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X2X: A new conceptual solution on the edge of information systems and supply chain management

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PREFACE

This thesis represents the final part of the Master of Science in Logistics program at Molde University College. Our thesis explores the X2X conceptual solution of the X2X Maritime AS developed for the major oil and gas company on the Norwegian Continental Shelf.

As the concept is still being developed for its further implementation we had a challenge to analyze its potential by using exploratory and explanatory research design methods. In our research we utilized the data obtained from the reports of the X2X team and the relevant literature.

We appreciate the opportunity to thank sincerely our supervisors who work on the development and deployment of the X2X concept:

Associate Professor Bjørnar Aas for his great support during these months. His thoughtful advice and comments, creative ideas and constant feedback helped us to realize the thesis. Bjørnar continuously assisted us with important information about the X2X, company's reports and useful literature articles. We really appreciate his attitude and encouragement and are grateful for inspiration he gave us.

Professor Steinar Kristoffersen for his experience which he shared with us to improve our thesis. We appreciate the technical advice about the X2X solution and the ideas about the relevant topics to be included in the thesis.

We also feel very grateful for our teachers at Molde University College who helped us to obtain the knowledge which we were able to apply in our thesis.

Finally, we would like to thank our family for their love and support during all this time!

Molde, May 24, 2011

Anastasiya Karalkova and Katsiaryna Kilcheuskaya

SUMMARY

Globalization and increased market competition force companies to improve their supply chain management: increase collaboration, reduce costs and streamline processes. The oil and gas industry has an extremely complex supply chains and therefore, effective supply chain management is a crucial factor to gain a competitive advantage in this sector.

The goal of this thesis was *to define and investigate the role of a new conceptual solution of X2X Maritime AS in serving the needs of the supply chain management in the oil and gas industry.*

The *X2X concept* is based on the *network-wide real time logistics information sharing on the operational level.* At the present moment the X2X solution is being developed as the information hub for the upstream logistics of the major player at the NCS.

Therefore, within this thesis we investigated the X2X concept and solution from *three basic perspectives*: *Supply Chain Management; Integrated Operations* as a major oil and gas industry trend; and *Supply Chain Management Information Systems.* This approach allowed us to evaluate the relevance of the X2X concept to the Supply Chain Management; the role of the concept in order to obtain Integrated Operations in oil and gas industry; and to define the place of the X2X solution within the Information Systems used for the Supply Chain Management needs. For the purposes of the research we used the exploratory and explanatory research methods. In order to answer the research questions we conducted the extensive review of the relevant literature.

After a careful study of the X2X concept the following propositions were made:

(i) *The X2X concept is an essential concept within supply chain management as it enables information sharing and increases collaboration within supply chain;*

(ii) The X2X concept goes in line with supply chain management objectives and helps to achieve them: reduce costs, streamline processes, enhance flexibility and agility;

(iii) The X2X concept is an appropriate solution for information sharing improvement within the oil and gas multi-channeled upstream supply chain;

(iv) The Integrated Operations concept is a part of the supply chain management concept;

(v) X2X goes in line with the focus of the Program 3 and Generation2 of the Integrated Operations concept;

(vi) Information systems are the key enablers of SCM concept deployment and development;

(vii) The X2X solution serves to run the business needs on the cross business processes level;

(viii) The oil and gas industry needs information systems in order to cope with their existing challenges;

(ix) The X2X solution has a potential for further development within the oil and gas industry.

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List of abbreviations and acronyms

B2B	-	*Business-to-business*
BI	-	*Business Intelligence*
EDI	-	*Electronic Data Interchange*
ERP	-	*Enterprise Resource Planning*
HSE	-	*Health, Safety and Environment*
HTTP	-	*Hypertext Transfer Protocol*
IO G1	-	*Generation 1 of Integrated Operations*
IO G2	-	*Generation 2 of Integrated Operations*
IaaS	-	*Infrastructure as a Service*
ICT	-	*Information and Communication Technology*
IO	-	*Integrated Operations*
IoT	-	*Internet of Thing*
IOS	-	*Inter-organizational Information System*
IS	-	*Information System*
IT	-	*Information Technology*
NCS	-	*Norwegian Continental Shelf*
OLF	-	*Oil Industry Association*
PaaS	-	*Platform as a Service*
PPTO	-	*People, Processes, Technology and Organizations*
RFID	-	*Radio-Frequency Identification Technology*
R&D	-	*Research and Development*
SaaS	-	*Software as a Service*
SC	-	*Supply Chain*
SCM	-	*Supply Chain Management*
TMS	-	*Transport Management Systems*
VMI	-	*Vendor Managed Inventories*
WAP	-	*Wireless Application Protocol*
WMS	-	*Warehouse Management Systems*
XML	-	*Extensible Markup Language*

1. INTRODUCTION

In this part of the thesis the underlying reasons of the choice of the topic are highlighted, the general overview of the company X2X Maritime AS (www.x2x-maritime.no) and the X2X concept is provided.

1.1. Background

The modern trends of globalization and increased market competition force organizations to collaborate closely and build partnership relations. Therefore, the efficient cooperation among supply chain members is considered as an essential issue for sustaining companies' competitive advantage. The organizations which are able to cooperate with the other actors in their supply chains are supposed to prosper through increased product quality and reduced costs and lead times.

Moreover, the chief executives of the companies realize the necessity to broaden the area of analysis, decision making and control within the supply chain. The competition at the moment is no longer considered to be between single business units but between the supply chains. The supply chains include three main flows, they are product, information and financial or payments flow. Therefore, the main manager's task is to ascertain a well established integration and coordination of these flows within and across companies, in order to achieve the effective supply chain management (SCM).

The current boost of the availability and diversity of the Information Technologies (IT) provides supply chain decision makers with a vast amount of tools, that can be used to improve the overall supply chain performance through the effective information flow management.

X2X Maritime AS is a Norwegian company, working to provide solutions for complex supply chains of the oil and gas companies presented on the Norwegian Continental Shelf (NCS). The company came up with a new advanced software solution for the upstream supply chain purposes of a major player among Norwegian oil and gas companies.

This X2X concept came to be of particular interest for our research as it might grow into a new advanced IT solution for the real time information sharing and become a new edge of Information Systems in SCM. In particular, we found it interesting to investigate in our thesis *the relevance of the X2X concept from the SCM perspective; the relevance of the concept in order to obtain Integrated Operations (IO) in oil and gas industry; and to define the place of the X2X solution within the information systems (IS) used for the supply chain management needs.*

The main goal of this thesis is ***to define and investigate the role of a new conceptual solution of X2X Maritime AS in serving the needs of the supply chain management in the oil and gas industry.***

Therefore, this thesis is supposed to combine three fields of study: Supply Chain management, Integration Operations, Information Systems used for SCM; with the ambition to provide both new conceptual and practical output for companies and the basis for the further research. It should be mentioned that there seems to be a lack of scientific literature describing both the IT and SCM fields together; therefore, an indirect goal of this thesis is also to provide the general overview of the interaction between the aforementioned areas of study.

Our thesis is a useful research for the following parties:

- X2X Maritime AS, in order to check their concept against existing ones and to define the role the company's idea plays in the SCM of the oil and gas industry.

- Companies being a part of the oil and gas industry, in order to evaluate a potential introduction of the X2X concept into their operations.

- Molde University College, to further investigate the implementation and improvement of the new idea in the field of logistics. Moreover, it will bring knowledge and new directions on how it would be possible to better combine the IT studies together with the SCM. Something that further can be used for teaching at the Bachelor and Master Degree levels.

- The authors, to implement and broaden the knowledge obtained in MS program courses in Industrial Logistics and Supply Chain Management. We consider these courses to be professional knowledge which we are going to apply into practice.

Regarding our personal motivation to explore this topic in our thesis, we would like to admit that we believe the X2X concept could potentially grow into the new supply chain integration solution. Therefore, it is a great honor for us to be a part of this essential project.

The rest of this thesis is organized in the following way. Further in this section X2X Maritime AS general overview and the problem description are presented. In the second chapter the research problem is described, the objectives of the research are set and research design is presented. Then it is followed by the theoretical background on the SCM with the particular attention paid to collaboration and information sharing within this field. Going forward, the Integrated Operations (IO) concept is reviewed as it serves the particular needs of the oil and gas industry. Further, in the fifth section we provide an overview of Information Systems used for SCM needs. And, finally, in the chapter 6 we discuss the findings of the research. In the last section the conclusions of the research and further research issues are presented.

1.2. X2X Maritime AS, Company Description

X2X Maritime AS is a recently established Norwegian company which works on the development and the implementation of the X2X concept (will be discussed further), and offers an advanced solution for "*real time information sharing in dynamic heterogeneous environments" (the company's slogan)*.

The core business of the company is to offer the software design, service of the technology development and deployment of the information system. This system enables the entire supply chain to share information about all kind of logistics events efficiently and timely.

X2X Maritime AS was founded in the logistics environment of Molde University College (www.himolde.no). The basic idea of the concept belongs to the founder of the company Mr. Petter Aamot who proposed an alleged innovative architecture which allows computer systems to be significantly more dynamic than nowadays. Mr. Aamot has got a great experience in the Logistics and SCM fields: as the founder of the ERP-system Movex at the moment owned by Lawson (www.lawson.com); and as an international consultant in the area of lean production. Moreover, Mr. Aamot participated in transport robots development for logistic needs (www.servus.eu).

The Knowledge park (www.mkp.no) is the working environment of X2X Maritime AS. Moreover, there is a well established partnership between the company and educational institutions as Molde University College specialized in Logistics. This working environment and partnerships ensure the creative approach and a competitive advantage of the company in the market of creative solutions for SCM and Logistics.

1.3. Conceptual framework of the X2X

As it was mentioned before, the X2X concept was designed for the oil and gas industry. Therefore, we find it necessary to start with the description of the current situation in this industry.

The present state of affairs in oil and gas industry is characterized by the pressure coming from the global competition and the need for tight collaboration across the supply chains. In order to be competitive, companies have to streamline the supply chains and develop highly reactive information sharing systems.

Moreover, the NCS's oil and gas production follows the trend of the Hubbert's curve (Figure 1.1). Hereby, we should mention that the Hubbert's oil depletion theory states that for any given geographical area the rate of petroleum production follows the bell-shaped curve, and gains its peak (http://en.wikipedia.org).

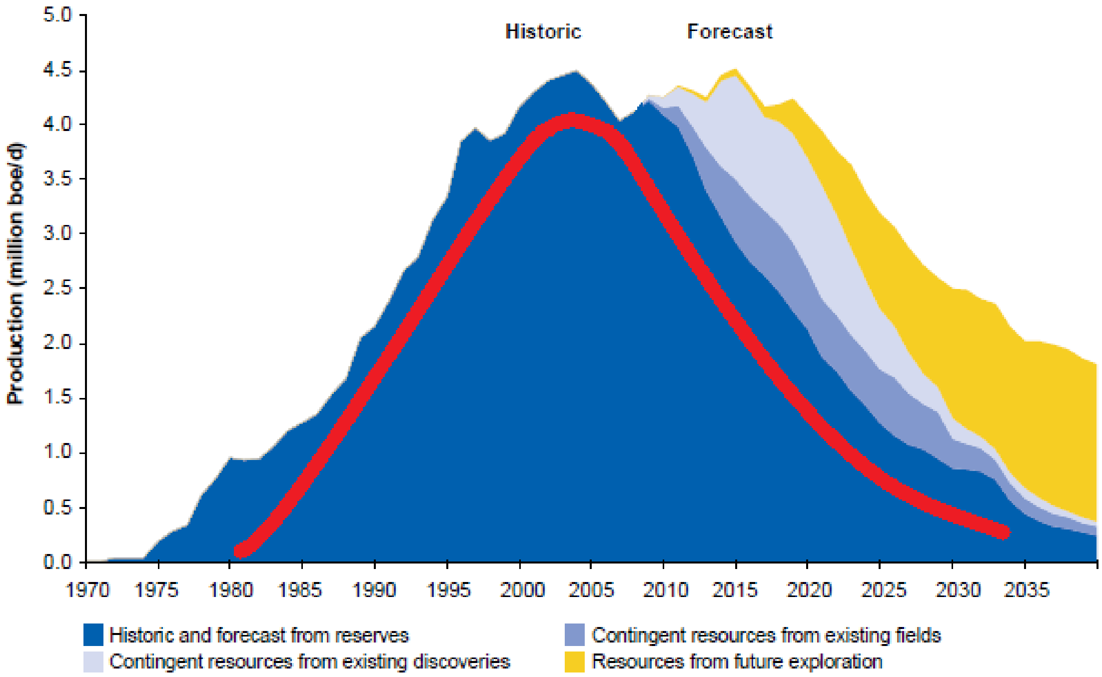

Figure 1.1 NCS oil production based on NPD's historical data and Hubbert's curve trend illustration (Source: adapted from Konkraft, 2008, p.16)

The Figure 1.1 is based on the historical data and predictions from the Norwegian Petroleum Directorate (http://www.npd.no). From this figure we can observe that the NCS oil production has already reached its peak. Therefore, the industry faces so called '*tail-production*' phenomenon. And this aspect forces the companies to decrease the costs of the oil extraction because with the tail production the costs percentage ratio in respect to profits tends to be much higher.

The investigation of the upstream logistic processes on the NCS has shown a considerable potential to improve the coordination between the various actors in its complex value chain.

The Norwegian Oil Industry Association (OLF) claims that over the recent years the oil and gas industry has faced a rapid development in the information and communication technologies. Moreover, there has been also observed an essential improvement in sensor and standalone systems in the industry. The aforementioned technological advances together with the changes in the operational concepts in the industry are referred to as the "Integrated Operations" initiative. The IO concept is an operational concept enabled by the use of the real time data, collaborative techniques and the utilization of multiple expertises across disciplines, organizations and geographical locations. The deployment of the IO is supposed to decrease the operational costs as a result of more accurate and timely decision-making. Moreover, the discussed operation concept is also supposed to improve the overall Health, Safety and Environment (HSE) performance in the oil and gas industry.

However, to take an advantage of such an improvement the companies should enable a more efficient cooperation system through an increased sharing of operational data.

Logistics planning at strategic, tactical and operational levels plays the key role in every organization. And the latter type of planning includes such operations as transportation planning and routing, planning of the supply base operations and planning of the internal logistics. To obtain the sufficient decision making at all these levels, and especially at the operational one, the company should ensure collection and distribution of all the relevant logistics information.

Therefore, to enable the accurate logistics decision making and planning, the company should ensure the availability of all current information and some sort of problem solving capabilities.

The big players in the oil and gas industry have an extremely complex supply chains as they have to deal with a great number of suppliers that should be multiplied by the number of tiers as shown in Figure 1.2.

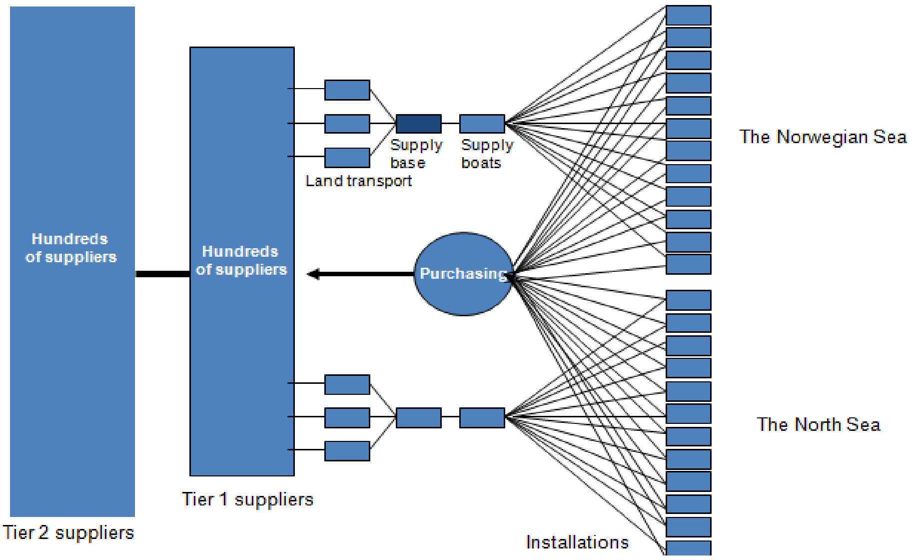

Figure 1.2 Extended supply chain network structure (Source: Aas B., 2010)

Moreover, logistic planning in the oil and gas industry has some other challenges. First, there should be ensured continuous supply of the installations as the idle time coming from the breakdowns of the equipment at the platforms is really costly. Second, the companies are forced to fulfill the cost-efficient operations. Furthermore, the logistics should be conducted in an environmentally friendly and safe way.

However, the complexity of the heterogeneous supply chain structure, the long distances between the supply bases and the offshore platforms, the high degree of uncertainty in demand, and the storage capacity offshore that is limited, complicate the task of logistics planning. For example, different sources indicate that around 80-90% of all the transport in the company is notified only the same day the shipments are retrieved (Aas, 2010). And as a consequence it becomes difficult: to dimension the supply vessels fleet properly, to route the transportation in an efficient way, to fill up the trucks. High level of the fleet underutilization is observed in the oil and gas industry due to these complexities.

Furthermore, the short planning horizon of 0 to 7 hours (Aas, B., 2010), in comparison to the average time between the voyages of 54 hours, is becoming an obstacle to accurate estimation of the transportation needs and to the optimal vehicle routing. The improved data availability in transportation planning would result in better and timely use of supply boats. For example, the companies would be able to increase the utilization of supply boats in the context of improved filling, reduced load and unload times and the optimal choice of sailing speeds.

Therefore, X2X Maritime AS, based on the aforementioned ideas and technologies, has come up with a possible innovative solution within the SCM and IT fields: the '*X2X concept'.* This new idea represents a "*network-wide real time information sharing on the operational level, where all so called "events" are recorded, stored and distributed to the decision makers"* (www.x2x-maritime.no). In other words, the underlying idea of the X2X concept is to make available the logistics information to all the involved actors throughout the whole upstream value chain in order to improve planning and operations. Hereby, it should be mentioned that the purpose of the X2X concept realization is to fill in the internal and external information gaps in all organizations, both offshore and onshore. The availability of the real time data through the whole supply chain will help the companies to increase its cost efficiency and environmental performance.

On the basis of this concept, X2X Maritime AS is developing the IT solution. The X2X solution is supposed to transform both the behavior and performance of the upstream supply chains targeting the Installations on the NCS by allowing all actors to utilize the X2X-hub, see Figure 1.3.

The X2X hub is an information system where so called '*events'* are collected from the existing systems of the actors: suppliers, carriers, supply bases, supply boats and installations. It is enabled by the X2X system's scalability and ability to support different communication standards. In fact, it was realized by the founders of the concept, that there is a gap in logistics information sharing on the operational level in the upstream supply chain. Some of the entities on the internal and external sides of the upstream supply chain use specific applications which are not interconnected. For example, the carriers use their own applications for the shipments tracking, and offshore installations use their own information systems for inventory control and etc.

