Master's degree thesis

LOG950 Logistics

Concept of informational hub
for oil and gas networks

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Preface

The oil and gas industry is a global business. Traditionally it has been dominated by big companies and big oilfields. However, in recent years the industry has been changing into a more heterogeneous and diverse network of businesses, and the oilfields are getting smaller and more diverse. One reason is the dwindling oil reserves and the increase in specialized companies that can extract hydrocarbons; another reason is the restructuring and globalization of the entire business as well as some new technology implementing.

Since oil and gas-related companies must also communicate and interoperate, in long or short term projects, there are many connections tying companies together. The connections can be economic, technical, project- or logistics-based, etc. The way the companies interact can be described by network models, and by analyzing these models it may be possible to visualize structures and dynamics in the oil and gas business that may not be obvious.

This thesis is an exploration of some of the “network properties” of the oil and gas business. Based on the tools and techniques described in this thesis, it is possible to analyze and visualize data about the global business – provided that the data is possible to obtain.

We have developed some tools and techniques and applied them to a small data set. We have also extrapolated what kind of topics can be researched when or if bigger data sets become available.

Key words: Collaboration, information sharing, network, data minig, RDF-scheema.

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Summary

Today oil companies faces oil extraction depletion and increasing of the demand. The number of wells with high production level and low costs is catastrophically low. Such conditions make oil companies invest money into new fields with difficult extraction conditions like offshore oil, shallow oil etc. And oil production became much more complex and expensive. Common way to manage such complexity and avoid bureaucracy growth is implementation of much tier collaboration and new information technologies. From the other point increasing of the number of wells with low production rate together with the need of the big companies to outsource some non core activities led to creation special niche on the market for the small companies. And such companies can also collaborate with the others and provide joint projects.

Such projects require close collaboration and information sharing. The common standard ISO 15926 was developed for that purpose, and the narrow standard with the common principles WITSML was implemented into a real drilling operation.

RFID technology is an Automatic Identification and Data Capture (AIDC) method. It allows for the identification of an item, the collection of data about it, and the transmission of those data to a computer system. The Semantic web provides data structuring methods, good navigation tools for information encapsulation and data processing (including data about real items). Taken together, these technologies allow to collect and structure data for future use.

Using of such tools allows the companies to provide data mining analysis out of RDF (resource description framework) or semantic web data stores. It also allows companies to extract knowledge and improve the learning process for employees. Graph visualization of the links between different items and topics leads to a better understanding of all processes by improving cooperation between the different partners. Also, such graphs display necessary information in an easy and clear form.

Other consequences of the use of common tools is a changing dynamic of trust. For most companies, it is hard to share their data, even with the partners and certainly with all players. Common rules and restrictions can provide the necessary security level to facilitate mutual trust.

Another consequence of information sharing is an improved image of the company. It shows that companies have nothing to hide or fear. Also, the graph visualization of

relationships offers the possibility of tracing "dirty business" and cartels. This can be one of the branches of future work in this area.

Summarizing all the above stated, during this work we have analysed O&G market and found patterns of collaboration growth. Using principles of information sharing and RDF-scheme we have developed a system model for data storage. We have described the following cases that could be solved using the data extracted from such system:

- Improvement of operational management using online data coming from every item
- Timely maintenance
- Better utilization of the items
- Understanding of existing market trends and long-term planning
- Configuration management
- Increasing of security level and fraud detection.

We have analysed existing oil sphere trends and create tools for data storage and information extraction. This system could be involved into decision making process and provide tools for successful collaboration and project management.

Contents

1.0 Introduction and description of the problem

The worldwide oil and gas industry is one of the world's most complex business networks, and is connected with almost every supply chain branch. It includes international and domestic transportation, materials handling, ordering and inventory visibility and control, import/export facilitation and information technology. Every year the companies face consumption growth and increased exploration and extraction costs, according to the Hubbert peak theory (Hubbert, M.K. (1982). This means that eventually all oil and gas companies will face the problem of resource scarcity.

The market naturally tries to find new solutions, such as working harder on exploration and analysis to increase the proved reserves and explore new options for extraction, or finding alternative sources of energy. Companies try to spend more money on exploration, but it is hard to find a field with large capacity and low extraction costs. Sometimes an exploration ship finds nothing, meaning that the exploration projects led to nothing but increased expenses. Maintenance of the new fields is difficult and complex because of the conditions: deep water offshore and other extreme areas.

In such conditions companies try to reduce costs and non-core activity. They must collaborate with other players in the market, who are the narrow specialists in the O&G activity (drilling, exploring, manufacturing etc.) .

The increasing oil prices and the development of information technologies create conditions for small companies to establish new niches in the market. Such companies can extract oil from the fields with low margin value (e.g. old fields, fields with difficult conditions, non-traditional fields like shale oil extraction) and can expand the supply chain by proposing flexible and highly specialized services. For example, TDW operates around the world providing pipeline services, and has 450 employees as opposed to Halliburton's 60 000 employees which also works at the same sphere. Companies such as TDW provide fast and effective operations by taking advantage of their ability to provide flexible services and collaborate with other companies. In addition, they are able to avoid bureaucracy (which is usually a feature of large, vertically-integrated companies) and some additional costs. Such structures are the most suitable for "ad-hoc" projects.

As it was mentioned above, there is a lot of players on the market, which need to collaborate and to provide joint operations. But for succeed planning and acting collaboration must involve much more broad number of organizations and persons, which can directly or indirectly affects on the final goals. Managing of the whole number of different players called stakeholder management. Operator of the well, owner of the platform, owner of the equipment, supplier -all of them just one visible part of the business. But there are others: government agencies, tax services, Greenpeace etc. Every player should has necessary information about the project and he should share common vision of the project. Otherwise such situation could lead to the delays and increasing costs. That is why it is important to share not only pieces of information but to create common picture of the whole project for every stakeholder to illuminate possibility of misunderstanding. Rob Llewellyn(2009).

All oil and gas upstream business has recently become more and more complicated. New sources of hydrocarbons appear:

- shale oil
- shallow oil
- deep-water oil, etc.

It requires different equipment, professional teams and informational technology. When these components are contained in one structure, the result is a highly bureaucratic machine with low flexibility and high adding costs. Another approach is a project-oriented structure with collaboration between highly specialized companies or special teams inside the big corporations. We call it integrated operations (IO). (Bjørn Holst et all.,2007)

Oil companies are facing decreasing oil production and fruitless exploration. They want to keep their profit, which is why companies cut costs and create joint projects. (Bjørn Holst et all.,2007) But, a problem exists in the creation of tools for collaboration. We will argue that the development of such tools is important for the following reasons:

- Managing projects are easier with access to necessary data and tighter collaboration between geographically distributed personnel

- An oil company may want to know how suppliers are connected. It is necessary for business engineering.
- Planning and logistics will benefit from getting more data about what is really going on - both in real time and in retrospect

- Deeper analysis of data from different O&G spheres allows to make much more precise decisions. Jessica Leber (2012)

To summarize it up, cutting costs by using new information technologies and creating conditions for better collaboration is a very actual problem. Our aim is to analyze the roles of small and big companies on the market and provide a flexible solution for supporting common projects and information sharing.

The objectives of the thesis is to formulate principles for collaboration, develop tools for incorporation of all data into a single set and to visualize data for further analysis.

2.0 Theory review

The problem considered in this thesis involves the following main problems:

- Implementation of tools for collaboration and data exchange in the oil and gas sphere.
    - data collection
    - data exchange
- Data encapsulation and data mining

Some problems cannot be classified as clearly:

1. common standards for collaboration and different applications,
2. semantic web principles and data structuring,
3. decision supports.

The following articles shown different aspects of O&G market. Hubbert, M.K. (1982) suppose decreasing of oil resources and information from the official site of Norway in the US (2012) approved this.

Implementation of information technologies, tier collaboration and providing join projects are explained in the article Bjørn Holst et all.(2007). The article contains similar problems (oil depletion, cost grows) and shows way of integrated operations as the most suitable. But there is no explanation of data exchanging. The article focused on the processes reengineering on the whole.

Rob Llewellyn (2009) explore the importance of stakeholder management in every project to illuminate misunderstandings and decrease time delays. Schmeer, Kammi (1999) provided much more broader view on the stakeholder analysis.

Sensors for data collection and technology are described in Dr. Gary M. Gaukler (2009). The article concentrated our attention on the technical aspects and devices without any description of data processing.

Problems of collaboration and existing joint projects was studied in Christopher M. Chima (2007) and Richard Avant (2009) but both of them concentrate their attention on the questions of the process organization and fast reaction rather than on tools for information sharing. Kevin Ashton (2009) and the Report for the European Committee (2009) describe common principles for the communication sphere between the physical things and information acceptable for machines, but does not discuss implementation into a specific industry.

W3C/IETF URI Planning Interest Group (2001) explain possibilities and classification of Uniform resource identifier and EPC Tag Data Standard (TDS)(2012) added information how to connect real items with RFID-tags and Global Network to store and manipulate information about this items.

Previous references described how to find necessary object or information about it. Next article POSC Caesar Association (PCA)(2012) define how players on the market can exchange these data using ISO 15926 standard. Kari Anne Haaland Thorsen et al.(2008) pay attention on WITSML standard which already in use. Then they explain future integration of these two standards. Dr. Julian G. Pickering (2010) considers WITSML much broader but without any mentioning ISO 15926.

Next step is about structuring data and creation “web of data”- Semantic web. First principles of this were formulated in Tim Berners-Lee et al.(2001). W3C(2011) expanded this but without implementation into some specific sphere. Important part of semantic web is conceptual graphs which displayed relationships between subjects and objects. For the first time introduction of this topic was described in Sowa, John F.(1976) and then it was expanded in Sowa, John F.(1984). But these articles don’t include methodology for building complete picture of web with all types of links

Steve Pepper (2010) and Steve Pepper(2012) consists description of the building semantic structures -topic maps. This structures can organize data and encapsulate information in easy forms.

Marane, A., (2011) and article of U.S. Immigration and Customs Enforcement’s (ICE) (2005) exploring different aspects of frauds. Christopher R. Leslie (2005) gives his vision about the reasons of cartel and how to find signals of it.

3.0 Analysis

3.1 Analysis of problems in the oil and gas market. Description of the solution.

Oil companies implements new information technologies. It's allow to increase the profitability of old wells and continue the life of existing projects. Nice example is Brage platform. Hydro, the operator of Brage, redesign all the decision making processes, and move most of them onshore. Implementation of new communications for meetings and quick response, 3D-modelling for reservoir simulations, fast data transmission allows to improve the quality of decisions and make easier collaboration between operator and service companies. Bjørn Holst et all.(2007) Joint offshore projects require high speed and quality in communications between the participants.
This means the participants should have common tools for data exchange. Big companies implemented SAP systems which have special modules to connect different companies/partners with each other. However, SAP systems are an expensive and inflexible solution only suited for big companies with vertically-integrated structures. Is there a simpler way for all kinds of companies to communicate with each other?

The answer is quite simple – through the Internet. The World-Wide Web provides possibilities for communication, data storage and searching. There are tools available that allow the acquisition, exploration and production functions of an oil company to be managed in a more integrated, cohesive and balanced manner.

