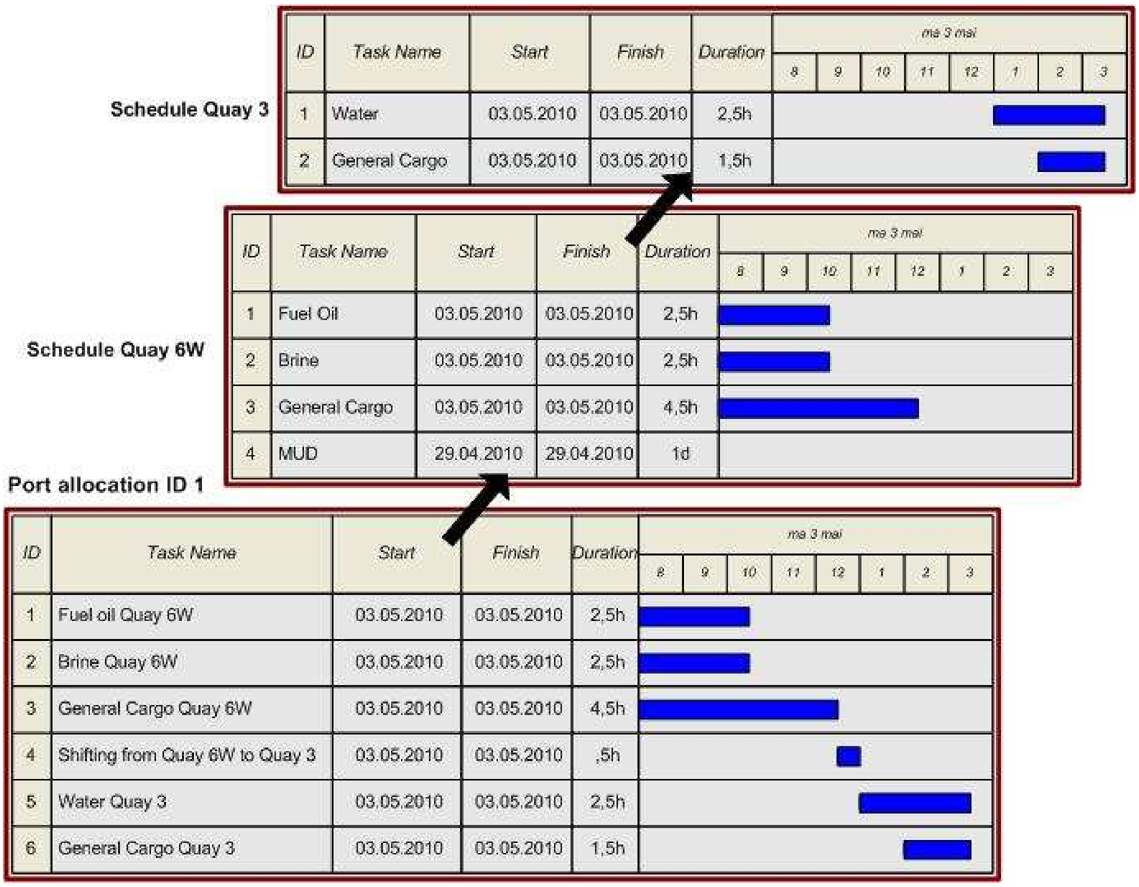
A Gantt chart is being used to illustrate a project schedule through a bar chart. The chart illustrates the start and finish time of different elements in the project. Elements could be differentiated through terminal elements and summary elements (Wikipedia i, 2010). To easily explain the difference between them one could say that summary elements consist of two or more terminal elements. Terminal elements are the lowest element in a schedule and cannot be further subdivided.

The chart is useful to keep track of elements in a project in terms of time consumption and dependency. It can be used to create an inner coherence in a port allocation system.

Although the Gantt chart is useful to keep track of elements in a project it has its limits in terms of displaying the information. For larger projects with several elements that stretch over a longer period of time it might not be suitable to give an overall overview over the project. One of the Gantt chart's criticisms have been that it communicates relatively little information per unit area of display (Wikipedia i, 2010). A port allocation system needs to display several ongoing projects simultaneously to give an overview over the current situation.

Thus a Gantt chart might be useful as a background process to keep track of each individual port call and its elements. To give an overview over each different project or port call it might be useful to only display a summary of each project as shown in Figure 25.

As displayed in Figure 24 each quay needs to have its own schedule to keep track of available and occupied resources. The port allocation and quay schedules need to be cross referenced. This method will create opportunities to continually monitor available resources at each quay and look for better solutions. When new proposals enter the system, a simple heuristic could make it possible to find a more suitable solution



Schedule Quay 3

ID	Task Name	Start	Finish	Duration
1	Water	03.05.2010	03.05.2010	2,5h
2	General Cargo	03.05.2010	03.05.2010	1,5h

Schedule Quay 6W

ID	Task Name	Start	Finish	Duration
1	Fuel Oil	03.05.2010	03.05.2010	2,5h
2	Brine	03.05.2010	03.05.2010	2,5h
3	General Cargo	03.05.2010	03.05.2010	4,5h
4	MUD	29.04.2010	29.04.2010	1d

Port allocation ID 1

ID	Task Name	Start	Finish	Duration
1	Fuel oil Quay 6W	03.05.2010	03.05.2010	2,5h
2	Brine Quay 6W	03.05.2010	03.05.2010	2,5h
3	General Cargo Quay 6W	03.05.2010	03.05.2010	4,5h
4	Shifting from Quay 6W to Quay 3	03.05.2010	03.05.2010	,5h
5	Water Quay 3	03.05.2010	03.05.2010	2,5h
6	General Cargo Quay 3	03.05.2010	03.05.2010	1,5h

Figure 24 Gantt cart schedules per quay make up

ID	Task Name	Start	Finish	Duration
1	Fuel Oil	03.05.2010	03.05.2010	2,5h
2	Brine	03.05.2010	03.05.2010	2,5h
3	General Cargo	03.05.2010	03.05.2010	4,5h

Figure 25 Gantt charts in port allocation forms the basis for each port call.

2.10.2 Theory of constraints

The theory of constraints is an overall management philosophy that is aimed to help organizations in achieving their goals. The thought behind the theory is that any manageable system is limited in achieving their goals by a small number of constraints, and that there is always at least one constraint. The process introduced in the theory seeks to identify the constraints and reconstruct its surroundings through the use five focusing steps (Eliyahu M Goldratt, 2004, Husby, 2007);

1. **Identify** the systems constraint: The resource or policy that prevents the organization from obtaining the goal.
    - In section 2.1; quays were pointed out to be a limiting factor for port allocation since not all quays are able to deliver all types of goods. To identify a constraint it would be natural to look for the quay that has the most influx and tends to build a queue. This might vary from day to day. However, as long as pressure lies on the quays with fewer resources it should not be a problem to divert vessels to quays with more resources and problem is solved. Hence the real constraint would become the quays with the most resources. If queues are forming at a quay with all resources, it will not be possible to divert traffic to quays with fewer resources[13].
2. Decide how to **exploit** the constraint: Make sure the constraint's time is not wasted doing things that it should not do.
    - This means that the quays that provide the most resources shall not be occupied by ships that do not need them. First priority for these quays shall be to serve vessels that need resources not available on other quays.
3. **Subordinate** all other processes to above decision: Align the whole system or organization to support the decision made above.
    - As displayed in Figure 23 there shall be an indication of which resources are available at each quay, even when the quay itself is occupied. This to support the exploitation of the constraint.
4. **Elevate** the constraint: If required or possible, permanently increase capacity of the constraint.

[13] Given that a vessel is in need of resources not available on other quays.

  - This could be done in two ways. Either to increase capacity of bulk delivery so that delivery of the products goes faster, or to equip more quays with the ability to deliver more products. Each of these options requires larger investments and might not be desirable. If the points mentioned above are successful new investments might be avoided.

5. If, as a result of these steps, the constraint has moved, return to Step 1. Don't let inertia become the constraint.
   - The intention of this point is to continuously revise and improve the system to avoid bottlenecks and increase throughput.

The most important focus is not to let a constraint waste time doing things other resources can do.

In terms of applying an automatic allocation procedure based on needs and requirements this will be useful. When an operator or suppliers enters requirements into the system, the system will automatically allocate the ship to the quay with only enough resources to fulfil the requirements.

2.11 Apply decentralization to the system

Ori Brafman and Rod A. Backstrom (2006) describes the strengths and differences between a centralized - , and a decentralized system in their book “The Starfish and the Spider”. Some the issues their describing is of interest for this research as they can help understand why a collaborative port allocation system shall be more in direction of decentralized rather than centralized.

Figure 26 from centralized to decentralized organization.

As displayed in Figure 26, a centralized system, shown to the left, would be more vulnerable for disruption. If one manages to take out or lose the “hub”, all other links will fall apart and the system is useless. As we move further right in the figure, chances of that happening decrease as the system gets more and more decentralized.

The port allocation system needs to be fed with information that requires frequent updates and ratifications. The choice stands between building and maintaining its own database, or gather this information from already existing databases that are maintained by others. Taking into account that it is time consuming and unnecessary to hold an own database it would be preferable to gather data that already exists from external sources. This brings the system close to something similar to the mid figure in Figure 26.

