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Remote Intelligence—The Future of Drilling is Here

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Abstract

It is well recognized that oil and gas companies have increased the implementation of collaborative centers to improve real-time decision making. This reduces non-productive time (NPT) and improves efficiency in oilfield operations. Emerging technologies now enable end users to receive and send intelligent commands while tools operate under downhole conditions. This not only provides the advantage of fewer trips in and out of the hole, but also the ability to control operations from an office-based environment.

In the last few years, Schlumberger has increased the number of collaborative centers, known as Operation Support Centers (OSC™), to work closely with operators throughout the world. Surface and downhole data are currently transmitted to these centers in real-time as part of the execution phase in the drilling optimization process. While the focus of this paper is on drilling, real-time data is clearly not limited to the drilling phase and in many cases has been used for completion monitoring and control.

As the implementation of these centers has continued, drilling activity increased more quickly than experts could be developed in all areas of operation and support, despite aggressive recruiting and intense training and development. As a result, experts gathering in one room to advise jointly on several simultaneous rig operations became the norm and operators who experienced it quickly embraced the OSC™ concept.

Real-time centers, therefore, have become the chief venue for collaboration, data capture, sharing and training, in a way that better meets the needs of fast-growing operations. Interestingly, they have also become a focal point for better coordination of operational changes, as improved communication with tools downhole and with service personnel have facilitated reduced crew and support requirements.

This paper describes the challenges faced in implementing remote drilling operations, the work processes that allow one directional driller (DD) and one measurement while drilling (MWD) engineer to oversee several rigs simultaneously, and details the necessary infrastructure, communication systems and operating results.

Introduction

In the past few years, directional drilling services companies increased their capacity by adding more tools and new hires while investing in training and technology to satisfy the oil and gas drilling activity demand. It has also been an unprecedented period in time where directional drillers and MWD engineers have spent less time at home than on rigs or at the office. This in part was due to the many new engineers requiring additional supervision and support.

The value of real-time centers has been discussed at various industry events, meetings and workshops, conclusively demonstrating reduced NPT, improved collaboration and increased rate of penetration (ROP); in short, the ability to reduce total drilling operating cost. Having experts from the various petro-technical disciplines, co-located in one area or zone, with access to all relevant surface and downhole data from sensors, tools and services, gives the flexibility of operational monitoring regardless of the location. Effective decisions can be taken when valuable real-time data is available and discussed with all experts.

The implementation of real-time centers can also be considered a general response by major oil and gas exploration and production companies to the shortage of expert personnel in their own organizations. It is therefore a very dynamic and ever-changing environment as companies implementing this concept recognize value and hence add additional deliverables or requirements.

Now, with the introduction of new concepts and capabilities to the real-time center model, this approach is beginning to prove equally effective in meeting the increased demand for directional drilling services, achieving desired levels of service quality and technical support despite the shortage of expert personnel.

In a recent series of projects in northern Mexico, existing support center resources including workstations, satellite communication and transmission systems, and visualization devices were operated by expert personnel to remotely control directional drilling operations in an efficient and economical manner, optimizing the value of existing resources without compromising the quality of service.

This paper will describe this non-traditional approach to directional drilling. The implementation process will be described, illustrating how existing real-time infrastructure can be taken from merely monitoring to actually controlling a number of remote directional drilling operations from a single OSC™.

The location

Reynosa is located in the northern part of Mexico in the border with southern Texas. Fig. 01 shows the location in the northern part of Mexico.

The Burgos project resides in "La Cuenca" de Burgos region, which contains fields that exploit the Wilcox reservoir trend (roughly 50,000 Sq km). Schlumberger has had an important presence in the Burgos basin for over 10 years. There were several contracts executed through the past years within the integrated project management framework. Wells require directional services, predominantly "S" shaped type wells that included build-up, tangent and drop off to vertical, while maintaining the trajectory within the targeted reservoir established by the asset group. See figure 02. The majority of the wells require either motors or rotary steerable systems (RSS) in different wellbore sections. The use of RSS depends on performance drilling requirements in predetermined sections where penetration rate can be improved over conventional mud motors by eliminating slide drilling.

