DYNAMIC POSITIONING CONFERENCE
October 17 – 18, 2000

VESSEL EXPERIENCE

DP Conversion of Existing Drilling Semi-Submersibles

Karl G Jansson, Robert Ludwigson, and Rolf H Andersson

GVA Consultants (Gothenburg, Sweden)

Abstract

This paper is intended to present the novel "DP Add-On" concept allowing dynamical positioning upgrade of any existing two-pontoon drilling semi-submersible to meet IMO DP Class 3 regulations, with focus on cost and schedule control.

The evolution of this concept has been matured through the experience gained in connection with deep-water DP-upgrade of "Petrobras 23", as well as other previous conversions GVAC have been involved in. The conversion of the "Petrobras 23" to a dynamical positioned drilling unit for operation in water-depths up to 6,300 feet is briefly presented.

It should be noted, that the drilling industry has seen limited number of DP-upgrade of existing MODU´s. However, due to the increased requirements for deepwater drilling units, there is an increasing interest within the industry for deep-water DP-upgrades.

The "DP Add-On" concept proposed for a typical Aker H3 or Pacesetter Semi-submersible is shown and results of engineering work performed so far is presented. The cost difference between DP Class 3 and DP Class 2 is discussed.

Introduction

In recent years focus has turned more and more to exploration in deeper waters, especially deepwater Gulf of Mexico, Brazil and West of Africa. The increase in deepwater exploration and production drilling has lead to a noticeable demand for deepwater drilling units. Traditionally Dynamical Positioned (DP) Drilling Units have been used to avoid costly and time-consuming handling of long mooring lines in deep water.

To meet the demand for DP-drilling units, the industry has seen a number of new-built MODU's, both Drill Ships and Drilling Semi-submersibles, but also a number of conversions of existing units for deepwater drilling. One of these recent projects is the conversion of the GVA 4000 "Petrobras 23", from a moored drilling Semi-submersible for 1,500 ft water depth to a DP deepwater drilling unit for water depths up to 6,300 ft.

Compared with conventional moored shallow water MODU's, a Dynamical Positioned Deepwater Drilling Unit has higher requirements on variable deck load (VDL), improved available deck spacing as well as increased storage for drilling consumables.

One of the most challenging problems when converting an existing, moored, drilling unit to a dynamical positioned, is the redundancy requirement for the machinery, electrical and control for the DP systems.

The configuration and lay out of these systems in connection with DP-conversions, has so far more or less made it impossible to achieve the higher redundancy requirements to meet DP Class 3 (IMO Class 3). The lack of achievement is both from practical and cost point of view. The rigorous redundancy and separation requirement of various machinery and electrical systems for IMO Class 3 cannot be met. This has resulted in DP Class 2 configuration for most DP-conversions so far and often resulted in costly "surprises" during the projects.

A possibility to achieve an IMO Class 3 configuration for a DP-conversion of a MODU is the novel "DP Add-On" concept developed by GVA Consultants. The "DP Add-On" method solves the problems with redundancy and separation aspects, as well as the increased VDL and deck area requirements needed for the deeper waters. The concept is based on adding pre-fabricated, pre-outfitted sections to the existing MODU. The concept also gives the advantage of reducing the time the MODU have to be tied up at a yard during the conversion.

Objectives for DP Conversions

While the number of potential oil field found in deep water Gulf of Mexico, West of Africa and Brazil, the demand for dynamically positioned units is increased. In the same time, the market for moored shallow water units has been weak. Objectives for DP based drilling are, for example:

- In deep water, the length and the weight of the mooring lines will increase; giving reduced horizontal stiffness of the mooring system. In addition, a deep water mooring system is more complicated, costly and time consuming to handle and install.

- In areas with a high number of subsea wells also the number of flow lines and other equipment and structures on the seabed will increase, which may interfere with MODU mooring system.