2.11.1 Mashup

A mashup is a website or web application that combines data and/or functionality from more than one external source to create a new service (Wikipedia g, 2010, Numotion, 2010). The content is typically sourced from third party providers, whose core activity is more in accordance with gathering the data than the incumbent firm. This is a feature that has increased in popularity since the emergence of Web 2.0. An example seen almost daily is the use of Google's map service in newspapers web additions.

Since most mashups utilize information from established companies and data providers, the issue of ownership and user rights assert oneself. Thus it is important to map copyright protections and make sure that all legal terms are fulfilled.

There are mentioned different kinds of mashups in the literature. Business mashups combines own resources, applications and date together with other external data sources. The data is focused into a single presentation and allow for collaborative action among participants (Wikipedia g, 2010).

This is the model port allocation shall be based upon. Vestbase provides its own resources and vital data, but gathers some necessary data from third party providers as shown in Table 12

Table 12 possible mashup composition in port allocation

	Data	Who:
Vessel Information:	Name / IMO?	3rd Party
	Destination	3rd Party
	ETA	3rd Party
	Max Draught	3rd Party
	Length	3rd Party
	Width	3rd Party
	Tonnage	3rd Party
	Position	3rd Party
Quay Information:	Length	Internal
	Depth	Internal
	Resources	Internal
Shipments Information:	Order number	Internal
	Tonnage	Internal
	Information	Internal
Contracts:	Vessels operating service	Both
	Contract details	Both
Customer Information:	Information	3rd Party

2.12 Augmented reality

"Augmented reality is a term for a live direct or indirect view of a physical real-world environment whose elements are augmented by virtual computer-generated imagery" (Wikipedia h, 2010). A head-up display in an airplane that displays speed, virtual horizon and compass, while looking at out of the cockpit, is a good example for augmented reality. The concept is to display artificial information on top of the real world view. Figure 27 displays the virtuality continuum; two extremity real environment and virtual environment, in between is a mixed reality zone.

Figure 27 the virtuality continuum scale.

Collaborative port allocation could work in terms of an augmented reality by gathering up-to-date information giving an artificial view of the real world around the quays at Vestbase. By creating views that let the users in an instant get an overview over the situation instead of having to look around, valuable time could be saved.

For port allocation it would be of interest to be able to create a view that easily can give an answer to the five W's and one H;

1. **Who?** Be able to tell who is involved; which ship, operator and supplier are taking part.
2. **What?** Be able to tell what is going to take place in terms of cargo operation.
3. **When?** Be able to tell when it is going to happen.
4. **Where?** Be able to tell at which quay it is going to happen.
5. **Why?** Be able to get an insight in why it is happening as it is.
6. **How?** Be able to tell how it happened. Give reports.

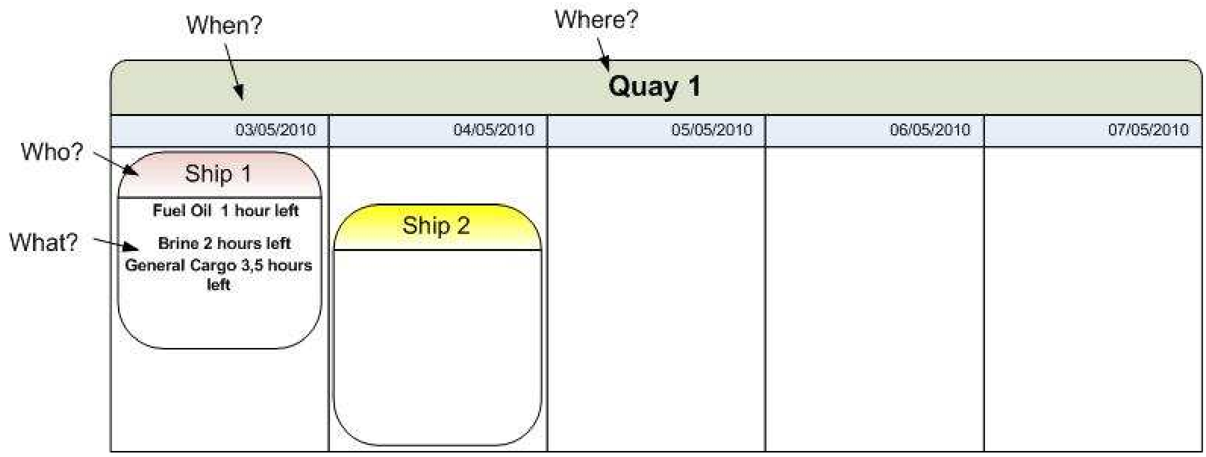


Figure 28 the concept of augmented reality in port allocation presented in a calendar view. Quay per week view.

Figure 28 presents a concept of augmented reality in port allocation which tries to give answers to as much questions as possible in one easy-to-follow view. To filter unwanted information, only ships under own control displays information about what, such as cargo operations.

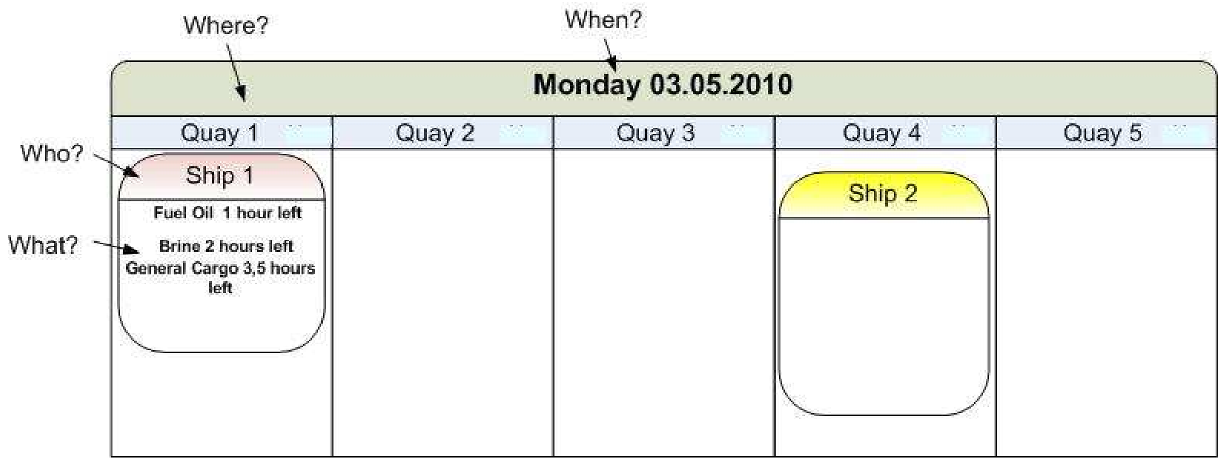


Figure 29 the concept of augmented reality in port allocation, Each quay per day view.

Another method of display is shown in Figure 29 where one gets a clear overview of allocations per quay for the entire day. Entering each allocation will give more precise information about each element as shown in Figure 25

2.13 Technology

XML (Extensible Markup Language) is a set of rules for encoding documents electronically (Wikipedia b, 2010). It is a tool for sharing of structured data between information systems, especially on the internet. XML has become one of the most widely-used formats for sharing structured information between programs, people, and computers today (W3C, 2010).

XML is similar to HTML. However, the syntax rules of XML are stricter. XML tools will for instance not process files that contain errors. This means that most XML documents can be processed reliably by computer software (W3C, 2010), like ERP- and invoicing systems.

The XML design is based on simplicity, generality and usability over the internet. The format is text based with support via Unicode. This makes it readable for humans as well.

XML is recommended for a port allocation system as;

1. Separation of content for presentation is simple.
2. XML has become a widely-used format.
3. Changes in technology do not affect XML due to platform independent characteristics.
4. The primary purpose of XML is to support sharing of data on the internet.

3. BASIC COLLABORATIVE PORT ALLOCATION

To be able to optimize the process of port allocation the knowledge and knowhow of each participant needs to be taken into consideration. Everybody possesses a share of information that everybody can take advantage of in order to achieve a port allocation that is in the direction of optimization.

3.1 Collaborative port allocation

Port allocation as shown is a process which involves a lot of different participants that does not always have mutual and corresponding objectives. There is an extensive use of different coordination channels and personnel in the allocation process. This method could lead to situations where there is a mismatch between resource allocation and actual requirements. There is also a danger for errors and omissions that could cause ripple effects throughout the supply chain.

A collaborative port allocation system will change how information-exchange between the different participants works. The coordination will get more extensive, but more distributed and thus give Vestbase fewer decisions to handle. Gathering and displaying up-to-date information in one place could contribute to a more perspicuous decision process.

A more general and streamlined supply chain with closer integration between different activities is a recognized method to lower the logistical costs. This is also pointed out in Kon-Krafts report from 2004, when looking at the Norwegian offshore industry. It is however some obstacles worth pointing out that make integration and co-operation challenging;

- Different ERP systems
- Attitude towards information exchange

The creation of a shipping pool that was intended to utilize shipping resources in a more efficient way than with normal conduct has unfortunately not been as successful as one would have hoped for. This is partly caused by the fact that there are several different ERP systems in use, which does not necessarily communicate with each other. It might also be that the willingness to make them communicate is not present. This complicates the conduct of a well organized shipping pool.

