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Emergency Environments for the Oil & Gas Exploration and Production Industry *

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Abstract. The objective of this poster is to present some of the key challenges faced when defining and building virtual workspaces for oil & gas Exploration & Production (E&P) activities, such as 3D geomodelling, seismic interpretation, real-time drilling follow-up and correction, offshore structures' design, static and dynamic simulations of these offshore structures, oil pipelines' monitoring and emergency situations' handling. Also a case study focusing on emergency scenarios with extreme conditions is discussed in details.

Keywords: virtual reality workspaces, virtual environments, collaboration, oil & gas.

Resumo. O objetivo deste poster é apresentar alguns dos principais desafios enfrentados quando se define e constrói workspaces de realidade virtual para atividades de Exploração e Produção (E&P) de óleo & gás, tais como modelagem geológica 3D, interpretação sísmica, acompanhamento e correção de perfuração em tempo real, projeto de estruturas offshore, simulações estáticas e dinâmicas destas estruturas, monitoração de oleodutos e tratamento de situações de emergência. Também é analisado um estudo de caso focando em cenários de emergência sob condições extremas.

Palavras-chave: *workspaces* de realidade virtual, ambientes virtuais, colaboração, óleo & gás.

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1. INTRODUCTION

The oil & gas industry has been a leading player in exploiting the power of virtual reality technology to enhance its business processes. The motivation for deploying such advanced technology in this industry is due to the difficulties that the companies were facing in the late nineties, with the price of oil hovering near all-time lows.

The Virtual Reality Centres (VRCs), large projection rooms with features such as 3D and stereoscopic images, soon became very popular in the oil & gas industry, since they gave specialists the ability to quickly and comprehensively interpret large volumes of data, thus significantly reducing cycle time for prospect generation [American98].

Petrobras built the first Latin America VRC in its R&D centre (CENPES) in 1998. The idea was to test moderate-priced configurations, show the benefits of this technology and encourage the installation of similar VRCs at other operational units of Petrobras.

Another VRC was built in the company's headquarters in 1999 and now Petrobras has already ten VRCs being used all over the country, including a holo-space installed in its headquarters.

However, due to ever increasing business pressures, there are further demands on researchers to extend the capabilities of the VR technologies, so that it can be fully utilised in all the oil & gas exploration and production (E&P) phases.

2. TYPES OF E&P PROCESSES

This section discusses the main processes of the oil & gas E&P industry and the main challenges within each process. The work presented here is based on the authors' experience with oil & gas projects at Petrobras in Brazil.

2.1 Reservoir Exploration Phase

During this exploration phase, the goal is to elaborate the subsurface models that best represent the reservoirs. Whether it is a seismic cube or a stratigraphic geological model, what is important in this phase is to build an individual mental representation of the model. Therefore the key tasks in this phase are 3D geomodelling and 3D seismic interpretation.

2.1.1 3D geomodelling

3D geomodelling involves a large spectrum of skills, spread over different domains (geophysics, geology, reservoir and petroleum engineering). During its lifetime, a numerical earth model is shared by people with different types of specializations. The model evolves continuously over time, by absorbing various inputs from the team members [Reis01], as shown in Figure 1.

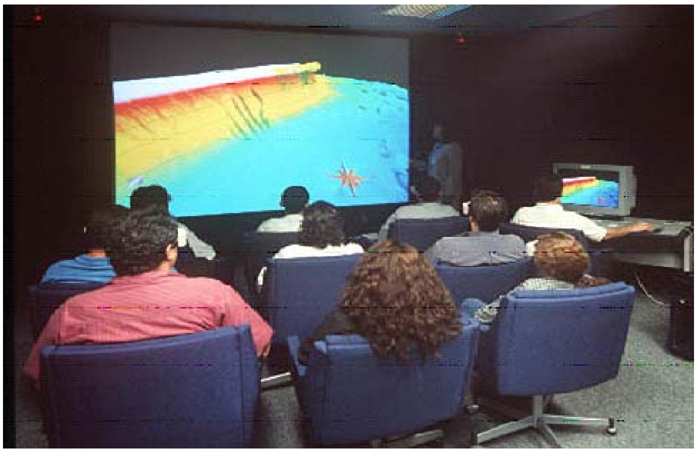

Figure 1: Team members discussing a 3D geological model.