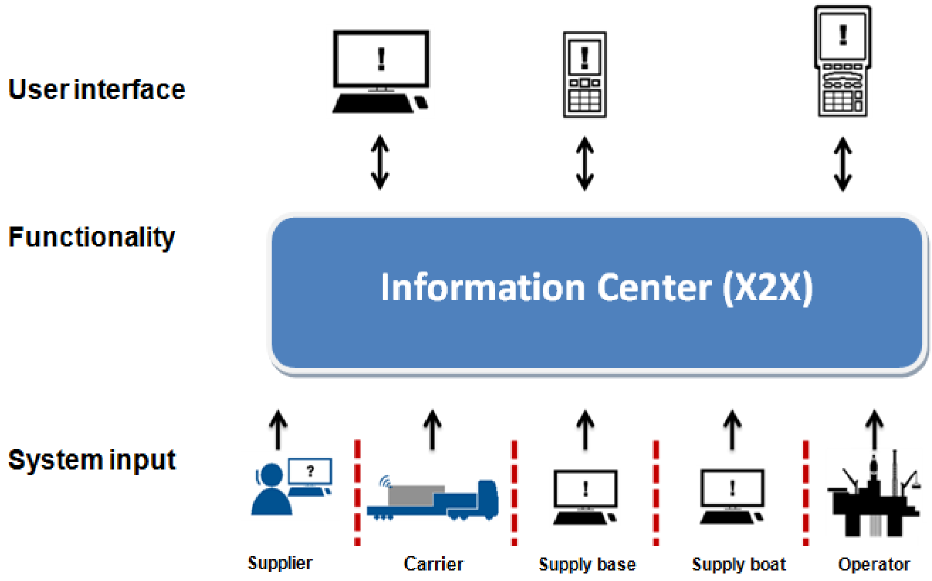

Figure 1.3 The X2X hub system design. (Source: Aas B., 2010)

The development team claims that implementation of the X2X hub will result in three key areas of benefits: costs reduction, greener environmental performance and the improved safety (Figure 1.4).

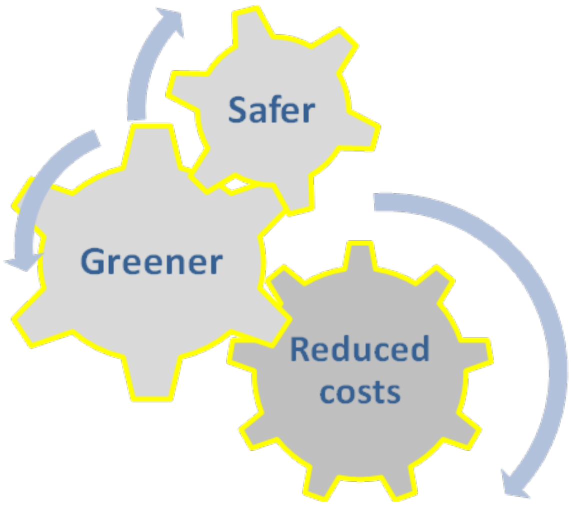

Figure 1.4 The benefits of X2X. (Source: Aas B., 2010)

Hereby, we should highlight that all these benefits are the result of the improved planning. Since, availability of timely and accurate logistics information on all the events in the supply chain results in increased transportation planning accuracy. And as a consequence it leads to increased fleet utilization, decreased CO_2 emissions and enhanced safety of operations.

Obviously, there might be an alternative to the X2X hub - the direct integration with each player in the chain. However, it would be a really complex way of the information integration comparing to the central hub solution. Moreover, the ERP systems - the main provider of the event information for the X2X hub, are rather inflexible for the integration with each other.

Therefore, the X2X concept and solution are highly important for the industry. Furthermore, in the future the company is planning to expand the data collected and presented by deployment of advanced automated data collection technologies as the Radio Frequency Identification (RFID), trip computers, geo-fencing and etc.

The interposition of the X2X concept on the edge of IT and SCM, and its ability to serve the highly challenging oil and gas industry, makes it an interesting subject to investigate.

2. METHODOLOGY OF RESEARCH

In this part of the thesis we clearly state the research problem. Then we set goals, objectives under the research problem and formulate the research questions. We also describe the methodology that we will use in our research in order to answer the research questions and achieve the goals. Then we define the boundaries and the structure of the research.

2.1. Research problem

Based on the X2X concept's description presented above, we can state that it is considered to be highly potential and favorable for the SCM. The deployment of the X2X solution is supposed to enable the companies to benefit from the already existing information systems and to establish a high level of collaboration among SCM actors.

However, it would be interesting to investigate the relevance of the X2X concept and solution to the needs of the SCM, as we found out this issue are not clearly defined at the moment.

Moreover, the topic of the relationship between the IO practices in the oil and gas industry and the X2X concept also represents a subject to explore, as the oil and gas companies emphasize the importance of the IO development and deployment.

Finally, as the X2X is also the IT-based solution we consider it's important to clarify the place of the X2X among the other Information Systems designed for the SCM framework.

Therefore, the main research problem is to evaluate and analyze the place of the X2X as a concept and solution in serving the needs of oil and gas upstream supply chain.

2.2. Goal and objectives

Considering the aforementioned challenging issues, we formulated the main goal of our thesis as the following: ***to define and investigate the role of X2X in serving the needs of oil and gas industry SCM*.**

Under this goal, and based on the X2X concept description, we found the following ***objectives*** to be relevant to our research:

- *Review the relevance of the X2X concept to supply chain management*. Even though it is taken for granted that the X2X concept serves the SCM needs our task is to specify the role it plays within SCM;

- *Explain the relationships between X2X and the Integrated Operations practice.* As we have already discussed it represents a particular interest for us to explore the way in which X2X fits into the IO concept development and implementation, as IO is the industry major trend;

- *Identify the X2X solution's place within the existing supply chain management Information Systems.* In order to understand the major differences, and predict the future directions of the X2X solution's evolution, we find it necessary to identify its current position in the pool of the IS used for the SCM needs.

- *Specify the potential evolution of the X2X solution.* As the system at the present moment is still in its development phase, we find it essential to propose potential roadmaps of its future evolution.

2.3. Research design

In order to achieve the goals and objectives of this thesis we cover and investigate the issues of the special needs of SCM in the oil and gas industry, and, moreover, take into account the industry trend as the IO. The case study research is an appropriate methodological tool for the purposes of current research, as we explore the contextual conditions for the X2X concept.

Obviously, the unit of analysis in our case is the X2X concept. Furthermore, the main research questions of this study, presented later in this section, have the 'how" and “why” nature, and according to Yin (2003), to answer such questions the single-case study research methodology is used.

Moreover, based on the formulated goal and objectives and taking into account the review of research design literature we should state that the research we are going to carry out in our thesis is of qualitative nature. According to Ritchie and Lewis (2003) qualitative methods are used for research questions requiring explanation of some social phenomenon and its contexts. Moreover, Ellram (1996) claims that the result of qualitative research creates a better understanding of relationships or complex interactions. Therefore, the defined goal of our research determines its qualitative nature. And our task is to examine the body of the relevant literature to determine the place of the X2X concept within SCM and industry practices.

Furthermore, we should point out that in order to achieve the discussed goal and objectives we will use the mixture of explanatory and exploratory research methods.

We find it reasonable to use an explanatory research method as it is used to show connections and relationships between the variables, to suggest reasons for events and to make recommendations for change (Hart, 1998) For instance, we will use explanatory method for the issues, where we know that X2X concept serves the needs of SCM or is related to IO, however, we would like to explain the reasons for this relevance.

The exploratory method is considered to be the main one for our research. According to Hart (1998) it’s used to provide better understanding of the subject and illumination on the process or problem. Therefore, it’s suitable for our thesis to assist to evaluate the potential of the X2X concept being developed by the X2X Maritime AS.

What is more, according to Hart (1998), a literature review is an integral part of the success of the research, providing academically enriching experience to obtain more knowledge and understanding of the subject.

Therefore, we are planning to undertake a literature review focused on the questions we highlighted as relevant in the research problem. This analysis of the literature will allow us to answer the questions of the research and provide propositions in our thesis.

The data that will be used in our thesis is internal data from the X2X Maritime AS reports and external data from articles published in the academic journals, textbooks, industry reports and the relevant information from the official web sites of the organizations involved in the subject. In particular, for the literature research we will use the resources of Molde University College's library and moreover we utilized the online databases as ScienceDirect and ProQuest.

By conducting a solid literature research, we are supposed to answer the following main ***research questions,*** which were formulated under the goals and objectives of the current research:

1) *Is there an interconnection between the X2X concept and SCM?*
2) *How does the X2X concept fit into SCM framework?*
3) *Why the X2X concept is an appropriate solution for improvement of information sharing within oil and gas industry?*
4) *What is the interconnection between the IO and the X2X concepts?*
5) *How would the X2X solution fit into the framework of the IO practice in oil and gas industry?*
6) *What is the role of Information Systems in SCM?*
7) *How would the X2X solution fit into the framework of the existing SCM applications?*
8) *What are the perspectives of the evolution of the X2X concept?*

2.4. Structure of the research

Our thesis will be based on the describing, examining and analyzing of the X2X concept and solution with the help of sound theory investigation. The literature review will be structured in the following way:

- *Chapter 3* which represents SCM theory, where relevant concepts of information sharing and collaboration will be considered and the relevance of the X2X concept to SCM will be reviewed;

- *Chapter 4* which represents Integrated Operations description, where its development will be investigated and the position of X2X within IO frames will be explored;

- *Chapter 5* which represents Information Systems designed for SCM theory, where various enterprise applications used for SCM needs will be investigated, in order to provide better understanding of the X2X concept's role among them.

In Chapter 6, based on the abovementioned literature review, the discussion on the research questions and the main findings of the research are provided.

2.5. Research boundaries

In general the X2X concept of '*network-wide real time logistics information sharing on the operational level*' could serve a vast amount of industries where the speed and efficiency of operational decision making is required due to safety or high cost of breakdowns reasons. However, in our thesis we focus our research on the application of the X2X concept only within oil and gas industry.

What is more, the concept is being developed for upstream logistics of the oil and gas industry. Therefore, we will concentrate on examining how the X2X can improve the processes within it and the downstream logistics will be out of consideration.

Further, the X2X solution in this thesis is considered from the point of view of SCM application rather than from the technical perspective of its IT structure. Therefore, all the technical specifications of the IT solution will be left out of scope of the research.

3. SUPPLY CHAIN MANAGEMENT AND ITS ITCENTIVES FOR COLLABORATION AND INFORMATION SHARING

As we mentioned above, the particular interest of this thesis is to explore the relevance of the X2X concept in relation to supply chain management (SCM). Therefore, in this section the definition and explanation of the SCM term and concept is provided. Furthermore, the SCM activities are described and the importance of cooperation is pointed out. Moreover, we found the issues of collaboration and inter-organizational relations in SCM to be pertinent in the terms of the X2X concept. The overview of information sharing notion is also included in the theoretical framework as it will assist us determining the reasons for the X2X concept incorporation in the oil and gas industry. And finally at the end of the chapter the role of the X2X concept within SCM is discussed.

3. 1. Definition of the SCM term and the concept

The SCM concept has become popular over the last twenty years and has been defined by many different authors (Christopher, 1992; Stevens, 1989; Lambert et al, 1998; Ellram, 1990, and Cooper et al, 1997). The researches in their articles attempted to explain how the SCM would improve companies' performance.

The reasons of the supply chain management popularity as a concept and managerial approach can be explained by the environmental uncertainty supply chains face due to the increased performance-based competition, rapidly changing technologies and economic conditions.

Referring to the historical roots, the concept is well known since 1982 when it was first introduced by a management consultant; Keith Oliver. Three years later Houlihan (1985) elaborated the SCM concept describing the benefits associated with information sharing and decision coordinating in a supply chain. In the late 1990s, the concept got significant attention and the further scientific research was carried out.

To start with, the definition of supply chain should be clarified. For the purposes of this paper we are focusing on the supply chain definition noted by Christopher (1992, p.138): *"supply chain is the network of organizations that are involved, through upstream and downstream linkages, in different processes and activities that produce value to the customer"*. This supply chain perception was also highlighted by Stevens (1989) who provided a simple model of downstream and upstream supply chain where a manufacturing organization involves its suppliers and customers in the supply chain management process. In this model the domestic and foreign suppliers constitute the upstream part of the SC. And manufacturing/distribution facility, distributors, retailers and customers are considered to be the downstream part of the SC (Figure 3.1)

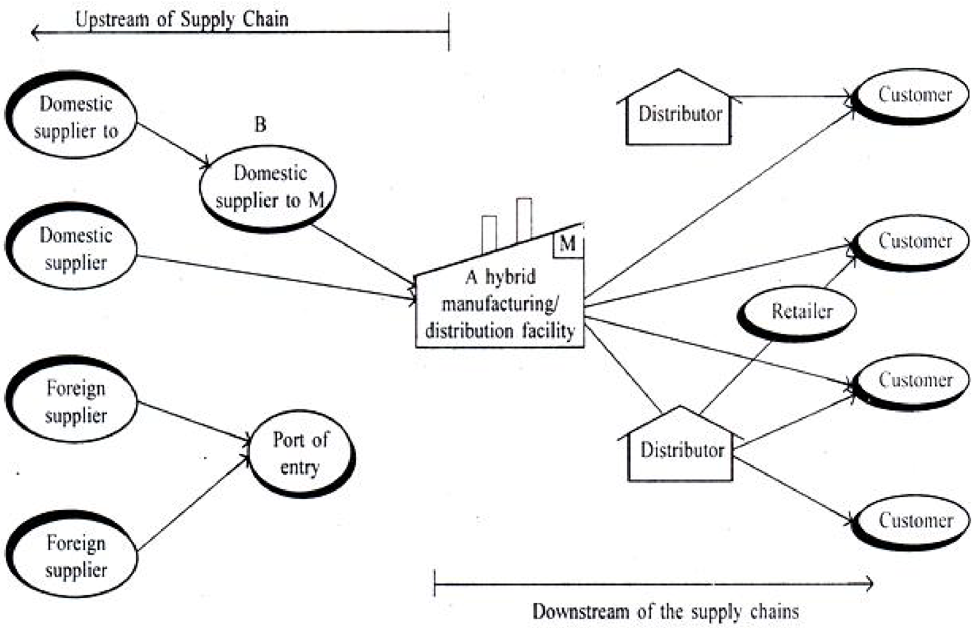

Figure 3.1 A supply chain network diagram of a global unit (Source: adapted from Stevens, 1989)

SCM is usually associated with such research areas as logistics, transportation, strategy, marketing, organizational behavior, economics etc (Demeter, 2004).

Russell (2008) claims that SC thinking can be described as an interconnection of information technology, logistics processes and customer support. This statement was also skillfully described by Friedman (2006) who considered SCM, and its enabling information technology revolution, as a crucial factor for continuous supply chain efficiency improvement. Therefore, it is essential to look more thoroughly at the interconnection between SCM and IT later in our research.

3.1.1. SCM activities

Based upon the literature review (Mentzer et al, 2001; Cooper et al, 1997; Ellram 1990 and Andel 1997) it is defined that SCM consists of the following activities:

Integrated behavior of all supply chain partners allows to coordinate their effort and to timely respond to end-customer needs (Mentzer et al, 2001).

Mutually sharing of information among supply chain members helps to enhance supply chain performance by planning and monitoring various processes (Cooper et al, 1997) and reducing uncertainties by sharing such information as inventory levels, forecasts, promotion and marketing strategies (Andel, 1997).

Mutually sharing of risks and rewards is crucial for long-term focus and cooperation among the supply chain members (Cooper et al, 1997).

Cooperation meaning coordinated activities of firms to produce superior mutual outcomes over time (Ellram 1990). This includes joint planning, controlling activities and evaluating the overall performance of the supply chain. The main benefits it can bring are reducing supply chain inventories, better quality control, improving delivery system, etc (Mentzer et al, 2001).

The same goal and the same focus on serving customers which is a form of policy integration helping to avoid redundancy and overlap, and allows supply chain members to be more effective at lower cost levels (Lassar and Zinn 1995).

Integration of processes such as sourcing, manufacturing and distribution across the supply chain. This can be accomplished through cross-functional teams, third party service providers and use of in-plant supplier personnel (Cooper et al, 1997). Moreover, integration of the processes should have the strategic orientation (Demeter, 2004). It means to make processes and operations able to contribute to the execution of company's strategies inasmuch as the final objective is to increase the competitiveness. Various programs and techniques (ERP, vendor-managed inventories, efficient customer response, quick response, e-commerce etc) along the supply chain can be applied to increase operational efficiency (Demeter, 2004).

Partners to build and maintain long-term relationships which means to extend the life of the contract between them. Mentzer et al (2000) argue that generally speaking SCM is itself the management of close inter-firm relationships, thus understanding partnering is crucial to develop successful supply chain relationships. Forming strategic alliances with supply chain partners such as suppliers, customers and intermediaries is considered to be a competitive advantage for a supply chain. Cooper et al (1997) argue that supporting of cooperation requires a small number of partners, but they should be the key partners.

For the purposes of research of the X2X concept, we find it essential to pay attention to the issue of cooperation with partners: collaboration and inter-organizational relationships in SCM and information sharing.

3.2. Collaboration and partnership in SCM

Increased competition, higher customer requirements and scare resources make executives strengthen supply chain integration and gain sustainable competitive advantage by maintaining partnerships. This requires from companies the ability to synchronize interdependent processes, to integrate information systems and to cope with distributed learning (Simatupan et al, 2002). However, the question is whether the partnership is a requirement for achieving business success (Lambert et al, 1996).

The importance of building and managing relationships among members of the supply chain was recognized by many authors such as Cooper and Gardner (1993), Lambert and Emmelhainz (1996), Barratt (2004), Sabath and Fontanella (2002), Awad and Nassar (2010). The reason is that SCM involves many independent organizations, thus, ***managing intra- and inter-organizational relationships is a crucial factor to obtain the supply chain efficiency*.** What is more, the significance of effective inter-company relationships to supply chain integration is captured in detail in the researches carried out by Mentzer et al (2000), Power (2005), Demeter and Gelei (2004), Sehgal (2009), Simatupan et al (2002).

To start with, Sehgal (2009) defines ***supply chain collaboration*** *as any processes within companies which are conducted collaboratively in order to provide better planning and execution or sharing of information*. In other words, collaboration determines the way companies cooperate with each other within a given chain (Demeter and Gelei, 2004).

Simatupan et al (2002) argue that *collaboration between independent companies in a supply chain*, such as raw-material suppliers, manufacturers, distributors, third-party logistics providers and retailers, *is significant for achieving the flexibility to improve logistics processes*. Lack of coordination among the SC partners can result in unbalanced operational performance, including higher inventory costs, longer delivery times, higher transportation costs, higher levels of loss and damage, and low customer service.

3.2.1. Forms and Types of Collaboration

Barrat (2004) indicates four forms of collaboration such as internal, external, vertical and horizontal collaboration (Figure 3.2).