Although a collaborative shipping pool might not be fully functional due to different circumstances it shows that there is a shift in focus towards logistical optimization in the industry.

3.2 Participants, views and rights

The different participants have different needs according to the business they conduct. Hence it would make sense that different participants are given different views and rights within the port allocation system. As discussed earlier this is a matter of sharing information with other participants. It is a question about what is going to be available for other participants to see, and which amendments each participant should be allowed to do.

3.3 Views

For simplicity the different views have been divided into three categories as shown in Table 13. Other administrative views will be needed; these are however the main views in terms of port allocation.

Table 13 main views in port allocation system.

Views:	Functionality
Create / Amend:	Assign Ship Insert Resource Requirements Insert Ship Service Insert Time
Allocation:	Detailed view of allocation Message Log
Overview:	Calendar view of all allocations Change between Day / Quay view

- **Create / Amend:** Generate and amend allocations in terms of assigning ships, time and resources. For invoice purpose it will also be necessary to assign what kind of service the ship operates. There is a difference between creating and amending a port call, this is a matter of states discussed in section 3.4 below.

- **Allocation:** Information about the allocation. Gantt chart view that displays the allocation in details. Message log to view amendments and communication.
- **Overview:** Calendar view to give an overview and summary of the big picture. Displays which allocations are taking place where and when. Possibilities to change between day view to see all allocations for one single day, or quay view to see allocations for one quay for a specific time period.

3.3.1 Operator

Operators are responsible for a vessels arrival at Vestbase. Hence they should be given the possibility to add a proposal for a port allocation, this will be done in the create allocation view. This is where an allocation is first created or proposed. The operator assigns ship and required resources for the port call, together with estimated time of arrival and estimated time of departure. For integration with suppliers, the operator also needs to assign which supplier is being used for each resource. The proposal has to be accepted by Vestbase.

Table 14 Operator rights

Views:	Rights
Create:	Assign Ship Request Time Insert Resource (and supplier) Withdraw Resource Insert Ship Service
Amend:	Request Time Insert Resource (and supplier) Withdraw Resource
Allocation:	Full view of own ships
Overview:	Able to see detailed summary of own ships Simple view of other ships

Once the allocation is accepted is might be amended as required. Operators should be able to request new estimated time of arrival and departure. It might also be necessary to add and withdraw resources.

In the overview window it might be desirable that an operator only sees details for its own ships. This is due to the current culture for information sharing within the sector. Operators might feel that this information should not be revealed. In time this might be subject for discussion as sharing of this information could increase comprehension of the supply chain.

3.3.2 Supplier

The supplier acts on behalf of the operator, thus it does not need the possibility to create a port call. When given the right from an operator to participate on a port call the supplier might be supportive in the amendment process in terms of inserting resources and withdrawing them.

Table 15 Supplier Rights

Views:	**Rights**
Create:	No Rights
Amend:	Insert Resource Withdraw Resource
Allocation:	Full view in participating allocations
Overview:	Able to see detailed summary of ships they supply Simple view of other ships

The supplier often has firsthand knowledge about local conditions and could contribute in giving more precise time estimates of each operation.

The information visible in the overview window shall be on the same terms as for operators. Detailed summary information shall only be available on allocations the supplier takes part in.

3.3.3 Vestbase order administration

The rights of Vestbase order administration are quite similar to an operator, except that they do not need to request changes. In addition they are able to relocate vessels to other quays.

Vestbase are able to create allocations, thus they are given the rights as a normal operator. Vestbase order administration should however not be able to add and subtract resources on ships they do not operate. This is to avoid situations where Vestbase might overrule allocations. This will also force suppliers and operators to contribute to the system.

Table 16 Vestbase order administration rights

Views:	Rights
Create:	Assign Ship Request Time Insert Resource (and supplier) Withdraw Resource Insert Ship Service **Assign Quay**
Amend:	Change Time Change Quay Insert Resource (own ships) Withdraw Resource (own ships)
Allocation:	Full view
Overview:	Full View

3.3.4 Vessels and other contributors

To increase the accuracy of incoming data and information it would be of value to the system to let vessels and key personnel at the offshore installations contribute with information. Vessels could for instance contribute with a much more precise estimated time of arrival, and data on backload. It could also be of value to the vessel to get an insight in which cargo to be expected for the next trip.

3.3.5 Viewer

A view only option could also be valuable for members of the supply chain to increase utilization and to get a deeper insight to the system. If members were given the possibility to look at the ongoing activity, they might after some time aim to place orders that could be intertwined with this activity, instead of just placing orders blindfolded into the system.

3.4 States

The allocations entering the system need to be given some sort of state so that it is possible to differentiate the allocations different stages. It is also necessary to give Vestbase as administrator and owner the possibility to set a final solution to avoid delays. Adding states could also improve the quality, and reduce the number of unnecessary incoming proposals as the participant knows that each proposal has to be checked and approved by an administrator.

To be able to measure improvements according to KPI, the states also need to form a basis for this.

- **Proposal**: The first state is a proposal for a port allocation. This will primarily be done by the operator as shown in section 3.3. Details about the port allocation are entered and submitted to Vestbase.
- **Approved**: If the proposal is approved by Vestbase, the allocation will turn green and get the status approved. In principle this is now how the allocation will be. However, there is chance that this allocation needs amendments; in that case the status will go back to proposal.
- **Active**: At ETA of the vessel, the status will turn to active. This to indicate that the allocation is present and resource-demanding operations have started. Amendments at this stage might require shifting operations. Active loading/discharge operations will now display time left in accordance with data from the Gantt chart.
- **Finished**: When the vessel has left the port, the allocation is finished. This is so to speak the final solution of the port allocation. Data from loading and discharging operations might be used as basis for invoice. Amendments at this point are not possible.
- **Cancelled**: There needs to be an option to cancel a port allocation. This could however only be done from the states proposal and approved, prior to the ships arrival at Vestbase. Once the ship has arrived and the status is active, the only way to change

a port allocation is through the state proposal. At this stage it makes sense to propose a new departure time.

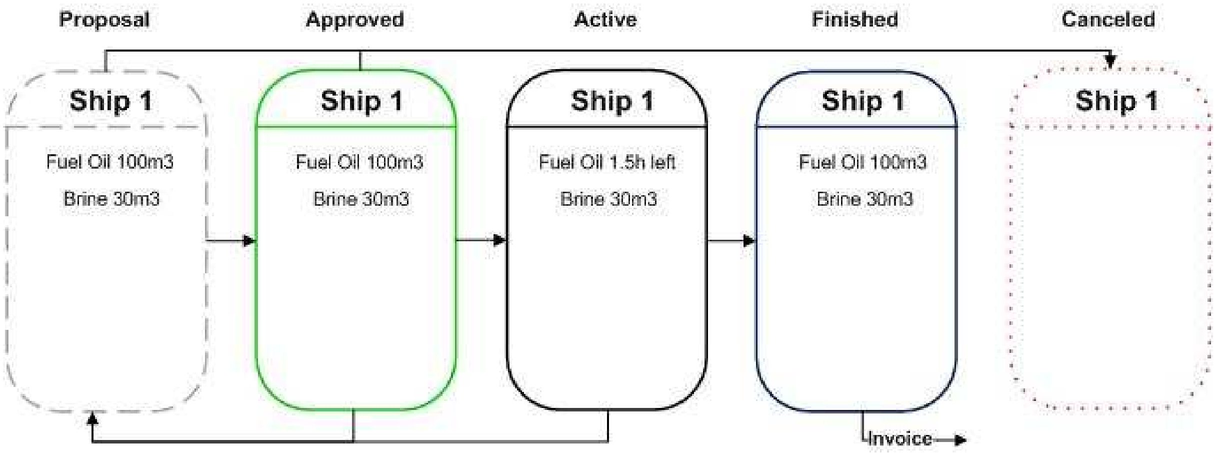


Figure 30 different states in the port allocation process.

3.4.1 KPI and states

States could be an opportunity to be able to measure improvements in the system. The following measurements could be applied;

1. The number of times the allocation shifts between Proposal and Approved.
2. The time between Approved and Active
3. The number of times the allocation shifts from Active to Proposal.
4. The number of shifting operations in one allocation.
5. The total time an allocation is active.
6. The ratio between loaded goods and total time an allocation is active.

3.5 Adding constraints

As mentioned in section 2.9, the port allocation is subject to constraints. These have been categorized by hard and soft constraints. In connection to the actual port allocation process the constraints are bound to the quay's characteristics and resources. For Vestbase these constraints are as displayed in Table 17.

Table 17 Constraints in the port allocation system. Specifications for quay 4 and 5 are still uncertain.