The above has lead to a growing demand for dynamically positioned deep-water drilling units. The industry has in recent years met this demand by ordering a number of new-built DP-units, both Drill-ships and Semi-submersibles. Considering Semi-submersibles only, about 20 of the total number of about 165 semis are DP-units. *Of these, only two (the Noble Paul Wolff and the Petrobras 23) are conversions from moored shallow water drilling units to deepwater DP units.* Both these units were converted in accordance with IMO DP Class 2 regulations

The reason for the limited number of DP-conversions is several, but some factors are:

- Existing, not newly built, Semi-submersibles has limited VDL capacity and can accordingly not carry the added weights related to a DP-conversion, and increased drilling loads due to the increased water depth.
- Existing Semi-submersibles are limited in available deck area and have not sufficient space to house all the added equipment and systems related to a DP-upgrade, nor drilling equipment.
- Existing Semi-submersibles are in most cases not built to meet any redundancy requirements. Accordingly these units are not able to meet redundancy requirements without extensive modifications.
- The costs related to modifications of existing systems and arrangements in connection with a DP-upgrade are in many cases prohibitive.
- The conversion schedule related to modifications of existing systems and arrangements in connection with a DP-upgrade are in many cases prohibitive.

However, due to the present focus on deep water in connection with a slow market for shallow water drilling rigs, the interest for upgrading existing second and third generation Semi-submersibles to dynamically positioned deep water drilling units are constantly growing.

The "Petrobras 23" deep water DP Class 2 conversion

In 1997-98, the "Petrobras 23", ex "Vinni", was upgraded from a moored drilling unit for 1,500 feet of water to a 6,300-foot water depth DP drilling unit. The "Petrobras 23" conversion was an engineering, procurement and construction project.

The "Petrobras 23" is a third generation drilling unit of GVA 4000 design delivered from Götaverken Arendal in December 1985. The unit was designed for moored drilling operations in water depths up to 1,500 feet, and was built to NMD, UK and USCG rules and had DNV classification.

The power generation plant of four 3.1 MW diesel generators located in two engine rooms. For propulsion and thruster assist, the unit had four 2,4 MW azimuthing thrusters. The unit had a living quarter for 100 persons. Typical drilling equipment included a 650 tons derrick with top compensator, 3 x 1,600 HP mud pumps and a 15,000-psi BOP-stack. The unit was equipped with two 50 tonnes deck cranes.

At delivery the Deck and Column payload in operation was about 4,100 short tons and the total transit payload was about 3,000 short tons. The unit had an operating displacement of about 25,000 long tons.

During the mid-90-ties the operator investigated the possibility of a deepwater upgrade of the "Petrobras 23". After a pre-engineering phase in co-operation with Petrobras, an EPC-contract was signed in 1996.

Figure 1 Petrobras 23 after conversion

Although the original MODU was a relatively modern vessel with two engine rooms and four thrusters installed, the utility systems for the two existing engine rooms was not redundant and accordingly it was only possible to achieve DP Class 2.

To accommodate the new increased power plant, the upper hull was extended aft for the new engine rooms and switchgear rooms. This layout also provided increased deck area to the Main Deck, needed for the deepwater services, see Figure 1. To carry the added weight of the DP related power and propulsion equipment and increased drilling loads, additional column stability fenders and pontoon sponsons were added. Further the wheelhouse was enlarged to house the DP control center.

New switchboard rooms and four new diesel generators, each 3.1 MW were arranged in two new engine rooms in the new deckbox extensions aft, giving the converted unit four engine rooms, as shown in Figure 2.

Four new thrusters, with variable speed fixed pitch type of propellers each giving 2.4 MW, were installed in four new thruster rooms arranged in former water ballast tanks in the two pontoons, see Figure 3. Thruster frequency converters installed controlled the variable speed. The existing four thrusters of constant speed controllable pitch type of propellers were overhauled and reinstalled.

One of the more extensive work tasks during the conversion was the installation of a completely new integrated automation system, covering both the newly installed equipment as well as the existing, connected to a new DP control and rig management system. This included re-wiring of the complete vessel.