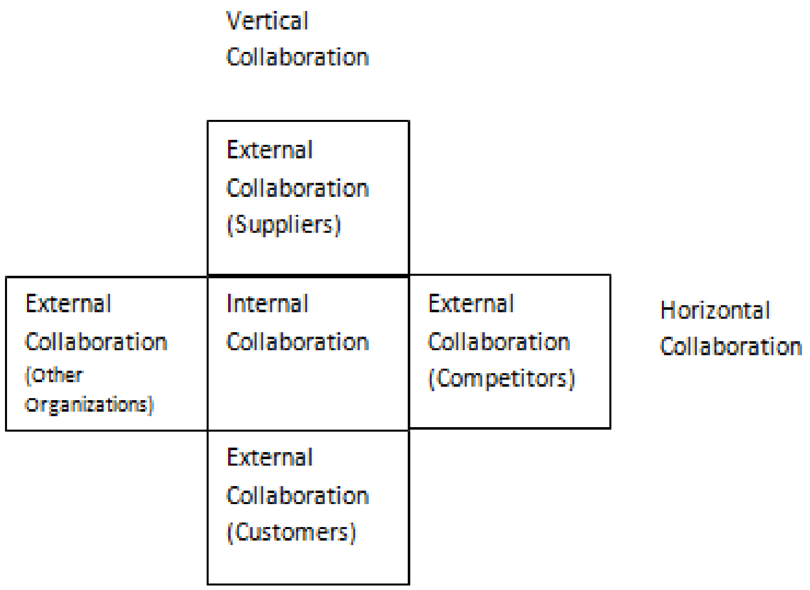

Figure 3.2 Types of Collaboration (Source: adapted from Barratt, 2004)

According to this classification, *internal collaboration* takes place between departments or functions from a single firm, *external collaboration* occurs outside the company's boundaries across independent parties. *Vertical collaboration* is external collaboration with suppliers or customers, while *horizontal collaboration* occurs with other firms such as R&D partners, competitors or non-profit organizations.

The main focus of this paper is on vertical collaboration, in particular with suppliers, as the X2X concept is considered to be implemented to increase collaboration between supply chain partners. According to Charvet and Cooper (2010), vertical integration can take many forms such as sharing point-of-sale information, joint forecasting, setting mutual sales targets and resolving quality problems together.

The cooperative relationships focus on sharing of information between companies, being conscious of common interest areas and mutual competitive advantage. In the context of a complex rapidly changing SCM environment, the ***cooperative behavior has become a critical element for effective implementation*** (Power, 2005).

Generally, companies tend to have partnerships with suppliers and customers, ranging from arm's length relationships (consisting of either one-time exchanges or multiple transactions) to vertical integration of the two organizations, see Figure.3.3 (Lambert et al, 1996).

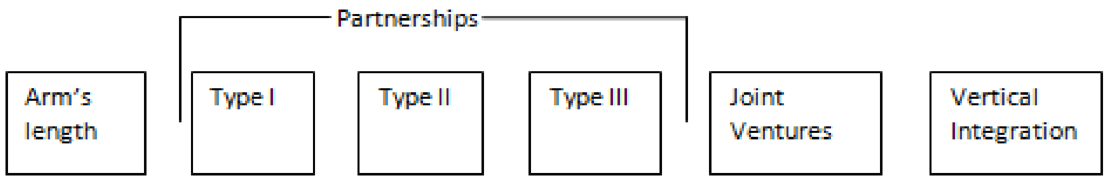

Figure 3.3 Types of Relationships (Source: Lambert et al 1996)

Arm's length relationships represent an appropriate option in many situations and can be described as relationships between two organizations conducting business with each other for some period of time. They involve multiple exchanges without joint commitment or joint operations. Eventually, when the exchanges at hand end, the relationship ends.

On the other side, ***joint ventures*** involve some degree of shared ownership across two parties. And ***vertical integration*** refers to a form of business organization in which all stages of production in the SC are controlled by one company.

Lambert et al (1996) has indicated three types of partnerships:

- ***Type I.*** Partners on limited basis coordinate activities and planning. Usually this partnership involves only one functional area or division within each organization.

- ***Type II.*** Relationship is long-term oriented, but not supposed to last "forever". Activities are coordinated and multiple divisions and functions are involved in the partnership.

- ***Type III.*** Significant level of operational integration is developed in such relationships. Partners are considered as an extension of their own firms and there is no "end date" for this partnership.

Based on the above classification of partnerships, we can observe that any company can have a wide range of relationships to prosper in the market. Lambert et al (1996) argue that the majority of these relationships are not partnerships at all, and can be associated with the arm's length type of relationships. He also claims that most of the partnerships are of Type I within a SC. And there is a limited number of Type III partnerships as they are established with the key suppliers and customers for the business. Partnerships are required when the partners could gain benefits such as cost efficiencies (reductions in transportation costs, information costs, product costs, handling and packaging costs), customer service improvements (reduced inventory, shorter cycle times, more timely and accurate information), marketing advantage (easier entry into new markets, better access to technology and innovation).

Another relevant classification of types of partnerships is proposed by Mentzer et al (2000). The authors divided ***partnership*** in ***strategic, operational and transactional*** partnering based upon the orientation of the partners and the degree of implementation of partnering between two independent companies.

According to this classification, *strategic partnering* is a long-term inter-firm relationship built to achieve strategic goals and objectives, add value to customers and increase profitability to the collaborating partners (Demeter and Gelei, 2004).

In its turn, *operational partnering* tends to attain parity with rivals to increase supply chain efficiency in the short term. Operational partners don't share strategic initiatives, but considerable operational coordination takes place.

Transactional relationships occur on purchase-by-purchase basis and do not look beyond the scope of the individual purchase and, therefore, do not address the level of operational partnering or strategic partnering.

Two aspects of the efficient SCM described by Mentzer et al (2000): ***partnering orientation*** and ***partnering implementation*** are critical to obtain and sustain competitive advantage for any supply chain.

The *orientation of the partners* refers to *shared values and beliefs existing between partners* needed to better understanding how the partnership functions. Partnering orientation is implemented, for instance, when the relevant information is shared and common based technologies are utilized.

However, to build a strong partnership, just understanding the potential benefits are not enough. According to Lambert et al (1996), to make partnership grow and strengthen corporate compatibility, mutuality and a similar managerial philosophy are important. Furthermore, Demeter and Gelei (2004) supposed that the development of information sharing processes in collaboration has an outstanding importance.

Moreover, some research point out (Sabath and Fontanella 2002; Mentzer et al 2001) that supply chain collaboration is also connected with people. Simatupan et al (2002) identified basic challenges of building partnering relationships regarding the "human component". Examples of this are not willingness to share their private information in an optimum way with their partners and motivation of individual members to align local decisions with the mutual objectives. These issues are also crucial for the X2X implementation in the supply chain as one of the problems it can face could be an unwillingness of supply chain partners to share information.

Based on our review of the body of relevant SCM literature, we found that information sharing is one of the fundamental success factors in order to obtain true SCM in a supply chain. Consequently, for the purposes of our thesis, this subject is examined in details in the following section.

3.3. Information Sharing in SCM

The objective of this section is to reveal the important issues of information sharing in a supply chain. SCM implies both material and information flow coordination and control. It is widely accepted by SCM researchers that efficient information sharing helps partners to improve the overall performance of the supply chain as a whole. (Yu et al, 2001).

Furthermore, the development of advanced IT allows the companies attaining of the continuous integration within supply chain at rather low costs (Huang et al, 2003; Siau and Tian, 2004; Choi et al, 2008, Baihaqi et al, 2008). Due to the vast amount of mordern technologies, as Electronic Data Interchange (EDI), the Internet, mobile computing, Wireless Application Protocol (WAP), web service and Extensible Mark-up Language (XML), available nowadays the era of information sharing is boosting. Therefore, Baihaqi et al (2008. p.2) point out that ***the problem of 'whether to share information or not' is irrelevant nowadays,*** however, the essential issues are ***which information to share***, ***how to choose the appropriate mechanisms for exchanging the information***, and ***how utilize the available information in order to improve decision making and to be competitive in the market.***

Every business deals either while ordering or dispatching of goods are accompanied, with a minimum of information exchange. Madlberger (2008) claims that *information sharing* is considered as *information exchanged between organizations that exceeds the abovementioned minimum.* However, even though information sharing exceeds the regular exchange of cross-organizational trading data, this type of data is included in information sharing.

The Global Logistics Research Team addresses *information sharing* as *"the willingness to exchange key technical, financial, operational and strategic data"* (Global Logistics Research Team, 1995).

Information asymmetry is a main reason for inefficiency of any system. And according to Madlberger (2009) information sharing deals with one of the most important issues in SCM – the information asymmetry of the players in the supply chain which leads to uncertainties within a supply chain and as a consequence, for instance, unnecessarily high levels of inventory; the so called Bullwhip affect. (Lee et al, 2000, Zhiling et al, 2006). Moreover, many researchers claim that information sharing can significantly reduce the SC costs (Gavirneni et al, 1999; Huang et al, 2003; Cheng, 2010) and enable the companies to achieve competitive advantage.

Baihaqi et al (2008) argue that information sharing provides necessary linkages between partners in order to orchestrate all the activities in a SC, and effective SC is a prerequisite to quality of service and profitability. They highlight that poor information flows result in adding up 10 to 20 percent to manufacturing costs, and therefore efficient management of information flows and their synchronization with the other processes is essential while gaining competitiveness in the market. (Lee et al 2000, Baihaqi et al 2008).

Obviously, the companies gain cost efficiency and visibility of the processes in supply chain through the information sharing. However, it is still not clear which information the companies should exchange.

3.3.1. Classifications of Information Sharing

Malderberger (2009) regards information sharing as a multidimensional construct comprised with four dimensions of **information characteristics**:

- *content* - the type of information shared, for instance, poin-of-sales data;
- *frequency* – the oftenness of information shared, for example, the daily or quarterly data exchange;
- *level of detail* – how much detailed or aggregated the information is;
- *actuality or up-to-dateness of the information shared*, for instance, the current or the past period data.

Lee and Whang (2000) discussed the **types of information shared between partners** in a typical SC. Based on the investigation of information sharing in different industries they, came up with five general types of information exchanged:

- *Inventory level data;*
- *Demand information or sales data;*
- *Order status tracking data;*
- *Sales forecasts;*
- *Delivery schedules.*

However, due to a vast diversity of information content and a large number of information sharing modes it seems rather difficult to classify the level of information sharing in a SC.

Therefore, Seidmann and Sundararajan (1998) proposed to treat the level of information shared not from the point of view of its content, but based on the impact it has on the parties sharing the information. Using this idea, they came up with four broad categories of information sharing: ordering information, operational information, strategic information and strategic and competitive information, shown in Figure 3.4.

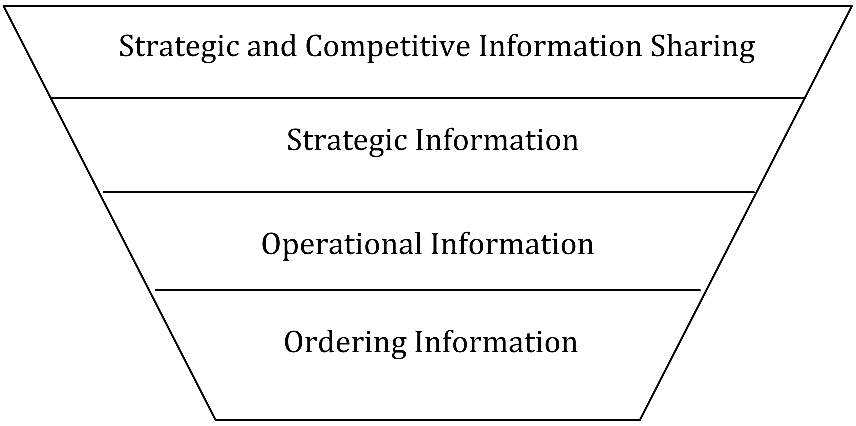

Figure 3.4 Levels of information sharing (Source: Seidmann and Sundararajan 1998, p.113)

Hereby, the *'ordering* information level' represents the exchange of transactional information as order prices, quantities via EDI or related technologies. It is one of the oldest and most common forms of information sharing that is aimed at reducing transaction costs and the order cycles' duration. In this case both parties gain from reduced order cycle times but each party improves efficiency independently. However, if we see the discussed above Madlberger's (2008) definition of information sharing this level even cannot be considered as information sharing at all, as it is just the basic and compulsory information exchange needed for trade between organizations and no information is shared beyond the transaction.

The next level, according to Seidmann and Sundararajan (1998), involves sharing of *operational* information as inventory levels. Vendor managed inventory system is one of these cases, where by the usage of superior expertise beyond the organizational boundaries the parties can improve the efficiency of their operations.

The third level presumes the *strategic* value of the shared information. Seidmann and Sundararajan (1998) claim that the information sharing of this level happens when one of the organizations possesses information that it can derive little value from, but the other can use it to generate strategic and operational benefits. The example of such information may be point-of-sales data which can help the supplier improve forecasting accuracy.

The last and the highest level of information sharing add both *strategic and competitive* benefits to the parties exchanging the information. For instance, the buyer can provide the supplier with broad market information, as category point-of-sales data, that provides competitive and strategic benefits to the supplier getting the market information.

Samaddar et al (2006) proposed the typology of interorganizational information systems, that takes into account both charactheristics of organizational scope (strategic or operational) and the volumes of information shared between the partners in supply chain.(Figure 3.5.)

The authors argue that when t*he strategic importance and volumes of information shared are low* it is **Type 1** inter-organizational information sharing. For example, if the product is well established and has a stable demand, then there is a minimal information requirement. The **Type 2** information sharing is the aforementioned situation, thus requiring frequent information flows. However, it should be mentioned that the large volumes of information sometimes lead to unnecessary increase in the cost of its processing, and this cost is substantial compared to the efficiency gained from information sharing. **Type 3** is the case of high strategic importance and low volumes of information shared, for instance, joint development of a new product design. Regarding the **Type 4** of information sharing, it presumes the high volume of strategic information exchanged; that serves in constantly changing markets with the need for frequent information sharing.

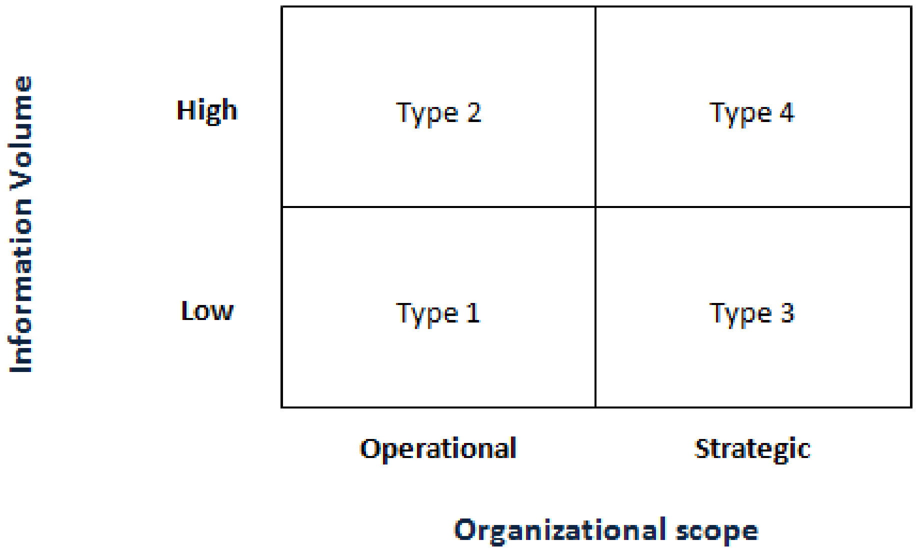

Figure 3.5 Typology of inter-organizational information sharing (Samaddar et al 2006)

Moreover, the authors examined the relationship between supply network structure and the efficient information sharing typology. Based on the literature and current practices research they found out, that if the supply network structure is dyadic then it would be essential for the partners establish the information sharing of strategic level (Type 3 and 4). However, for multi- channel supply networks it would be more profitable to achieve high volume operational information exchange of the Type 2. Further, when the number of stages in supply chains grows the Type 2 of inter-organizational information sharing is proposed.

3.3.2. Benefits of Information Sharing

The benefits of information sharing have been exceedingly discussed and explored by researchers: Lee and Whang (2000), Yu et al (2001), Lin et al (2004); Guo et al (2006); Byrne and Heavey (2006); Choi et al (2008); Baihaqi et al (2008) and others.

Lin et al (2004) argue that information sharing enables the companies *lower the total cost*, achieve *higher level of customer service* and *shorten the order cycle time* (Li and Lin, 2006). Moreover, effective information sharing is considered as tool to cope with Bulwhip effect occurance (Lee and Whang, 2000; Yu et al, 2001; Byrne and Heavey, 2006). In general, there were revealed the following *benefits of* transparency achhieved by *information sharing*:

- cost effieciency,
- improved forecasting,
- higher customer sattisfaction,
- higher service levels,
- quicker response to the market needs,
- shorter lead times.

Furthermore, Chu and Lee (2006) assert that information sharing enables the companies to use the popular supply chain practices as vendor managed inventory, click and mortar, drop shipping and vendor hubs, which allow the firms to maintain efficiency on keeping inventory. The same fact was proved by Zhou and Benton (2007), they investigated the relationship between the supply chain practice implementation and information sharing. Examining the literature and current practices they found out that effective information sharing meaningfully enhances effective supply chain planning, just-in-time production and delivery practices.

Even though many studies have proved the evident benefits the companies obtain from information sharing, the research conducted by Baihaqi et al (2008) shows that the firms are reluctant to share intensively operational and planning information, and they seem still to act independently to achieve their own operational efficiency and disregarding the system wide supply chain approach.

3.3.3. Modern Trends in Information Sharing

Most managers nowadays realize the significance and benefits of collaboration and information sharing with their partners, as the *performance of supply chains depends on the availability and quality of timely information.* Therefore, Ballou (2007) claims that *boundary-spanning management is the future of SCM* as the broader and systematic approach to supply chain decisions leads to high cost savings and improves customer service. He states that advancing technologies allow the improvements of quality, quantity and spreading of information within supply SC. And, therefore, information sharing creates the basis for implementation of boundary-spanning management in SC (Ballou 2007).

Moreover, nowadays it is widely discussed, not only information sharing within supply chains, but knowledge sharing and management. The knowledge and information sharing terms are often misused, thus there is a clear difference between them. To see this difference we refer to Ackoff and his article “From data to Wisdom” (1989), the author claims that:

- *Data* is raw, and it does not have any meaning itself; for example, a list of numbers obtained from observations that do not tell anything to the reader;

- *Information* is the treated and organized data which already gets the meaning; for example, the spreadsheet with the order number and price.

- *Knowledge* is the accumulation of appropriate information in the way that it should be purposeful, it can be some way of organizing the set of information in the way to gain some control over the system; for example it could be some instructions or control systems.

Samuel et al (2010) state that under the current conditions of economic crises and hyper-competitive environment the profits fall and costs increase. Therefore, they argue that new trade-offs should be found and new organizational models should be developed in order to enhance the decision-making process. The authors pointed out that knowledge cooperation and sharing within supply chain is the basic tool for being competitive under the current market conditions. However, the research Samuel et al (2010) conducted reveals the lack of knowledge sharing, as only 38% of the interviewed companies declared creating common tools with their partners.

Furthermore, Huang and Lin (2010) claim that sharing knowledge in the supply chain is crucial, but here arises the problem of interoperability of data as the existing technologies are useful to transfer information rather than knowledge. The authors proposed the solution for knowledge sharing via semantic web based on the semi-structured knowledge model and sharing platform. The new solution allows the entities in the supply chain to share the knowledge and practice on problem solving and decision making, and it helps to find the way to deal with the problem at hand based on previous experiences, and moreover to get in contact with experts in the SC in order to find the solutions to the problems.