<table>
<tr><th>Quay</th><th>1</th><th colspan="2">2</th><th colspan="2">3</th><th>4</th><th>5</th><th colspan="2">6W</th><th colspan="12">6E</th><th colspan="12">7</th><th>8</th><th colspan="2">9</th></tr>
<tr><td>Length</td><td>12m</td><td colspan="2">60m</td><td colspan="2">45m</td><td>80m</td><td>80m</td><td colspan="2">63m</td><td colspan="12">63m</td><td colspan="12">63m</td><td>100m</td><td colspan="2">40m</td></tr>
<tr><td>Depth</td><td>6m</td><td colspan="2">10m</td><td colspan="2">8m</td><td>N/A</td><td>N/A</td><td colspan="2">10m</td><td colspan="12">10m</td><td colspan="12">7,3m</td><td>21m</td><td colspan="2">10m</td></tr>
<tr><td rowspan="2">Water</td><td></td><td colspan="2">120m3/h</td><td colspan="2">120m3/h</td><td></td><td></td><td colspan="2">110m3/h</td><td colspan="12">110m3/h</td><td colspan="12">120m3/h</td><td></td><td colspan="2">120m3/h</td></tr>
<tr><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td></tr>
<tr><td rowspan="2">Gassoil</td><td></td><td colspan="2"></td><td colspan="2">190m3/h</td><td></td><td></td><td colspan="2">N/A</td><td colspan="12">190m3/h</td><td colspan="12">190m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Baseoil</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">100m3/h</td><td colspan="12">100m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Bentonite</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">50m3/h</td><td colspan="12">50m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Barite</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">50m3/h</td><td colspan="12">50m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Brine</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">100m3/h</td><td colspan="12">100m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Meg</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">100m3/h</td><td colspan="12">100m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Mud</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">120m3/h</td><td colspan="12">120m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">LNG</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12"></td><td colspan="12"></td><td></td><td colspan="2">30m3/h</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td></tr>
<tr><td rowspan="2">Cement</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">70m3/h</td><td colspan="12">70m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Slop</td><td></td><td colspan="2">60m3/h</td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="12">N/A</td><td colspan="12">60m3/h</td><td></td><td colspan="2"></td></tr>
<tr><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>Supplier</td><td>Veolia</td><td>Vestbase</td><td>Veolia</td><td>Vestbase</td><td>Statoil</td><td>N/A</td><td>N/A</td><td>Vestbase</td><td>Statoil</td><td>Vestbase</td><td>Statoil</td><td>Haliburton</td><td>MI Norway</td><td>SAR</td><td>Swire</td><td>Norcem</td><td>Baker</td><td>Petrochem</td><td>YX</td><td>MWM</td><td>Veolia</td><td>Vestbase</td><td>Statoil</td><td>Haliburton</td><td>MI Norway</td><td>SAR</td><td>Swire</td><td>Norcem</td><td>Baker</td><td>Petrochem</td><td>YX</td><td>MWM</td><td>Veolia</td><td>Vestbase</td><td>Vestbase</td><td>Statoil</td></tr>
</table>

As can be seen from the table, all suppliers do not deliver products at all the quays. This needs to be taken into consideration as operators have different agreements and preferences when it comes to choosing a supplier.

The bulk constraints will have to be added as a resource to each quay's schedule according to Table 17. A helpful feature will be to add pump capacities to the system. This could be used to calculate necessary time needed to complete a loading operation. There are however large variations in the pump capacity from vessel to vessel, so each supplier should be able to influence on the capacity for each allocation.

3.6 The meaning of flexibility

In section 2.9 the concept of flexibility and how this could be applied in port allocation was discussed. By gathering the different quays and their resources in a Gantt schedule, the concept of flexibility could be displayed as in Figure 31 below.

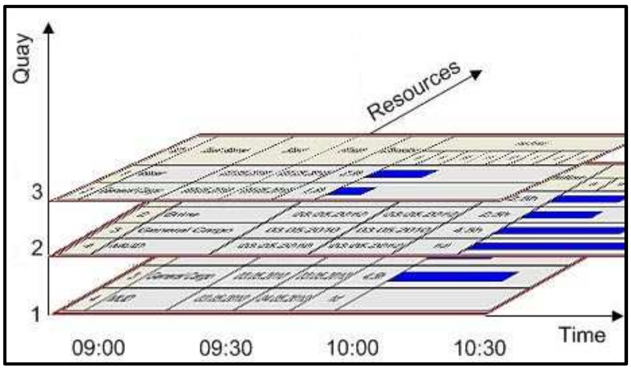


Figure 31 putting the flexibility concept into action

To find a solution that satisfies the allocations needs, matching the different quay schedules against each other will be necessary.

3.6.1 Finding the worst possible solution

The meaning of finding the worst possible solution is that ships are not given a quay that has more resources capabilities than necessary.

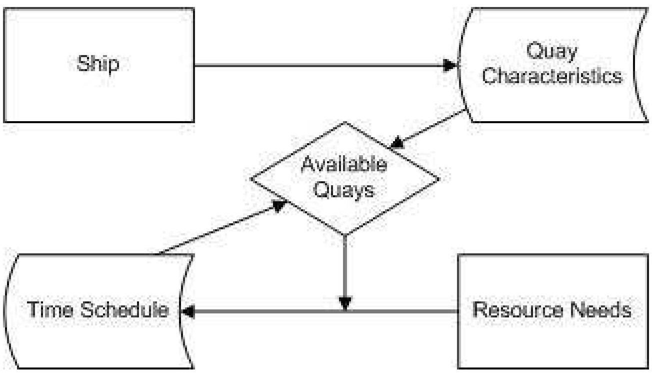


Figure 32 simple illustration of the process of finding the worst possible quay.

Figure 32 displays a simplified process of finding the worst quay available. When a ship's id or name has been entered into the system, its characteristics in terms of length and depth are checked against maximum specifications for each quay. This will give available quays based solely on the ships characteristics. If there are requirements of any cargo resources, this will be checked against each quay's time schedule and constraints from Table 17.

This could be performed by the use of pseudo codes, which is a compact description of a computer programming algorithm readable for humans (Wikipedia n, 2010).

3.7 Collaboration to optimize

The method described above is a matter of satisficing the needs with minimum resources available. By adding collaboration it might be possible to find optimal solutions that an automated system is not capable of seeing. There might be situations where the "optimal solution", as seen from the systems perspective, in reality is not the optimum when taking secondary information into consideration.

To be able to achieve a better solution than given by the system, the participants need to be given the possibility to collaborate. This is done by allowing them to add, subtract, and communicate around each port allocation in order to find converging solutions.

The proposed allocation is first checked by the system against constraints and minimum requirements before Vestbase receives the proposal. This is revised and might be discussed with the operator to reach an agreement before the allocation is approved. Throughout the allocation there might be continuously amendments to the allocation.

Figure 33 below shows how the port allocation system could work when adding the different states, participants and flexibility together.

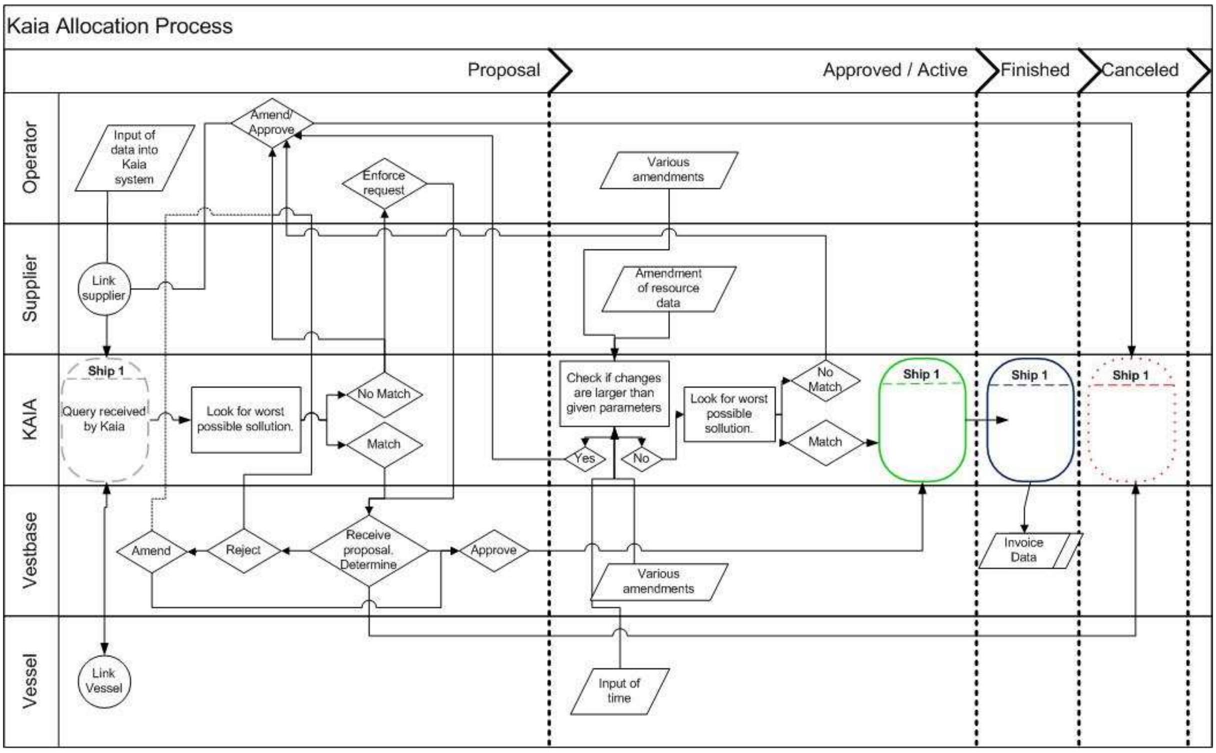


Figure 33 Allocation process in a simple heuristic. Kaia is the name of the allocation system. A larger view of this heuristic is available in Appendix 1.