The main software that have been used in 3D geomodelling until now include GOCAD, Landmark, Schlumberger and Earth Vision from Dynamic Graphics. Petrobras is already using synchronized viewing of the earth model among different specialists.

2.1.2 3D seismic interpretation

The advent of VRCs and stereoscopic images opened a door to a new world for seismic interpretation, allowing the users to visualise and explore in an interactive manner. The work became much more easier since specialists no longer need to use their knowledge and imagination to draw a mental picture of the area and to feel immersed in it. A mapping that used to take months began to be drawn in just a few hours [Petrobras99].

In terms of software, several geophysical visualisation programs have been developed, namely, in-depth Reverse Time Migration, 2D and 3D acoustic and elastic seismic modelling, and seismic volume visualisation [Silva03], such as the one seen in Figure 2.

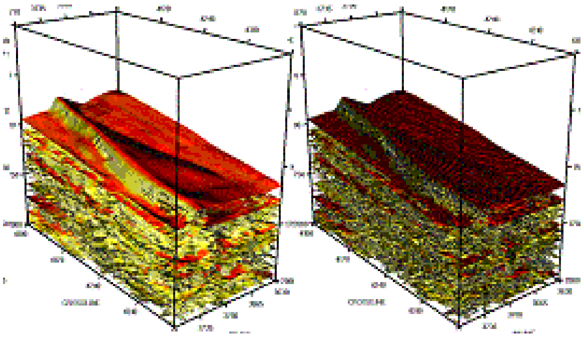

Figure 2: Seismic volume visualization with different methods.

2.1.3 Real-time follow-up and correction of the course of a deepwater horizontal well

Mostly in the early stages of the oil field's development, the reservoir may not always be found as forecast and as a result a well of about US$ 20 million may be lost. One of the challenges is to explore the use of optic fibre cables, connected to a VRC, to monitor the real-time drilling to make sure the rig will hit its target and will not skip the reservoir [Petrobras99].

Petrobras is already using this technology in the exploration phase, including an in house development known as gWLog [Campos02].

2.2 Design and Construction Phase

During the design phase, the oil & gas industry is interested in visualising offshore structures, performing static and dynamic simulations of these structures to ensure their stability, examining the construction processes, analysing procedures for monitoring oil pipelines and emergency situations etc.

2.2.1 Reviewing the construction process

The engineers need not only to have access to every single part of the model and its characteristics, but also to review the model from different perspectives.

When dealing with virtual reality applications over these types of data, the focus is in visualising and walking through the facility with good performance and sufficient realism. It is necessary to treat the data before visualising them.

For this purpose, many recent works have been developed searching for efficient solutions for the conversion of CAD models to VR models. An example is the ENVIRON tool [Corseuil04], shown in Figure 3.

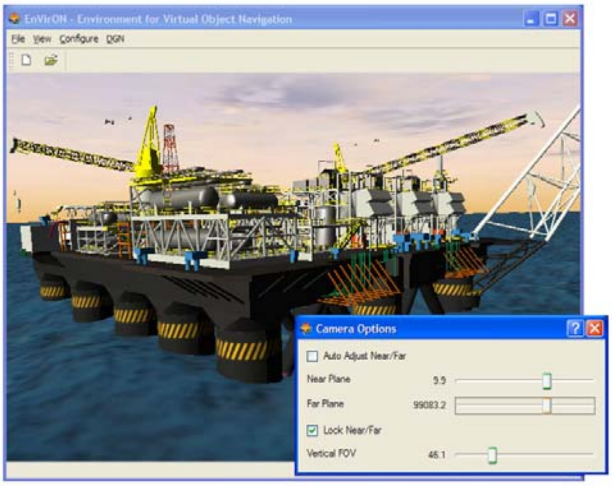

Figure 3: ENVIRON screenshot.

