Group Collaboration And Group Decision Making Information Technologies In Petroleum Industry

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ABSTRACT

The technical management of important natural resources such as oil and gas resources is a challenging responsibility that faces oil companies. The increasing global demand for oil and gas coupled with declining oil and gas reserves has forced the oil industry to make significant changes in its business processes.

Major oil companies have exploration and production operations that span several continents. Massive amount of data that is generated at all levels in an oil company has to be stored, analyzed and disseminated. In this paper, the changes in the management practices and business processes in the oil industry are traced over the past several decades. The use and application of information technology as change agents is also explored and evaluated. In particular, this paper focuses on the role of visualization centers in the oil and gas industry in revolutionizing effective group decision making that has enabled teams to be more productive, innovative, and outcome-focused.

Introduction

The oil industry has made significant changes in its business processes, going from almost isolated pre-1990 discipline-focused teams to more integrated reservoir management teams. In the 1990's there was an increased emphasis that proper exploitation of oil and gas reservoirs involves the effective use of multidisciplinary teams at all stages during the life of a field, both during exploration and throughout the later stage of appraisal, development operations and production. This led to the development of an integrated reservoir management approach for maximizing economic recovery of oil and gas. In this approach there is a maximum coordination of various disciplines including geoscientists, reservoir engineers, production engineers and facilities engineers.

However for an integrated reservoir management team to be successful, there needs to be a collaborative analysis of data so that more informed and effective group decisions can be accomplished thereby reducing capital risks and faster decision making.

Visualization centers have provided this collaborative opportunity that has helped many experts unleash new ideas, improve decision making and lower drilling risk. Visualization centers add value along the entire value chain - from planning, through acquisition and processing, and ultimately to production.

In this paper, we discuss the changes in business practices in the oil industry and how the use of information technology has affected these changes. We are interested in the application and use of information technologies that aid group decision making and collaboration. In particular, we are interested in visualization systems and their use by various companies involved in oil exploration and production. We also discuss the technology involved.

Reservoir Management

Reservoir management is the application of available technology and knowledge to a reservoir system in order to control operations and maximize economic recovery within a given management environment.

Sound reservoir management practice relies on the utilization of available resources (i.e., human, technological and financial) to maximize profits/profitability index from a reservoir by optimizing recovery while minimizing capital investments and operating expenses [3]. Thus, the basic purpose of reservoir management is to control operations to obtain the maximum possible economic recovery from a reservoir based on facts, information, and knowledge. By applying integrated reservoir management approach one can enhance recovery and maximize profit from the same reservoir through sound management practice.

The prime objective of reservoir management is the economic optimization of oil and gas recovery. That is, the most common objectives of reservoir management are:

- To decrease risk
- To increase oil and gas production
- To increase oil and gas reserves
- To maximize recovery
- To minimize capital expenditures
- To minimize operating costs

This can be obtained by carrying out the following steps:

- Identify and define all individual reservoirs in a particular field and their physical properties.
- Deduce past and predict future reservoir performance.
- Minimize drilling of unnecessary wells.
- Define and modify (if necessary) well bore and surface systems.
- Initiate operating controls at the proper time.
- Consider all pertinent economic and legal factors.

The various disciplines in oil industry include geophysics, geology, reservoir engineering, production engineering and facility engineering. A geophysicist defines the architecture of the reservoir (reservoir structure). A geologist defines the depositional environment of rocks that contain oil and gas reserves, determines rock properties and provides information on distribution of oil, gas and water in a reservoir. The primary role of a reservoir engineer is to most efficiently produce oil and gas reserves. Production engineers focus on the optimization of oil and gas production and drilling engineers are responsible for drilling wells. Facilities engineers are responsible for collection and separation of the produced fluids.

Before 1970, oil companies were organized as separate discipline teams. Figure 1 illustrates a conventional oil company organization. The organization reflected more a relay team where each team worked independent of each other. Once a team completed its task, the work was passed on to the next discipline team in line. There was minimal interaction between various disciplines teams. Such kind of approach resulted in longer times to produce reserves. For example, a reservoir engineer would wait on geologists and geophysicists to do their part before he/she could plan a well. Once the geological and geophysical interpretation was provided to the reservoir engineer, and if the interpretation did not suit the reservoir engineer, the process would start all over again. This approach not only delayed drilling a well but most importantly, due to lack of collaboration, resulted in many missed opportunities and poor planning. No one team felt responsible for the end product i.e., the most efficient exploitation of a reservoir.