4. ADDING MASHUP CAPABILITIES

As previously discussed it would be useful to add some data from third party information providers. Some of the data is available free of charge. Most importantly; it's available, updated by others and could be useful information for the allocation process. These are no need for Vestbase to maintain this information themselves.

4.1 External sources

4.1.1 AIS

Vestbase has access to AIS[14] data through Oddstøl Shiplog. AIS data contains both static and dynamic information about each ship. It's possible to extract this data from the system and make use of it in the port allocation system. The static AIS data could however prove to be inaccurate and imperfect in many cases (Kystverket, 2010). Thus static data about the ships specification might be supplemented from other sources

Adding information from the vessel could improve the accuracy of the system in terms of arrival times. It might however be situations where the vessel does not report arrival times into the system for various reasons. Adding data from AIS could then work as a secondary information source if first hand data is not available.

AIS signals from the ships gives information about ETA, this is however information that the ship has to remember to provide. It's also possible to assign sectors in the AIS map so that when a ship enters the assigned area, it's possible to calculate an estimated time of arrival.

Subsequent to the input of ETA by the operator in the initial allocation proposal, ETA from the vessel or AIS could give support to a more accurate ETA. This information should be prioritized as shown in Table 18.

Table 18 Priority of AIS information

Priority	
1	Vessels own report into the system
2	ETA from AIS signals
3	Calculated ETA from sector at AIS map

[14] Automatic Identification System for ships. Reports data of the vessel and position through the use of VHF signals.

4.1.2 Ship information

As AIS data does not always provide accurate static ship data, this should be gathered from a more reliable source. There are several providers of ship's registers where this information could be gathered. Table 19 gives an overview over available information in the ship's registers that might be of use for the port allocation system.

Table 19 Useful information to gather from ship's registers.

	Data
Vessel Information:	Name IMO number Length Max Draught Tonnage Owner

This is information that needs to be cross referenced with the constraints of each quay and needs to be accurate. As Vestbase has approximately a total number of 350 individual ships arriving each year it makes sense that this information should be gathered from third party providers.

4.1.3 Shipments information

Information about cargo (general cargo), or shipments could be useful to implement to support the basis for invoice. Vestbase are charging per tonnage loaded, and this is weighed by the trucks. There is being work done to create a system that tracks individual shipments. By implementing this data one could get a more integrated system for billing, resulting in fewer errors and time saved.

4.1.4 Weather

There is also a possibility to implement information about weather and tides. Easy access to information about the next hours could give indications about delays in arrivals and loading operations.

It could also be possible to implement information about tides in the event of heavy loading operation that could only take place at high tide, due to limitations in the draught.

This might however be features that shall not be prioritized when implementing the system.

4.1.5 Contracts

The offshore industry is subject to a variety of different charter agreements, hence ships and operators should be charged on different terms to different times. This creates challenges when trying to maintain overview in a constantly shifting environment.

It might be possible to collect and display information about each different contract when there are elements of uncertainty in how to charge the different vessels.

4.2 Views

It will in some cases be necessary to extract data out from the system. There are various methods to do this. In order to achieve this in a quick and efficient way, RSS, KML and UUID might be used. This will make identification and use of information outside of the system possible.

4.2.1 RSS

RSS (Rich Site Summary) is a web feed format for delivering regularly changing web content in a standardized format. An RSS document includes full or summarized text, plus metadata such as dates and time of update, and who did it (Wikipedia j, 2010).

The benefit of using this technology is that users might subscribe to updates from a given source and receive notifications when there has been a change or update. Thus the user does not have to look around in order stay updated.

This requires that an RSS reader view is implemented to the system. The RSS reader checks the user's subscribed feeds regularly, and provides a user interface to monitor and read the feeds.

The RSS format is specified using XML.

4.2.2 KML

KML (Keyhole Markup Language) is an XML based language that is used to express geographic annotation and visualization on internet-based maps (Wikipedia k, 2010). This technology might be used to track and display moving vehicle, trucks and equipments within the port facilities. This is under implementation at Vestbase, at will contribute to a simpler holistic evaluation in terms of utilization of resources. This feature might be implemented into the port allocation system.

4.2.3 UUID

UUID (Universally Unique Identifier) is an identifier standard that is used in software's to enable distributed systems to uniquely identify information without significant central coordination (Wikipedia m, 2010). A UUID is a 16-byte number; the theoretical number of possible UUID's is therefore 3×10^{38}. Thus it is possible to create UUID that with reasonable confidence never will be used to identify anything else.

Each port allocation might be given a unique UUID to be able to identify it, and to be able to relate all communication to one specific UUID.

For instance it might be possible to tie a mail string to a given port allocation by giving the UUID in the header field of the e-mail. This will assure that all communication can be identified by the system, gathered and logged under one specific port allocation.

5. PUTTING IT ALL TOGETHER

So far this research has presented different elements that might be useful in a port allocation system. A system is a set of interacting or independent entities that form an integrated whole. Creating this integrated whole comes with different challenges. The two main challenges are perhaps;

- To create a functional user interaction or interface that is intuitive and easy to use.
- To gather and validate data from various sources when creating a mash-up.

This is some of the technological challenges that a development of this system faces.

A key success factor for this system is that it is that everybody participates. This will require a system that is easy to use, and easy to understand.

The danger is to create a system that for the users seems to do the same as their own ERP system. This could lead to unwillingness to participate in feeding the system with information.

5.1 Message log for collaboration

Creating a log so that it is possible to track all activities and communication that has taken place within one specific port allocation is necessary in order to identify who did what and when.

An activity or communication that is going to be logged comes from three entities within the system;

- Mail treads between participants
- Instant messaging (XMPP)
- Changes in allocation

In order to indentify the activities they need to be tied to one specific UUID.

Figure 34 below displays the message log concept. Each allocation window will have its own log window that displays activities that has taken place. It's possible to review both mail treads and instant messaging communication. The log window displays only a short summary to give a quick overview.

It should be possible to search through the log in order to quickly find relevant issues.

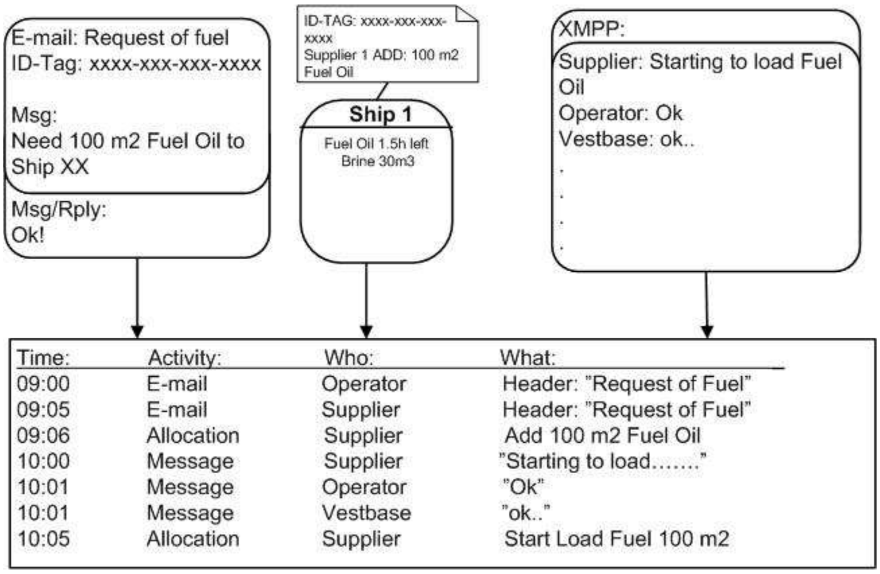


Figure 34 Message log for each allocation.

5.2 Links to the world

By aggregating the system through mashup technology, the system will be improved and get more agile. This will result in less data stored within the system. The challenge is however to be able to get hold of the data and validate it. There is always a chance that 3rd party data might contain errors, and this has to be taken into consideration. It is however doubtful that this shall be a problem if users are aware of this and act accordingly.

Table 20 below gives an overview over mash-up sources that are relevant for this system. Most of these sources are possible to extract through the use of XML.

There are however a challenge tied to the gathering of data from manifests. Vestbase needs this information in order to know what cargo is going where. For backload, cargo that is arriving from the offshore installations, this information is set and final upon arrival. For outgoing cargo, the manifest is not being printed until the last cargo is aboard. In order to obtain live information about ongoing cargo the operator will have to grant access to their ERP systems, or feed the system with this information.

Vestbase are developing a system to track down jobs performed by each truck on the port facility. This will give an overview over the number of general cargos going onboard and the weight. Implementing this information into the system will give a better overview, and make it possible to use this information as a basis for billing.

Table 20 mash-up sources for use in port allocation.