3.4. The relevance of X2X in SCM

The X2X concept is being developed to serve the upstream oil & gas industry supply chain's needs, therefore first we consider it as essential to look closer at the upstream supply chain's structure of the oil and gas production field, see Figure 3.6.

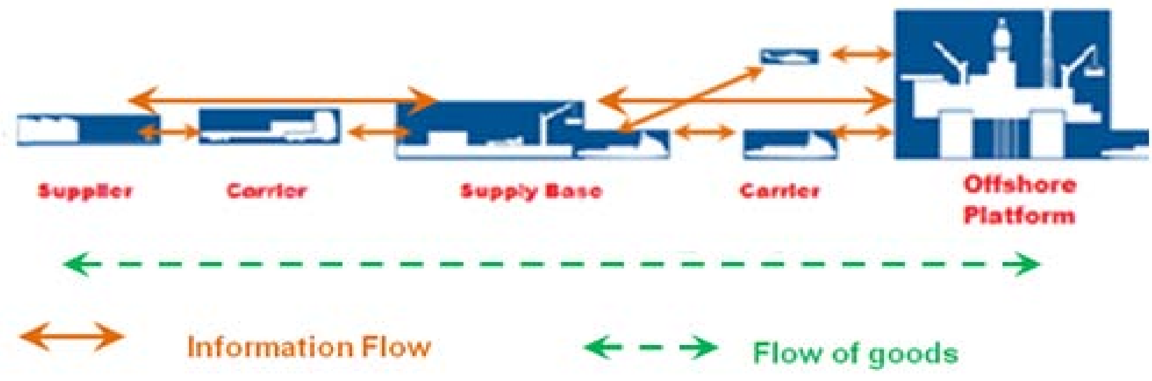

Figure 3.6 The upstream supply chain of oil and gas production field (Source: self developed)

From this figure we can observe, that the information flow interconnects mostly the adjacent actors in the supply chain, while the other actors do not get the same data when needed from each other. For instance, the information exchange becomes insufficient when Supplier does not get the information when required directly from Offshore Platform, but only from supply base. Moreover, the flow of goods goes in both directions in this supply chain as about 80 % measured in weight goes in return from the installation.

Therefore, to improve supply chain efficiency in the oil and gas industry, a new philosophy is required in terms of collaboration, acquisition of sophisticated information technology, information sharing and asset optimization (Hussain et al, 2006; Young, 2005). And for this purpose, the X2X concept might be the most reasonable solution.

Demeter (2004), for instance, claims that SCM helps to gain competitive advantage for all collaborating parties. It is argued that implementation *of SCM requires some level of coordination across organizational boundaries, including integration of processes and functions within and across the supply chain* (Cooper at al. 1997).

We have examined different types of partnership and assume that the X2X concept should be focused on *vertical collaboration with the suppliers* of the major player on the Norwegian Continental shelf, *in form of sharing real-time operational information*. This information will give the better view of operations; will allow improvement in collaborative planning, monitoring events and reacting faster to any changes arising in a dynamic environment as the oil and gas industry is.

Furthermore, information technologies are considered to be an important success factor of SCM efficient performance among SCM activities such as integrated behavior, mutually sharing of information, mutually sharing of risks and rewards, cooperation, the same goal and the same focus on serving customers, integration of processes, etc (Mentzer et al, 2001; Cooper et al, 1997; Ellram, 1990; Andel, 1997).

The X2X concept is based on the idea of network-wide real time information sharing on the operational level. Obviously information sharing is an essential part of SCM, as it helps to deal with the issue of supply chain information asymmetry. Insufficient inventory levels, high lead times, uncertain supplies and low service level of offshore installations are indicators of low information sharing between the parties on an intra- and inter-organizational level in the supply chain. The key players at the NCS have already revealed this problem and established fiber optic connection between the major offshore platforms and onshore supply bases. This constitutes a modern infrastructure with the necessary capacity allowing efficient communication and information sharing within the company.

According to Samaddar's et al (2006) research, described in the previous section, the Type 2 information sharing is adaptable for the oil and gas company. The supply network of such company is complex and multi channel; in such case it is essential to achieve high volume operational information sharing. The X2X concept presumes sharing of operational information within and between the companies allowed by extraction of information contained in existing systems.

Based on the literature review we can claim that the information sharing improved via X2X implementation will allow the companies: to be more cost efficient, improve customer service level and shorten order cycle times (Lee and Whang, 2000, Yu et al, 2001). Moreover, the X2X concept together with some other developments in the field as, for instance, IO concept (discussed in the next section) may lead to the boundary-spanning management practice in oil and gas industry in the future.

Having considered the above mentioned components of the successful implementation of SCM, we believe that the X2X concept is relevant within SCM as it includes mutual information sharing, integration of processes and better coordination among the supply chain partners.

First, as the X2X will function as an info-exchange-hub for the oil company and its suppliers, providing supply chain partners with real-time operational data when needed. This will allow real time information sharing in an oil and gas industry.

Second, the coordination within supply chain will be improved as partners will have the access to the required data immediately though integrated information systems.

Third, more efficient operational and tactical decision making is enabled with the help of X2X, which is beneficial for all the partners among the supply chain.

The X2X concept has critical characteristics required for efficient SCM implementation and therefore, can be considered as potentially reasonable solution for further development and deployment in the information systems of the major player on the NCS.

4. INTEGRATED OPERATIONS

The Integrated Operations (IO) is considered to be a relevant topic within our thesis as the X2X concept can be closely related to the IO practice, or even contribute to the introduction of a new generation of the IO in the oil and gas industry. Our goal in this chapter is to examine and define the IO and to position the X2X concept within the IO frames.

The concept of IO is not new and it has evolved together with the information and communication technology (ICT). Its underlying idea has been used by military, racing and spacecraft organizations for a long time and now it has become popular in the oil and gas industry (Yayha, 2010). However, it's should be admitted, that there is not too much literature regarding the IO so far, as this term is relatively new and seems to have become developed particular for the oil and gas Industry mostly in the NCS. Therefore there has been set up an IO Center in the Petroleum Industry (www.ntnu.no/iocenter) in Trondheim at the Norwegian University of Science and Technology. This center conducts research, innovation and education within the field of the IO, to promote the increased oil recovery, accelerated production, reduced operating costs, and the enhanced safety and environmental standards.

The companies working in the oil and gas industry realize the high potential of the IO; thus, it is becoming one of the areas of the high business interest and benefits from the increased investment monies. The high concern to the IO concept is stimulated by some important challenges in the industry as a lot of fields are approaching the end of their life cycle and the cost of their operation soon exceeds the profits. Moreover, some of the new fields are located in the remote and challenging environments. In its turn, the IO aims to reduce operational costs of the assets and increase their profitability. The IO concept also represents a step forward towards fully autonomous offshore platform that will be controlled from the onshore operation centers.

What is more, the NCS has been one of the regions with a greater uptake and success of the Integrated Operations than anywhere else in the world (Konda and Evensen, 2008). And one of the biggest players in the NCS, for whom the X2X concept is being developed, was a pioneer among those who recognized the potential of the IO.

The management of this company believes that implementation of the IO allows to increase the oil recovery and improve the overall performance through new processes linking the advanced real-time sensing capabilities in the field (Yayha, 2010).

4.1. Definition of Integrated Operations

To start with, the explanation of the IO concept should be given. The IO term is provided and used by the Norwegian Oil Industry Association (OLF) (http://www.olf.no/en/). It is also described in some academic articles, companies' reports and white papers, and master theses. It should be mentioned that IO also, at least in the early days, went by other names – as Smart Field, Intelligent Field or Field of the Future, i-Field, Intelligent Plant, Digital Age Operation, Real-Time Collaboration (Yayha, 2010). However, the key elements of all this concepts are the same and in this thesis we will use the IO as the main term.

OLF refers to the IO as to ***"real time data onshore from offshore fields and new integrated work processes"*** (OLF, 2008, p.5). Statoil, one of the Norwegian oil and gas companies, broadens the IO definition: *"collaboration across disciplines, companies, and organizational and geographical boundaries, made possible by real time data and new work processes, in order to reach safer and better decisions – faster"* (Andersen et al., 2008).

IO Center in their annual report (IO Center, 2009, p.2) also describes the IO notion and highlights that *"IO is the integration of people, work processes and technology to make smarter decisions and enable better execution"* (Figure 4.1.). This methodology allows the petroleum industry to gain the benefits and value from the synergic effect of the integration of people's expertise, clear process understanding and advanced use of the ICT.

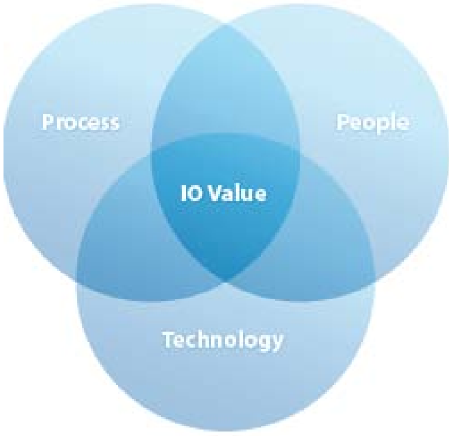

Figure 4.1 Integrated Operation key elements (Source: Capgemini Report, official website: http://www.capgemini.com)

The IO is empowered by the use of the ubiquitous real time data, collaborative techniques and the multiple expertise across disciplines, organizations and geographical locations (Figure 4. 2).

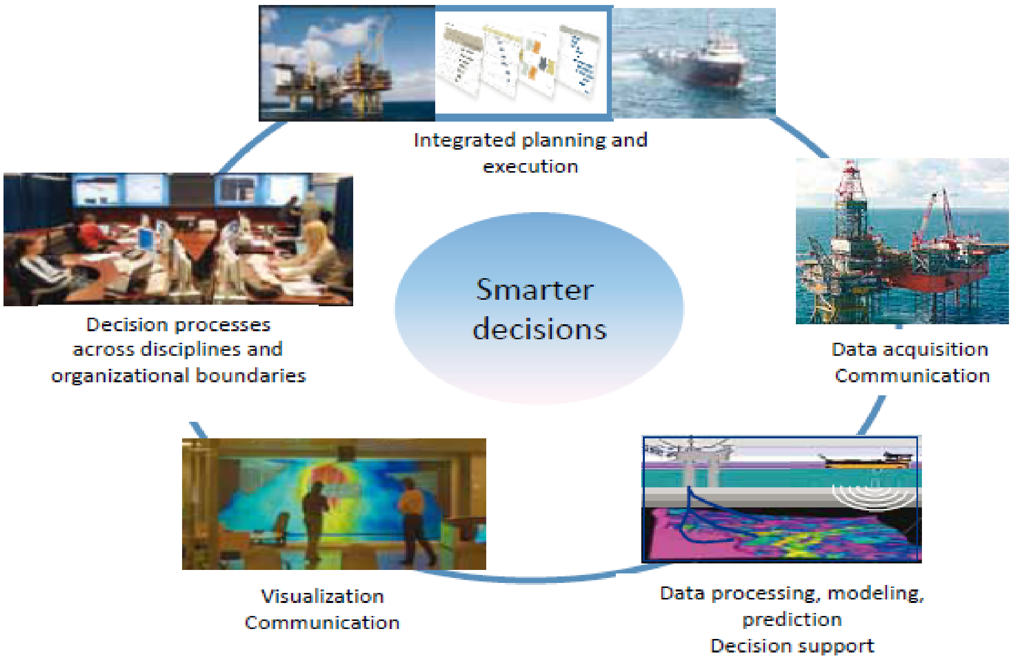

Figure 4.2 Key elements of IO operational philosophy (Source: Annual report 2009 of the IO Center, p.2)

This new way of the operations is based on the “Smarter decisions”. They are made by virtual teams working across the functional and geographical domains and having access to the real time information from the different advanced IS.

Further, Seehusen (2008) argues that the IO is needed to introduce new working methods in the oil and gas industry, based on the increased use of modern ICT.

OLF (2008) highlighted several objectives, or so called ambitions of the IO (Table 4.1).

Table 4-1 The IO’s Ambitions (Source: OLF 2008, p.9)

IO Ambitions	Characteristics
Remote Operational Support	Seamless collaboration between offshore, onshore and 3rd party/OEMs;
Remote Performance Management and Support	Performance of all major items of equipment and systems monitored remotely by company experts or 3rd party/OEMs;
Remote Maintenance Management	Maintenance management systems; integrated with asset planning and linked to remote performance management;
Integrated Decision Making	Information available to global/regional teams to assist decisions; Better decisions in real/near real time based on holistic approach;
Cross-Discipline Multi-organization collaboration	Information available in real time to experts irrespectively of their geographical location; Common visualization environment for all asset data;
Contract Support Strategy	3rd party/OEMs offer new service lines to support operations

In other words, the main goals of the IO implementation are to transfer maximum of the activities to onshore by the ability of remote support and management and involve the multi disciplinary expertise into the decision making.

According to the Centre's for Research-based Innovation report (2010), the main directions of research now for NCS are represented in four programs:

1) **Drilling and Well Construction:** *focuses on the development of the technologies for safer and more efficient drilling operations.* The research on this project has started 15 years ago and by the moment has resulted in the development of a model-based decision support technology and a diagnostic system.

2) **Reservoir Management and Production Optimization:** *is oriented on the development of methods, technologies and work processes enabling maximized reservoir performance.* The research within this field started also15 years ago and resulted in the development of the highly significant reservoir data set that will form the basis of an upcoming "Applied Technology Workshop". The program is still being developed as it requires increasing the robustness of the modeling and optimization techniques.

3) **Operation and Maintenance:** *focuses on the issues of the predictive maintenance control and aggregating the real time data to support vital operational decisions and the integrated planning.* Within this area the general data analysis platform for diagnostics and prognosis was developed. In addition, condition monitoring methods are being developed using acoustic, gamma-ray and other techniques, for the monitoring of safety-critical, static equipment such as valves, separators, etc.

4) **New Work Processes and Enabling Technology:** *is focused on development of the set of tools and methods used to improve the work and the decision-making processes.* By the moment the group of researchers working on this issue obtained the new insights of communication processes within distributed teams and the enabling of cross-discipline cooperation.

The IO center plans to continue the further development of these programs as the need for tighter integration between the main projects has been recognized. The main idea is to provide interaction between the programs focusing on the science of integration, integrated planning and logistics, proactive environmental protection and monitoring, and optimal asset management and production optimization.

Having examined four programs the IO Centre works on, we found that it's relevant to have a closer look on the Program 3 (Operations and Maintenance). The key components of this program are: the predictive maintenance control and aggregating the real time data to support vital operational decisions and the integrated planning are closely linked to the X2X concept of the real-time operational data exchange among the supply chain partners in the oil and gas industry (IO Center, 2009).

The program 3 involves the logistics support optimization plans in pursuing of the Integrated Planning objectives (Figure 4.3).

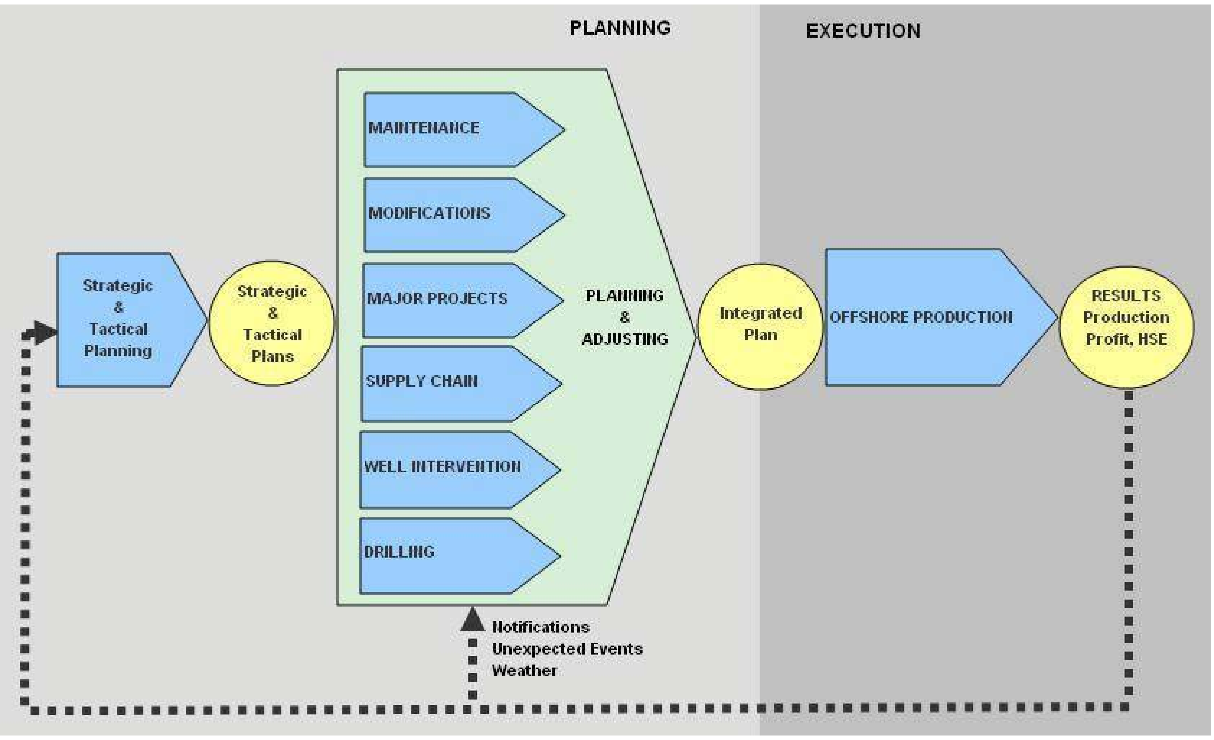

Figure 4.3 Integrated planning execution (Source: Annual report 2009 of the IO Center, p.11)

The goal of the project of the Integrated Planning is to join together the different disciplinary or domain-specific activity plans into one general plan in order to optimize the use of common resources like logistics support and maintenance expertise. Figure 4.3 shows that one of the focuses of the integrated planning is incorporating of the supply chain planning.

Further, in order to enable the use of the IO, OLF together with the leading standardization organization, POSC Caesar Association (www.posccaeser.com), has developed the oil and gas ontology for the important upstream business processes as drilling, development, production and operation. This has become possible due to the development of industry information standards as, for instance, ISO15926 which now allows sharing of the data.

Thus, we believe that the development of the IO is now very active due to the potential benefits of the data utilization it can bring to the companies working in the oil and gas sector. The information in this industry has a great value and the companies working at the NCS have invested in data acquisition and analysis systems for years. However, the utilization of the available data has been low. Moreover, the need for structured well organized data and information was revealed by the industry as relevant information is the main asset to gain competitive advantage.

The X2X concept and the IT-based tool, in their turn, are being developed for the improvement of the data sharing within the upstream supply chain. The deployment of the X2X solution in the company can contribute to the better planning of supply chain processes and contribute to implementation of the Program 3.

From an the IT perspective, the IO is about large scale networked systems, the data fusion algorithms, machine learning, computerized decision making, safety critical domains, autonomy and automation, resource scheduling in the highly dynamic environments and semantic web technologies, see Figure 4.4.