At the time of the pilot project conception, there was a high volume of directional activity in the area. The rig count went from 5 to 11. With the OSC™ infrastructure in place and staffed since 2004 and basic processes and workflows already established, the time was right for deployment of remote drilling operations.

Developing on an idea

The idea to implement remote drilling operations from the OSC™ in Mexico North (Reynosa) began in January 2006. Based on the experience already achieved around the world in the support center framework, operations in Reynosa accepted the challenge to utilize this technology in a new and novel way, to supervise the drilling process remotely and prove to operators the advantages of having directional drilling monitoring and control from a single office with co-located experts.

The initial goal was to support up to 10 jobs simultaneously from an office-based remote environment. The experienced DD and MWD engineers who would normally be spread across several single well operations were now primarily concentrated in the OSC™. Having expert eyes and years of experience now able to monitor and assist more than one operation, in a controlled environment, allowed for more efficient use of personnel. Having the OSC™ located in the engineering and operational area will increase collaboration and giving operator personnel exposure to more than one well scenario, with experienced personnel support from the service company. Of particular importance is the strengthened interaction between the drilling engineers and real-time engineers.

Changing paradigms

The support center concept has been proven and described in previous papers[1, 2]. While the efficiency gains may be well understood and accepted in some areas, expanding this concept remote drilling operations is a new frontier.

As the directional driller is the person responsible for the controlling the trajectory of any directional well, the notion of distancing him/her from the rig-site and without face to face contact with the wellsite supervisor creates natural skepticism.

Besides steering, DD tasks performed at the rig site typically include bottom-hole assembly (BHA) makeup, BHA component measurements, alignment of high side of the motor's bent housing with the MWD tool, witnessing the surface test, monitoring trips, and optimizing drilling performance for ROP and trajectory control. Additionally the MWD engineer has several responsibilities around the care and operation of those tools and equipment.

When considering moving any of these expert personnel off the wellsite, many questions naturally arise. How does an operator maintain its comfort level without an experienced DD on the rig floor? Who is now responsible for these tasks? Who will give advice for proper execution of any of these tasks? Have service companies found a way to reduce exposure to risk?

In order to change this paradigm, several initiatives were developed to ensure the success of this new process and workflow:

1. Perform a pilot test. Without removing the directional drilling or measurement engineers, the concept needs to be first proven, to ensure all parties involved in the process accept the changes.

2. Ensure satellite and communication systems, along with hardware components, work together seamlessly and reliably.

3. Create a new set of standard procedures considering fewer experts at the rig site. This includes redefining the process to rig-up and rig-down all surface equipment,

troubleshooting all components, procedure to makeup the BHA and communication workflows.

4. Design training material to all parties involved: Drillers, toolpusher, company man and drilling engineers.

5. Define job descriptions, training and development of all personnel, including directional drillers, MWD engineers, well site supervisors and supporting personnel.

Pilot test

Performing a pilot test was crucial before implementation of remote drilling operations. A clear objective was set for critical components such as telecommunication services, data visualization, personnel intervention, driller's reaction etc. The complexity and directional requirements of the well dictated how remote drilling operations would be performed. The idea of the pilot was to identify to what extent operations can be fully controlled from the support center and what level of experience is required at the well site. This pilot was also valuable in testing hardware and software and identifying gaps in the communication process between the support engineers, drillers, rig supervisor and drilling engineer in charge of the well.

At the end of the pilot, demonstration of the following was required:
1) How many wells can be controlled by one engineer at the center?
2) Is it necessary to have a field engineer at the rig site during the job? If so what level?
3) Does the operator agree with the current performance with directional drilling remote drilling operations?
4) Is the driller sufficiently familiar with the directional operations or is additional training required?
5) What is the preferred method of communication to the well site?
6) What is the need for backup or redundancy in the transmission and communication system?
7) Are the regular workflows in directional drilling jobs executed normally?