Data	Owner	Purpose	Availability
AIS	Oddstøl Shiplog (kystverket)	Give better and more precise information about arrival times	Vestbase already has access. AIS raw data is possible to extract from the system
Ship Schedule	Statoil	Give information about which duty each vessel performs. (supply or ahts)	Available through Statoil VTMIS. Intention is to share information with supply bases
Shipment Manifest	Statoil Shell, more	Give information to Vestbase about incoming and outgoing shipments	Outbound manifest constantly changing. Inbound possible to get through operator.
Shipment	Vestbase	Get information about number of general cargo and weights.	Vestbase are developing a system to track individual jobs. Could be integrated.
Customer Info	Vestbase	Tie user information to already existing databases	Vestbase has a customer database, Agresso.
Ship Information	Ship Registers	Gain updated information about each vessel without having to update an own database	Available through various online ship registers. For instance Lloyd's list
Weather	Yr Storm	Give information about weather conditions	Available free of charge

5.2.1 Examples of XML

For several of the applications that the system need to import data from, there already exists XML formats. One such format is KML – a XML based format for exchanging information about locations. Here is an example of a placemark for a ship that can be viewed by Google Earth:

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns=http://www.opengis.net/kml/2.2 xmlns:gx=http://www.google.com/kml/ext/2.2
xmlns:kml="http://www.opengis.net/kml/2.2" xmlns:atom="http://www.w3.org/2005/Atom">
<Placemark>
<name>HAVILA BORG
        </name>
<Snippet> maxLines="2">AKER BARENTS-KR.SUND (ETA May18 14:00)
        </Snippet>
<description>
        <![CDATA[<a href='http://aprs.fi/?call=257431000'>[click here to track on aprs.fi]</a> <br />
        2010-05-21 11:29:51z - 2010-05-21 13:26:51z
        <br />71°<br />
        <span style='color:#0a7100; font-style:italic;'>AKER BARENTS-KR.SUND (ETA May18
        14:00)</span><br />
        [3YJK&gt;ais via LA2PJ]<br />]]>
        </description>
<styleUrl>
http://aprs.fi/aprsupdate.kml?units=metric&amp;units_temp=C&amp;BBOX=7.652569657270424,63.0
6538803959884,7.898777458243886,63.14207262802297#t794526
        </styleUrl>
<MultiGeometry>
<Point>
<coordinates>7.79082,63.10081,0 </coordinates>
         </Point>
        </MultiGeometry>
        </Placemark>
        </kml>
```

Other XML formats may be defined specifically for the system – e.g. information about one specific call given by a UUID:

```
<?xml version="1.0" encoding="UTF-8"?>
<kaia xmlns="http://www.kaia.net/kml/1.0">
<portcall>
        <uuid> 550e8400-e29b-41d4-a716-446655445566 </uuid>
        <name>Havila Borg</name>
        <ais-id> .... </ais-id>
        <arrival> 2010-05-21 11:30:00z </arrival>
        <departure> 2010-05-21 20:50:00z </departure>
<port>
<name> Vestbase </name>
<location>
<Point>
<coordinates> 7.79082,63.10081,0 </coordinates>