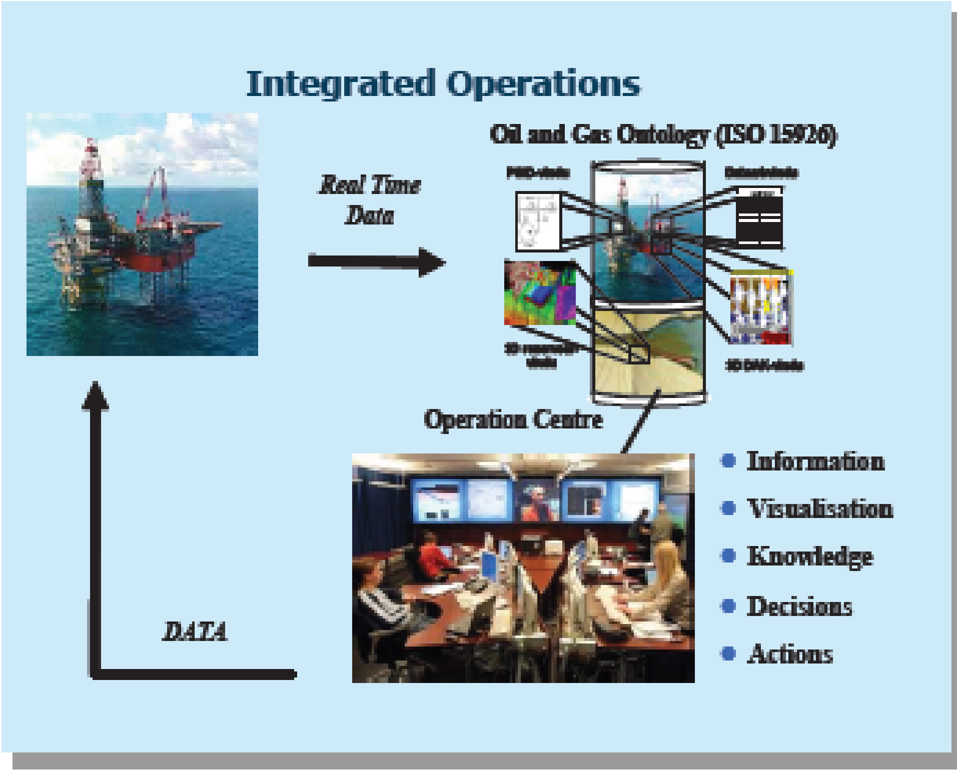

Figure 4.4 IO from an IT perspective (Source: Langeland, StatoilHydro report, 2009, p.2)

Moreover, Rong (2009) claims that cloud computing is the technology that allows industrial collaboration across disciplines and enterprise boundaries. Therefore, the author presents the IO as an industrial cloud, so called the inter-enterprise integration concept.

As we can see, there are many approaches to define the IO. According to Edwards (2008), there are two main philosophies in the industry. The first one considers the new work processes as the enabler of the change in organizations and people for the new operational IO approach. And the other one highlights the technological part of the IO, so it emhasises the technological deveplopment (Strasunskas, 2009).

For the better understanding of the IO concept we will explore its key elements in the following section.

4.2. Key elements of Integrated Operations

Strasunskas (2009, p. 4) points out the ***key elements of the IO*** as People, Processes, Technology and Organizations (PPTO):

1. ***People.*** This aspect deals with the responsibility distribution and organizational and cultural issues of knowledge sharing and usage. This involves the development of skills and expertise, collaboration in virtual teams with the internal and/or external experts, internalizing and sharing of multidisciplinary knowledge, use of collaboration and ICT tools.

2. ***Process.*** This element comes to process description and understanding. The dimension involves tools and systems used for specific tasks, leveraging from vendor expertise for collaborative and the real time decision making.

3. ***Technology.*** This aspect is mostly about technology that allows the real time data information sharing to ensure operative decision making and optimal process execution. This aspect has to deal with various tools for the condition monitoring and remote diagnostics, sensors and automation.

4.***Organization.*** This dimension concerns all the managerial issues as the organizational structure, business strategy, the HSE management and legal matters. This element provides the basis for the interaction of the abovementioned elements.

Therefore, Strasunskas (2009, p.1) concludes that *"IO concerns the deployment and integration of technological advances In a composite manner changing organizational structures, roles and processes in order to improve collaboration and decision-making".*

As it was mentioned before, the integration of these key elements allows the companies in the oil and gas industry to benefit from the IO synergetic approach.

4.3. Benefits of the Integrated Operations

According to Deloitte (www.deloitte.com/us/about), the IO is an important tool for the oil and gas companies searching for ways to bring the full value of their information to bear on the business more quickly.

OLF (2008) claims that the success and the benefits of the IO are based on the ability to implement collaborative decision making relying on the real time data sharing among the onshore and offshore personnel. Strasunskas (2009) argues that to maximize the benefits, all the techonological advances should be related to the organizational structure and the business goals (Figure 4.5).

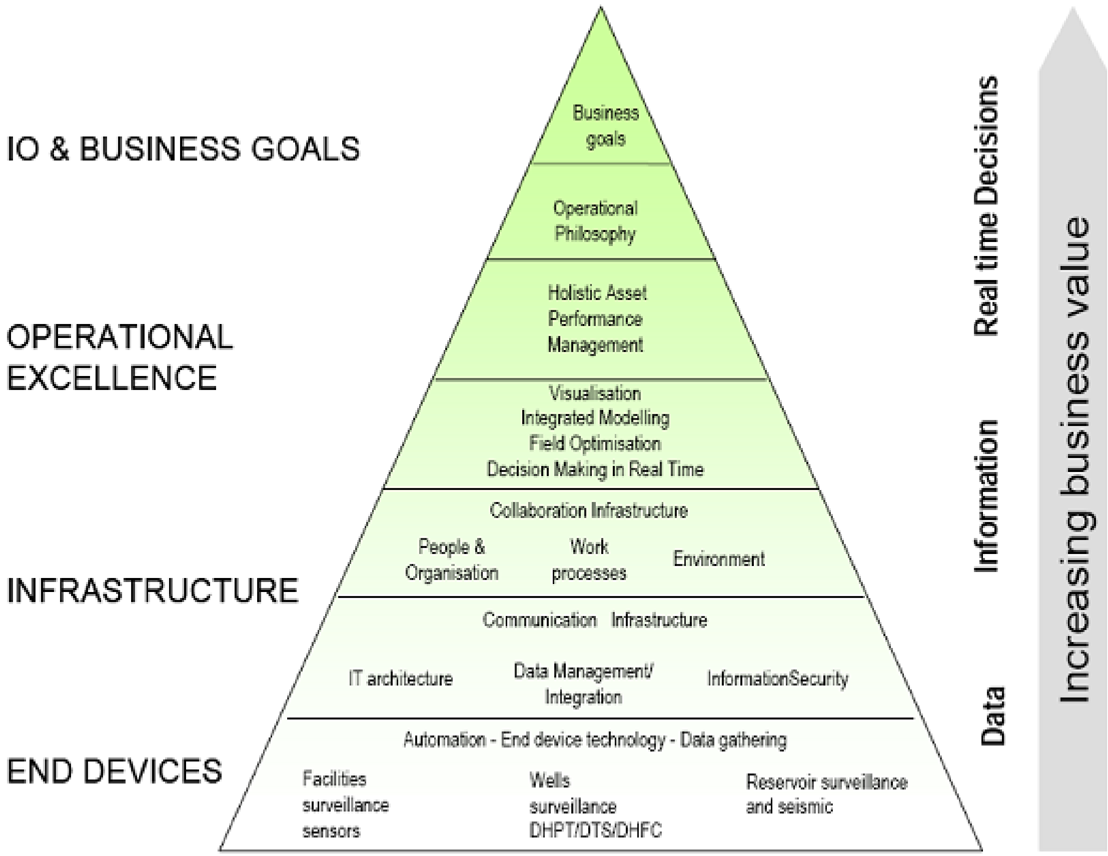

Figure 4.5 The relationship between the levels of the integration and the business value (Source: Strasunskas 2009, p.8)

As we can see, the business value and the benefits from an the IO initiative increase while the IO concept is incorporated in higher level business processes of an organization.

According to Konda and Evensen (2008) primary drivers of the IO are accelerated production, extend reserves reduce costs and increased safety. More particular, the authors highlight that the potential benefits of the implementing the IO could be:

- improved offshore / field & onshore / base offices collaboration,

- improved multi-disciplinary collaboration,
- appropriate location of decision making, either offshore or onshore,
- integration of real time data,
- technology improvements,
- redesigned work processes to make full use of all other benefits.

Some researches (Strasunskas and Tomasgard, 2011) working on the estimation of the IO benefits suppose that not all the benefits of the IO can be quantified by now.

However, some of the IO benefits have been measured, hearby the potential value of IO on the NCS was recognized some years ago when OLF reported that oil and gas companies active in the NCS would increase their revenue by US$45 billion over the next 10 years simply by integrating their operations. And if the companies reject the implementation of the IO, they could expect to lose about US$10 billion in the potential revenue within the next few years (Yayha, 2010).

The awareness of the potential benefits from the IO accelerated the development in the oil and gas industry. Moreover, the latest survey has found that the IO is no longer the future way of working, but increasingly the current way of the conducting business at the NCS (Konda and Evensen, 2008).

4.4. Integrated Operations Generations

The implementation of the IO is a process that began with a long-term scenario for the NCS and evolves through two generations, called G1 and G2 (the integration of on- and offshore operations, ca. 2003–2010 and the integration of companies, ca. 2007–2015 respectively, Figure 4.6.) (Gonzales et al., 2005).

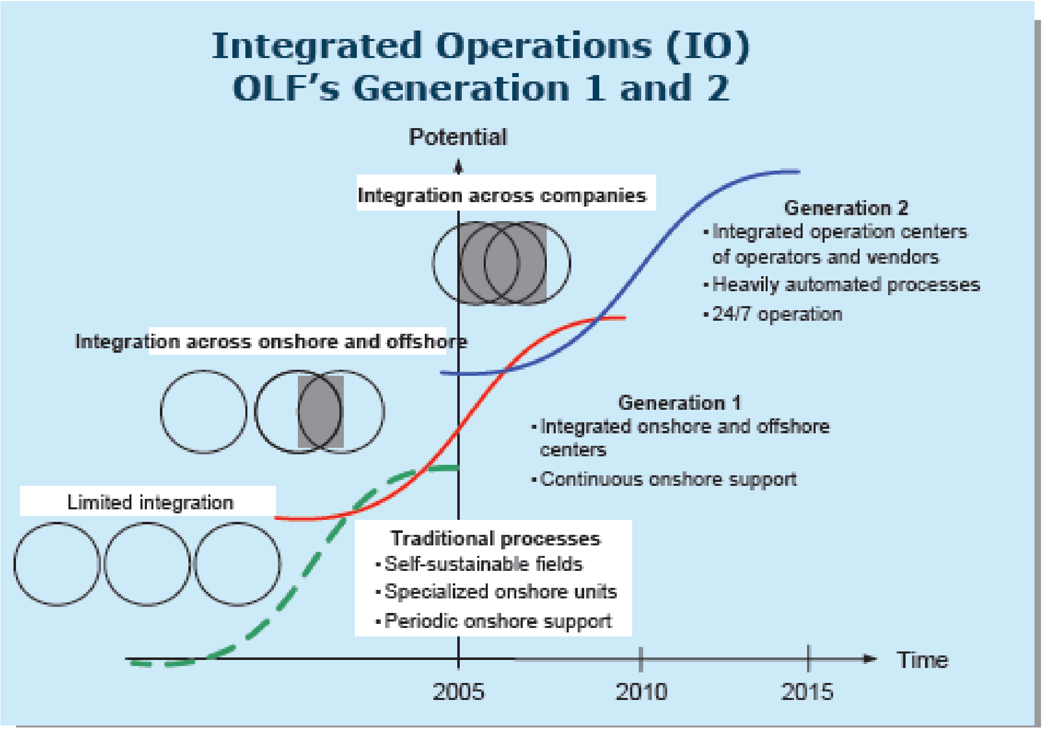

Figure 4.6 The IO Generations (Source: Langeland, StatoilHydro report, 2009, p.3)

The IO revolution in the oil and gas industry lead to the dramatic changes in the traditional separate assets approach. A limited integration between units and limited onshore offshore communication now moved to the onshore support, enabling the onshore decision making.

4.3.1. Generation 1

What concerns the G1 its primary focus is to *integrate the processes and workers onshore and offshore* by the usage of the ICT.

In order to achieve this goal the data sharing between onshore and offshore should be improved. Therefore, the basis of the G1 is the ability for the real-time data transmissions between the oil platforms offshore and the operation centers onshore, see Figure 4.7.

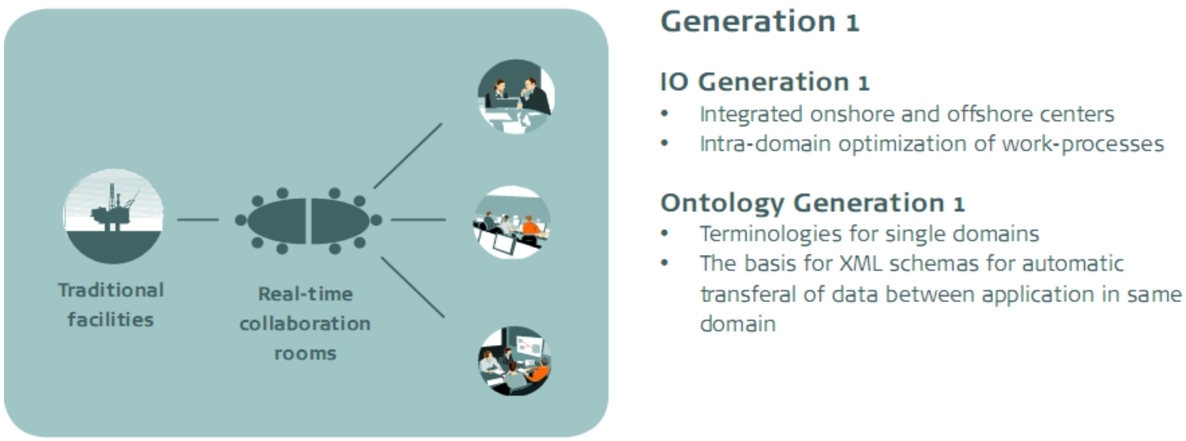

Figure 4.7 The IO Generation 1 (Source: OLF, 2008, p. 5)

The usage of the advanced ICT and the developed oil and gas ontology allows the data to be sent back and forth between the centers onshore and offshore. Moreover, the advanced technologies enable sharing and analysis of the data in the real-time, independent of geographic locations. This fact creates possibility for offshore personnel to collaborate with groups of experts onshore. Furthermore, according to Bekkeheien (2010), the G1 implies real-time data presented in ways that support decision making, which allows the multi expertise make decisions in a quick and effective manner.

However, it is important to see that the IO of the G1 supposes just to improve ***intra-organizational*** cooperation and the collaboration and that the G2 goes even further.

4.3.2. Generation 2 and beyond

The second generation (G2) is considered as a step further to the highly automated platforms and even autonomous assets. Through the collaboration with vendors and service centers the oil and gas companies improve the operation and maintenance and the R&D processes through the usage of vendors expertise and skills. (Figure 4.8).

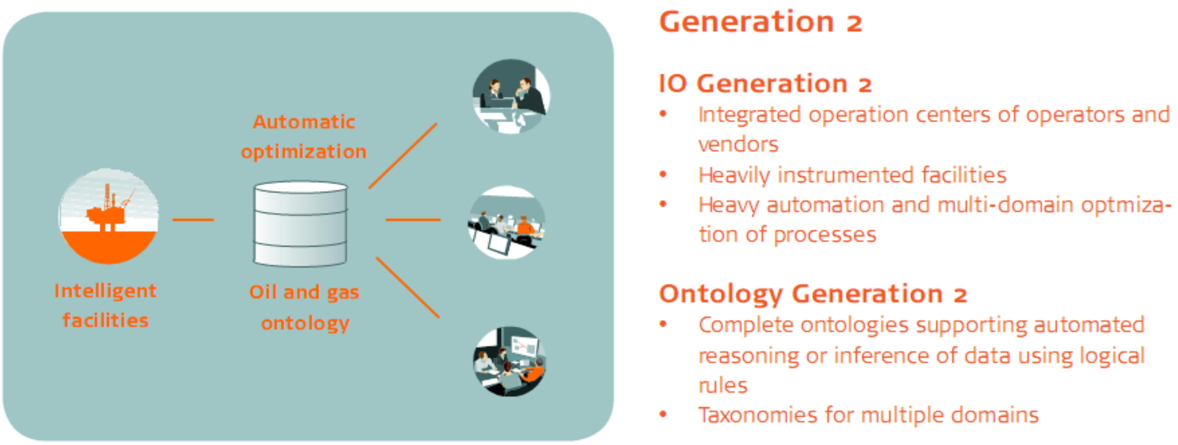

Figure 4.8 The IO Generation 2 (OLF, 2008, p. 5)

OLF describes the G2 as the integration ***between operator and suppliers*** and more automation. The period of its implementation is meant to be in year 2010-2015, therefore it is currently a working project (Langeland, 2009).

The main idea of the G2 is to enable virtual collaboration related to engineering and maintenance work, to develop so called *'digital services'*, providing a large amount of the functionality required to operate a field remotely. However, the IO of the G2 realization would require the significant strategic changes, such as redefined relationships between operators and vendors, service centers, as well as the further standards and ontology development.

Moreover, Konda and Evensen (2008, p.2) coined the term 'IO@anywhere', referring to the transition of IO from the initial *'point solution's and more into the mainstream upstream operational business – and recognition of the holistic nature of IO'.* In other words, Generation 3 (G3) IO proposed by Capgemini group will allow going further and gaining the ***industry collaboration***. The authors claim that the G3 is focusing on creating value, while G1 and G2 do only realize value from assets. The IO of the third generation will give the companies flexibility and freedom from centers, and this will result, for instance, in outsourcing and service consolidation abilities. The idea of G3 IO is still in the beginning of its development and therefore it has not been clearly defined yet.

However, we believe that development of the ICT technologies will enable the further evolution of the IO, and lead it to an industry wide solution.

4.4. Integrated Operations and the X2X concept

Based on the above literature review, our conclusion is that IO can be described as the application of the new technology to create cost-efficient operations in order to increase the utilization of the available resources, production capacity and reduce operational costs. The key elements of the IO are:

- widespread use of the advanced ICT and the real-time data,
- introduction of new work processes based on the real-time access to that data,
- organizational change.

In the beginning, just after the first steps of the IO investigation we came to the conclusion that the IO concept so far deals mainly with the exploration and production activities in the oil and gas industry. Therefore, we decided that the IO has to do more with the technical side of the production automation and has little to do with the SCM. However, after the deeper literature review of the programs included in the IO and the IO generations we detected the interrelation between the SCM and the IO. Therefore, we worked out the comparison table 4.2., where we highlighted the main characteristics of both the IO and the SCM.