Two pilot tests were executed without removing the rig crew - one vertical and one directional well. The objective was to test the communication workflows and the personnel behavior through the new process, Figure 3 shows the timeline since the project development.

During the test, an experienced DD and MWD engineer were added to the existing staff of the support center. The acquisition and processing system normally used at the well site was replicated in the OSC™, including all well site displays and logs.

Network system

The amount of data processed through the OSC™ in the execution of remote drilling operations requires a robust and reliable transmission system. A dedicated internal information technology (IT) support provider is used to ensure the center's core work processes are well supported. A reliable satellite transmission kit was designed by IT experts to connect the MWD surface equipment configured at the rig-site to the hardware in the operations support center.

Special remote-control software

A reliable remote control application is required, which allows users to view and fully interact with one computer using a simple program on another computer desktop, anywhere on the internet.

The virtual networking system created has a wide range of applications, including system administration, IT support and helpdesks. The system allows several connections to the same desktop, providing an invaluable tool for collaborative or shared working within and outside the OSC™.

As shown in the figure 04, one common domestic scenario in using this application is to help troubleshoot the computer of a distant less-technically-savvy relative. In other words, sitting at your desk in the support center, you could use the virtual network software to take control of your engineer's computers in the field.

Based on the software capability, the same acquisition software is set up at the rig so that it is possible to use virtual networking to visualize and control the computer from the support center. Virtually, the remote operation engineer has control of the system running at the wellsite 100% of the time, giving the option to accept surveys, check MWD tool status, identify signal noise, and analyze drilling parameters needed to optimize the drilling process.

Support Center Facility Setup

The OSC™ facility is practically composed of three different working areas:

- Drilling optimization area - dedicated to observing real-time data from the rig and other provider technical support based on trends, to reduce risk and avoid NPT.
- Remote drilling operations area - dedicated for directional drillers and MWD engineers.
- Meeting and collaboration area.

The remote drilling operations area is used by the directional drilling and MWD experts. They are focused on specific jobs utilizing the communication and transmission systems. If more expert involvement or meeting is required, then the expert can use the controls in this area to drive the meeting in the collaboration area.

The OSC™ has 3 remote drilling operations areas, each with three computers connected to four displays. Each area is used to control three different wells with a crew of one DD and one MWD engineer per shift. These areas are fully equipped with radio, internet telephony and cellular phones, internet connectivity, and the required computers and systems to facilitate an efficient workspace and hence ease of operational control. See Figure 05

The meeting or collaborative area has the capability to display any of the screens located in the remote drilling operations areas and seat more than 20 engineers to discuss any issues during the operations.

Workflows and procedures

A remote drilling operation from the OSC™ involves real-time well site monitoring and control through secure two-way communication of data and information. Data of almost any type may be exchanged and shared between the support center and the well site acquisition systems, including real-time drilling data, logs and recorded mode processed data.

Operation Support Centers are an integration of drilling optimization, survey management, drilling engineering and reservoir optimization services. The functionality of remote drilling operations is simply an extension of the existing experience that already existed and placing it at discrete distance from the well site.

Significant analysis was required to define and adapt the new standards and procedures to activate this new scheme of directional drilling services, including:

1. Personnel job descriptions, training and development
2. Drillers training
3. IT infrastructure and support
4. Planning and execution process for every job

Personnel

The personnel required can vary depending on the volume of activity, technology applied and environment. There are specific requirements to staff remote drilling operations. Strong technical proficiency and experience in directional drilling and MWD services is critical. Soft skills also allow for better interaction with the team in the office and well site.

Along with the remote drilling operations engineer (ROE), the drilling optimization engineer (DOE) should be co-located at the OSC™ as part of the group that will be in charge of the drilling surveillance and optimization process. Support is also required from the Information and Technology (IT) engineer to ensure that all hardware, software, satellite antennas and communication systems are in place to avoid delays or failures.