</Point>
</location>
</port>
</portcall>
</kaia>
```

XML can hence be used for obtaining data from external systems and exporting data from the system to other systems – e.g. the SAP system belonging to Statoil.

5.3 Views for everyone

Each different participant needs to be given different views and rights in the system. Figure 35 shows how this will work. The operator and suppliers are the main contributors to the system, while Vestbase acts more like a supervisor that approves allocations and make sure that operations go without delays.

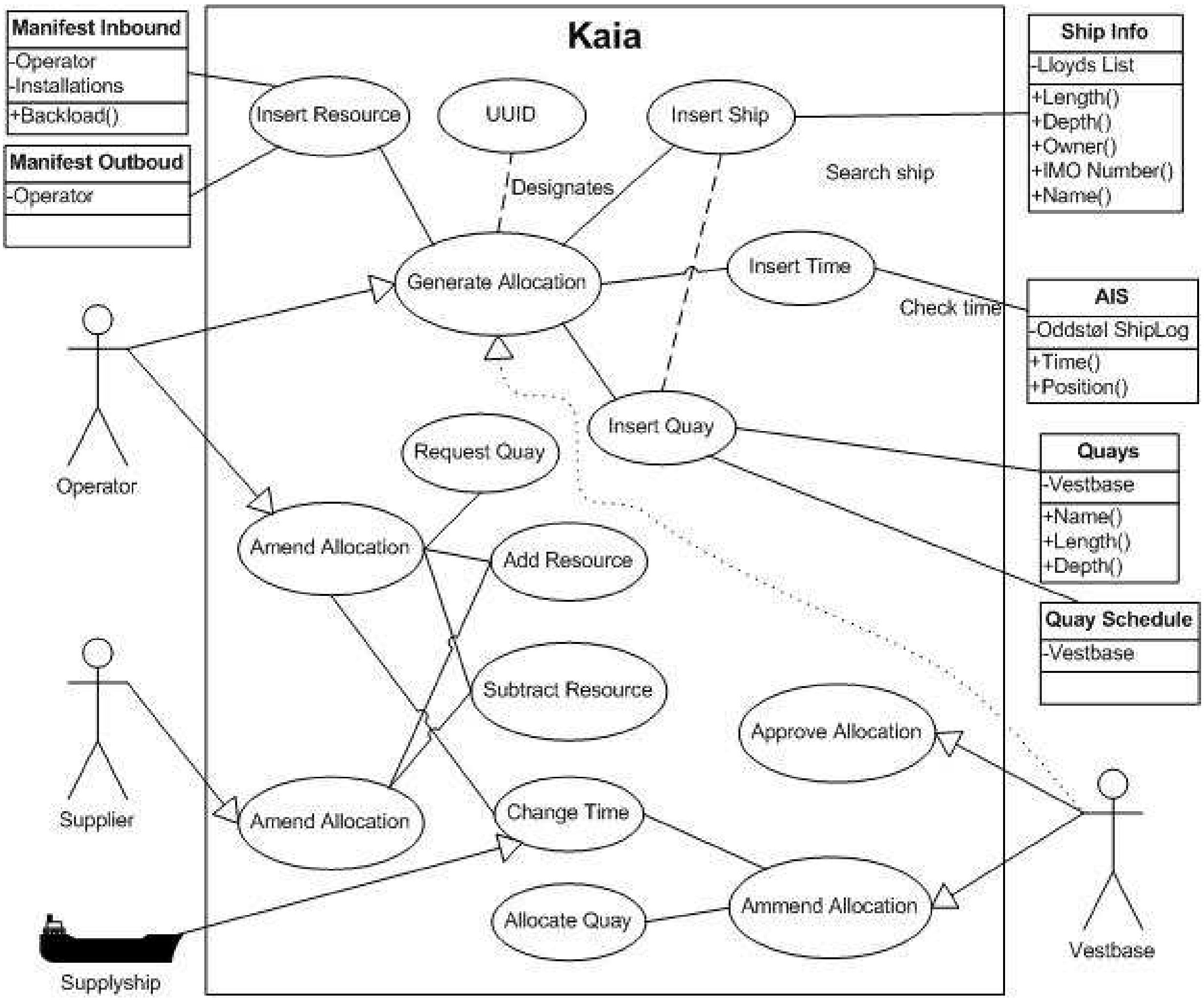


Figure 35 views and functionality for different users of the system.

Operator: The operator generates the allocation, input ship and necessary resources. It's also possible for the operator to request quay. The system will however check available quays up against the ship's specifications, and available resources. Once the allocation is approved, the amend process will give the operator chances to add and subtract resources.

Supplier: Once the operator has assigned the supplier to an allocation, he can take part in adding and subtracting resources to the allocation. The supplier will contribute with more accurate data on when loading and discharging operations are done.

Vestbase: Vestbase will approve and have the final saying in the allocation process. They will not have a saying in resources, but might change time and quay allocation. They will also need to be able to generate allocations as ships might arrive that do not have an operator that take part in the collaborative port allocation system.

5.4 Implementation

Implementing the system requires planning and relies first and foremost on the participation of all participants. It might be that building a simple system with only the basic functions at first might be best. This lets people get used to the system and see advantages before adding more advanced features. Implementation could be divided into two phases:

Phase 1:

- **Building:** Planning, building and testing the system take time. The first stage of the building should only include functions that let the users get familiar with the layout and basic principles of the system. This includes the basic collaborative features such as input of requirements, amendments and communication. It's important that there is a possibility to measure the systems performance through KPI's from day one.
- **Training:** Information and training of participants is necessary before the system goes live. Training sessions, and information videos will contribute to a greater understanding of the system. Agree upon a date for launch of the system.
- **Launch:** Give incentives to contribute as good as possible to the participants. It could for instance be given prizes to the week's best performer according to KPI's. There should be possibilities for the users to give feedback to system in order to improve functionality.

Phase 2:

- **Expansion:** Once the users are starting to get familiar with the system it is possible to start adding functions such as automatic allocation. Once the input data are starting to get accurate it is possible to use this for a basis for billing. It's important to inform users that input data will form a basis for billing.

5.5 Concept screenshots and functionalities

To provide a better understanding of the system a few sample screenshots have been made.

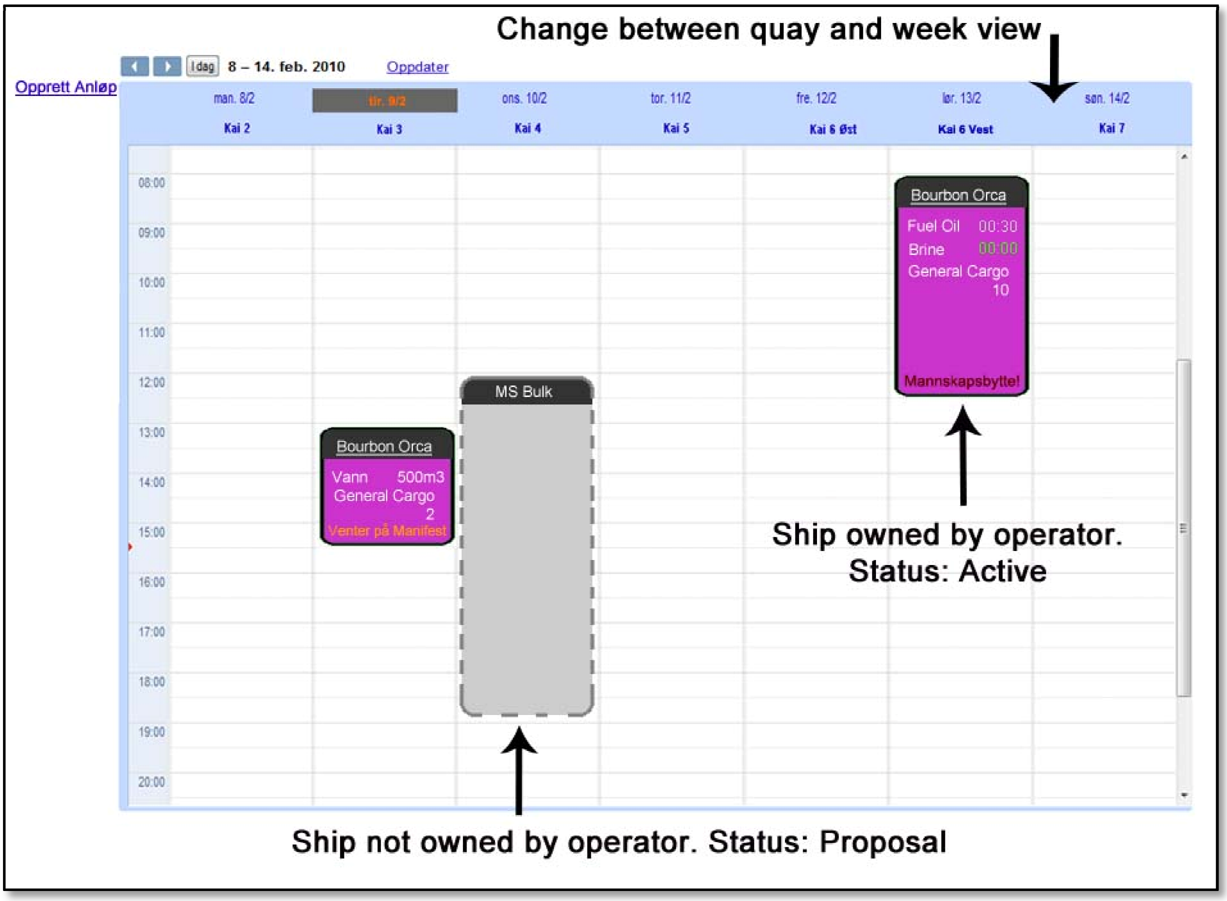


Figure 36 concept screen shot. Calendar overview.

Figure 36: Displays an overview window for an operator. The window gives an intuitive calendar view where it is possible to see all ongoing allocations. The current view shows present allocations per quay for Tuesday 9/2. This view identifies own ships, and ships owned by other operators. Owned ships gives a quick view over status for each loading operation in terms of time left, and planned quantity to load.

To generate a port allocation the operator could either click on the “opprett anløp” button, or click inside the calendar to automatically assign/request quay and time.

Participants that have proved to collaborate and behave well in the system might be given the right to allocate ships directly in the calendar view as described above. New operators that do not have the same experience as regular operators might not be given the right to allocate directly in the calendar. Instead the system will allocate the ship based on the minimum resources required.

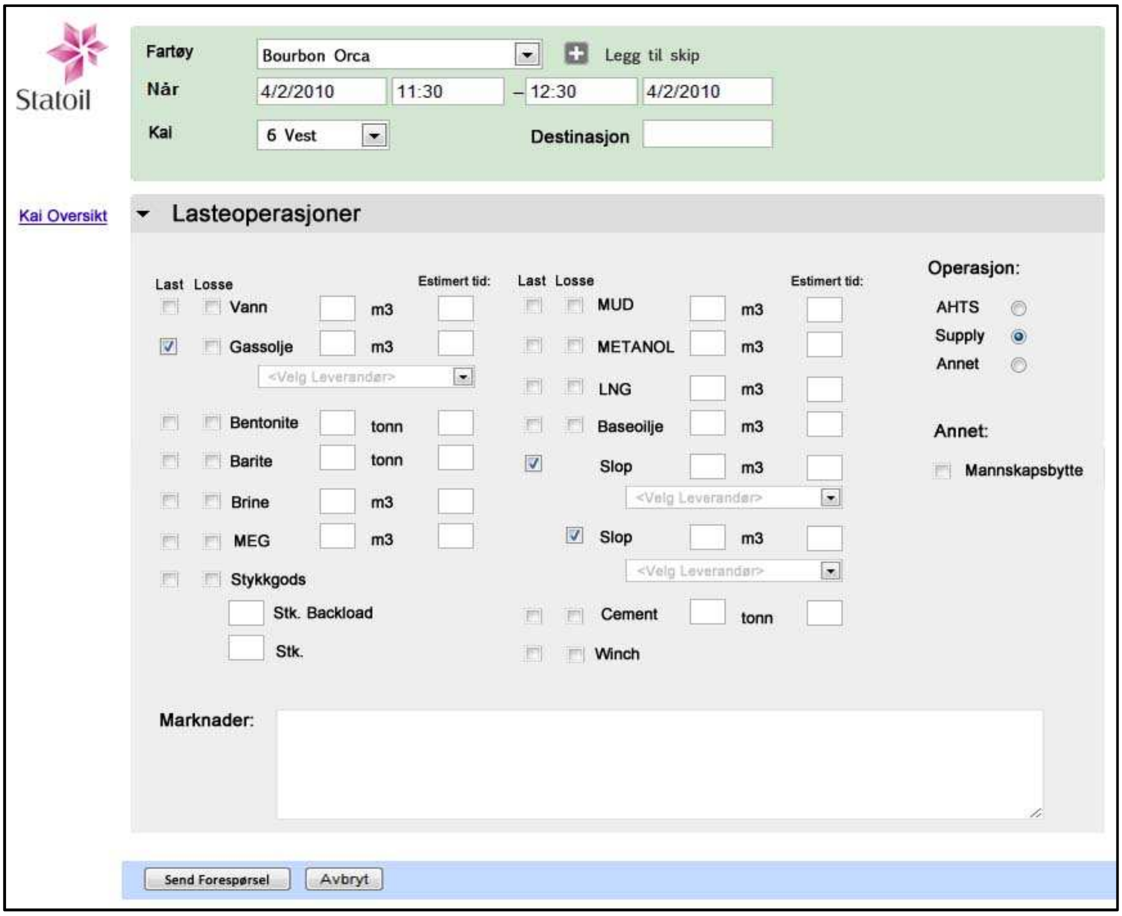


Figure 37 concept screen shot. Generate allocation.

Figure 37: The generate allocation window lets the operator select ship, time and date. Some operators might also propose quay.

The main feature is input of various types of goods for the port call. The operator selects which cargo is to be loaded and which is to be discharged. As seen from the figure, both loading and discharging of slop has been selected. Once selected, the operator needs to assign a supplier.

Wanted quantity is entered into the system, and estimated time is calculated based on quay capacity. The supplier might provide more accurate estimates, and time for each operation later on.

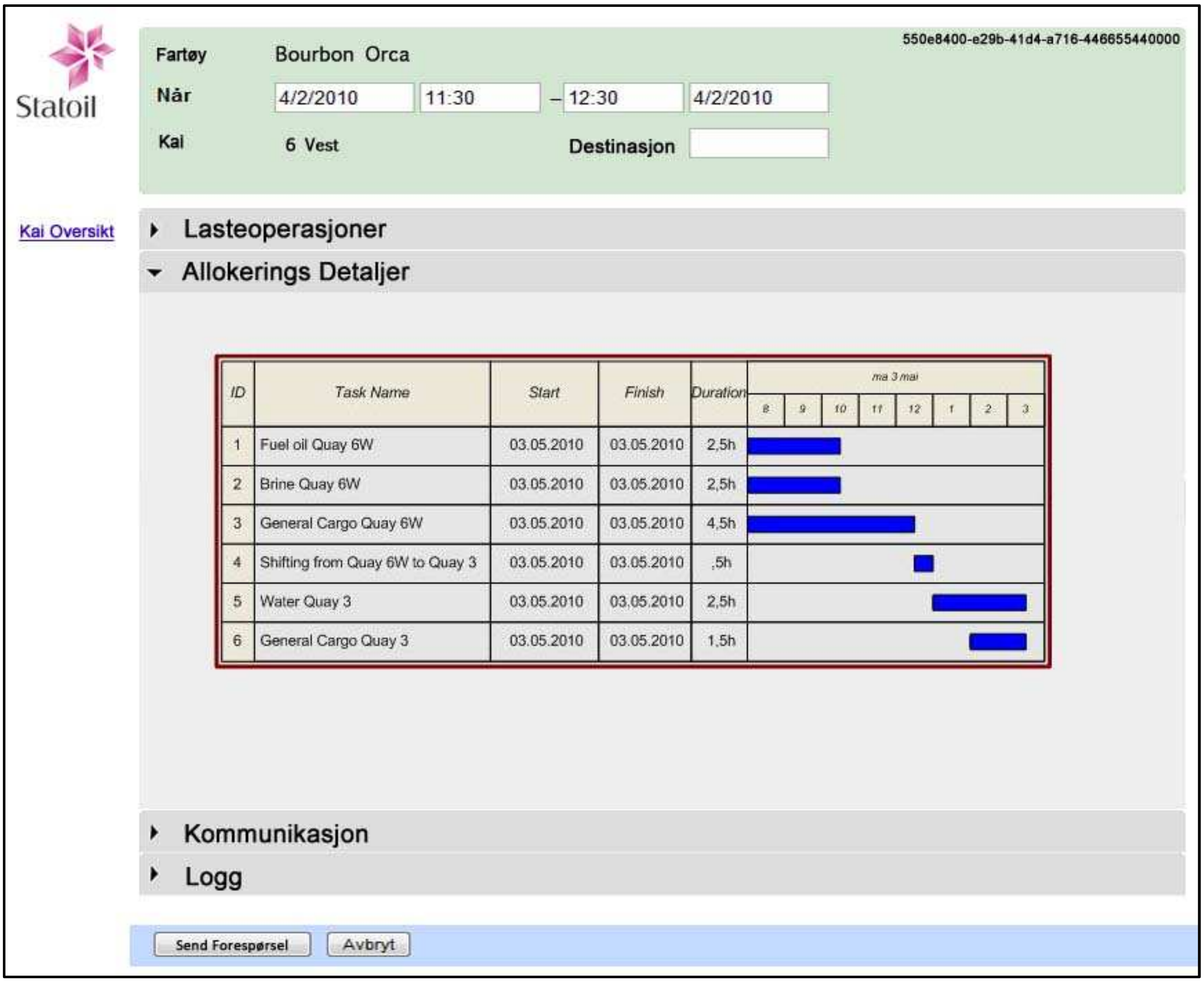


Figure 38 concept screen shot. Allocation view.

Figure 38: Once the allocation has been approved, amendments can be made, or it is possible to see a more detailed view of each allocation. The allocation has now been assigned a UUID in the top right corner.

It's possible to switch between 4 main views; loading operations, allocation details, communication, and log.

The loading operations view is still the place where resources are added and subtracted. Once a resource is added, it will appear in the allocation details window.

The allocation details window lets the operator and supplier set a start time and duration for each loading operation.

This view will let the operator request resources at other quays as well.

6. DISCUSSION

This research has tried to explore how port allocation is performed by Vestbase and NorSeaGroup today, and how this could be done differently. Although there are many details left to be straightened out, the main structure is starting to fall into place through this research.

Contact with the different participants has showed that the will to implement a better system for port allocation is present. There has not been found many concrete wishes among the participants about what a system should be capable of doing expect that it should improve communication and make port allocation more simple. Although there are not many clear visions for the system, the important factor is that all participants seem to be positive to some sort of collaborative port allocation system.

As shown by the traffic data there is an extensive use of shifting operations in today's conduct. This is partly a result of constantly shifting demands and allocations that is not able to meet demand. The allocations are not necessarily bad, but available information does not allow for better predictions. More available information on hand will hopefully result in better allocations and use of available resources.

If Vestbase is able to utilize the existing port infrastructure in a more efficient way, it might not be necessary to carry out expensive expansions. The cost of expansion will eventually have to be placed at the customers, and could result in poor competitive ability. This is a main incentive for the participants to join the system in an attempt to improve utilization and to avoid a raise in costs.