The oil and gas industry requires an immense array of supplies to be moved daily and frequently in large quantities domestically, globally, onshore and offshore. In addition, difficult operations like well-drilling are repeated almost every month, which requires more than 45 different services to complete an individual well. These operations can be conducted by one big company or as a joint project with several partners/suppliers. If the partners had the tools to become more flexible, the necessary resources would be highly consolidated and decrease non value-added activities. Only in that situation could we say that the project would be managed as an integrated and coordinated system(Christopher M. Chima, 2007).

Of course, partners in the joint projects can be from different "weight" categories, like Statoil (30000 employees) and Lundin Petroleum (480 employees). It is not easy to make them collaborate. Partnership can be long-term and short-term. Some projects come to the end, some of the projects are just in the beginning. It means the picture of the world's relations is dynamic and never static!

Another aspect of the market is hard safety restrictions, which became much more actual after the "Deep Water Horizon" disaster. Security requirements mean that new information is circulating within and between oil and gas companies and different government departments, which control the security of oil extraction.

Let us summarize all the facts and draw some conclusions:

1. Companies create joint projects to illuminate non-core activities and decrease their costs.
2. Joint project activity involves huge data transactions between the partners.
3. Small and big companies can be partners. Everyone has their own principles and rules.
4. All companies obey strict safety requirements. They must collaborate with government and prove their safety.

All these facts create conditions for developing of the tools which will be able to connect different companies. Such tools will have the following possibilities:

1. Involving different companies – from the big players to the small juniors
2. Integrating all branches of oil and gas.
3. Including tools for forming integrated operations: connections, information transfer.
4. Managing different equipment and items.

How we can create such tools and what solution will be the most suitable? As explained above, the SAP system cannot provide low implementation costs. We need a system with low costs and low critical threshold. Such critical threshold increases the spreading rate of our project and allows it to involve as many partners as possible (Albert-Laszlo Brabasi, 2002). But what exactly should the solution be? Are there some real examples of such tools that we can explore? Indeed.

Facebook

Provides a platform with an easy interface for creating an account, making connections between accounts, sharing information of different kinds (e.g. text, pictures, video, messages, common chats).

DHL

Provides delivery and mail services all over the world. Opportunity to control every stage of delivery: handling, loading, transporting.

GoogleDocs

Is a broad tool for sharing and editing text, tables, pictures, and presentations. Allows collaboration in editing with different users and provides types of authority for every participant.

Freelancer.com

Brings together buyers and sellers of services. Freelancers offer their experience, expertise and time, without entering the traditional exclusive relationship to one employer. Buyers place projects they cannot or do not want to perform themselves. The site allows buyers to select freelancers from their pool and to approach them directly. Freelancers are assigned an area where they can post their profile, resume, references and portfolios to present themselves to potential buyers. Normally marketplaces also offer some additional functions that provide more service or security for players. Examples are payment functions, rating functions for service providers (and sometimes even buyers), help and mediation functions, or community features (Dagmar Recklies, 2001).

There are many items and much equipment involved in oil and gas processes and projects, and we must have some module in our system for managing such things. What kind of mechanism do we need?

We can find the principles in DHL company, in which every item has a unique number that is used by the system to search the status of items. All information about actions with real equipment must be recorded, stored in special log files, and extracted by first requirement of authorized user. Of course such a numbering system already exists, for instance in EPC (Electronic Product Code) which will be discussed in the following chapters.

Another level of the system should allow for necessary information to be compiled into forms or documents for different partners, in order to send them invoices, geographical coordinates, graphs and more. In other words, this level of our system should work as an information hub. Using this hub we can not only connect different partners and nodes, but using statistical tools we can analyze the network and recommend better ways to collaborate.

The last level of the system can be based on semantic web principles. On this level the system provides the user with different possibilities:

1. Learning. User can explore existing nodes and their relations and expand their vision of all the processes of the organization. Such a common vision can lessen the understanding gaps between employees, departments and companies.
2. Fast navigation. System provide tools such as:

   - Word-search
   - Parameters for search “From *** to ***”
   - Surfing by the links and nodes

3. Applications can operate with data and encapsulate necessary information for the managers, providing the most suitable decisions (the closest vessel, the cheapest price, the most powerful equipment).

3.2 Long tail” in oil and gas

Existing trends on the market allow us to review the role of small companies in the oil and gas sector. If the industry was previously governed by the famous 80/20 rule (20% of firms produce 80% of oil), today the situation has become more challenging.

We can evaluate the Long Tail principle. This principle claims that under conditions of easy and effective communication, small players can create integrated clusters for joint projects and increase their market share using flexible and fast operations.
The following problems in the market can cause the Long Tail effect:

- decreasing of existing oil fields
- declining exploration capacity
- increasing oil demand
- increasing number of old wells with low profit
- increasing number of small companies.

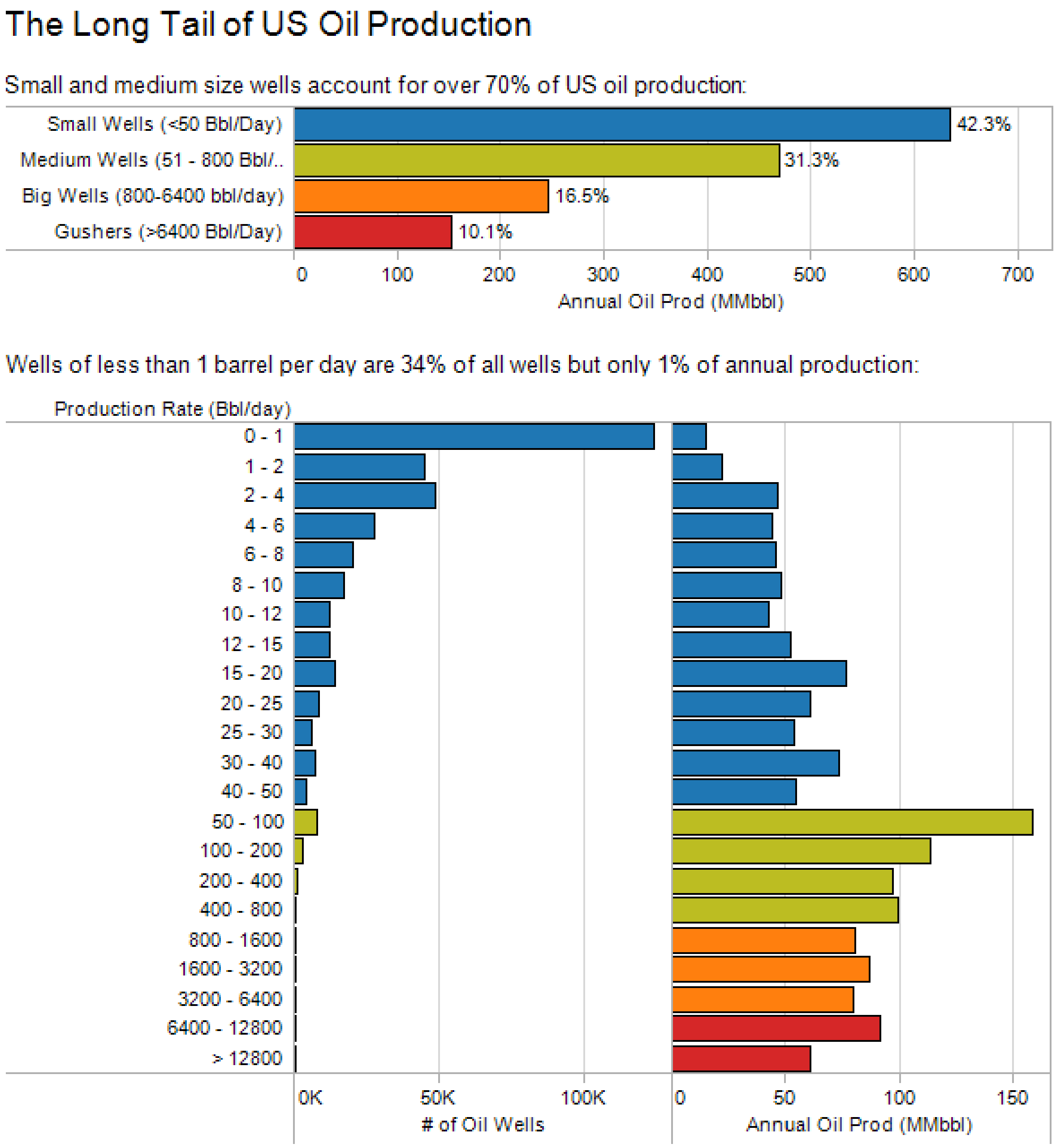


Figure 1 Long Tail of US Oil production (Paul Kedrosky, 2008)

Solutions:

1. Investments into exploration (requires large spending with high risks)
2. Increasing refining and extraction quality by implementing new technology (requires large spending with low risks)
3. Engineering costly wells (requires large spending)
4. Engineering alternative sources of energy (requires large long-term spending)
5. Engineering low-profit old fields (requires low funds, carries low risks, and produces low profit-niche for small companies).

Big companies are able to make high, long-term investments into the E&P sphere. That is the reason they are able to work with the first four points from the list of solutions. They are not interested in the last solutions, because if the profit is too small then big companies have no interest in holding the equipment. But that is not the case for the small companies. Small companies do not support huge departments of a variety of specialties as big companies do, and they can deal with low profit with low risks because they do not need to explore fields. They can just buy a licence for the old oilfield that has low production levels and develop it, having small margins. Increasing technology capabilities allow small companies to develop more and more low-profit fields to conquer their niche on the oil market.

Another way for small companies to decrease costs and increase profit is to collaborate. Small companies are more flexible and they do not need a great deal of coordination at the management level. As such, it is easier for them to combine human, technical and intellectual resources in order to make progress. In other words, small companies have a good opportunity to create integrated operations teams (IOTs). Drawing on Wikipedia, “The "crowds" of customers, users and small companies that inhabit the Long Tail distribution can perform collaborative and assignment work.”

Breaking down the process allows teams to focus on discrete tasks, which can be planned, scheduled, analyzed and improved. Utilizing a demand-pull system, wells are now planned according to the pace at which drilling rigs spud new wells. Size-based kanban are used to determine how many wells should be planned or are “Available-to-Drill” at any time. These teams also develop simple visual controls to monitor the current status of the number of Available-to-Drill locations against the target (Richard Avant et al., 2009) In other words, every company in the IOT must be highly specialized, providing unique experience and skills.

Other important factors in such collaborations are common processes, standards, and high speed links. This can only be achieved through the strategy of information sharing, where every partner can see every process when they need to. The best approach to such information sharing is online control of every stage. The following is an example of a company that implemented this approach.

The owners of Brage-Hydro have problems of decreasing production and loss of profitability. Instead of closing wells, the company began reengineering their business processes and implementing information technologies that enabled new ways of organizing work. The implementation of new ICTs (information and communication technologies), particularly the utilization of real-time data from offshore installations, allows a tighter integration of offshore and onshore personnel, operator companies and service companies. These IO (Integrated Operations) involve new work processes for better decision-making and new collaboration models. (Bjørn Holst et all.,2007)

In cases such as Brage-Hydro, new work spaces and visualization solutions can be developed to integrate and present relevant data in a way that quickly gives an overview of the state of various systems at the offshore installation. When personnel who work together across distances share this common view of the data, it facilitates collaboration. This may lead to improvements within fields such as:

- Production optimization
- Operations / process optimization
- Reservoir modeling, well planning and well history.