Table 4-2 Comparison of the IO and the SCM

Characteristics	IO	SCM
Definitions	"*Integration of people, work processes and technology to make smarter decisions and better execution by the use of ubiquitous real time data, collaborative techniques and multiple expertise across disciplines, organizations and geographical locations*." (IO Center, 2009, p.2)	*"Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. It also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service*

		providers, and customers”. (CSCMP official website)
Focus activities and processes	**Production**: *Drilling and Well, Reservoir management;* *Maintenance of existing facilities*; **Logistics**; **Research & Development**;	Sourcing; **Logistics**; **Production**; Marketing and sales; **Research and Development**; Finance;
Objectives	Increased oil recovery; accelerated production; reduced operating costs; enhanced safety and environmental standards	Greater efficiency; lower costs; enhancing flexibility and agility; improved customer service; optimized value chain (Boyle, 1998)
Underlying idea	Collaboration across disciplines, companies, and organizational and geographical boundaries. Integration of people, processes and technology;	Collaboration within and across organizations in the supply chain; Interconnection of information technology, logistics processes and customer support. Russell (2008)
Key enabler	Real time data sharing within and across organizational boundaries;	Increased level of information sharing between organization in supply chain
Requirement	Organizational change from individual processes to integrated processes;	Organizational change from managing individual functions to integrating activities into key supply chain processes;

According to this table, we can see that the IO and the SCM have much in common, such as the objectives to improve efficiency and reduce costs. Moreover, both concepts have the same underlying idea of the enhanced collaboration among the involved parties. Further, the focus activities and processes match as well:

production, logistics, R&D. The main difference is that the SCM can be implemented in all the companies, while the IO is developed for a specific industry: oil and gas sector. Both of the concepts require organizational change for the integrated processes and functions. For instance, the idea of the integrated planning activities on inter and intra organizational levels appears to be incorporated in both the SCM and the IO. And what is more, the key enabler of both concepts is the information sharing within and across the organizational boundaries.

Based on the abovementioned key similarities between the SCM and the IO concepts, we conclude that the IO concept can be considered as a part of the SCM concept for the oil and gas industry as it deals with the SCM tasks within the upstream supply chain and production processes.

Examining the place of the X2X within the IO concept, we suppose that the X2X, goes together with the idea of the IO key elements: people, process, technology and organization. It could be considered as a valid tool for improving and integrating planning processes in the supply chain within IO program being developed for the oil and gas industry, where all the required information between partners and vendors can be accessed at anytime and anywhere.

The IO concept is closely interconnected with the X2X idea of the real-time data access to all the partners in the supply chain. In particular, The IO Program 3 (Operations and Maintenance) with the key components of predictive maintenance control and aggregating the real time data to support vital operational decisions and integrated planning is closely linked to the X2X concept of the real-time operational data exchange among the partners in the oil and gas industry. The X2X is supposed to serve the planning needs by providing the real-time operational information throughout the whole value chain for the supply chain partners such as vendors and suppliers. The deployment of the X2X solution in the company can contribute to the better planning of the supply chain processes and also contribute to the implementation of the IO Program 3.

We discussed above that the G2 IO encompasses the idea of the information sharing with vendors and service companies. With the help of the IO G2 the oil and gas companies are going to collaborate in the sphere of operations, maintenance, research and development. Through the integrated centers with suppliers and vendors the companies would receive better operational support and solve the engineering problems.

With the help of the X2X solution the companies will be able to increase the visibility of the logistics processes through the whole value chain and enable integrated transportation and replenishment planning. And probably, the X2X will result in the evolution of the IO concept into the industry wide solution.

5. INFORMATION SYSTEMS IN SUPPLY CHAIN MANAGEMENT

Information Systems used for SCM's needs is a relevant topic for our thesis as the X2X concept is supposed to be implemented into the supply chains of oil and gas industry in Norway with the help of advanced Information Technologies (IT). This chapter explores the development of Information Systems (IS), and the role of IS in SCM in general. Moreover, various enterprise applications which support supply chain operations will be considered and the place of the X2X among them will be discussed.

5. 1. The role of Information Technologies in Supply Chain Management

Due to high level of competition, companies work towards improvement of their SCM's in order to lower costs, raise quality of products, increase speed to markets, etc. However, according to Gunasekaran and Ngai (2004) it is impossible achieve effective SCM without using modern IT tools designed for SCM needs.

SCM requires continuous collaboration and interaction between partners; therefore, there is a need for improved communication systems to connect geographically dispersed and often located all over the world actors in the supply chain. It means the evolution of the SCM concept demands for the development of the effective SCM software information systems

According to Wang et al (2009, p. 82) the term 'Supply Chain Management Information Systems or IS' means the IT systems used to coordinate the movement of products and services from suppliers to customers. Furthermore, Yang and Whitfield (2011) and Fasanghari et al. (2008) admit that *IT systems is a prerequisite for the success of a supply chain* because they enable the management to make decisions and get control over a broad scope of processes across organizational and geographical boundaries. This is for instance supported by Russell (2008), which claims that IT can be considered as some kind of glue that holds the whole supply chain together because in supply chain partners collaborate and need to share data through a common database. Therefore, it is clear that the role of IS in SCM should not be underestimated.

In the previous chapters we have already highlighted that the relevance, availability and accessibility of data are crucial factors of an efficient SCM. However, Bovet and Sheffi (1998), in their turn, claim that the main drivers of SCM development are consumer demands, globalization, high level of competition, availability of advanced information and communication technologies, enhancing government regulations, and arising environment issues, see Figure 5.1.

Figure 5.1 External drivers of supply chain management development (Source: adapted from Bovet & Sheffi, 1998)

Metz (1998) is even more specific and argues that the role of the technology is so critical in modern SCM that it can be regarded as a 'rocket science'. Moreover, he suggests that advanced use of the IT is one of the key success factors enabling accomplishments of the crucial SCM purposes such as monitoring, control and coordination of the flow of physical goods.

5. 2. Development of Information Systems in Supply Chain Management

According to Moore’s law, the computing and string capacities are doubling approximately every two years. As a result it has led to the rapid development of the IT. Moreover, the ability to transfer large volumes of information and high speed internet connections have enabled such systems as e-Commerce and e-Enterprises.

The World Telecommunication/ ICT development report (International Telecommunication Union, 2010) states that Information Communication Technologies (ICT) underpin almost every single activity of the modern world. According to the aforementioned report, the mobile network covers almost 90% of the world's population, and by the 2015 it is planned to reach 100% coverage. Moreover, the development of the broadband internet connection infrastructure allows most people in the developed countries to enjoy the high speed Internet. Consequently, the ICT is considered to be the single science with the critical impact on economic, cultural and social development.

Obviously, the IT has significantly changed the way the business is done due to the enormous number of business applications have been introduced. As we have already discussed, the evolution of the SCM concept depends directly on the advanced ICT. Furthermore, Metz (1998) argued that the IT was the critical enabler of the SCM concept development from the simple physical distribution management to the so called 'supper supply chain management' stage. This is also supported by Williamson et al. (2004), who in their turn, present a four stages framework of the IS development within the SCM. Based on the abovementioned studies we have developed a framework to show the relationship between the evolution of the SCM concept and the development of the IS for the SCM needs in the following table:

Table 5-1 The relationship between the IS's in the SCM and the SCM concept's development

The IS development stages	**The IS characteristics, according to Williamson et al. (2004)**	**The SCM initiatives characteristics, according to Metz (1998)**
Phase one	The paper information flow, paper copies of purchase orders, bills and invoices. Limited information sharing and cooperation between businesses.	The physical distribution of goods concept has its roots. Interrelationship between warehousing and transportation processes was recognized, and communication and analysis between them was improved. Results: inventory-reduction benefits, shorter order response times via faster warehouse handling

		and faster transportation.
Phase two	The EDI development, the information flows were facilitated. The invoices, purchase orders and other related documents could be processed with the help of the EDI systems.	The logistics stage characterized by addition of the manufacturing, procurement, and order management functions to the physical distribution management. Results: improved order processing, planning and forecasting.
Phase three	The ERP systems development from the MRPII applications. The integration of businesses such as suppliers and customers, through an integrated data base environment.	In the integrated supply chain management stage the previous stage's functions were integrated with suppliers at one end and customers at the other. Results: improved integrated analysis, planning and forecasting.
Phase four	Advanced ERP systems, the integration of information resources through the use of web development technologies such as XML and Java, enabling partners to integrate their information resources.	The super-supply chain management stage involves such functions as the product development, marketing, and customer service. Results: the integrated product design, the availability of the order and pre-order information to all supply chain participants, accelerated decision making within the supply chain management processes.

However, there has been a further technological development since Williamson et al. and Metz wrote their articles, something that probably has brought us into a new phase of the IS and SCM concept development. Therefore, in the following sections we will have a deeper look at the available current IS, concepts and the modern technologies used in the SCM in order to get an idea whether we entered the new evolution stage of the IS within the SCM.

5. 3. Review of Supply Chain Management Information Systems

There can be observed a great variety of the available IT solutions for the SCM processes. Yang and Whitfield (2004) claim that nowadays the IS used for SCM needs within one SC represent a fusion of applications used by different actors in the SC. Moreover, this SCM systems are usually rather complex. Since, they are often used to span the stages in the SC via usage of different modules.

Fasanghari's et al (2008) research reveals the most impact of the IT on the following fields and processes of SCM: purchasing, operations, logistics, vendor and customer relationships and the company itself, in the sense of its organizational structure. For instance, e-marketplaces have significantly changed and facilitated the buying and selling processes within the global context of the supply chain (see also Eng, 2004). Moreover, the SCM systems have the analytical capabilities to support planning solutions and decision making at the strategic, operational and tactical levels. Furthermore, the supply chain tends to become very complex due to the global scope of operations; and, therefore, there is a need for supply chain capabilities that can be provided by the sophisticated IT solutions. Some software providers are tailoring the specific SCM software products to serve the emerging necessities of supply chains. They separately address such issues as inventory visibility, supplier management, or product development collaboration.

Yang and Whitfield (2011) observed that one effective way to improve supply chain efficiency can be reached through the collaboration – involving as many suppliers as early as possible in planning and development through the real time information sharing. Therefore, according to Hendricks et al. (2007) the information integration is a key benefit of the enterprise applications. It can replace functionally oriented and often poorly connected legacy software, and result in the savings in the infrastructure support costs. Moreover, the integration of the enterprise applications may also improve the operational integration of the entire organization and, therefore, may positively impact the company's performance. The ideas on the SCM IS integration will be further discussed in this chapter.

Regarding the benefits of the SCM IS deployment, it should be admitted that different research groups have been aiming at exploring and estimating the financial effects of the IS deployment in SCM. For instance, Dehning et al. (2007) in their research examined 123 manufacturing firms and found out that the SCM systems implementation has the direct impact on the companies' financial performance and results in the increased gross margin, the increased inventory turnover, a higher market share, the better return on sales, and the reduced selling and administrative expenses. Moreover, the authors claim that the strongest improvements were observed when the information systems were deployed to facilitate input or output processes within the supply chain; the links between the different members of the supply chain.

The improvement of the information coordination between the all interested parties in the supply chain can become a competitive advantage for any company as the availability and timing of the information in the supply chain can increase its overall agility.

5.3.1. Classification of enterprise applications for SCM

There is a vast diversity of the software applications based on the different IT solutions dealing with various processes in the supply chain. However, we have chosen to focus on some examples of the IS in the SCM classification.

Russell (2008) defines four categories of the information systems supporting the supply chain operations:

- *ERP software.* Refers to a software aimed at processing all transactions in all the functional areas and is enabling the real-time enterprise-wide data base access;
- *EDI or Internet connectivity.* Concerns systems empowering partners in the supply chain to share the decision-relevant information;
- *Electronic product code (EPC) technologies.* Covers the technologies allowing tracking and tracing of items or vehicles in the supply chain;
- *Supply chain analytics (SCA*). Relating to the analytical software tools designed to assess and improve the supply chain performance.

The research carried out by Sherer (2010) organizes and describes all the different applications for data sharing in the supply chain in a similar but more sophisticated and detailed way. The author states that the existing IS not only help to run and manage the business, but to support collaboration among the supply chain partners. Therefore, according to Sherer (2010) the existing enterprise applications can be divided based on their objectives into three main groups:

- *to run the business:* refers to the systems supporting transaction processing;
- *to manage the business:* deals with the advanced integration, analytical, and intelligence systems;
- *to support collaboration with partners*: concerns the systems allowing to manage the external and internal relationships with customers and suppliers .

Based on such an approach to organize the SCM enterprise applications, Sherer (2010) developed a classification framework for understanding various types of the information systems, see Table 5.2. In this framework the author organized the SCM applications and technologies by the basic processes of the Supply Chain Operations Reference (SCOR) model (source, plan, make, deliver, return), and moreover, took into account the application supporting the SCOR and the SCM related processes as the design and engineering and sales. Furthermore, the abovementioned classification takes into the consideration the communication and productivity systems, which allow the storage and organization of the company’s documents and the information, and the systems supporting the cross business processes.

Table 5-2 Enterprise information applications for Supply Chain Management (Source: adapted from Sherer, 2010)

		Run the Business	Manage the Business	Collaborate with partners
Communication and Productivity		Productivity/Communication Enterprise Content Management (ECM)		
Cross Business Processes		ERP	Business Intelligence (BI)	Collaborative work spaces
Supply chain SCOR Processes	Source	e-procurement	Supplier Relationship Management (SRM)	B2B Markets
	Plan		Advanced Planning &Optimization (APO)	Collaborative Planning Forecasting& Replenishment
	Make	Process control, Computer Aided Manufacturing (CAM), Environmental Health & Safety (EHS)	Manufacturing Integration and Intelligence (MII)	CPFR
	Deliver	Import/export compliance; freight ratings	Transportation Management Systems (TMS), Warehouse Management Systems (WMS)	Transportation Exchanges; Vendor Managed Inventories (VMI)
	Return	Reverse logistics Tracking	Reverse Logistics Management	
SC Related Processes	Engineering and Design	Computer Aided Design (CAD)/ Product Data Management (PDM)	Product Lifecycle Management (PLM)	Collaborative Product Development (CPD)
	Sales/ Marketing/ Service	Sales Force Automation (SFA)	Customer Relationship Management (CRM); Field service; spare parts management	B2B Markets

In the research Sherer (2010) found out that the ERP applications play an essential role in the cross functional transaction processes and management. Further, while the information systems continuously evolve, a single system to meet all supply chain needs still does not exist. Moreover, the author also considered some factors that can contribute to the further evolution of the IT applications such as the prevalence of grid computing, the greater integration of the Radio-Frequency Identification (RFID) technology, the enhanced tools from the simulations and "what-if" analyses connecting with the real time business intelligence and also the certification programs to insure the environmental sustainability in the supply chain design and execution. Therefore, it is essential for our thesis to look closer at the SCM IS integration approaches and the ERP systems.

5.3.2. ERP as an Information System within SCM

The most common and well-known information systems used by businesses to support the business transactions and managerial functions in the SC are the ERP systems.

What makes the ERP systems so popular in the modern business environment is their ability to replace complex and sometimes manual interfaces between the different systems with the standardized, cross-functional transaction automation.

From a SCM perspective, the ERP effectively helps to reduce the order cycle times (the time from when an order is placed until the product or service is delivered) which in its turn results in the improved throughput, the better customer response times, and higher delivery speeds (Cotteleer and Bendoly, 2006 and McAfee, 2002). From a financial perspective, the automated financial transactions carried out with the help of the ERP systems reduce cash-to-cash cycle times and the time needed to reconcile financial data at the end of the fiscal period (Mabert et al., 2000, 2002; McAfee, 1999, and Stratman, 2001). The result is usually a reduction in the operating capital and the headcount of the financial area (Hendricks et al., 2007).

The ERP itself is focused on the internal process integration of the traditional functions, such as sales, production, and inventory management, but it also usually provides different tools that can support the supply chain integration. Kelle and Akbulut (2005) marks out the two most important ERP tools for the supply chain integration:

- *for the real-time transaction tracking*: allows the exchange of the large amounts of the information on planning and operational data between companies, ranging from data on the annual contracts and periodic progress reporting to the real-time delivery and invoicing data in order to gain the supply chain efficiencies;
- *for the internal process integration:* supports the policy coordination which improves the operational decision making within the company, as all the enterprise data are collected once during the initial transaction, stored centrally, and updated in the real time (Hendricks et al., 2007; Kelle and Akbulut, 2005).

By implementing the ERP, companies enhance value across the total supply chain. In other words, the ERP helps both suppliers and buyers sharing the information required to run the business: for example, buyers can improve their own production plans and delivery schedules by having their suppliers' production and delivery schedules. In its turn, suppliers can use the buyer's real time store level data to plan their own inventory levels and production schedules. Furthermore, the ERP helps to improve customer service quality, speed up the payment cycle and provide cost savings by sharing the order status information among the supply chain partners. Moreover, Kelle and Akbulut (2005) claim that sharing the data such as lead times, quality specifications, return status, etc., helps the supply chain partners to identify and overcome the bottlenecks in the supply chain.

Further, the ERP systems are supplemented with the report generating tools which provide managers with a clear view of the relative performance of the various parts of the enterprise. It can be used to identify needed improvements, in order to be able to take an advantage of the market opportunities in the strategic planning (AT Kearney, 2000; Boston Consulting Group, 2000).

The main idea of the ERP systems integration is to perform common business functions through a common database. According to Awad and Nassar (2010), to reach this applications' integration, the firms must break down complex processes, support interactive process and integrate the business processes throughout the supply chain.

However, despite ERP systems' main strength to track, record, and integrate the information about all transactions and activities within a single enterprise, alone it is often scanty to manage a complete supply chain. Therefore, many corporations integrate additional software applications to run their supply chains because their needs are not covered or handled at the required level by the ERP systems. '

BI, for instance, is often used to supplement the existing ERP systems to improve the decision making processes. While the ERP is designed for efficient data entry and storage, the BI systems combine operational data with the analytical tools to present complex and competitive information to planners and decision makers. BI aims to demonstrate the capabilities available in the firm to the decision-makers, for instance, trends, future directions in the markets, the technologies, the models on competitors' behavior and the potential consequences of their actions (Negash, 2004).

Some companies even avoid the usage of ERP in every business segment due to the cost, legacy and lack of flexibility to support the dynamic business environments (Sherer, 2010). And, therefore, the other IS systems as, for instance, TMS and WMS are used to support business processes.

5.3.3. Concepts of the SCM systems integration

As mentioned before, the vast variety of the SCM applications lead to the question of their integration in order to improve the information flows through the supply chain. Therefore, the current attention of the IT specialists is focused on the integration of the data content from the disparate IS in order to present the real time data and information to all the participants in the supply chain.

Verwijmeren (2004), for instance, proposed the software component architecture for the dynamic organizational networks, see Figure 5.2. The author claims that for the SCM across the dynamic organizations, the fundamental systems as ERP, TMS and WMS are not enough due to their limited ability to store and elaborate information only within the organizations.