This research has broken down a system into different elements and described each of them separately. Collaboration and transparency are two central elements. Governmental decisions have more or less enforced Vestbase and the other participants to work together. As establishment of new base structures is costly and time consuming, it makes sense to do the best out of the situation and collaborate. They have already proved that co-operation between them is functional, thus it is likely that a new system will not affect the relationship in negative terms.

There are however a greater challenge in terms of transparency within the supply chain. The different participants are somewhat reluctant to share information, also within own ranks. The reasons for this might be many-sided, and subject for an own research. This creates without doubt challenges in terms of streamlining the supply chain.

When it comes to how to model a new system there might be several approaches. A port call might be looked upon as a product that enters a factory floor, and has to move through different work stations in order to be completed. There are several methods developed to solve these kinds of problems. A port call however, is subject to numerous different variables that might change several times during a single port call. This demands a system that is tailor-made and constantly up-to-date and able to cope with sudden and constant changes.

The system in itself does not do much. It provides information to the users and keeps track of the allocations. Hopefully it will provide a better foundation to take decisions.

The ability for the system to identify solutions that provides only the necessary resources is important in order to improve utilization of the quays. Thus it is important to develop a functional algorithm that is able to identify a quay that is able to serve the allocations needs with an absolute minimum number of resources.

It might be expected that some participants find good solutions and are able to contribute to a functional system. These participants might be able to see own solutions without help from the system. Thus is could be possible to grant these well behaving participants a more direct access to allocations. They could for instance allocate ships without asking the system for solutions.

Once the system is up and running it will be necessary to maintain a close contact with the user in order to constantly find improvements.

In could be discussed whether or not a new system for port allocation is necessary. The situation as it is today, with about 400 annual shifting operations, indicates that there might be too little information available during the planning process. Although there has been little concrete evidence in this research demonstrating that there is an extensive misuse of resources, there have been indications that there in some cases are a mismatch between requirements and use of resources.

As Vestbase are continuing to expand their activity, and new gas fields are being discovered (Aftenposten, 2010), chances are that the number of ship movements will increase in the years to come. This will demand more out of Vestbase in terms of planning, co-ordination and use of available resources. This speaks in favour of a new port allocation system.

The system might also acquire secondary functions as demands come into being. This could for instance be generation of reports concerning goods to the government.

This research has not had any focus on how the allocations could be optimized by the system. This could possibly be a helpful subsidiary function provided by the system, but requires a more thorough research in order to be achieved. By using the concept of flexibility, the system could figure out an optimized allocation, based on the current situation and given criteria's. The optimum solution is however subject to a numerous of different conditions and hard, if not impossible, to figure out. Most likely it makes sense to avoid some of the criteria's in order to achieve a solution that is not optimal, but closer to it than the first allocation.

7. CONCLUSION

Although the system is yet to be build and effects of its implementation are unknown at this point, this research give answer to some key questions concerning further development.

7.1 Is it possible?

The system in its entirety is quite small and does not do much. It gathers information from other sources, and displays it to the participants in order to help improve the port allocation process. The hard part is to be able to gather necessary data in a way that it is possible to make use of it within the system, together with creating a graphical user interface (GUI) that is intuitive. Once a satisfactory GUI has been developed, and permissions to gather data have been granted, development of the system rests on technological knowledge and know-how.

Participants of the supply chain are positive to a new system that can improve communication between operators, suppliers and Vestbase, and make the process of booking quays and resources more unproblematic.

Taking into consideration that it is technologically achievable, and participants are willing to take part; development and implementation of the system is possible.

7.2 Is it necessary?

Although it is possible to accomplish, it is not given that it is necessary to implement.

A possible raise in activity levels at Vestbase in the future, and expansion of the port facilities, together with expectations of a more profitable and efficient conduct might require actions to be taken. One of the expected benefits of implementing such a system are far better information flow that hopefully will increase Vestbase's capabilities to overcome these demands.

Other benefits may be the ability to benchmark activities in order to track changes in performance. The ability to run historical and prospective simulations could also contribute to an increase in utilization, efficiency and understanding of the supply chain.

Taking into consideration that such a system could help Vestbase to overcome expectations of the conduct, and achieve happy customers; development and implementation of the system is necessary.

7.3 Further work

As this thesis has explored the feasibility for a new port allocation process at Vestbase it has become clear that the oil and gas sector in Norway holds a culture that do not necessarily encourage sharing of information. To give a better insight into why this is, a more thorough research will be necessary.

There are some aspects that this research have not dealt with, but could be of interest for further work:

To let the system optimize the allocations, a closer study of the conditions is necessary. It is required that criteria's are calculated down to single units in order to find an optimized allocation. Examples of conditions could be;

- Costs of delays per ship, per time unit. (extreme variable)
    - Production delays
    - Ripple effects
- Costs of shifting operations per time unit.
    - CO2 omissions
    - Fuel costs
    - Crew agreements
- Costs saving per travelling distances ashore.

By reducing costs and increase cost savings it might be possible to get closer to an optimized allocation. This does however require that conditions like the ones mentioned above are mapped.

To justify the process of giving participants the so called worst possible allocation, it would be interesting to have a closer look at the value of having a vacant quay to serve bigger and more demanding ships. The option value of having a vacant quay will most likely vary depending on situation, quay, and ship.

Benchmarking from historical data and KPI's could give important insights to the ports progress in performance. Looking closer at how benchmarking tools could be developed, and how this could be applied within the system requires a more thorough research.

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APPENDIX 1 – PORT ALLOCATION SYSTEM PROCESS