New real-time collaboration arenas are adapted to the new work processes. These arenas bring together personnel from across geographical boundaries (onshore-offshore) and company boundaries (operators and service companies) and gather different kinds of competence when needed.

3.3 Internet of Things.

The Internet of Things refers to uniquely identifiable objects (Items) and their virtual representations in an Internet-like structure. The term 'Internet of Things' was first used by Kevin Ashton in 1999. The concept has become popular through the Auto-ID Center. Radio-frequency identification (RFID) is often seen as a prerequisite for the Internet of Things. If all objects of daily life were equipped with radio tags, they could be identified and inventoried by computers (European Commission, 2009).

The essence of such a system is based on RFID-technology. Compared to barcodes, RFID is very expensive but allows for information to be stored "on board" things and can transmit data over longer distances. RFID is a much more prospective technology, and technology's evolution will perhaps make implementation much cheaper eventually.

For being a part of the Internet of Things every object must have its own EPC (Electronic Product Code). This is a guarantee of unique identity for every object in the world, for any time. This structure is defined in the EPCglobal Tag Data Standard, The simplest representation of an EPC is a URI (Uniform Resource Identifier). In computing sphere, a URI is a direct address for name or resource identification in the Internet. Such unique address make it possible to find necessary data upon request (W3C/IETF URI Planning Interest Group, 2001).

The EPCglobal Tag Data Standard also contain additional versions of an EPC identifier:

- tag-encoding URI format
- binary format suitable for RFID tags (these have small memory for the EPC/UII informational store)(GS1, 2012)

The most efficient solution proposed by existing logistics models requires information to be online. Databases were created to hold information and location systems were improved, mostly for large units like ships and airplanes. With the evolution of technology, devices become much smarter, smaller and cheaper which solves this double problem of information storage and location identification. In that moment we try to think more globally: cheap and available technology can be implemented in every sphere of life. For example, it is possible to have a system that uses information about your current state of health (e.g. vitamin deficiencies), food allergies, and dietary preferences in order to cook a meal on time for you to step through the door. The Internet of Things has the potential to change the world, just as the Internet did(Kevin Ashton, 2009)

Further, the Semantic web can expand possibilities of the Internet of Things. The Semantic Web is a "web of data" that enables machines to understand the semantics, or meaning, of information on the World-Wide Web. It extends the network of hyperlinked human-readable web pages by inserting machine-readable metadata about pages and how they are related to each other, enabling automated agents to access the Web more intelligently and perform tasks on behalf of users (W3C Semantic Web Activity, 2011) RFID-tech also allows us to implement real things into this network to provide a direct communication path, positioning, and data store for every item. In the following section, RFID will be discussed in more detail.

3.3.1 RFID technology

RFID stands for Radio Frequency Identification, and is a wireless identification technology for objects. RFID has three major components:

1. RFID Transponder (i.e. tag), which is a silicon microchip with an attached radio antenna for sending and receiving information
2. RFID interrogator device
3. Backend IT system

Two main types of RFID:

- passive
- active, which means it has a battery on every tag

Advantages of RFID:

1. high level of capacity for storing information about object
2. fast connection speed
3. possibility of reading it through the packaging or surface of the device

We consider the implementation of such technology in the sphere of upstream logistics. Upstream:

- Drilling equipment and chemical production
- Oil and gas exploration and production

Implementation of RFID should occur during the stage of drill pipe manufacturing, covering all steps such as forging, tubing, blanking, etc. We can then see the implementation of RFID tags through every pipe having its own chip that contains all information, like length, diameter, age,condition of usage, and so on. These tags allow online monitoring of inventory and delivery.

By keeping track of historical use data, RFID tags can help predict the remaining lifetime of a drill pipe or its associated usage risks. Through this monitoring, we can learn about the likelihood of drilled fluid-based corrosion. Different factors influence the corrosion:

- Temperature
- Flow rate velocity
- Heterogeneity
- High stresses
- pH

Their influence can be predicted with the help of RFID tags which could collect data from deep in the well. Managers would have all the data that would otherwise come from a manual inspection of the pipes. This data offers the possibility of reducing the incidence fatigue failures and errors.

RFID tags can be affixed to every item, and can transmit all necessary data online 24/7(see figure 2). They provide absolutely new possibilities for Integrated Operations and collaboration. RFID tags can serve as new tools for planning with a high degree of accuracy, and they reduce costs and eliminate mistakes.

The biggest challenge for the implementation of RFID in the upstream supply chain is developing tags that can withstand high degrees of environmental wear (e.g. high temperatures, high pressure, aggressive pH, etc.), and that are able to collect data underground.

Advantages of RFID implementation

1. Online inventory monitoring
2. Reduction of manufacturing mistakes
3. Monitoring of fatigue failures

Disadvantages:

- High level of investment required

High investments allow to the company decrease number of mistakes and control all equipment movements on-line (Dr. Gary M. Gaukler et al., 2009)

3.4 Impact of ISO 15926

The oil and gas industry collects and stores huge amounts of data. For example, Chevron alone currently has over 6,000 Terabytes of data, most of it technical in nature (W3C Workshop on Semantic Web in O&G Industry, 2008). Of course there are many catalogs, data stores, models and other tools for analysing and encapsulating information. But the difficulty is the absence of a common format, and related difficulties of transmitting data between the data stores and searching for information. For that reason, the industry requires a standard for data exchange and information sharing.

ISO 15926 -"*Industrial automation systems and integration—Integration of life-cycle data for process plants including oil and gas production facilities*". This standard was developed to create better conditions for collaboration. Standard consist 11 parts:

- Part 1 - Introduction, information concerning engineering, construction and operation of production facilities is created, used and modified by many different organizations throughout a facility's lifetime. The purpose of ISO 15926 is to facilitate integration of data to support the lifecycle activities and processes of production facilities.

- Part 2 - Data Model. A generic 4D model that can support all disciplines, supply chain company types and life cycle stages, regarding information about functional requirements, physical solutions, types of objects and individual objects as well as activities.

- Part 3 - Reference data for geometry and topology.

- Parts 4, 5, 6 - Reference Data, the terms used within facilities for the process industry.

- Part 7 - Integration of life-cycle data for process plants including oil and gas production facilities - Part 7: Implementation methods for the integration of distributed systems: Template methodology.

- Part 8 - Integration of life-cycle data for process plants including oil and gas production facilities - Part 8: Implementation methods for the integration of distributed systems: Web Ontology Language (OWL) implementation.

- Part 9 - Implementation standards, with the focus on Façades, standard web servers, web services, and security.

- Part 10 - Test Methods.

- Part 11 - Industrial Usage Guidelines.

(POSC Caesar Association (PCA), 2012).

ISO 15926 is used by the Norwegian Oil Industry Association (OLF) as the instrument for integrating data across disciplines and business domains for the upstream oil and gas industry. Possibly, it will be the next generation of Integrated Operations (IO), where a better integration across companies is the goal. Using the methodology of ISO 15926, and in close collaboration with the Norwegian offshore industry, POSC Caesar Association has developed an OGO (Oil and Gas Ontology) for the important upstream business processes: drilling, development, production, and operation (Kari Anne Haaland Thorsen and Chunming Rong, 2008)

3.4.1 WITSML

In spite of many efforts, the implementation of the common data exchange standard is still in the development phase. Yet, the potential of using such a standard is evident in considering the Wellsite Information Transfer Standard Markup Language (WITSML), which is a working standard in the narrow sphere of well drilling.

The WITSML provides information in an intuitive, understandable form for engineers and other workers. XML(eXtensible Markup Language) can extract information from WITSML documents and represent it. This encapsulated XML document can work with static and dynamic

data. The following is an example of data exchange with WITSML (see Figure 2). All data is available online.

The use of WITSML has been successful, and the University of Stavanger is exploring the possibility of integrating WITSML into ISO 15926. (Kari Anne Haaland Thorsen and Chunming Rong, 2008)

3.5 Semantic web

In 2001 Tim Berners-Lee predicted the creation of the semantic web as the next step in Internet evolution. In the ordinary Web, which is based on HTML pages, information is stored in text-form and people extract it using their browser. The Semantic web stores information as a semantic network using ontologies; an ontology represents knowledge as a set of concepts within a domain, as well as the relationships between those concepts (Steve Pepper, 2010). In the latter case, the client-program can extract information from the network and use it or can encapsulate it in a form useful to people. The Semantic web works parallel to the ordinary Web using HTTP

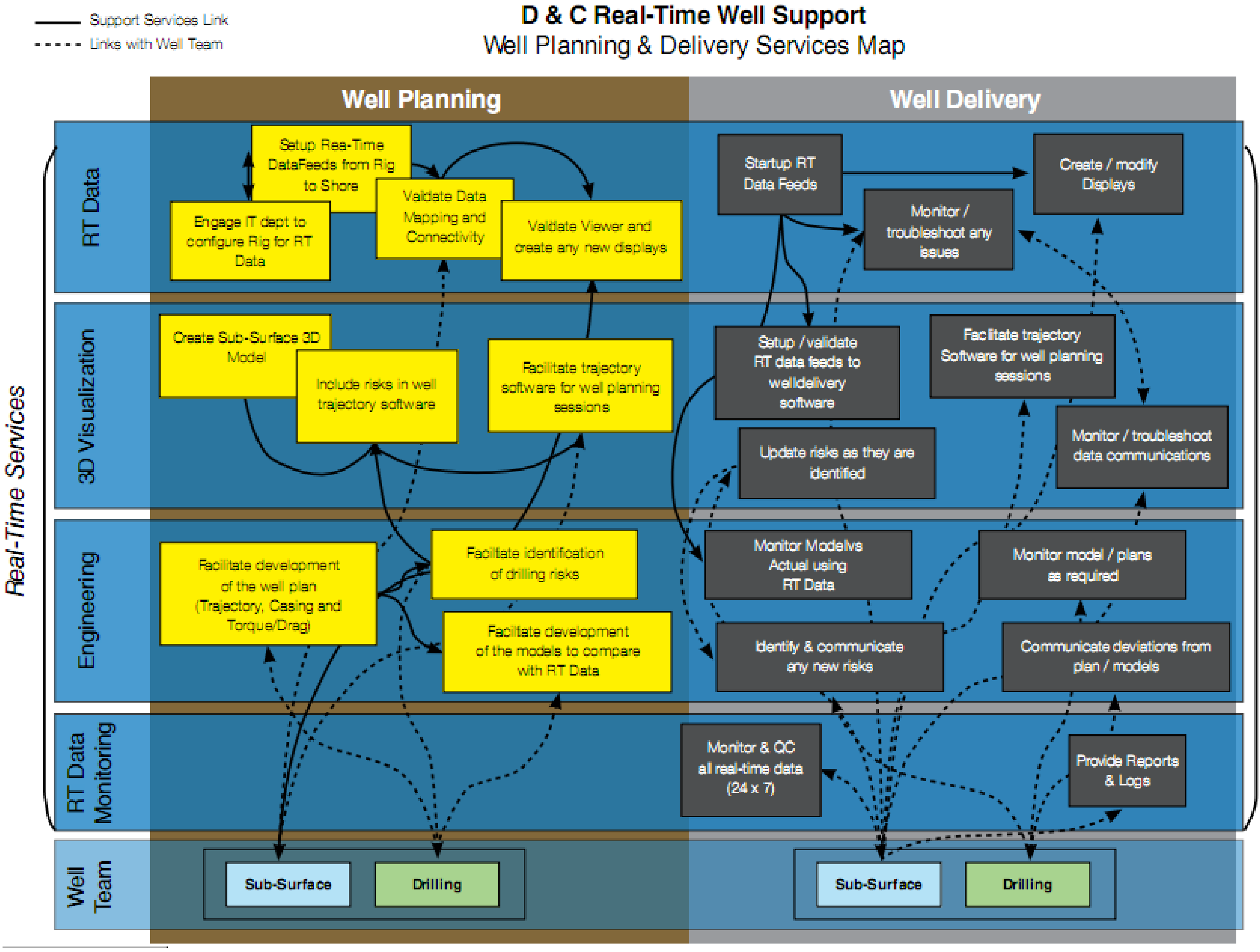


Figure 2 Deriving Business Value from Implementing WITSML (Dr. Julian G. Pickering,2010)

and a resource identifier URI. Ontologies create with the help of standard RDF descripted semantic graphs, where nodes and edges have their own URI. Information encoded in RDF could be interpreted with ontologies created with RDF Scheme and OWL to get inferences. RDF Scheme was the basic language for semantic web before 2004. OWL is next generation language and extension for RDF Scheme.