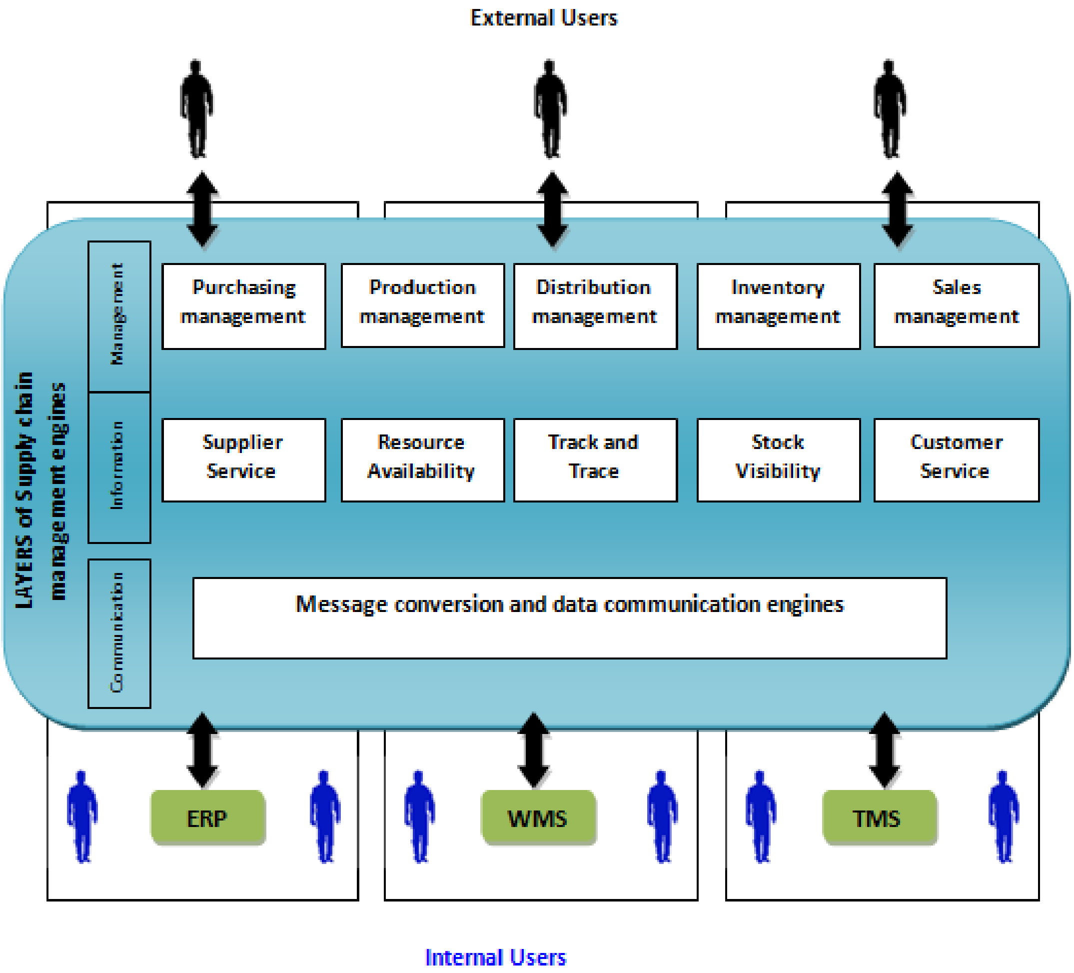

Figure 5.2 The software component architecture in the supply chain management (Source: Adapted from Verwijmeren, 2004, p.170)

Therefore, Verwijmeren (2004) proposes a solution based on the fundamental SCM systems in which the local management is conducted by using the already existing ERP, WMS and TMS applications, while the integral management in the architecture is executed through so called 'supply chain engines'.

The engines represent the software components running on the top of the aforementioned fundamental systems. These supply chain engines are of three levels: communication, information and management. In the communication layer the messages which are sent between the systems are supported, so the basic communication between the systems and its users is enabled. The information level's task is to empower the transparent information over the system in the supply chain, for instance, the stock visibility engine which helps to get the stock data from the different local systems within the SC. And finally the management layer consists of the advanced systems supporting the decision-making process.

And according to Verwijmeren (2004, p.176) the presented solution realized with the help of the advanced IT will provide "*extra intelligence for co-ordination as well as greater flexibility to cope with dynamics*" in the supply chain.

Moreover, recently, the SCM IS's integration through the use of virtual networks, so called 'virtual e-Chains' has been discussed. Manthou et al. (2004, p.241) claim that *'e-supply chain is the communication's and operation's backbone of a virtual network that links suppliers, business partners and customers together as one cohesive, collaborating entity'.* The virtual e-Chain model, the authors proposed, enabled its members to jointly, forecast, plan, develop, produce and deliver their products. The solution Manthou et al. (2004) discussed represents a framework platform with four broad modules, see Figure 5.3.

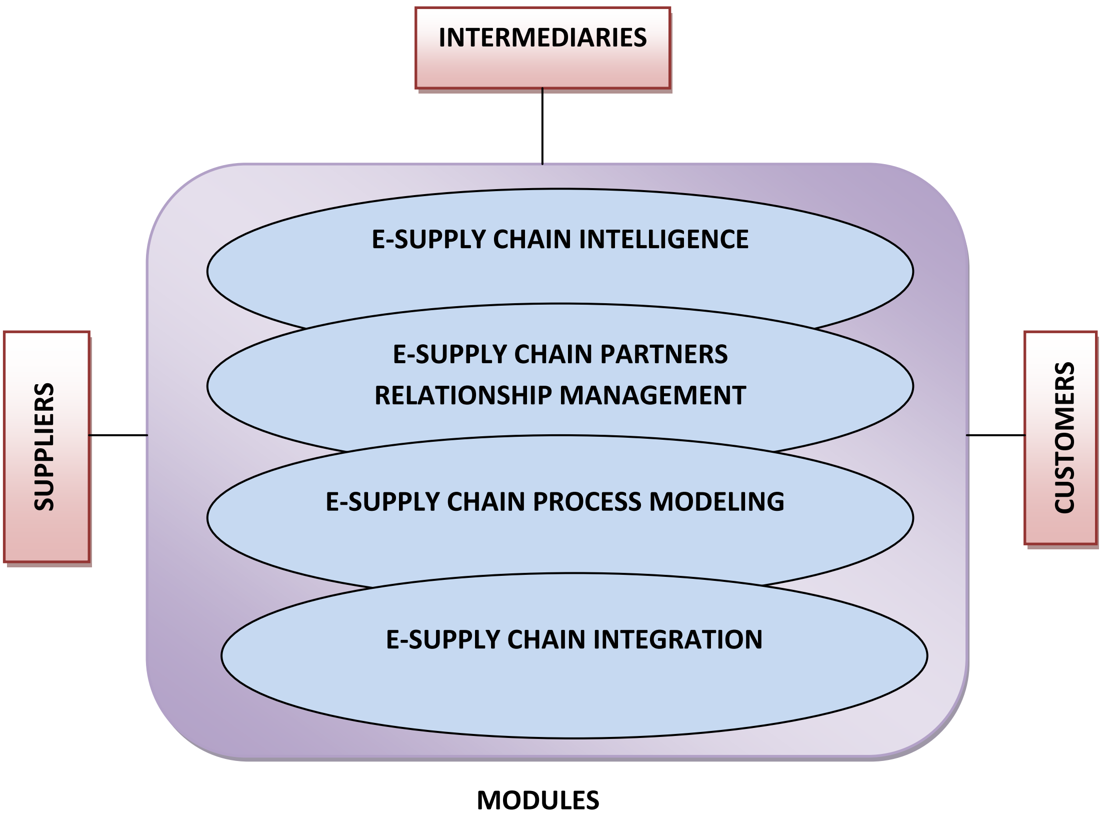

Figure 5.3 Virtual e-Chain model framework (Source: adapted from Manthou et al. , 2004)

The E-supply chain integration module of the abovementioned model serves to integrate the data from the existing best-of-breed IS of the actors in the SC through the common standards and modern technologies of data extraction and transformation. The e-supply chain process modeling module is used to develop a framework based on the business processes and the actor's roles and responsibilities in them. Furthermore, the e-supply chain partners' relationship module allows companies to manage the comprehensive relationships with their partners. Moreover, with the help of an e-supply chain intelligence module, the actors are able to analyze the overall performance of their supply chain and improve decision making processes.

Looking at these systems integration solutions from the point of view of Sherer's classification framework discussed above (see Table 5.2.), it is observed that their constituents either engines or modules may be subdivided into the same three categories: to run the business, to manage the business and to collaborate with partners. Therefore, for instance, the e-supply chain integration module and e-supply chain process modeling modules represent the solutions of 'to run the business' level, while the e-supply chain partners relationship management module serves the 'to collaborate with partners' needs of the supply chain.

Obviously, the IT companies developing the supply chain management solutions are not focused any more on the development of the individual processes software solutions, but rather working towards the integration of the existing IS in an efficient way.

5.4. Modern information technologies used for the SCM

5.4.1. Cloud computing

Nowadays companies have to adapt to a fast-moving business environment and redesign their supply chain to react immediately to the customer demands and market conditions in order to gain a competitive advantage. A modern supply chain is increasingly powered by the IT and, therefore, flexible IT-based solutions based on the "cloud computing" are an increasingly important part of a supply chain design (Schramm et al., 2011).

According to Erdogmus (2009, p.4) cloud computing is "*an emerging computational model in which applications, data, and IT resources are provided as services to users over the Web (the so-called —cloud)"*. In other words, by using Internet, companies can improve their performance through better response to the changing needs of the business, creation of new services and opening up new markets by accessing the IT-based services of third parties such as infrastructure, applications, platforms and business processes over a network (Schramm et al. 2011).

For instance, McKinsey (2009) claims that clouds are hardware-based services offering computing, networking and storage capacities where the hardware management is highly abstracted from the buyer who incurs infrastructure costs as variable operating expenditures.

Moreover, Warr (2009) explains that the difference between traditional outsourcing and a "cloud model" is in that there is no need for customers to hand over their own IT resources to be managed. Instead they plug into the cloud, treating it as they would do with an internal data center or computer providing the same functions.

According to Kim (2009) cloud computing aims to improve two main issues: the IT efficiency, as the power of modern computers is utilized more efficiently through the highly scalable hardware and software resources; and the business agility, by responding in the real time to user requirements through rapid deployment, parallel batch processing, use of the compute-intensive business analytics and mobile interactive applications. Marston et al. (2011) also added that cloud computing helps to reduce the need for huge upfront investments that characterize enterprise IT setups today as businesses will be able to use computational tools that can be deployed and scaled rapidly.

5.4.1.1. Types of cloud computing

IBM, Rackspace, Google, Amazon, Microsoft, Salesforce.com, AT&T, RightScale, Vordel, CapGemini are some of the large providers that offer different services as Cloud Offerings. The access to these services are based on the standard Internet Protocols like HTTP, SOAP, REST, XML and the infrastructure is based on the widely used technologies including Virtualization, and hosting (Cumulux, 2011).

The variety of the access modes to computing resources enabled by the cloud, and its 'infrastructure' is presented in Figure 5.4. (Marston et al, 2011).

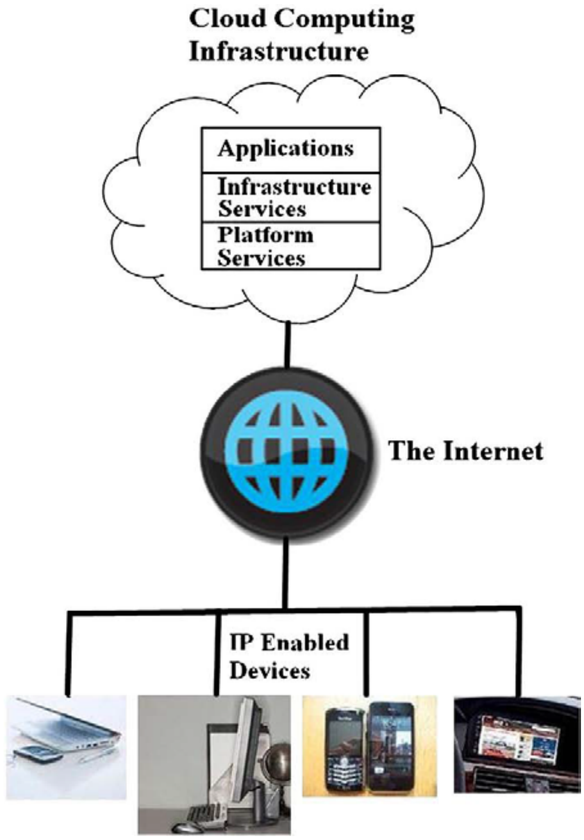

Figure 5.4 Cloud computing infrastructure. (Source: Marston et al, 2011, p.177)

Cumulux (2011) defines three basic types of Cloud Computing paradigm:

- *Infrastructure as a Service (IaaS)*: in IaaS, grids or clusters, virtualized servers, memory, networks, storage and systems software are delivered as a service. Amazon's Elastic Compute Cloud (EC2) and Simple Storage Service (S3) are two of the most famous examples of such services. Services are typically charged by the usage and can be scaled dynamically to increase/decrease the capacity on demand.

- *Platform as a Service (PaaS)***:** encapsulates a layer of software and provides it as a service that can be used to build higher-level services. PaaS offerings can be provided for every phase of software development and testing, or they can be specialized around a particular area such as content management.

Commercial examples of PaaS include the Google Apps Engine, which serves the applications on Google's infrastructure.

- *Software as a Service (SaaS):* features a complete application offered as a service on demand. A single instance of the software runs on the cloud and services multiple end users or client organizations (Sun Microsystems, 2009). Examples of the SaaS are E2open and GSX systems.

E2open, for instance, was founded in 2000 by IBM, Hitachi, and Seagate to provide B2B integration via a managed service. Now it is a software-as-a-service provider with a network of 45,000 trading partners and applications such as vendor-managed inventory and Collaborative Planning Forecasting and Replenishment using its messaging and data platform.

TheE2open enables business process management, business intelligence, and event management across both demand and supply chains. Moreover, the E2open Logistics Network allows customers to connect once to the network and take advantage of all the existing connectivity between shippers, transportation carriers, and logistics service providers (Lawrie, 2011).

The benefit the E2open can bring to the company is a minimizing of the total cost of ownership via a SaaS model as the solution is deployed as an on-demand, managed service. The E2open is responsible for the complete software, hardware, solution configuration, on boarding and training of trading partners, as well as operating the system to global performance-based service-level agreements (SLAs). This results in faster time to value with the minimal IT investment (E2open, 2011).

Describing cloud computing, the three core technologies that are enabling it should be mentioned: virtualization, multitenancy and Web services (Marston et al, 2011).

Virtualization is the technology that hides the physical characteristics of a computing platform from the users, instead presenting an abstract, emulated computing platform (Vouk, 2008). Multitenancy is a single instance of the application software that serves multiple clients which allows better utilization of system's resources in terms of memory and processing overhead. A Web service is "*a software system designed to* *support interoperable machine-to-machine interaction over a network*" (W3C, 2011). Web services help standardize the interfaces between applications for a software client to access server applications over a network (Marston et al, 2011).

5.4.1.2. Benefits of cloud computing

Based on the literature review (Dubey and Wagle, 2007; Marston et al., 2011; Cumulax, 2011; Schramm et al., 2011; Bechtolsheim, 2008), the main benefits of cloud computing can be described as:

- lower cost of entry for the small firms and even for the third-world countries by taking out the upfront capital investments needed for hardware and software licensing;
- immediate access to the hardware resources, leading to a faster time to market in many businesses
- no ongoing operational expenses for running a data center;
- the ability to use commodity server and storage hardware;
- lower IT barriers to innovation;
- makes it easier for the enterprises to scale their services according to client demands;
- makes possible the development of the new classes of the applications and delivers services that were not possible before: mobile interactive applications that respond in the real time to the information provided by human users, nonhuman sensors or from independent information services; parallel batch processing to analyze terabytes of data for the relatively small periods of time; business analytics to understand customers, buying habits, supply chains from vast amounts of data; extensions of compute-intensive desktop applications offloading the data crunching to the cloud, leaving only the rendering of the processed data at the front-end, with the availability of network bandwidth reducing the latency involved.

The benefits of cloud computing described are significant as they potentially lead to lower operational costs and huge potential savings. Therefore, researchers (Schramm et al., 2011) claim that the question is not whether the cloud computing will become a fundamental technology in the next decade; it is how successfully companies will profit from the capabilities it offers.

However, Cloud Computing is still in its infancy and it will probably take 5-10 years for this to be developed and adapted (Cumulux, 2011). Furthermore, describing the benefits cloud computing will bring to the enterprises, we should also mention its weak sides. One significant challenge is data security as many customers do not trust their data to “the cloud” (Bechtolsheim, 2008). Companies are also afraid of the loss of physical control over data that is put into the cloud. Some companies cannot switch from existing legacy applications, etc. However, the cloud computing service providers are rapidly adopting measures to handle these issues (Marston et al, 2011), and in the future the business will gain a lot of benefits from the cloud computing technology.

5.4.2. RFID technology

As we discussed earlier, the research of Sherer (2010) concludes that the evolution of the IT applications will lead to the higher integration of the RFID technology for the automated identification of objects and people.

In the past few years the RFID has got a lot of attention in academic research and practical use as large organizations, such as Wal-Mart, Procter and Gamble, and the United States Department of Defense, are deploying the RFID as a tool for the automated information collection within their supply chains to obtain a better oversight (Juels, 2005).

The RFID systems consist of four elements such as the ***RFID tags*** (the chips containing and transmitting some piece of the identifying information so that such objects may be identified, located and tracked), the ***RFID readers*** (the devices to interface with computers), ***the antennas*** and choice of the radio characteristics, and a ***computer network*** to connect the readers (Finkenzeller, 2003; LavaLink, 2004).

Nowadays, the RFID is used not only to identify and track products, cases, and pallets, but people too. Furthermore, the RFID adds value to the manufacturing, shipping, and object-related tracking.

The adoption of the RFID into the supply chain is often very beneficial within the logistics sector, from the raw materials manufacturers to distributors and consumers (Figure 5.5.). Among the major issues making the RFID attractive for the enterprises are its ability to reduce the supply-chain costs such as warehouse labor and inventory cost, improve the production planning, and increase the visibility of the supply chain (Motorola, 2011).

Therefore, the leveraging of the RFID technology creates the opportunity to improve the business efficiency for companies across the supply chains.

What is more, the researches believe that within the next 20 years RFID and related identification technologies will be further developed to the upcoming **Internet of Things (IoT)**. According to the European Commission and the RFID working group of EPoSS (2008, p.4) it will be a *“world-wide network of interconnected objects uniquely addressable, based on standard communication protocols”.* It is expected that every single object will be possible to make identifiable and addressable, devices will be able to direct their transport, adapt to their respective environments, self-configure, self-maintain, self-repair, and eventually even play an active role in their own disposal.

However, a lot of the technological innovations and developments will need to take place and time before such a level of ambient intelligence will be reached.

5.5. The place of X2X among SCM enterprise applications

The availability of a vast diversity of the IT applications, and the wide spread of Internet, have drastically changed the modes of doing business over the last years. It is technical possible to access the relevant business information easily whenever and wherever it is needed. Nowadays, the IS are providing support to every business process within organization and on its boundaries.

The evolution of the IT applications and concepts in Norway, within the oil and gas industry, is enhanced by the environment for technological developments supported by a government-sponsored initiative called OG21—Oil and Gas for the 21st Century. The OG21 stands for the partnering between the Government, the oil companies, the supply industry and the research institutions. The companies are working together to develop, test, and implement new technological solutions in various projects on the NCS (Wood, 2007).

According to the Forrester Research report (Lawrie, 2010), oil and gas companies are using the collaborative ICT architectures as the key enabler to increase process efficiency and lower the operational cost to cope with the different challenges such as supply security in the upstream chain and the shrinking margins in the downstream chain. Moreover, WIPRO Research (2010) claims that the oil and gas industry nowadays faces a challenge of storage, retrieval and analysis of a vast amount of data which needs to be utilized. Therefore, the data and knowledge management have become a prime concern to meet industry demands. Furthermore, as vendors have different IS applications to support their operations in the SC they may face some problems such as different data structures and formats while collaborating with each other which X2X can cope with.