In addition to the DP upgrade, a significant upgrade of the drilling tool were made, meeting requirements for drilling in 6,300-foot water, included:

- Four new double riser tensioners, total tensioning capacity of 1,824 kips
- Guideline less upgrade of BOP-stack
- New multiplex BOP control system
- New pipe rack gantry crane and riser trolley for handling of risers.
- New drilling riser for 6,300 feet water depth

Drill floor and derrick upgrade included:

- New topdrive
- New iron roughneck
- New drawworks discbrake
- New computerized drilling control system.

The vessel arrived to the yard in June 1997 and left the yard for trials in June 1998, 12 months later. The converted MODU was delivered third quarter of 1998.

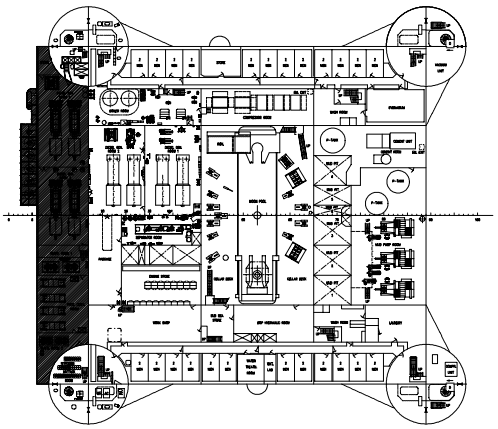

Figure 2 ” Petrobras 23” – Aft upper hull deckbox extension

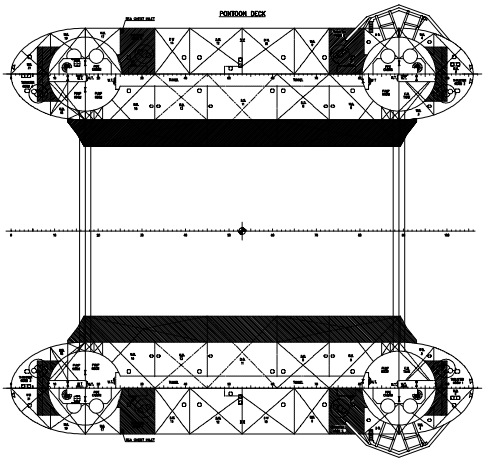

Figure 3 Lower hull extensions and new thruster rooms

A large conversion project, such as the “Petrobras 23” DP-upgrade involves a lot of challenges and problems to be solved during the way. Not all of these were known from start of project. These challenges and problems gave a lot of valuable experience for future projects. Some of the experience gained by the Owner and GVA Consultants is summarized below:

- To integrate new equipment and systems with existing is always an enterprise. The reason for this can be limited detailed design drawings available for existing systems, modifications during the life of the unit not monitored, existing equipment and systems have reduced performance/function due to age, make etc.
- The integration of existing controls into the new integrated automation system was an extensive work-task.
- To convert an existing WB tank to a thruster room requires a long dry docking period and is an extensive work task, considering all new systems (bilge, HVAC, service air, electrical, controls, etc.) that shall be connected to the room.
- The installation of piping and cables for new machinery into the existing structure (mainly columns) is a challenge from a space and segregation point of view.

The "DP-Add-On" Concept

The extensive experience gained in connection with the resent "Petrobras 23" conversion gave incitement to develop a concept to improve this type of projects. Different ideas and concepts have been discussed and evaluated before the "DP Add-On" concept was launched. The "DP Add-On" concept, patent pending, is a concept suitable for DP upgrades of any drilling unit with two or more pontoons. Figures 6 and 7 shows upgrade examples of Pacesetter and Aker H3 units.

Objectives

The main objective with the "DP Add-On" concept is to give drilling contractors the opportunity to upgrade their existing moored drilling units to dynamically positioned deepwater drilling units with a minimum of interface to the existing unit. The concept shall allow for low conversion cost and the drilling unit shall not be tied up at the yard for long periods.