Now we will try to figure out the implementation of the Semantic web into our vision of the collaboration tools:

1. Easy-to-understand interface. The Semantic web provides user-friendly networks with main topics like nodes and relations like edges. The whole network or some part of it can be displayed as a kind of geographical map. The user can see the location of every

topic (item) among the others and relations between topics (links), as in maps of metro lines.

2. Effective navigation and possibility of information analysis. The user can navigate in the Semantic web using ontologies and associations. Data could be structured and suitable for statistical analysis.
3. Managing of different equipment and items. The Semantic web provides managers with the possibility of extracting all necessary data about the items (status, conditions, location, etc.)

In the previous section we explained different tools for knowledge structure mapping that exist implicitly in books: indexes. Now we will evaluate the scheme of knowledge representation with the help of conceptual graphs that include two main blocks:

- concepts
- concept relations

The following is a conceptual graph for the phrase “Shell drill well”. Concepts ('Shell', 'drill', 'well') are displayed in square brackets, and brackets denote relations of 'object' and 'agent'.

[Shell] <- (agent) <- [drill] -> (object) -> [well]

Similar graph structures have been represented in various forms under names such as “semantic nets”, “partioned nets”, “associative nets”, and “knowledge maps” in many AI systems. In the first published paper on conceptual graphs, John F. Sowa(1976) used them to represent the conceptual schemas used in database systems. His first book on conceptual graphs (John F. Sowa, 1984) evaluated a wide range of topics in cognitive science, computer science, and artificial intelligence.

It should be mentioned that knowledge and information are two different things, because there is a difference between understanding how things work and merely having information about something.

The development of social computing tools (such as bookmarks, blogs, and wikis) have allowed more unstructured, self-governing or ecosystem approaches to the transfer, capture and creation of knowledge, including the development of new forms of communities, networks, or matrixed organizations. However such tools for the most part are still based on text and code, and thus represent explicit knowledge transfer. These tools face challenges in distilling meaningful re-usable knowledge and ensuring that their content is transmissible through diverse channels ("Knowledge Management". 2009).

3.6 Definition of the system

Now we can combine all the components of the informational system into one concept. Progress in the sphere of RFID will provide new tags, that could be used in aggressive conditions. URI with RFID tags make it possible to trace items in every locations and get direct access to the linked with this item data. Due to common standard ISO 15926 different companies can share data and use information from their partners. Semantic web expanded possibilities of the system through the data structuring. The customers can extract information from the data and use it for activity planning. Conception of this system is an informational network (see Figure 3) with several Hubs (Informational Hub) which include data generation (RFID tags), data transmitting (clear address URI, communications and ISO 15926) and data structuring for future use.

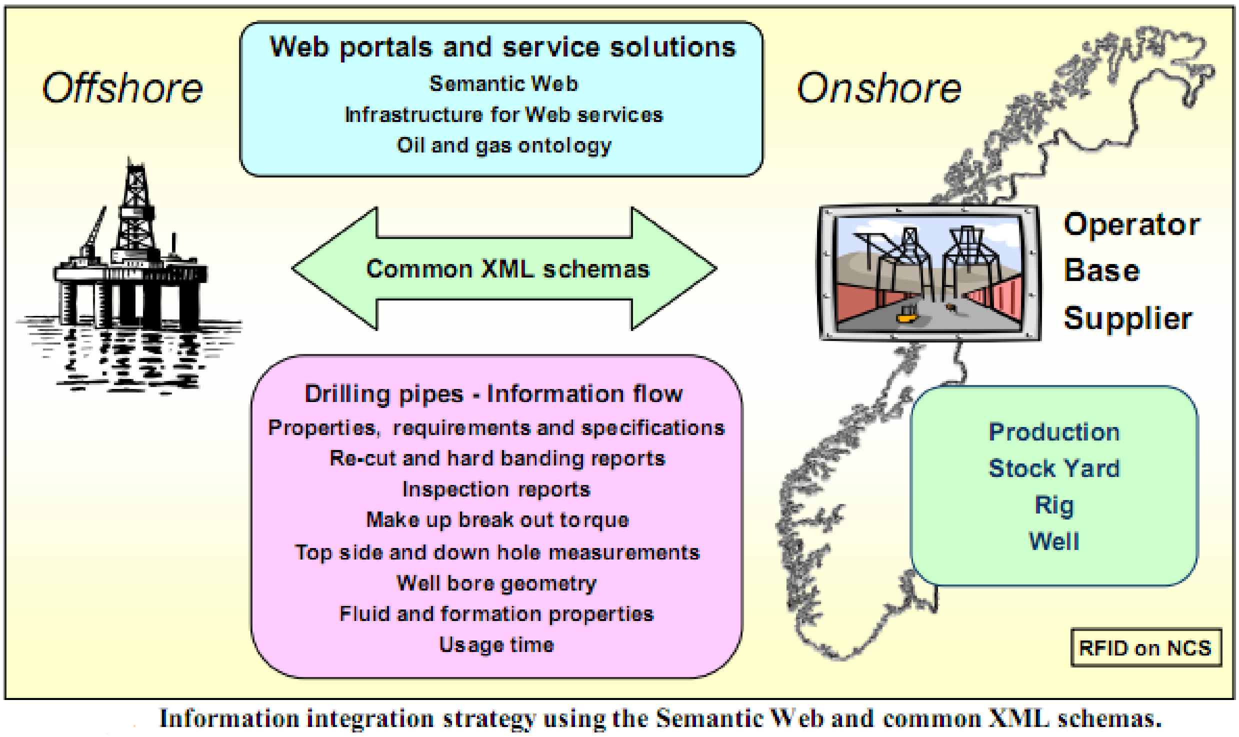


Figure 3 Information integration strategy (Dr. Gary M. Gaukler et al., 2009)

Possibilities of such system will be considered in the following chapters.

4.0 Stakeholder analysis

Exploring relations between different partners in O&G industry we should notice that network of relations are very broad and include not only operators, suppliers and customers, but also different players that has their own, possibly non-profitable interest. All players of the network that has their own interest called stakeholders. Before starting any O&G project, all steps should be planned and all groups of players should be ranged and be involved into planning. That is called stakeholder analysis. **(**Schmeer, Kammi, 1999)

Stakeholder analysis should be focused on specific policy, that should be implemented among all interested parties. The mission of our policy is creating conditions for tider collaboration and information sharing due to implementation of common data store. The objects is the following:

1. Broad using of informational tags RFID or QR-codes. It allows to trace Items and to store associated data
2. Implementation of common repository which will use ISO 15926 standard for data and RDF schema for structuring
3. Rules and restrictions for leaks pretending and security improvements

Stakeholder	Interests	Position	Knowledge of policy	Limitations
International companies (Statoil, Lundin)	Improve Item management, elluminate mistakes, decrease costs due to tider collaboration	Supports.	Understanding of online communications advantages.Implementation of narrow standard WITSML for drilling operations. The principles of WITSML are very close to ISO 15926. Developing long term strategy using Integrated Operations (IO)	Reengineering of whole business processes, modernization of the Items, compatibility with existing informational standards.
Specialized	Improve Item	Support	Participants of joint	Modernizatio

companies (Due to their contacts may be the hub) (Halliburton, Swire)	management, elluminate mistakes, decrease costs due to tider collaboration		projects with online communications.	n of the whole Items. Compatibility with existing informational standard
Small companies (TDW)	Improve Item management, elluminate mistakes, tider collaboration, promoting services to the new customers	Support	Understanding of collaboration principles	Modernizatio n of the whole Items
Public (Ministry of finance (Department of taxes, Customer service etc.) Ministry of Oil and Energy)	Security improvement s, fraud detection	Support	Development of the conceptions of the common informational field.	Not specified.
Labor Unions	preservation of jobs, better work conditions	Neutral	No clear view. Possibility of job cuts because of modernization	Not specified.

Nongovernmental organizations Ecology (Greenpeace, Bellona, WWF)	Security improvements, reduction of the offshore activity	Opposite	No clear view. Possibility of activity increasing.	Not specified.

Table 1 Stakeholder analysis

Stakeholder	Resources	Potential Leadership	Alliances	Strategy
International companies (Statoil, Shell)	Large (human, management, finance)	High. Could promote policy using resources	Potential participant	Promoting of the advantages. Successful examples of collaborations due to WITSML
Specialized companies (Due to their contacts may be the hub) (Halliburton, Swire)	Large (human, management, finance)	High. Could promote policy using it's connections	Potential participant	Promoting of the advantages. Successful examples of collaborations due to WITSML
Small companies (TDW)	Small	Low	Potential participant	Demonstration of the advantages.Searching for the new clients
Public (Ministry of finance (Department of	Large (human, administrative, possibly financial)	High. Administrative potential	Potential participant	Promoting of the advantages. Successful examples of collaborations due

taxes, Customer service etc.) Ministry of Oil and Energy)				to WITSML
Labor Unions	Large (human, administrative)	Low	Potential participant	Improvement of the working conditions due to better information. Reducing number of mistakes and emergency situations
Nongovernmental organizations Ecology (Greenpeace, Bellona, WWF)	Medium (human, administrative)	Low	Potential participant	Reducing number of mistakes and emergency situations. Security improvement

Table 2 Stakeholder strategies

As we can see the major players on the market have their own interests in such collaboration strategy. Policy makers should concentrate their resources on providing complete knowledge to all stakeholders and pay their attention on the most attractive points. The best result could be creation of the alliance of the main players for policy implementation. They could support each other and be participants of the common process. Unions and ecology organizations influence the formation of public opinion. Important thing for unions improvement of the working conditions and safety. The main features for Ecology organizations are security improvements and better Item's management that will lead to the optimization of the transportation and possibly decrease pollutions.