In 1980’s and 1990’s a new business process approach was adopted. An oil field was divided into different assets that could contain one or several reservoirs. Asset management teams comprised of experts from all disciplines. Figure 2 shows a typical integrated reservoir management team. This approach resulted in greater interaction between various disciplines and improved decision making and reduced time to drill a well and produce oil. The synergism provided by the interaction between various disciplines resulted in successful reservoir management practices. An asset team felt responsible for the most efficient exploitation of its asset. During this period, the advent of technology accelerated the pace of drilling new wells.

Role of Information Technology

Due to enhanced computing power, detailed reservoir description could be accomplished utilizing geological, geophysical, and reservoir engineering data to build geological and reservoir simulation models. Petroleum industry is a highly data intensive industry. Its needs encompass exploration, production, drilling, business-decision analysis and data management. Data integration is a key factor. Technology has helped integrate every phase in the typical life cycle of an oil field. It has helped exploration and production professionals to flexibly integrate field operations data (data acquisition, drilling, enhanced recovery) with "knowledge work" (data processing, analysis, interpretation).

Technology has played a very important role in the petroleum industry. There has been a drop in oil/gas finding costs by over 60% in North Sea, UK, off-shore Mexico, Brazil and Venezuela. There is a reduction in risk and an increase in the probabilities of striking oil/gas finds. Marginal fields have become more profitable to develop. Technology continues to move forward in the form of 3-Dimension (3-D) seismic interpretation, advanced reservoir simulation techniques, and horizontal drilling.

Visualization Centers

In late 1990's, visualization centers were introduced. Visualization is the process of representing information in a graphical manner. The first such center was introduced by Texaco in 1997. Visualization centers introduced the concept of viewing data simultaneously and collaboratively by multidisciplinary teams. Combining high-performance computing and data management technologies with advanced collaborative visualization capabilities allowed geoscientists, engineers to make faster and effective decisions.

Visualization systems help promote better understanding of complex data and encourage collaborative work among interdisciplinary team members. Visualization systems make efficient use of integrated data and have resulted in optimized workflows that encompasses all phases of the oil field life cycle, which begins at the planning stage, followed by well construction and finally by production. Visualization centers provide environment to work concurrently and collaboratively to harvest the collective experience and insight of an entire organization. They empower teams to review, collaborate and visualize their development plans as they exist in real life. Such centers enable teams to interact with their designs in real time and conduct reviews at full size. Remotely connecting facilities into virtual collaborative networks allows experts from various disciplines to work together to create and share information, leading to fewer changes during project planning. The interactive environments provided by visualization center can convey information from different disciplines to members of a team, highlighting problem areas to entire teams thereby reducing risks and saving valuable time.

In oil industry visualization centers allow oil and gas companies around the world to analyze geo-scientific and engineering data in highly visual, three-dimensional formats for exploration and development of hydrocarbon reservoirs. Increasingly, data are viewed simultaneously and collaboratively by multidisciplinary teams dispersed in locations around the world. Combining high-performance computing and data management technologies with advanced collaborative visualization capabilities allows geoscientists, engineers and researchers to gain new insight through analysis of critical data in innovative and cost-saving ways. For the work team, viewing multiple images simultaneously provides a much more comprehensive evaluation of data than crowding around paper maps or a small computer screen. The computers help scientists convert massive amounts of complex seismic and production data into a three-dimensional panorama of the area's subsurface called geological models. Scientists can then move, slice, and explore the area using the computer's 3D visualization system.

Visualization centers in oil industry utilize a high-tech, three-dimensional theatre for the advanced exploration of oil and natural gas. They integrate super computers, high-speed graphics systems, four screens, and digital stereo projection equipment to transform large amounts of seismic and well data into sharp 3-D models of the subsurface. A visualization center projects dynamic and vibrant geological images onto a large, curved screen [2]. Viewers don electronic 3-D glasses and underground structures jump off the screen, immersing geologists, geophysicists and engineers inside target reservoirs.

Visualization centers can vary from real large to desktops. The main types of 3-D Visualization centers are:

- Large curved screen with multiple high resolution projectors. LCD flicker glasses need to be worn in order to view true 3-D stereo image of the projected data. Curved screen creates an immersive environment. In a "sweet spot", peripheral vision is completely filled with the 3-D image because of the curved screen.
- Power Walls – large flat screen used for data projection, less immersive than the curved screen systems because of their inability to fully fill the peripheral vision.
- Caves – small rooms where 3-D images are projected from the outside. It gives one a feeling that one is inside the data. It can also be projected on the floor.