Experience has shown that the correct profiles within the OSC for this type of operation are:
1. A remote operation engineer for measurements while drilling (ROE-MWD),
2. A remote operation engineer for directional drilling (ROE-DD),
3. A drilling optimization engineer for every 3 wells being monitored.
4. IT Engineering support for both field and office systems.
5. Additionally, one field engineer is required at each drilling location.

Highlighted responsibilities for the personnel are:

a) Remote Operations Engineer-MWD

Engineer is in charge of:

- Surface MWD test before running in the hole (Shallow Hole Test – MWD/DD)
- Surface/downhole system troubleshooting
- Signal demodulation
- Survey acceptance
- Daily reporting
- Survey tracking
- MWD battery tracking

b) Remote Operations Engineer – Directional Driller

This DD expert is primarily responsible for monitoring and executing jobs in real-time from the Operation Support Center to ensure high-quality service delivery to the client. S/he is also in charge of the operation to ensure that communication with the driller and company man is provided based on information available in the center.

Having all surface and downhole data, including motor orientation on a separate display, the directional driller has control of some aspects of the well execution and is able to establish communication once an orientation is required to maintain, build or drop angle, specifying weight on bit and RPM.

The role can also expand to other areas such as dog leg severity (DLS) monitoring, BHA/bit performance assessment, ROP optimization, rotary steerable system performance monitoring, survey quality control, shock and vibration mitigation and ensuring that tools are run within specifications. It is key for proactive client communications to ensure action plans are generated and transmitted to the driller and company man while capturing data for post run detailed analysis.

The ROE-DD is in charge of:

- Anti-collision monitoring
- Maintaining control of the slide and rotation report
- Survey control and projection ahead of the bit
- Keep track of survey record
- BHA performance records
- Writing end of well reports

c) Drilling Optimization Engineer

The Drilling Optimization Engineer is charge of one or several of the following:

- Torque and drag analysis
- Hydraulics analysis
- Drilling optimization
- Risk identification
- NPT analysis
- Pore pressure surveillance
- LWD interpretation and correlation

d) IT Engineer

The IT Engineer is responsible for ensuring that all systems are in place, including hardware, software, and infrastructure and running without latency or failures. Some of the highlighted responsibilities are:

- A guaranteed minimum, two way communication
- Communications and data transmission, configuration, set-up and contingency duties.
- Support in IT software and hardware.
- Introduction of new technology to increase the performance of the operations.

Experience has shown, with the crew described, it is possible to reduce personnel at the rig site, which reduces HSE risk and logistics costs to operators at the well site. But far more significant is the benefit gained from experienced engineers monitoring the general drilling parameters across multiple wells, focusing on optimization, and capturing lessons learned, each of which plays an important role toward a step change at reducing cost per foot on current and future wells.

Drillers training

The drillers at the well site are the most important asset in this new concept. During traditional services the driller and the directional drillers are interacting on the rig-floor.

Their communication and relationship is a key aspect in success.

In remote drilling operations, the directional driller is not present at the well site. It is important therefore to ensure that the drillers understand the instructions from the OSC^{TM} to effectively perform tasks based on directional drilling needs.

As part of the deployment plan, a directional drilling training module was designed to train the drillers assigned to a specific rig. On-the job training was also carried out with directional drilling experts to ensure the rig site drillers' understanding of BHA behavior under various conditions, including drilling parameters, bit types, formation types and configurations.

Rig personnel and drilling engineers involved in the project who may have also received prior basic DD training would benefit from this module. Four training sessions were performed at the collaboration area in the OSC^{TM}. Participants were exposed to the remote drilling operations and presentations were done by directional drilling experts.

IT infrastructure support

Reliable two-way communication of voice and data is essential to the successful implementation of the remote drilling process. Redundant systems are used to ensure an uninterrupted flow of information between the support center and the rig floor. The choice of technologies depends on each location specific characteristics. In this case, three modalities were used: FM Radio, cell phone and Internet phone.

Data communication with the OSC^{TM} is provided by a set of satellite antennas linking each rig site to the Internet. Using secure transmission protocols, data and displays from the rig site computers can be monitored in real time.