5.0 Data structures model

As it was discussed in the previous chapters, O&G players increase their efforts in collaboration and information sharing. That is why creation of common data base store is just a question of time. Now we need to clarify the most important
Now we need to clarify the basic elements of such store:

1. Identifiable item – it is anything that could be define as physical or virtual item. (for example drill). All items should be identify as unique e.g. system should be based on AIDC.
2. Attribute – description of the Identifiable item. Everything, that could expand knowing about the item.
3. Event – action that shows relocation of item or changing it's status (tracing from point A to point B)
4. Organization – stakeholder, who participate in any action, connected with item or group of items. Organization also has an Unique Identifier and can be owner or producer of data/information about items.
5. Traceability of items. Separated into two sections:
    - Internal –inside an organization
    - External – between organizations, including ownership changing.
6. Location – is an identifiable item shows the actual position of the item. Closely connected with events.
7. Owner of Identifiable Item. Normally it is an organisation
8. Information/Data owner. Organization which produces information about Identifiable item. This organisation can be owner or user
9. Part - information related to the life-cycle of items
10. Master data -represent data about organizations, resources and parts.
11. Event data -relocation of Identifiable items during a certain time period
12. Individual View - filtered information for user, who don't need the whole amount of data, only special information. This information can be traceability information in a given life cycle perspectives or maintenance information.event
13. Composite event - event of combination different items into new item. Packing of several items into one container.

14. Movement event - Movement of items between organizations or resources
15. Life cycle event -change of state for Traceable Item including production, maintenance, utilization etc.

Such structure supports traceability of the items and containers (Cargo Carrying Units). Most of equipment are transported in the containers.
Purposes of the model contain two main things:

- Creation of common understanding of business processes and which information needs to be managed by the stakeholders participating in common information storage (Hub).
- Supporting the development of data architecture and technical requirements for Hub

Traceability contains two parts:

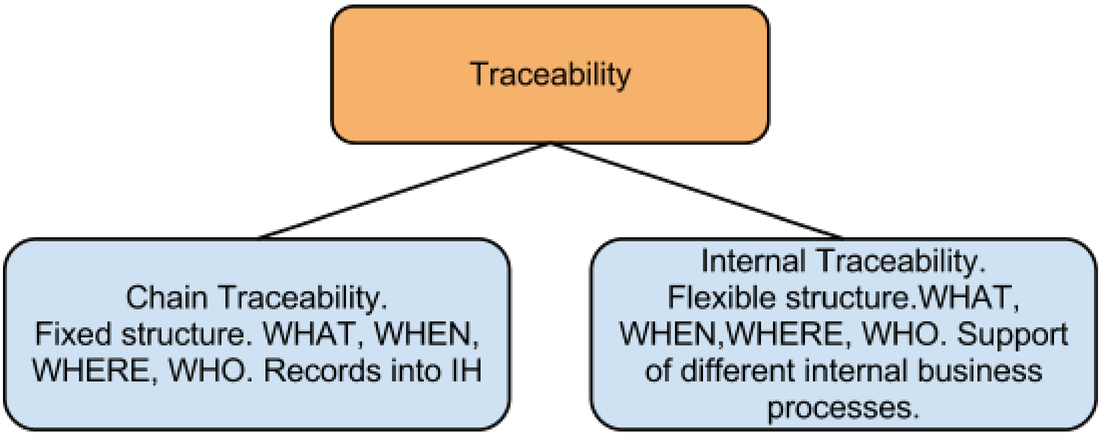


Figure 4 Traceability

- Chain traceability is a fixed structure contains information about four main questions: WHAT, WHEN, WHERE, WHO. All information must be recorded into IH.
- Internal traceability is a flexible structure with the same information. Also this structure supports internal business processes through recording of the internal event data

Figure 5 What, when, who, where identification

Navigation in the system consider several basic elements:

- Trace events are generated by the companies
- Traceable item has several trace events
- Trace events could use multiple Locations. One Location could be used for several trace events.

This elements allow creation of two layers of data - event data and master data. Event data involves all information about lifecycle of the traceable items. Master data is about players and their activities, which lead to the generation of event data.

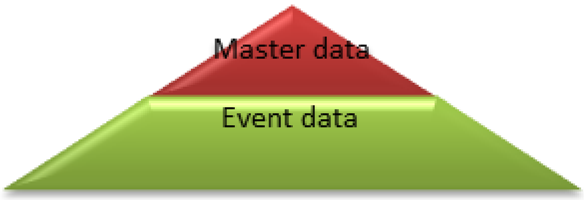


Figure 6 Hierarchy of data

Information should be transmitted and stored in XML-format. The data will be extracted from internal ERP-systems, from PDAs or other clients. All organization will be able to send and receive information and provide all two types of data. These conditions are very important for building chain traceability which become a cornerstone of mutual trust. All necessary information for supporting internal business processes also should be provided.

To illuminate all mistakes and misunderstanding, organization should implement common concepts as location etc., or create special form for events as drop-down-menu at recording. Architecture of the IHub will allow to secure information providing authorization for access.

List of events that stakeholders will provide the following things (see Figure 7)

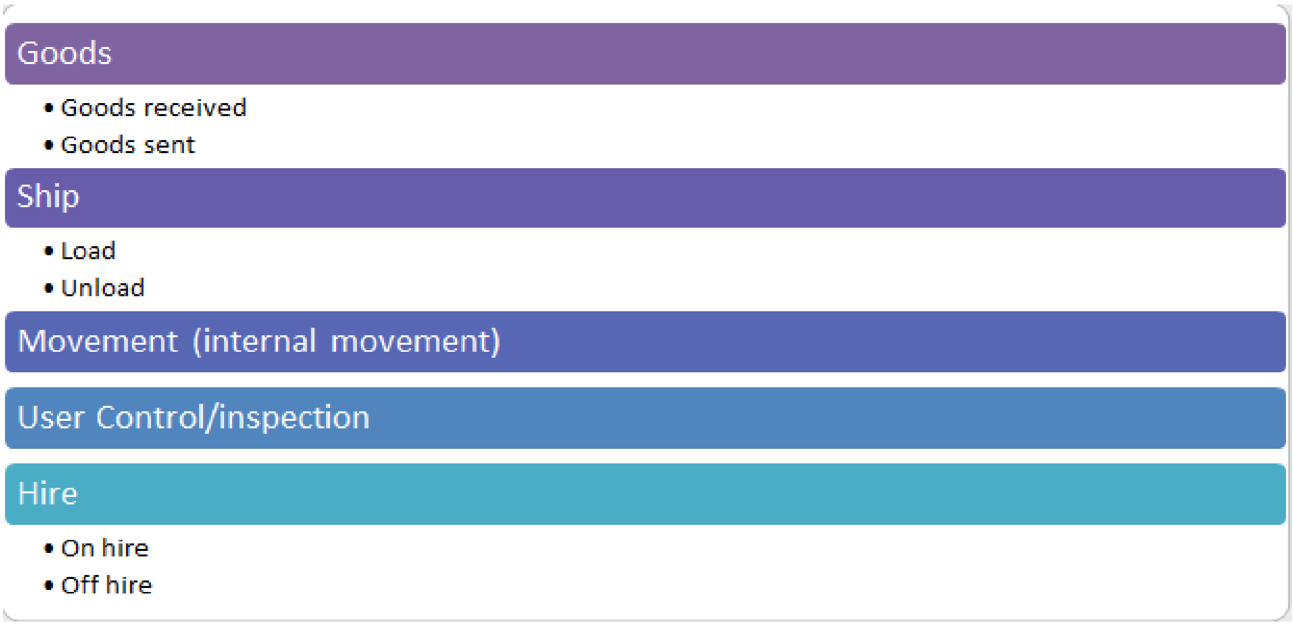


Figure 7 List of stakeholders events.

Attributes that has to be provided by stakeholders:

- Cargo weight
- Status (ready, broken etc.)

Master Data from stakeholders

- Owner of the item
- Hirer
- Hirer period
- Resources: ID, name, geo-location. Could be hierarchical
- Type/part information: ID, name, size, type, weight.

Stakeholders will define the following information (See Fugure 8).

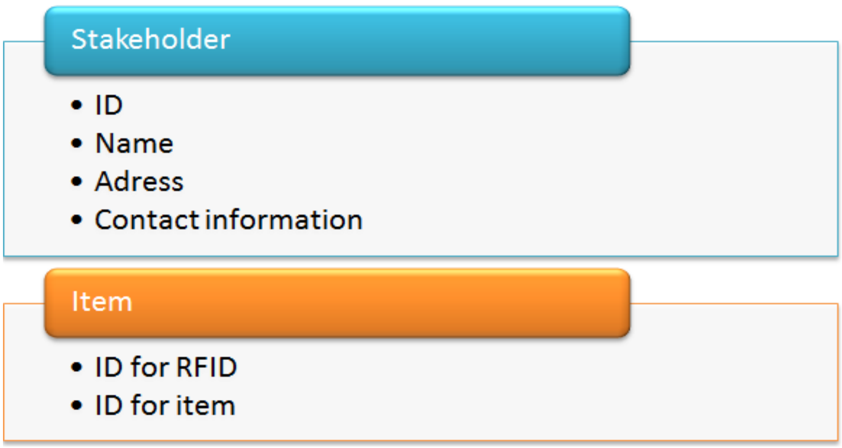


Figure 8 Stakeholders identification

There is four main groups of stakeholders, which are the most important for the system (see Figure 9).

Figure 9 Four main stakeholders groups

After clarifying all basic concepts I can present common structure of IHub. The system will collect data from PDA (employees) and tags: barcodes and RFID-tags. Information will be transmitted in XML-formats into local server and common IHub servers. Using information from both local and common IH servers stakeholders will plan their actions with more accuracy and see common picture of the whole project to illuminate possible mistakes and wastes.

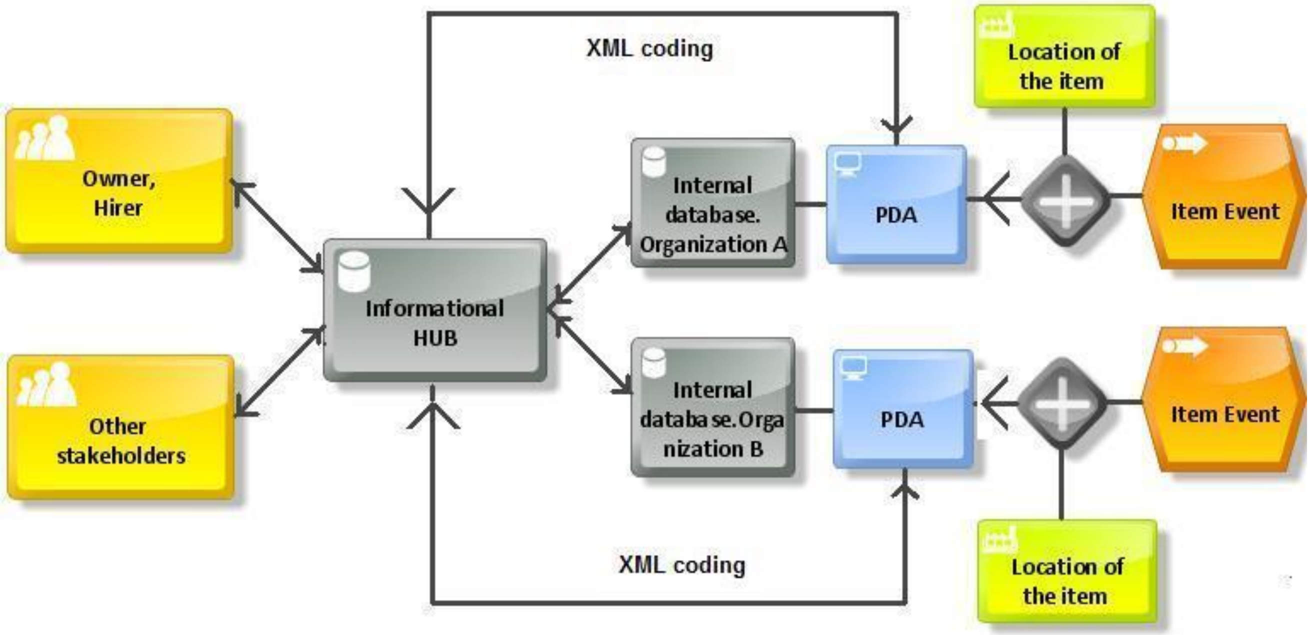


Figure 10 Scheme of data transmitting

The following cases will show possibilities of common data repositories and ways of future development, when large amount of data will be available.