The actors within the upstream supply chain within the oil and gas industry uses a great variety of tailor made programs and the company configured ERP solutions (see Figure 5.5.) that are enabling information exchange and control of the physical flow through message exchange and some tracking data availability.

Figure 5.5 The IS supporting the logistics activities in oil and gas upstream supply chain (Source: self developed)

However, based on the literature review it is clear that the main focus of the IS development is on the integration of the existing IS in an efficient way, in order to provide the greater visibility and the better control through the whole system. The researchers are working towards development of the integrated SCM concept through virtual e-chain deployment and realization of the existing ERP, WMS and TMS integration concepts.

X2X Maritime AS also realized the emergent necessity of a higher degree of the IS integration and came up with the X2X solution, which would help the oil and gas companies to improve the overall visibility and agility of the upstream supply chains.

The evolution of the cloud computing technologies empowers the X2X solution to provide the service of the real-time data on goods movement across the supply chain. It can be considered as a SaaS type of cloud computing since the software of the X2X solution will be accessed through an IP enabled devices, (Figure 5.6).

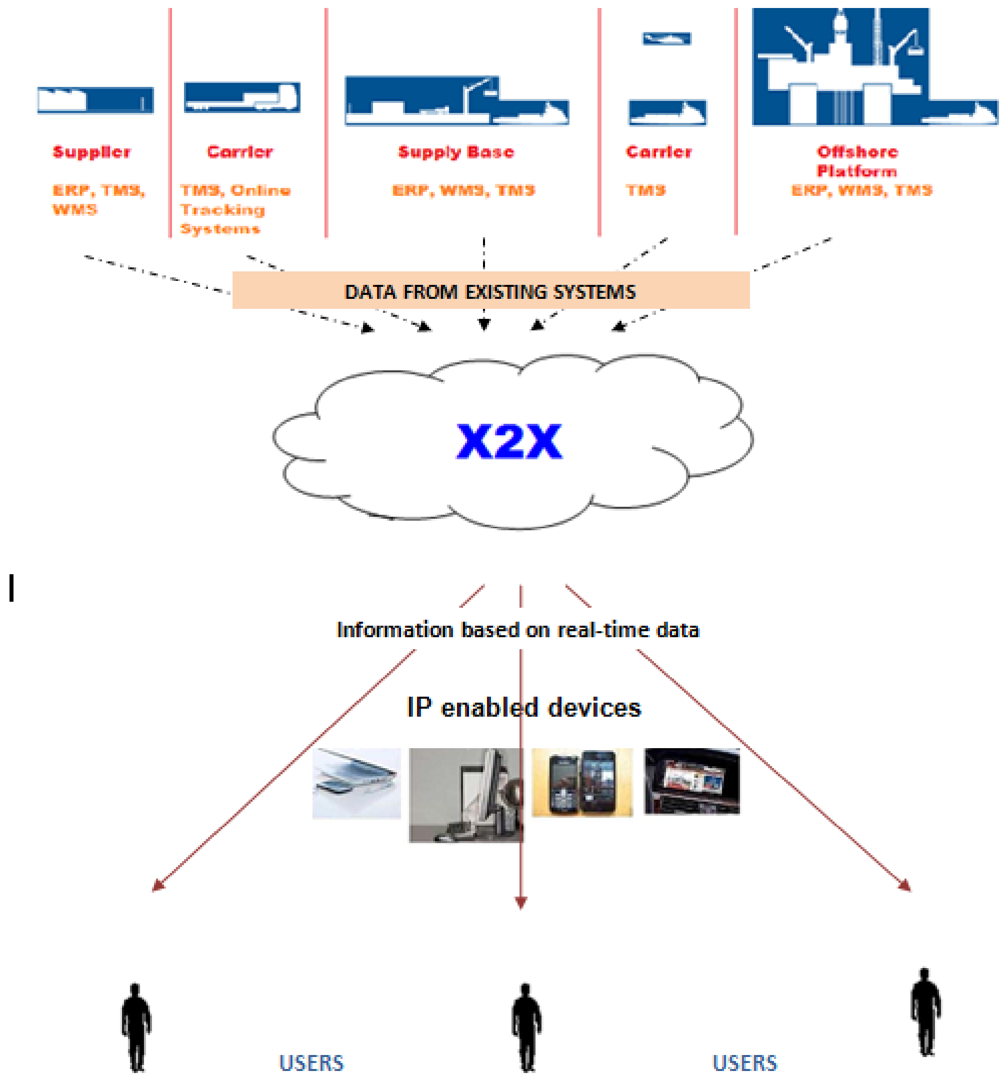

Figure 5.6 The X2X as a cloud computing based solution

However, we should admit that such solutions as GSX and E2open, which were discussed in the previous section, are also based on cloud computing. With their logistics visibility applications they are providing mostly the same types of information as the X2X. Nevertheless, the X2X can be considered as an industry specific solution as it will take into account the specific needs of the oil and gas industry.

According to the reports of the X2X team, the X2X solution enables access to the real-time data to the supply chain actors in order to improve processes at the operational level. The main idea is to feed typical planning and decision-making tools with the needed data. Therefore, it is a solution which incorporates and presents the necessary data from the existing systems such as ERP, RFID, TMS, WMS trough the whole supply chain. For example, the RFID technologies will be integrated with the X2X solution in order to improve visibility and tracking abilities in the supply chain of the major player at the NCS.

It is essential to highlight that the X2X solution is supposed to be used as a source of the relevant information rather than a decision making tool, even though it will be supporting the decision making process at the operational level. Therefore, we propose the future development of the X2X solution and its integration with the decision making tools and business intelligence applications utilized for the SCM needs.

The **main benefits the X2X solution** can bring to the major player at the NCS are:

- *access to the needed data on demand*; which can be used for the decision making improvement;
- *improve the collaboration between partners in the supply chain and integrate work processes through the use of the real-time data*;
- *improve processes by automatic message generations*, for instance, providing automatic warnings (based on artificial intelligence functions) to the relevant actors, if any problems arise and if actions are needed to be taken immediately.

To conclude, we should say that it is rather hard to define the place of X2X among the other applications. Nevertheless, based on the above literature review and the facts about theX2X we believe that theX2X is an information system where the main purpose is to enable the efficient business operations. Therefore, within the Sherer's (2010) framework it can be classified as the system used to run the business within cross business processes (Table 5-3).

Table 5-3 The X2X's place within Sherer's SCM enterprise applications classification

	Run the Business	**Manage the Business**	**Collaborate with partners**
Communication and Productivity	Productivity/Communication Enterprise Content Management (ECM)		

Cross Business Processes		ERP, **X2X**	Business Intelligence (BI)	Collaborative work spaces
Supply chain SCOR Processes	Source	e-procurement	Supplier Relationship Management (SRM)	B2B Markets
	Plan		Advanced Planning &Optimization	Collaborative Planning Forecasting& Replenishment
	Make	Process control, Computer Aided Manufacturing (CAM), Environmental Health & Safety (EHS)	Manufacturing Integration and Intelligence (MII)	CPFR
	Deliver	Import/export compliance; freight ratings	Transportation Management Systems (TMS), Warehouse Management Systems (WMS)	Transportation Exchanges; Vendor Managed Inventories (VMI)
	Return	Reverse logistics Tracking	Reverse Logistics Management	
SC Related Processes	Engineering and Design	Computer Aided Design (CAD)/ Product Data Management (PDM)	Product Lifecycle Management (PLM)	Collaborative Product Development (CPD)
	Sales/ Marketing/ Service	Sales Force Automation (SFA)	Customer Relationship Management (CRM); Field service; spare parts management	B2B Markets

However, during the investigation of the X2X solution we have realized its great potential for the evolution. And, therefore, we believe that after the X2X solution deployment into the major oil and gas player operations, the opportunities for the further development will be observed. The X2X may grow into the sophisticated tool used not only to run the business. And we suppose that it has two directions of further development. For instance, by incorporating some BI or decision making tools the X2X solution will grow into “to manage the business” application. And on the other side by incorporating some tools for integrated planning on the basis of theX2X it can become a collaborative workspace.

6. DISCUSSIONS AND MAIN FINDINGS

In this chapter the literature review is summarized, analyzed, and discussed in order to answer the research questions we raised to be investigated in our thesis. The main findings based on the literature review will be stated. The discussion is organized in accordance to the formulated research questions:

1) *Is there an interconnection between the X2X concept and SCM?*
2) *How does the X2X concept fit into SCM framework?*
3) *Why the X2X concept is an appropriate solution for improvement of information sharing within oil and gas industry?*
4) *What is the interconnection between the IO and the X2X concepts?*
5) *How would the X2X solution fit into the framework of the IO practice in oil and gas industry?*
6) *What is the role of Information Systems in SCM?*
7) *How would the X2X solution fit into the framework of the existing SCM applications?*
8) *What are the perspectives of the evolution of the X2X concept?*

Answering the research questions based on the literature review we came to the following conclusions in regards with the X2X concept.

6.1. The interconnection between the X2X concept and SCM

1) The X2X concept is an essential concept within SCM as it enables information sharing and increases collaboration within SC

SCM is focused on coordination across organizational boundaries, including integration of processes and functions within and across the SC (Cooper at al. 1997). At the same time the X2X concept is focused on vertical collaboration with the suppliers in form of sharing real-time operational information. The X2X solution helps to increase the level of the processes integration within SC.

Moreover, we believe that the X2X concept is relevant to SCM as it empowers mutual information sharing, integration of processes and better coordination among the supply chain partners.

Therefore, the X2X concept of "network-wide real time logistics information sharing on the operational level" – is an essential part of SCM concept. The X2X solution improves Logistics planning and coordination - one of the focus activities of SCM.

2) The X2X concept goes in line with supply chain management objectives and helps to achieve them: reduce costs, streamline processes, enhance flexibility and agility

Based on the literature review we can claim that the information sharing improved via X2X implementation will allow the companies: to be more cost efficient, improve customer service level and shorten order cycle times (Lee and Whang 2000, Yu et al 2001).

With the help of X2X solution based on the X2X concept, the companies will increase visibility and agility in their SCs as availability of real time data will assist planning and decision making in the SC. Moreover, the visibility of the goods flow will result in streamlining of the logistics process, for instance, transportation and warehousing.

3) The X2X concept is an appropriate solution for information sharing improvement within the oil and gas multi-channeled upstream supply chain

Information technologies are considered to be an important success factor of SCM efficient performance among SCM activities such as integrated behavior, mutually sharing information, mutually sharing risks and rewards, cooperation, the same goal and the same focus on serving customers, integration of processes, etc (Mentzer et al. 2001; Cooper et al. 1997; Ellram, 1990 and Andel, 1997).

The X2X concept is based on idea of network-wide real time information sharing on the operational level. Obviously information sharing is an essential part of SCM, as it helps to deal with the issue of supply chain information asymmetry. Insufficient inventory levels, high lead times, uncertain supplies and low service level of offshore installations are indicators of low information sharing between the parties on intra- and inter-organizational level in the supply chain.

According to Samaddar's et al (2006), the Type 2 (high volume and operational level of importance) information sharing is adaptable for the complex and dynamic multi-channeled supply network. The oil and gas industry is just the example of such network, therefore it is essential to achieve high volume operational information sharing within the SC. The X2X concept presumes sharing of operational logistic information within and between the companies that is why we conclude that it is the right solution for the oil and gas industry.

6.2. The relationship between IO and the X2X concept and tool

4) The Integrated Operations concept is a part of the supply chain management concept

Within the relevant literature review we have revealed similarities between SCM and IO concepts. Based on them we conclude that the IO concept can be considered as a part of SCM concept for oil and gas industry as it deals SCM tasks within upstream supply chain and production processes.

IO and SCM have the following commonalities: objectives of improved efficiency and reduced costs. Moreover, both concepts have the same underlying idea of enhanced collaboration among involved parties. Further, focus activities and processes match as well: production, logistics, R&D. Both of the concepts require organizational change for integrated processes and functions. For instance, the idea of integrated planning activities on inter and intra organizational levels appears to be incorporated in both SCM and IO. And what is more, the key enabler of both concepts is information sharing within and across organizational boundaries. The main difference is that SCM can be implemented in all the companies, while IO is developed for a specific industry: oil and gas. Therefore, we can state that IO is the interpretation of SCM concept for the specific needs of the oil and gas industry.

5) X2X goes in line with the focus of the Program 3 and Generation2 of the Integrated Operations concept

Within our study of the IO concept we detected that it is closely interconnected with the X2X idea of real-time data access to all partners in supply chain.

In particular, IO Program three (Operations and Maintenance) is closely linked to the X2X concept of real-time operational data exchange among the partners in oil and gas industry. The program three is focused on predictive maintenance control and aggregating real time data to support vital operational decisions and integrated planning. The X2X is supposed to serve the planning needs by providing real-time operational information throughout the whole value chain for supply chain partners such as vendors and suppliers. The deployment of X2X solution in the company can contribute to the better planning of supply chain processes and contribute to the IO Program 3 implementation.

Moreover, the G2 IO goes in line with the X2X concept as it is encompasses the idea of information sharing with vendors and service companies to collaborate in the spheres of operations, maintenance, research and development. Through the integrated centers with suppliers and vendors the companies would receive better operational support and solve the engineering problems.

6.3. The role of the X2X tool within Information Systems

6) Information systems are the key enablers of SCM concept deployment and development

We have already mentioned that information sharing and collaboration are the underlying ideas of supply chain integration in order to reach SCM needs. The IS have significantly changed the way the business is done through time. The enormous number of business applications was introduced to support, control and manage various business processes.

Moreover, Metz (1998) and Williamson et al (2004) reveal in their research the key interconnections between development on SCM concept and IS within SCM. And furthermore, the authors argue that IT is the critical factor for SCM concept development.

What is more, with the help of emerging modern IT, as cloud computing technologies and the web-based collaboration workspaces, the SCM will probably gain the next stage of its development. This stage will be characterized by invisible and efficient integration of the processes within SC.

7) The X2X solution serves to run the business needs on the cross business processes level

The X2X solution's main purpose is to provide the real time data for the actors in the supply chain in order to improve operational level processes and decision making.

Based on the literature review we state that X2X is an information system with the main purpose to support efficient running of the business by access to real time data. Moreover, the X2X solution facilitates the cross business processes by integration of the data from the existing systems of the actors in the supply chain.

Therefore, we defined X2X within the existing supply chain management applications classification framework as the system used to run the business on the cross business processes level.

6.4. The potential of the X2X within oil and gas industry

8) The oil and gas industry needs information systems in order to cope with their existing challenges

The recent studies (Hussainet al, 2006) showed that the supply chain of the oil and gas industry is extremely complex compared to other industries. The logistics network in the oil and gas industry is highly inflexible.

Major challenges described in study of Hussain et al (2006) are:

- *high transportation costs,*
- *high levels of in-transit inventory and high inventory carrying costs*;

- *the need for deployment of information systems to integrate the process*;
- *the need to maintain relationships and collaboration with partners* in supply chain networks.

The company working on the NCS where the X2X is planned to be implemented faces different challenges while supplying consumables to offshore installations:

- *uncertain demand pattern* of the offshore maintenance needs as it is rather difficult to predict breakdown occurrence;
- *high lead times and order cycle times* due to remote and hard to reach fields location;
- *uncertain delivery times to offshore platforms* stipulated by high frequency of bed weather occurrence;
- *limited storage capacity at offshore installations* does not favor keeping huge stocks;
- *lack of systems for efficient control over the assets* because most of them are extremely expensive in this industry.

Upon the conducted research on SCM and the oil and gas industry challenges, we state that the X2X solution can be considered as a tool to deal with the above mentioned challenges and problems in the sector.

9) The X2X solution has a potential for further development within the oil and gas industry

While examining the X2X solution and oil and gas industry needs we realized the X2X solution has high potential for deployment and evolution.

The **main benefits the X2X solution** will bring to the oil and gas companies are the following:

- *access to the needed data on demand and adjustment of the plans and actions in accordance with the relevant data*; which can be used for operational decision making and planning improvement;

- *improved collaboration between partners in the supply chain and integrated work processes through the use of real-time data*;

- *improved processes through the fast and efficient reaction to the operational changes by automatic message generation function*, for instance, providing automatic warnings to the relevant actors, when the problems arise and some actions need to be taken immediately.

We conclude that the X2X solution has significant opportunities for further development. Apparently, the X2X may grow into sophisticated tool used not only to run the business. First, by incorporating some BI or decision making tools with the X2X solution can grow into "to manage the business" application within Sherer's (2010) framework of applications designed for SCM. Second, the X2X can become an application to serve the collaboration needs of the company, if an integrated planning tool will be incorporated in it.

7. CONCLUSION AND FURTHER RESEARCH

In this chapter the conclusion based on the research goal and objectives are stated, and the limitations and propositions for further research are suggested.

7.1. Conclusion

The main goal of the thesis was to ***define and investigate the role of X2X in serving the needs of oil and gas industry SCM.*** In particular, we have examined the specific questions to identify the relevance of the X2X concept from three perspectives: SCM concept, IO concepts and IS within SCM.

The exploratory and explanatory research methods allowed us to fulfill the objectives of the thesis and to answer the formulated research questions.

The main findings from our thesis are presented by the following propositions which we introduced and described in Chapter 6 of our thesis: *(i) the X2X concept is an essential concept within SCM as it enables information sharing and increases collaboration within SC; (ii) the X2X concept goes in line with and helps to achieve SCM objectives: reduce costs, streamline processes, enhance flexibility and agility; (iii) the X2X concept is an appropriate solution for information sharing improvement in the oil and gas multi-channeled upstream supply chain; (iv) the IO concept is a part of the SCM concept; (v) X2X goes in line with the focus of the Program 3 and G2 of the IO concept; (vi) IS are the key enablers of SCM concept deployment and development; (vii) the X2X solution serves to run the business needs on the cross business processes level; (viii) The Oil and Gas Industry has a need of IS applications to cope with their existing challenges; (ix) The X2X solution has a potential for further development within the oil and gas industry.*

In other words, with the help of our extensive literature review we were able to characterize the X2X concept in relation to the different existing perspectives. And finally, we argue that X2X is a SCM solution which improves the operational information sharing on the cross business level and that it together with the IO concept would help the oil and gas industry improve the supply chain performance.

This finding will be useful for the future development and deployment of the X2X concept within the industry.

7.2. Limitations and further research

The findings of the current study are based on the review of the relevant literature. The research of the supply chain of a particular company was not the focus of this thesis. However, we believe that the X2X concept and tool should be further investigated in close collaboration with a certain oil and gas company. Working together with the industry players the researches will obtain more detailed and practical information.

The technological issues of the IS were left out of the scope of this thesis. So, for instance, the classification of SCM IS was reviewed from SCM processes perspective rather than taking into account the technological characteristics of the IS. Therefore, it is an interesting subject for further research within both fields of study. And the further research on the empirical implementation of the X2X tool in the company's operations is needed to reveal the weak sides and improve the technical issues of the solution.

Moreover, we should state that the interconnection between IS and SCM development represent a challenging issue for further investigation, as IT is the key enabler of SCM concept evolution.

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