A backup antenna was provided in case the main one failed. The system can automatically switch between the main antenna and the backup to avoid any latency or interruption in the signal.

The use of the FM Radio and the cell phone/radios depend on signal availability at the rig site. The FM radio is quite reliable over long distances and the Internet phone was used mostly as a backup.

Running a directional drilling job

Planning phase

At the beginning of a project, the remote operations and IT engineers determine the equipment required to maintain reliable two-way communication and data transmission at that specific location. The selected equipment package—including laptop, antenna, cables, radio and sensors—is tested prior to deployment in the field to ensure it is configured and functioning properly.

Execution phase

Once a job begins, one directional driller and one MWD engineer working from the OSC^{TM} oversee drilling at three separate wells. A total of 12 screens display a broad range of real-time data from the rig sites as well as system and software interfaces.

A field crew goes to the wellsite for rig-up and BHA make-up. An IT engineer and a field engineer are in charge of rigging the surface sensors and communication system; they also prepare the downhole tools. After successfully performing the Shallow Hole Test, all but one member of the field crew can leave the rig site. One field engineer remains at the rig at all times in case of contingency.

The directional driller at the OSC™ gives instructions to the driller on the rig floor using Internet phone or radios. He can continuously monitor the driller's display and communicate recommended parameters directly to the driller. See figure 6 and 7. The MWD engineer monitors the MWD tool status to ensure good performance and prevent premature failure. While remote operations are in progress, the optimization engineer monitors all drilling parameters to identify and respond to any risks that might result in NPT.

At the rig site, the driller rotates slides and takes surveys according to instructions from the directional driller and MWD engineer in the center. Surveys are typically taken after each 30 m increment is drilled, with the MWD engineer communicating instructions to the driller. Survey values are immediately displayed on the screens and input into drilling software for analysis and projections. Based on the results, the directional driller provides the driller with instructions for drilling the next stand.

The engineers generates a number of reports, including morning reports, slide-sheet reports and survey reports, which can be shared immediately via e-mail or chat program to the client and the wellsite supervisor.

As soon as the well is finished, a crew goes to the site to rig down all surface equipment and sensors. At the center, a final report is prepared and sent to the client.

Results

In the first eight months of operation, the remote directional drilling process completed more than 100 jobs with steerable motors and MWD, 12 jobs with rotary steerable systems (3 simultaneously) and had a maximum of 5 rigs under remote control at the same time. The DD were performing as if at the well site, the difference being the lack of physical presence at the site only.

The directions given by the directional driller were the same as if present on the rig floor, making the transition for the driller easy. The company man was there to oversee rig site safety and good practices, however, decisions were being related from the clients' office in consultation with drilling engineers and other experts.

Due to the concentration of expertise in one area, drilling operations were more efficient and experienced less downtime or uncertainty.
A well drilled in one of the field in Reynosa, drilling operations were controlled satisfactorily in constructing an S-shaped well with an 8 ½-in. build section and a 6 1/8-in. vertical drain hole. No NPT was experienced due to voice communications, data transmission or misunderstandings between the driller and the OSC™. On average, a 33% improvement in ROP was realized.

Second well, a 3,181-ft (970 m) section was drilled with an 8 ½-in. bit in four days, representing a 20% ROP improvement compared to area offset wells. The well was the first one drilled with the rotary steerable system. The build section was drilled with 6 RSS downlinks to make steering adjustments, which were all performed by the rig driller under the direction of the OSC™. Considerable efficiency was realized compared with predicted drilling time based on past experience in the region. The well was completed in only 15 days compared to the planned 26 days.

The operator felt confident that the correct steering decisions were being made, because they were carefully considered by the expert team 24/7 before they were relayed to the rig. The IT infrastructure was designed to ensure the least possible interruption to data existed.

Ultimately it was determined that the number of rig site personnel remaining at the well site depends on the complexity of the well. For more complicated wells, one DD and one MWD engineer would be left at the well site and the crew at the OSC™ will be maintained.