The objective is also to provide a concept that increases drilling pay loads in operation and transit, in excess of carrying the weights of DP related equipment.

Description

The "DP Add-On" concept is based on hook-up of pre-fabricated "corner sections" to each of the four corners of the unit, see figure 4. A new power plant for the DP system and new thrusters to be fitted in the pre-fabricated corner sections. All sections are pre-outfitted as far as possible, including piping, cables, equipment and secondary outfitting. Accordingly the time during which the rig is tied-up at the yard is minimized to the actual hook-up of the new built sections.

The existing power plant is remained and used for marine and drilling systems. Existing thrusters or propulsion systems to be removed. This releases MCR positions for new drilling equipment.

Each of the four new, identical, corner sections includes a pontoon extension with a new thruster room, a column and a deck structure with new engine room and electrical rooms.

The pontoon extensions and added columns give the needed displacement increase, allowing additional deck load capacity to carry both increased drilling loads and DP-related equipment weights, while the deck extensions give the extra space required for machinery installations and to some extent drilling equipment and storage.

The particulars for the "DP Add-On" upgraded unit are naturally dependent on the size and capacity of the existing unit.

The following capacities can typically be achieved:

- Increased water depth operations, up to 5,000-7,500 feet
- Increased deck and column payload in operation, about 4,400-6,000 short tons
- Increased total payload in transit, about 4,400-5,500 short tons

Each pre-fabricated corner section includes the following equipment:

- Two diesel generators (typical 2.0-3.5 MW/each)
- One high voltage switchboard
- One 450 V switchboard
- One frequency converter for thruster AC-motor
- One thruster motor
- One azimuthing thruster with fix pitch propeller (typical 4,5-5,5 MW)

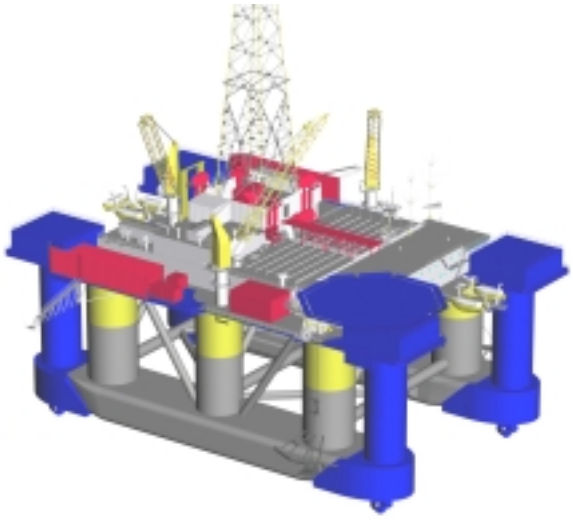

Figure 4) DP-Add-On upgrade of semi-submersible

A new control and rig management system is installed to support the new dynamic positioning system. The new rig management system is used for control of the new engine rooms and new thrusters. Each corner is arranged as a "stand alone" DP failure group. This means that the DP system is analyzed and designed to keep the unit on location with a DP failure in a 1-year storm condition. This implies that the DP system is designed to hold the unit on location with "one corner" not working.

The existing control systems for the marine and drilling system should be kept "as is".

With the "DP Add-On" concept, full redundancy is achieved between the four corners and accordingly, DP Class 3 is achieved without any extra costs, with exception for added DP Class 3 computers and sensors.

In addition to the DP-upgrade, a drilling system upgrade to meet the increased operating water depth is required. This upgrade typically includes the following:

- Riser tensioner capacity upgrade
- BOP-stack guide-line less upgrade
- Multiplex BOP-control system
- Riser handling equipment upgrade
- 3:rd mud pump
- Increased liquid mud storage capacity (active/secondary)
- Increase of riser storage area
- New deep water drilling riser
- Increase of Living Quarters (option)

Conversion Schedule

The "DP Add-On" concept is developed with the objective to minimize the time the Semi-submersible drilling unit is tied up at the yard. To facilitate this, the conversion is based on pre-fabricated and pre-outfitted sections. The size of these sections depends on lifting capacity at the yard. Typically each new "corner structure" is divided in two or three sections (pontoon, column and deck sections).