2.2.2 Stability analysis

The stability analysis needs to take into account the stress conditions, sea currents, waves and wind pressures on semi-submersible platforms and FPSOs (Floating Production, Storage and Offloading unit). Additionally, these production units may be floating in the sea, which is more than two thousand meters deep, and therefore requiring the deployment of complex mooring systems.

Most of the current simulators (Figure 4) are still static such as Sstab [Coelho03], but the demand for dynamic simulations is growing in the oil & gas industry to conduct rich simulation of offshore structures to ensure safe operation. Examples are Dynasim [Coelho01] and NOT (Numerical Offshore Tank) from Petrobras.

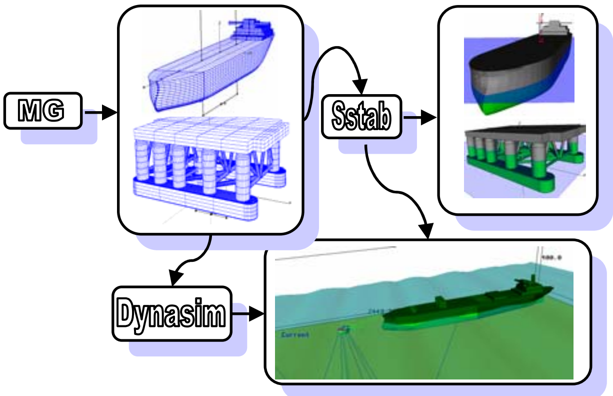

Figure 4: Integration among simulation tools.

2.3 Production Phase

The main aim of this phase is to support efficient and safe production of oil & gas. This requires putting in place a well trained work force for operation, plant monitoring, maintenance, emergency handling etc.

2.3.1 Monitoring

During the production phase, the virtual reality technology has the potential for supporting better monitoring of plants. Examples of such monitoring tasks include remote monitoring of oil pipelines (Figure 5) to avoid oil spillages, stability of the offshore structures and off loading operations, all of them already being employed by Petrobras.

Figure 5: Virtual pipeline trajectory over a satellite image.

To better analyse oil pipeline deformations, it is possible to use post-videos over the structural analysis results. Petrobras is also analysing solutions to allow the manager or the specialist to receive a visual representation of the oil pipeline directly from the field, in case of an accident or during a maintenance operation.

2.3.2 Emergency Scenarios

An oil spillage could have a devastating consequence on the environment costing millions of dollars to constrain the damage. Virtual reality can play a significant role in developing systems for training people for handling such situations and also for connecting experts during such a disaster situation to advise the workers, on the ground, to control the situation.

One such system, which has been developed to manage and control actions during a leakage of a pipeline is InfoPAE [Carvalho02], shown in Figure 6. It provides facilities to manage conventional and geographical data, associating them with the plans.

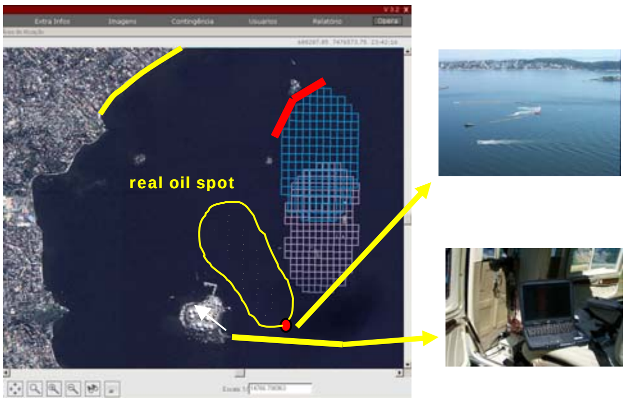

Figure 6: InfoPAE: emergency scenario application.