Conclusions

The concept implemented in Northern Mexico to perform directional drilling jobs remotely has proven successful. Contrary to early concerns, drilling performance was actually improved due to the workflows and infrastructure available at the OSC™. While the initial implementation of remote drilling operations was driven by the scarcity of experts (both operator and service company), it in fact produced a more efficient use of expertise and processes which in itself is the step change required to reduce cost per foot.

This paper described an initial idea and development of an overall process to implement it. This concept is far from fully explored as technology advancements in automation and other areas will bring further changes, resulting in increased ROP, reservoir contact and further reduction in cost per foot.

It is important to highlight the key factors for success of a similar project:

- **Management commitment.** Clearly, commitments from senior managers or engineers are important especially in the implementation process to provide the necessary support for resources and review all feedback for improvements required
- **Data communication.** IT infrastructure, data management and communication is key.

- **Roles and responsibilities.** A new set of standards and procedures need to be implemented to clearly define the new roles and functions.
- **Engineer selection.** Matching the right profile with the requirement for the workflows in place. High caliber MWD engineers and DD are required in the OSC™.
- **Driller training.** Use the set of training modules to keep the driller and others involved in the project updated in directional drilling knowledge and tools technical specifications.
- **KPIs.** Define and implement a set of key performance indicators to review on a monthly basis. The indicators will not only relate to overall drilling performance but also, communication and IT transmission related issues.

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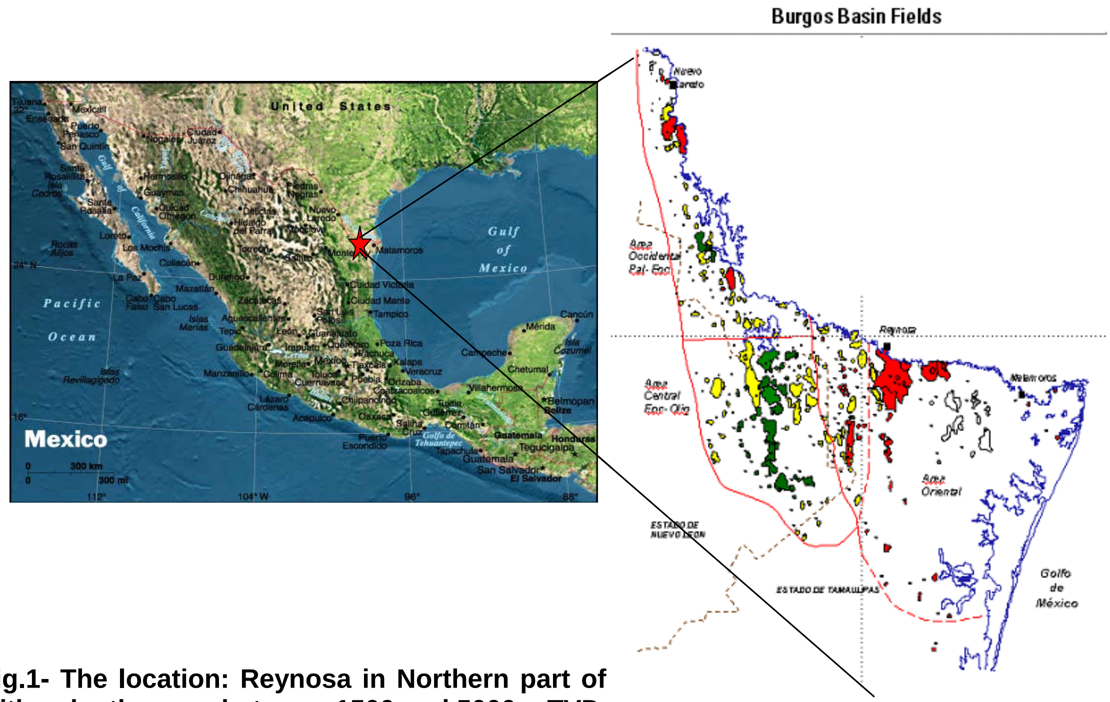

Fig.1- The location: Reynosa in Northern part of ... han 200 fields with a depth range between 1500 and 5000m TVD