Case 1. Logistic optimization and planning

Network contain information about major stakeholders, location, using time periods, maintenance, participating in composite events. All data are connected with each other. Such network allows to create common informational field and give necessary information to stakeholders.

Owners and hirers will have necessary information about items: sending, receiving, time periods, status, location. It will illuminate non-productive time and decrease costs. Such system with on-line information are close to just-in-time principles. All partners has clear view about their Items and can manage it more efficient.

The same principles are used in case of internal planning for company. Organization can search for all of their Items online and avoid low utilization of their equipment or/and containers. Also such planning illuminate overloading warehouses, because Items will be in use. Distribution of goods lead to decreasing of transportation costs.

Information about Identifiable Items, terms of using, attributes and other important information can be used by forwarding companies for planning and covering internal and external needs.

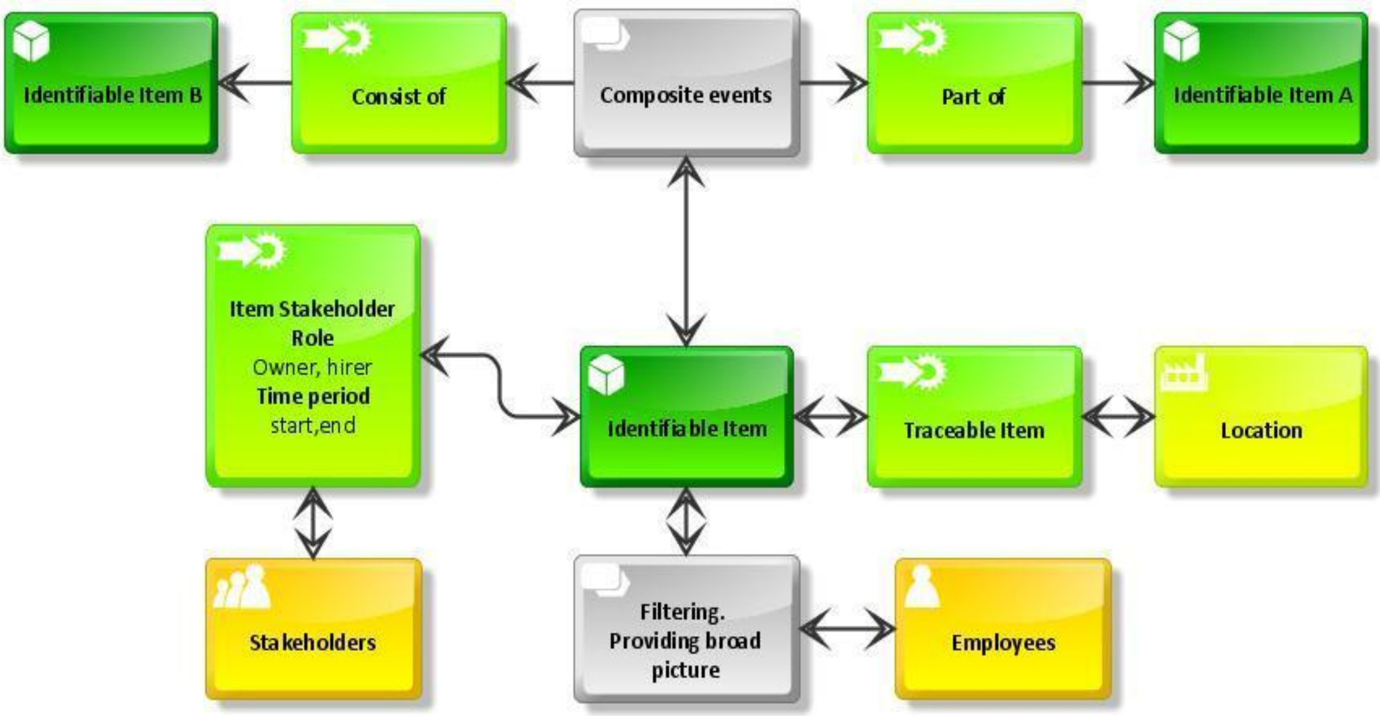


Figure 11 Scheme of information encapsulation

When large amount of data will be available, system could provide ready made solutions and connect hirers and out-of-hirer Items. The main goal will be decreasing costs, taking into account distances, technical characteristics of Items, costs of hiring and transportation. Other words such system allows to provide route-planning optimization.

Case 2. Maintenance

O&G sphere has very strict safety standards, and quality of the Items should be high. Precise information about conditions and time periods allows to increase quality of maintaining. Number of lifts, lifted weights, time periods - this information from the system allows to implement maintenance depending on container's use. Such principles will lead to cutting costs, because company will repair their containers when it's needed.

In case of Items as equipment the system dealing with much more complex environment. Engineers should clarify necessary list of requirement data for every Item. For example pumps conditions of using include the points are shown on the Figure

Using sensors, system can collect such data and provide support for technical services.

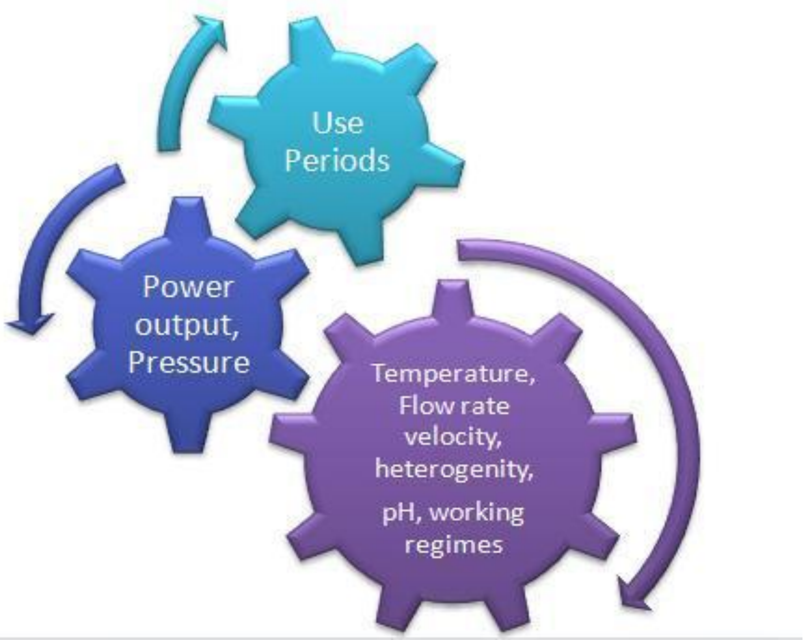


Figure 13 Corrosion factors for the equipment.

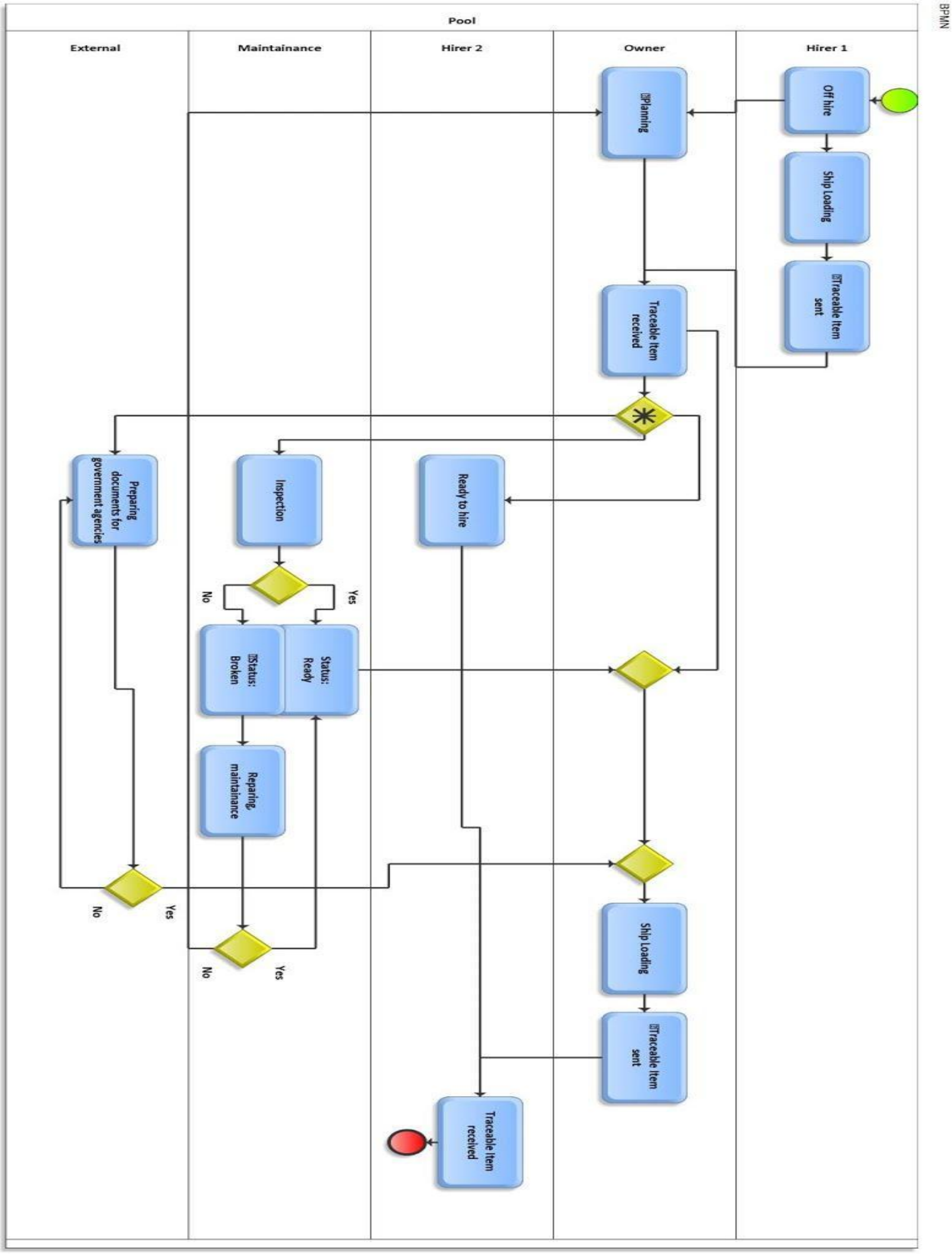


Figure 12 BPMN diagram of hiring process.

It is easy to provide an inspection on board of the vessel or rig, but there is much more difficulties if the equipment are used underwater or even underground. The decision is in implementation of RFID-tags inside the equipment and connect it with necessary sensors. Gary M. Gaukler et al.(2009) described such technology for pipes. But it can be expand at all kind of equipment with extreme conditions (see Figure 13). Such scheme increase offshore oil production safety, illuminate out-of-work periods cutting costs, because company don't need to buy new equipment if the existing ones has enough resources to work. There are technical difficulties with the development of tags for extreme conditions, but it will be solved.