Another typical emergency scenario in the oil & gas area, described in the next section, is a crisis situation in an offshore structure, when the structure becomes unstable.

3. DISASTER MANAGEMENT OF OIL & GAS OFFSHORE STRUCTURES

Offshore units disasters can not only cause deaths and important environmental impacts, but also have a strong impact on business. Companies can lose billion of dollars by losing an offshore unit and further billions of dollars due to the cease of the oil production.

Petrobras faced two major accidents in the beginning of this decade. In 2001, the largest semi-submersible platform in the world P-36 (40 story-high, weighing 31,000 tons) sunk, killing 11 employees and ceasing a daily production of 84,000 barrels of oil and 1.3 million cubic meters of natural gas.

In 2002, the FPSO (Floating Production, Storage and Offloading) unit P-34 with a daily production of 35,000 barrels and a storage capacity of 58,000 m^3 of oil, weighting 62,000 tons, had a stability problem and almost sunk, immediately ceasing its operation. Fortunately at this time, Petrobras managed to rescue the unit without loss of lives.

Petrobras, as one of the oil & gas companies seeking to employ efficient processes and technologies to respond to such events, had taken important actions in order to ensure safety.

The implementation of such processes involves bringing together a large number of diverse and geographically distributed groups and resources to make appropriate decisions within a short period of time. Such groups are comprised of many technical experts and decision makers such as naval engineers, structural engineers, risers analysts and oceanographers, as well as managers.

The high-level decision group will operate from the operational unit headquarters. The technical staff, running various simulation programmes which take into account the waves, wind, currents and other forces on the unit, operates either from a base on earth near the disaster, from the company's headquarters and/or from various research centres.

These groups need an efficient communication media with the operators inside the unit, divers and security team, and perhaps with experts who are travelling to execute the rescue plan and work towards consensus.

Petrobras has an on going project to develop a distributed ICT environment for the technical groups to work as a virtual team to explore various simulation options and to communicate their results to the high-level decision makers (Figure 7). To achieve this aim, there are some actions involved:

- a survey is being conducted to identify the requirements for the distributed workspace, from the stakeholders involved in a disaster scenario;
- a distributed workspace environment is being designed and built for the technical team to engage in the rescue efforts;
- the usability and functionality of this environment will be evaluated for training and operational purposes.

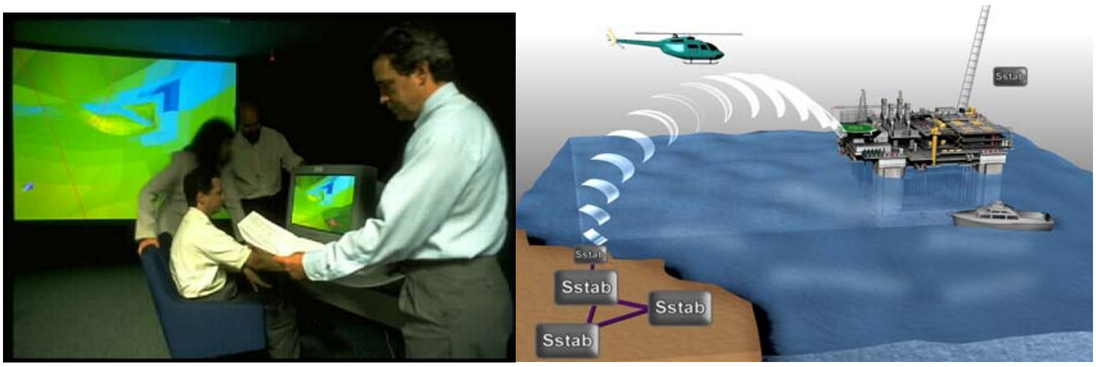

Figure 7: Emergency oil & gas E & P scenario with distributed people and resources.

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