The four corners structures including extent of outfitting are identical. Minor adjustments related to the attachment of the new structures to the existing pontoon ends and upper deck may occur.

A typical Master Schedule has been developed for a "DPAdd-On" conversion, see figure 5. After a conceptual pre-engineering up to Outline Specification level the total conversion time is about 15 months. Of this, the semi-submersible drilling unit is tied up at the yard for only five months. During the pre-fabrication period the semi-submersible can continue to work in its present mode. Compared with the Petrobras 23 conversion the time, which the rig is tied up at the yard, has been reduced from twelve to five months.

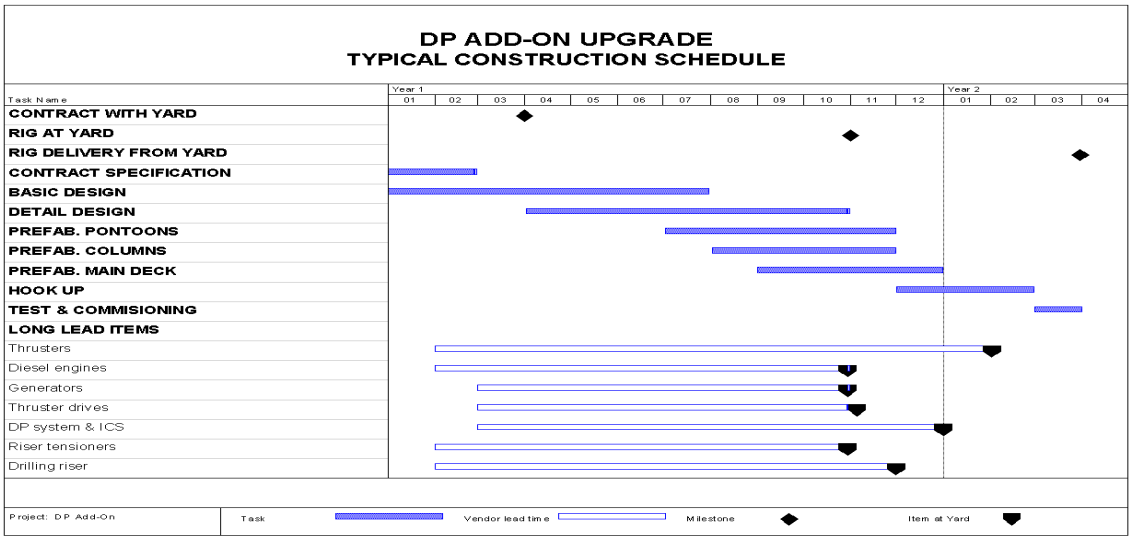

Figure 5 Master Schedule for a "DP Add-On" upgrade

Verification Work Performed

GVA Consultants has performed conceptual designs for "DP-Add-On" upgrades of both Aker H3 and Pacesetter type drilling Semi-submersible, see figure 6 and 7. The conceptual design has been performed up to Outline Specification level and has included General Arrangement drawings, stability and weight control analysis, motion analysis, DP analysis and preliminary global structural analysis. The global structural evaluation has confirmed that its possible to achieve 15 years remaining fatigue life after the "DP Add-On" upgrade for operation in moderate environments, such as Gulf of Mexico, Brazil and West of Africa.