Next the group collaboration aspects of Visualization Centers are discussed.

Group Decision Making and Group Collaboration

"A picture is worth a thousand words" is an old adage that reiterates the fact that a human brain is a powerful visual information processing system. It executes millions of visualizations everyday when performing routine tasks. Cave paintings were one of the first forms of visual communication tools used by humans. Of all brain functions, vision has the highest capacity for processing information. The human brain uses images to explain complex phenomenon and it can identify patterns in data through visualization.

Before the use of visualization centers, geologists, geophysicists and engineers had to browse through volumes of data in the form of numbers, spreadsheets, line graphs, and bar charts. The entire life cycle of exploration and production would take weeks or months. With the advent of visualization centers, scientists and engineers can meet face-to-face or virtually at one time. This has increased productivity and has led to more accurate and effective decision making. It has also led to reduction in the planning and execution phases.

We briefly discuss five decision-making models and conclude the model that best describes the decision-making followed by a reservoir management team [1].

Decision-Making Models

- Rational (classical)
- Organizational (neoclassical)
- Political (adaptive)
- Process (managerial)
- Garbage Can (random)

The Rational Model is founded on quantitative disciplines and is a closed decision-making process that aims for a maximized outcome. Fixed objectives are set forth by the group. The Organizational Model operates on attainable objectives with a short-term horizon. The decision-making process is open and the decision-making strategy is judgmental. It operates on the principles of bounded rationality. In the Political Model, there are ambiguous or nonexistent objectives. Decision-making strategy is compromised and there is no bounded rationality. In the Process Model, the objectives of the group are dynamic and long-term in nature. The decision-making process is open and judgmental and it accommodates innovation. In the Garbage Can Model, decisions are random and unsystematic. Choices are inconsistent and involvement of participants is fluctuating. The technologies adopted are not clear.

Interviews were conducted by the author for a single petroleum company that uses Visualization Centers. As per interviews conducted by the author, the group decision-making adheres to the Rational Decision Model for the most part and to the Process Model for some cases.

More research and interviews are under way, and the results will be published in forthcoming articles.

Conclusions

Volatility of oil industry and uncertainty in E& P demands very high group interaction for an efficient and effective decision-making process. Organizational structure and business processes in the petroleum industry have evolved to enhance group decision making. Visualization centers represent latest in business process modification, which has led to increased learning and knowledge sharing and increased individual participation.

Suggestions for Future Research

To research existing technology and its usage by small to medium sized petroleum companies. Another important area for future research would be to determine the constraints faced by virtual teams when using Visualization Centers and the effect on the decision making process in this case.

References

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Figure 1: A conventional Pre-1970's Petroleum Organization

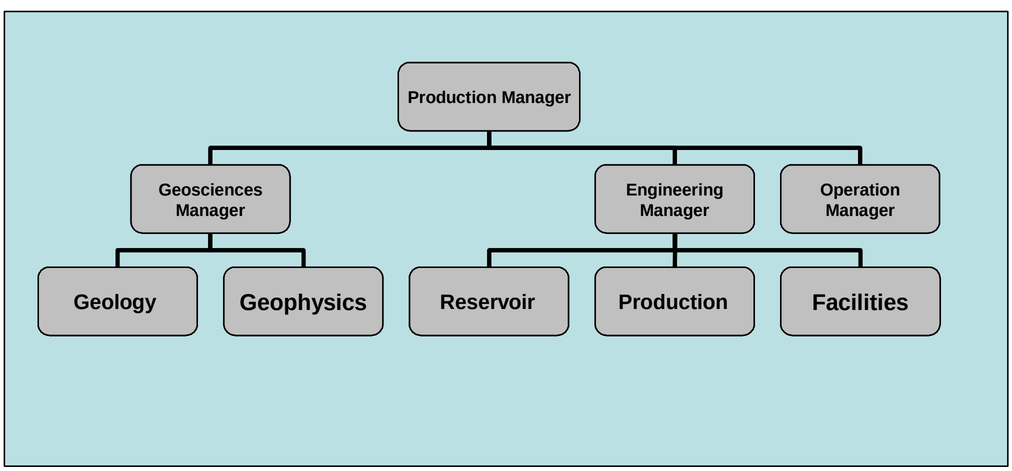

Figure 2: A Typical Post-1990's Integrated Reservoir Management Team