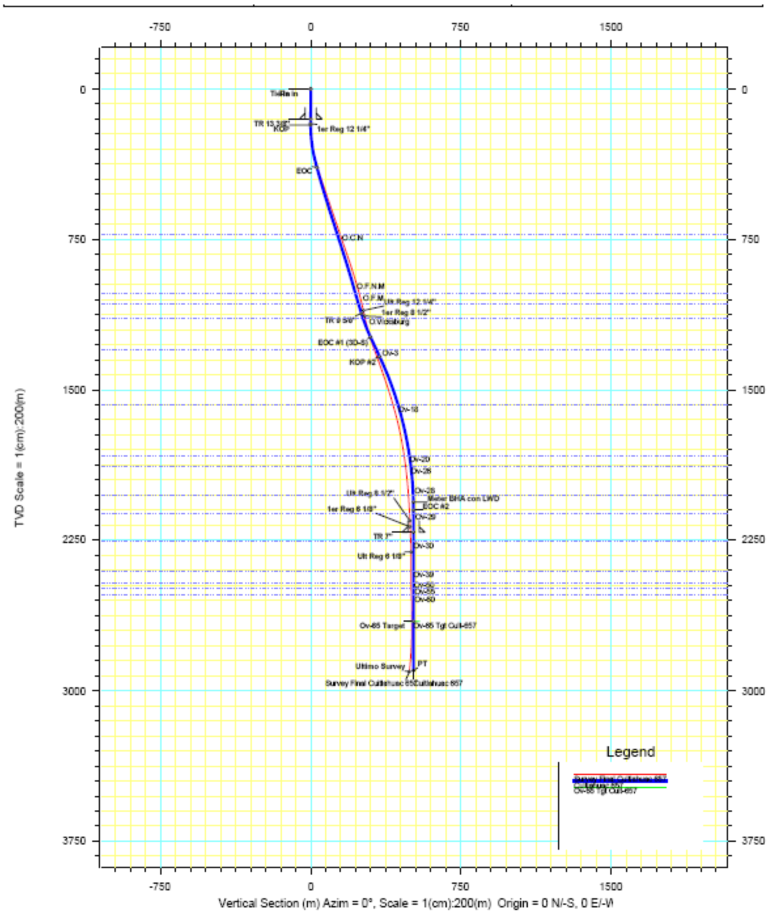

Fig.2 – Typical well profile in Burgos Basin.