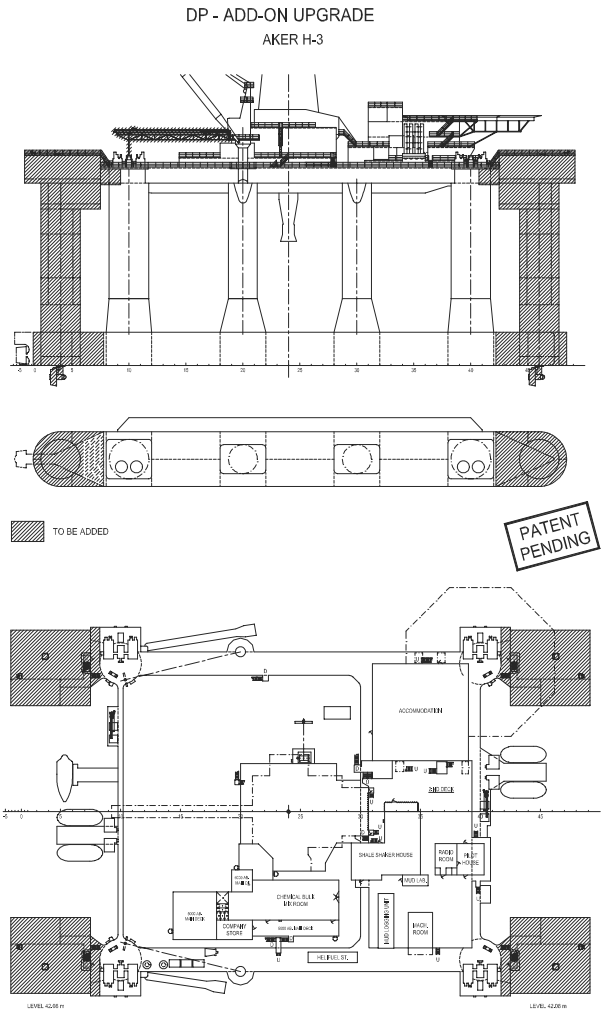

Figure 6 "DP-Add-On" Upgrade for an Aker H3

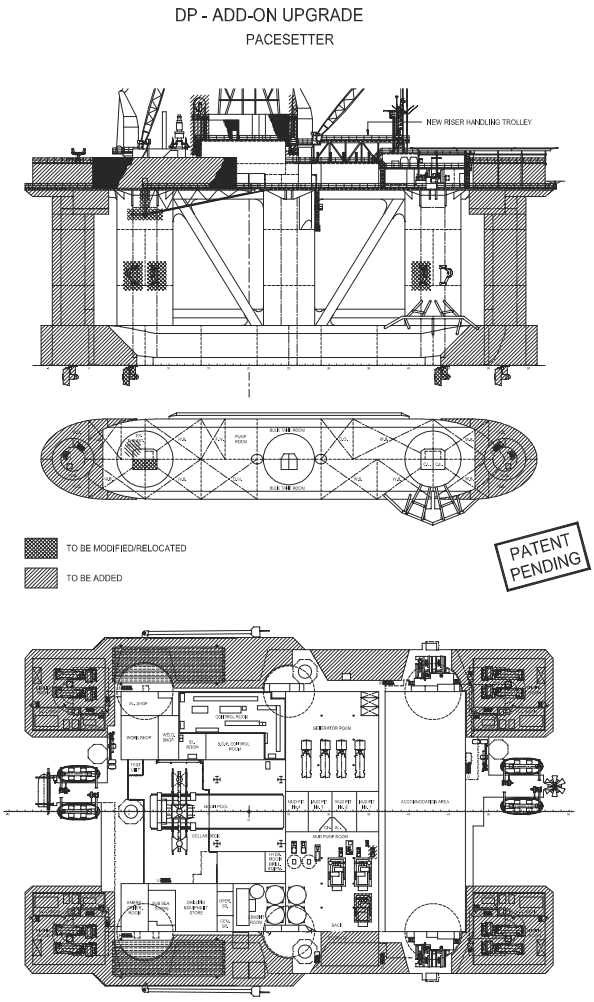

Figure 7 " DP-Add-O"n Upgrade for a Pacesetter