Case 3 Statistical analysis for partners.

Owners and hirers can use data from the IHub for analysis and searching patterns. IHub will provide following information about the Traceable Items (containers):

1. Days in use/ Days out of work
2. Lifted weight
3. Locations
4. Movements between locations

Finding patterns will be important for optimization. Such planning will illuminate time wastes and increase utilization of owned/hired fleet.

Statistics for Traceable Items (equipment) will be the same. Players could see how to use their tools with maximum efficiency and minimize transportation and others costs.

Case 4 Statistics for NCS

Increasing of transactions will lead to creation of big amount of data. And it will be possible to extract information and find patterns of future directions in O&G. In most examples the data will be provided without specific information that could compromise Item owners or hirers. Analytics can combine different data, depending on needs.
Let's provide several examples:

Example A. Summarizing data about number of Items(containers), it's locations, number of using days, number of empty days, lifted weights, number of lifts, specialists can create a maps for better understanding of existing O&G trends. Where is the concentration of Items, where is the highest utilization, where is highest weights and so on.

In case of Identifiable Items as Equipment, maps can show the same information(see Figure 14), data of using, technical characteristics (Attributes), number of composite Items, number of parts.

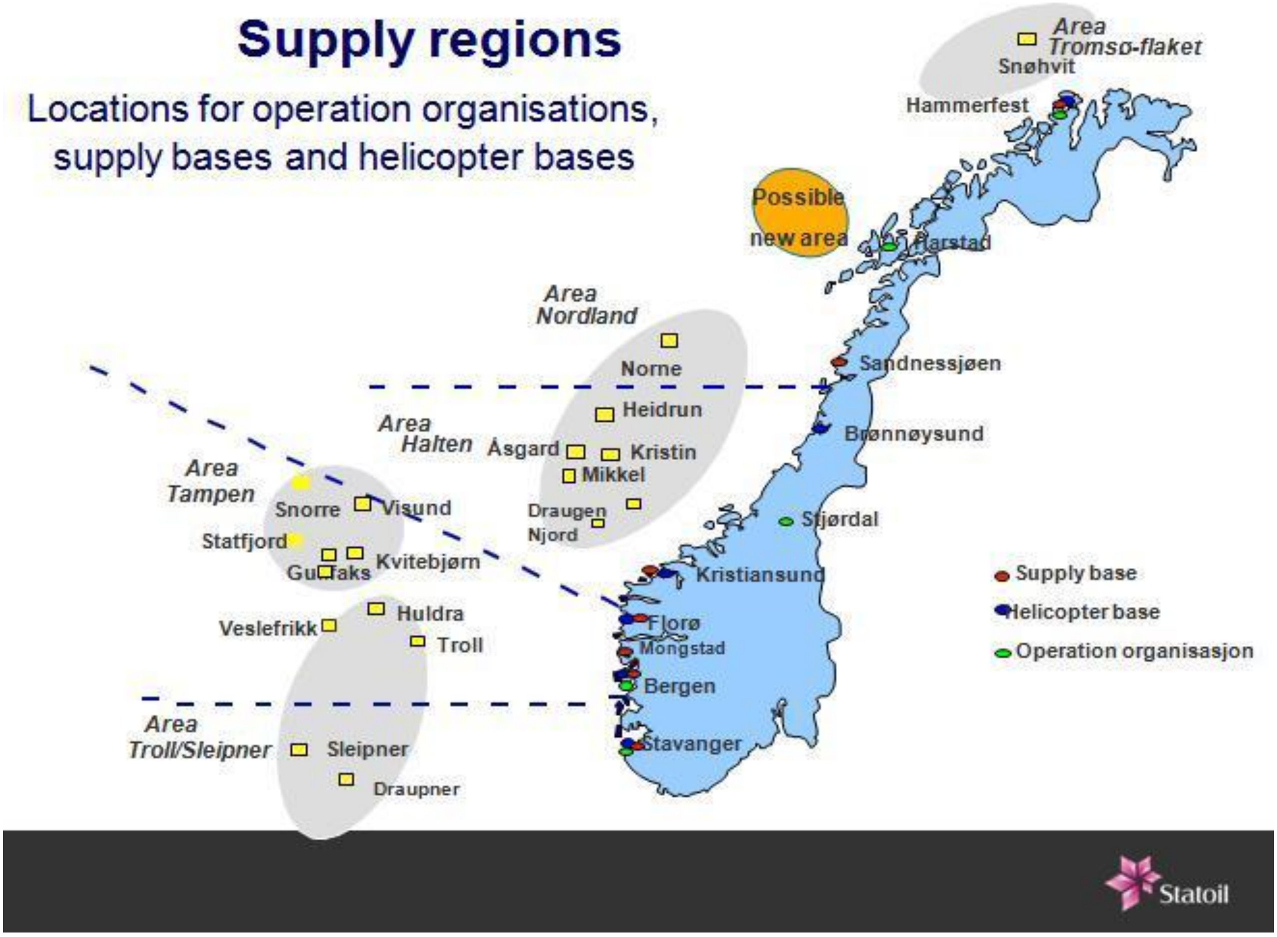


Figure 14 Supply regions (Statoil presentation.Logistics and Base operation, 2011)

Example B. Movement events are clue to the maps of incoming and outcoming flows. Accumulating data for different time periods make possible to see the development of new areas in action and make forecasts for future.

Example C. As it was mentioned below, specialists will be able to find patterns using data from IHub. But it is not easy to find hidden patterns that could be very useful. That is why there should be implemented multidimensional tools. Such tools will make possible to compare every variable with each other and generate multiple decisions.

“Deductor Studio academic” This is a very powerful tool in statistics and

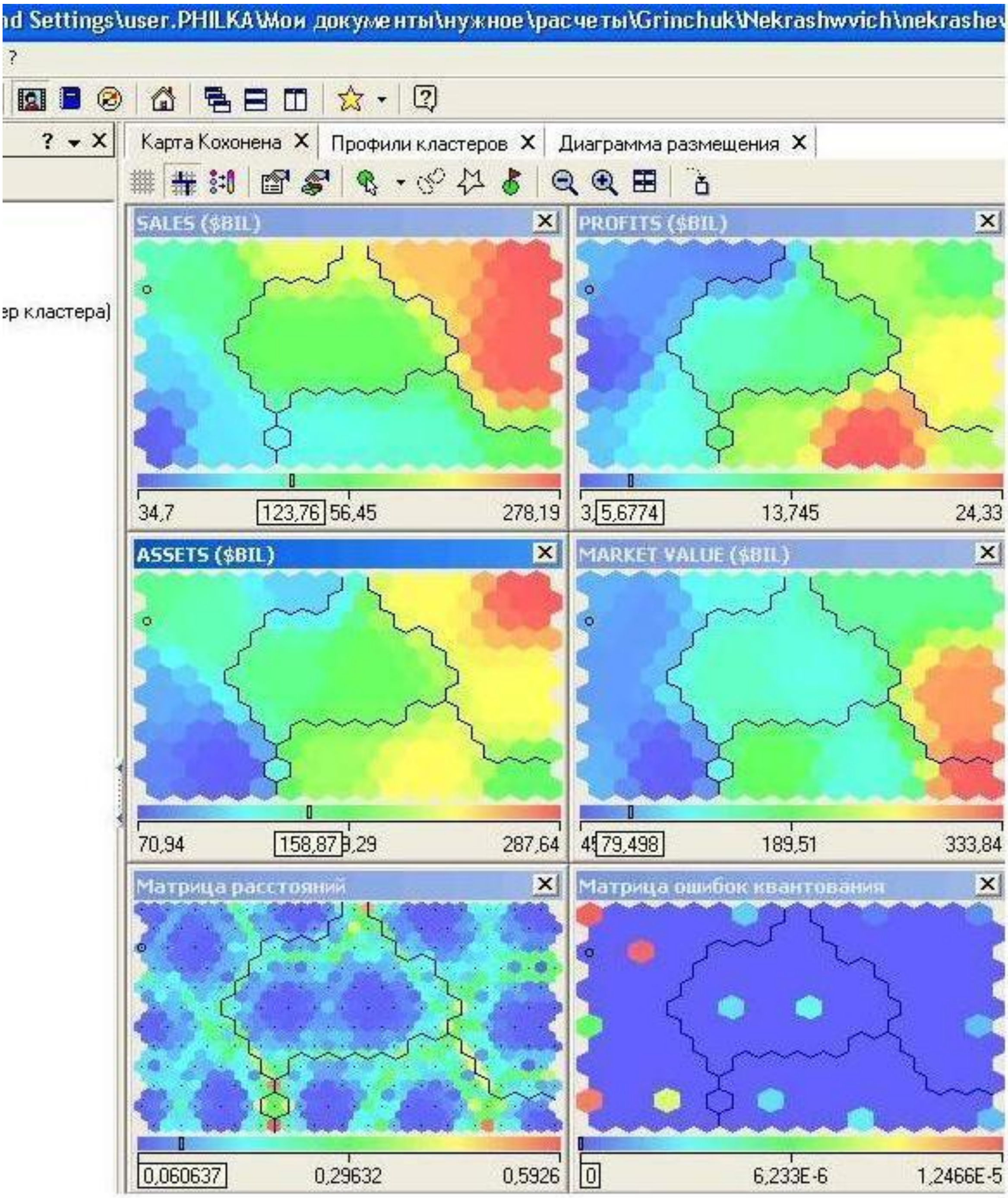
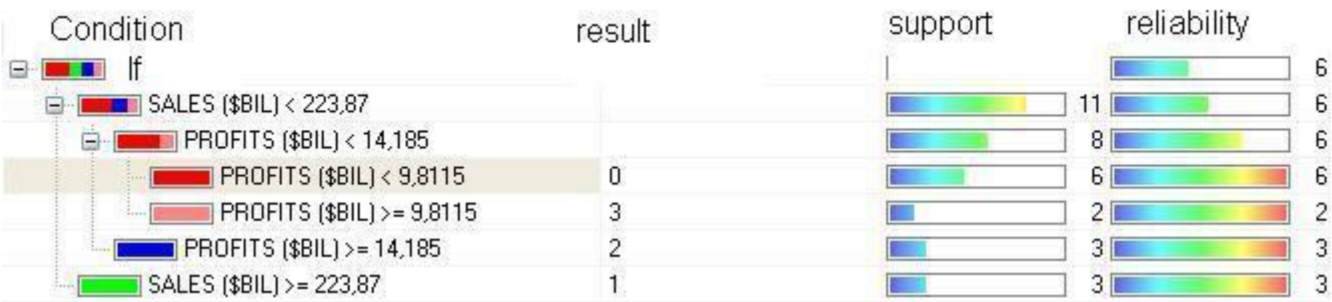


Figure 15 Cluster analysis of oil companies financial aspects.

neurons-networks. Data from IHub has a lot of links between it: containers, equipment, ships, it’s owners, hirers, different locations, statuses, movements. It is very hard to operate this data and not to lose some important information. That why it is so important to understand every number ,every change ,every step. Because it can give new trends and even new alternative decisions. ”In short,to act with foresight, the company must act on signals, rather than on pain.” (Arie de Geus, 2009) That is mean analytics has to understand all changes in the system. Full picture allows to analyse every number from one department or document with the other one number from the other department which can not be connected directly, but they can be connected through the several unobvious links.