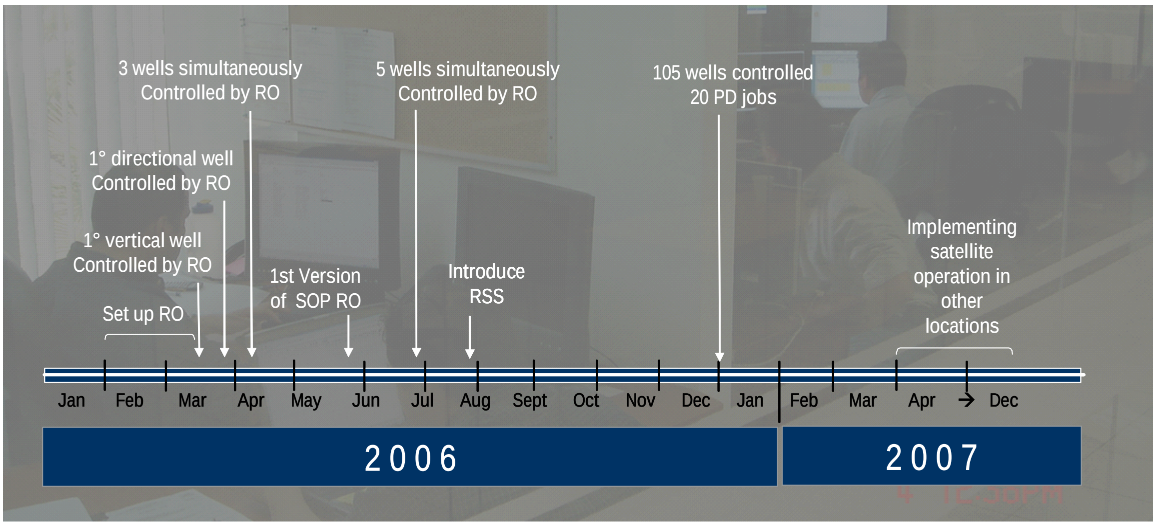

Fig 03 - Project development timeline

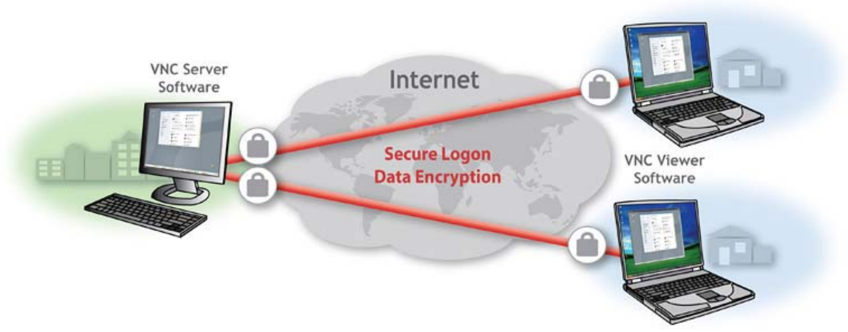

Fig 04 – Virtual network system

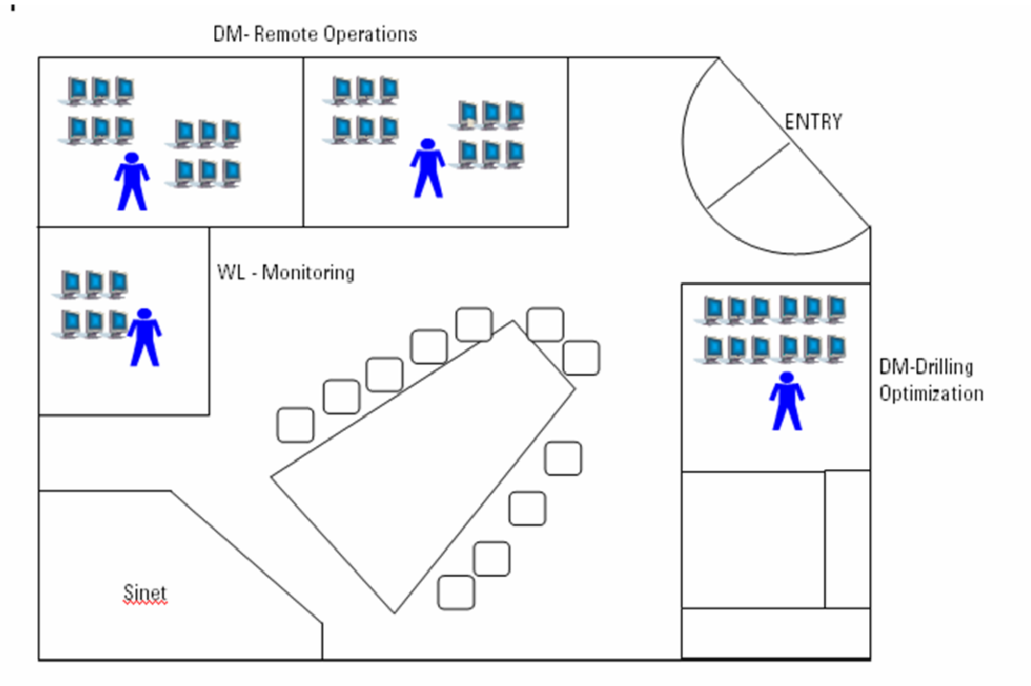

Fig-05 – Existing layout of OSC™ facility incorporating the remote drilling operation.

Fig. 06 and 07 – Experienced DD working in his own remote control station and establish communication with the driller while maintaining control of drilling parameters and well trajectory according with plan