In this case analytics face multidimensional analysis, which be able to operate with 4th dimensional space that is hard to imagine. In such situation specialists can use so-called self-organizing Kohonen maps.(Guido Deboeck, Teuvo Kohonen, 1998) This maps based on neuron networks with multilayer non parametrical regression. There is definite numbers of entrance data correlated with one or more numbers of exits. Other words program try to find any dependencies between any data. Then it allow us to provide clustering, and find nodes in the similar areas (See Figure 15). Example shows the basic principles of such analysis but with different data. This is financial information about oil companies collected from free sources.

These maps allows to compare different multidimensional data and find very interesting patterns between oil companies. For example, from the first sight we can see that companies with the biggest sales level are not the same who has the biggest profit (red clusters on maps "Sales" and "profit"), that only half companies with the biggest sales have "Market value" and so on. After that analytics can start thinking about questions "Why it is so? And what is the most important for the firms: sales or profit, market value or assets?" There is a great field for analysis and trends.



Condition	result	support	reliability
If			6
SALES ($BIL) < 223,87		11	6
PROFITS ($BIL) < 14,185		8	6
PROFITS ($BIL) < 9,8115	0	6	6
PROFITS ($BIL) >= 9,8115	3	2	2
PROFITS ($BIL) >= 14,185	2	3	3
SALES ($BIL) >= 223,87	1	3	3

Figure 16 The decision-tree for Cluster analysis of oil companies financial aspects

One more tool from Deductor is a decision-tree, where could be analysed cluster limits and searching some major differences between groups of firms (see Figure 16).

Case 5 Configuration management

Oil sphere include a lot of different and difficult composite items. Oil rig is also composite items which contain oil tanks, pumps, engines, pipes, drills etc. Every item should be compatible with every surrounded components and be technically sound. Configuration management cover this sphere. It is a management activity that applies technical and administrative direction over the life cycle of a product, its configuration items, and related product configuration information. Configuration management documents the product's configuration. It provides identification and traceability, the status of achievement of its physical and functional requirements, and access to accurate information in all phases of the life cycle by ISO 10007:2003 (International Organization for Standardization,2008) IHub will contain necessary information for such kind of managing items, providing data for planning.

Responsibilities and authorities.

Information about companies will contain responsibilities of every player and his authorities to make some decisions and implement changes into configuration of the items. To illuminate misunderstanding, the system will contain information about dispositioning authority i.e. who will have priority in configuration changings, technical approvals and consequences forecasting.

Configuration management planning

Coordination of configuration activities taking into account technical requirements and life-cycle events. IHub will contain all information for planning:

- Players
- their role, responsibilities and authorities
- Items, statuses, locations.
- Movements, actions, participation in composition events

Configuration management plan are based on this data.

Product configuration information

Technical data and operational information for different items will be stored by IHub, including following documentations:

a Specifications
b Standards
c Lists of spare parts
d Maintenance etc.

Analysis of large amount of data will support decision making system and possibly provide ready-made decisions for all interested players. Such mechanism are based on ranking of used items, links and it's characteristics. The same principles are used in recommendation application on Amazon site. If the customer make his choice, or just show his preferences, system analyses it and recommends some goods, based on choice of customers with similar wishes.

Configuration baselines

It is possible for the Ihub itself or some special modules to extract information from the data and provide configuration information for items in every time period during life-cycle(baselines) upon customer's request.

Log-files

Log-files contains keys from two main questions:

a Protection from unauthorized access

b Traceability of every change and decision.

All information should be available only for authorized personnel because of commercial secrets. But procedure of providing access shouldn't be complicated. Information should be available for all interested parties upon request.

As it was mentioned above, big amount of data will be analyzed for trend searching. In such cases confidential information could be used without any personalization (How many pipes are used in definite area without information who used every pipe and how)

Traceability are very important for building mutual trust (see Figure 17). It allows for all interested parties to control every stage of Item's life-cycle,

Figure 17 Control and security

clarify responsibilities and authorities disposition, to support informational availability for all interested parties and provide data for configuration audit.

Case 6 Security.

Information about life-cycle of the Items linked with the organizations, which manage it, create common informational field and illuminate possibility of mistakes and failure. Now information about Items become not the property of one company (or even one manager), but whole partners. And if some Item cannot be used as a part of some drilling system because of technical properties or without specific maintenance - it will be found by the system or operators itself. Such information openness will increase safety of oil&gas manufacturing.

Case 7 Fraud detection.

Oil industry with huge number of players, different locations, millions of Items, terabytes of data and projects with millions dollars is the perfect target for frauds. Different countries has their own laws, which regulated offshore and onshore manufacturing. That adds difficulties for global oil projects protection (Jeremy Beckman 1997).

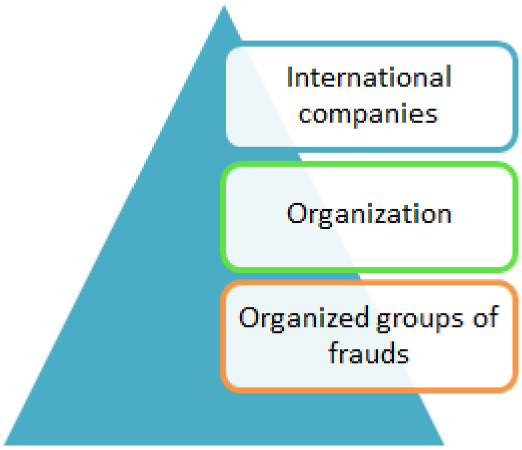


Figure 18 Levels of corruption and fraud.

The primary goals for organized groups of frauds and single organizations are getting the access to financial and material flows. System records every command and controls all accesses to the data store. IHub is also able to provide data about life-cycle of every item (who produces it, when, who used it, for how long, who controls it). Such analysis could prevent using of unreliable and old stuff (rusty drillpipes, old pumps, equipment without the necessary certificates, etc.).

Analysis of Item’s movements could show links between different projects, locations and players. And if some of these was connected with some fraud in the past - that is a signal to pay attention to it. (Example: A drill was used in some oil project with fraud. Than it was sold to some unknown company and now it was proposed for using in your project)

The same data may be used for further link analysis. During this searching analytics will deal not only with static picture of links itself, but with dynamic picture to trace growth of connections and it’s patterns. Abnormal behavior and large deviation from the common value are indicators for some possibilities of frauds(Andrew Marane 2008) There could be following “red flags” also:

- Frequent and unusual use of items
- Item utilization in locations with low control level or safety
- Connections of Owner/hirer with countries, known to be “tax havens” because of high level of crime and laundering of money (U.S. Immigration and Customs Enforcement’s (ICE), 2004)

Using this methodology, government agencies are able to improve security level of oil and gas business, increase investment attraction and operate this data to predict and prevent cartels between transnational companies. Cartels based on non-official agreements and it is hard to detect it (The Economist A-Z terms, 2012). The cornerstone of the cartels is mutual trust. There could be several factors for it following things

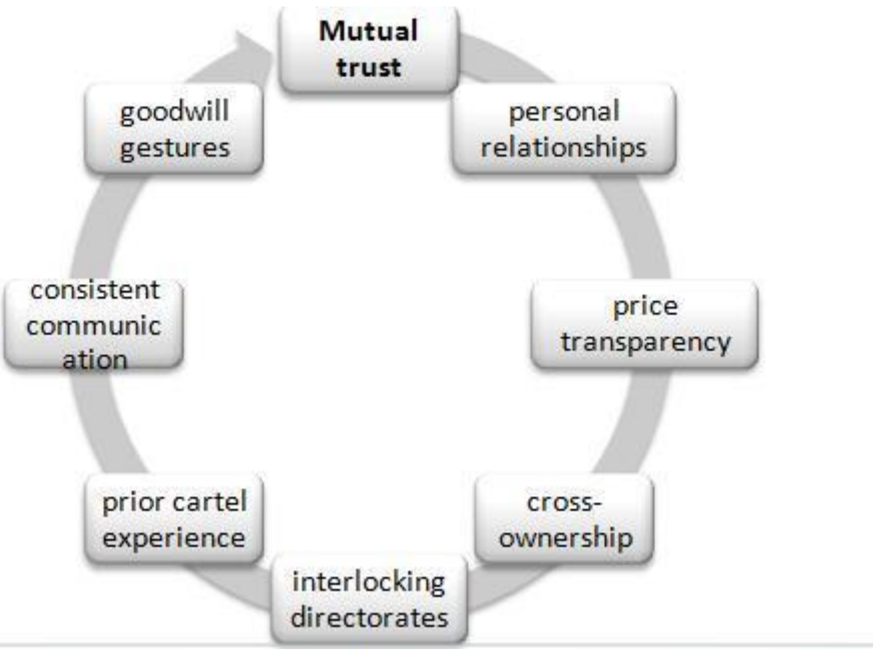


Figure 19 Main components of cartel behavior. Inspired by Christopher R. Leslie (2005)

Intensity of common operations and actions are indicate to the level of consistent communication and personal relations (how many items do the players share with each other, what projects do they make together, do they diversify their items with many players or not, how often do they act and what locations of their actions) Using such information from the IHub it is possible to provide map of players on the market and identify these companies which has the strongest connections between them. Cross-ownership of the items could be extract from the data about life-cycle and adds such information into the map of links between the companies. Combining material flows(Item's movements) with organizations and even persons, analytics are able to support cross-ownership, interlocking directorates and prior cartel experience searching.

6.0 Conclusions and further work

During this work we have analyzed O&G market and found the following patterns:

1. Oil extraction depletion and increasing of the demand. The number of wells with high production level and low costs is catastrophically low.
2. Oil companies invest money into new fields with difficult extraction conditions like offshore oil, shallow oil etc.
3. Oil production became much more complex and expensive.
4. Increasing of the number of wells with low production rate together with the need of the big companies to outsource some non core activities led to creation special niche on the market for the small companies.
5. It is hard to share information among organizations. Risks of fraud or leaks.

We clarified that joint projects is a common way for oil players to illuminate costs and increase production. Both big and small companies can be partners in such projects and provide complex operations. Such integrated operations produce big amount of data that should be shared with all interested players for effective collaboration. The objectives of the thesis was to formulate principles for collaboration, develop tools for incorporation of all data into a single set and to visualize data for further analysis.

We elaborate the following principles:

a) Using RFID-tags make it possible to trace every Item in the industry and to get all information about it. It's creates large amount of data.
b) ISO 15926 is a standard for data integration. We standardized our data.
c) Using of RDF schema for data structuring allows to extract necessary information and to work with it. We make linked data.
d) Take into account that amount of data is very large we propose to use distributed data store.
e) Security of the system. Access for the limited number of authorised users.

Using this principles we have developed a system model for data storage and provided stakeholder analysis to show all players and their benefits. We have described the following cases that could be solved using the data extracted from such system:

- Improvement of operational management using online data coming from every item
- Timely maintenance
- Better utilization of the items
- Understanding of existing market trends and long-term planning
- Configuration management
- Increasing of security level and fraud detection.

Other area of further research can be evaluation of network properties. There is a method based on graph theory that allows the network's future development to be forecasted. By comparing such methods with data mining tools and Artificial Neural Networks (self-learning neural networks) a powerful planning system can be created as a result.

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