A new generation DP drillship for 10,000 ft water depths

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DEEP WATER DRILLING requires specialized vessels, enabling economic exploration and further exploitation of deep water prospects. This paper describes a new generation of drillship developed by **IHC Gusto Engineering BV** and **Pride/Foramer**.

Vessel dimensions using the Gusto 10000 design aim at providing a high payload capacity to optimize field logistics and to offer superior motion behavior, thereby minimizing downtime. Although the vessel can work worldwide (including North Sea), it has especially been optimized to work offshore West Africa, Gulf of Mexico, offshore Brazil and in Southeast Asia.

The vessel can drill in up to a 10-year return-period storm and stay on location up to a 50-year storm. The large deck space and deadweight capacity will allow the unit to work long periods of time at remote locations.

Equipment is sized to obtain the maximum performance from the vessel, while reducing the costs of DP equipment and power generating plant. Model testing, simulations and comparisons with numerous operational Gusto drillships have verified these design aspects.

Toward 10,000-ft water depths: The Gusto 10000 design is being implemented in the Pride Africa drillship. The drillship is designed to operate in 10-year storms and stay on location during 50-year storms. The ship's single derrick can conduct dual operations, including making up triples of pipe or casing while drilling.

The hull size provides low costs due to reduced steel construction and delivery time.

It was also decided to avoid compromising on drilling performance in order to incorporate non-drilling functions. beyond making hole operations. For example, we believe that adding full production, storage and off loading capabilities would produce a drillship with only average performances in all functions. The capital cost of building a vessel with multiple capabilities would also be a handicap, and maintenance costs would likewise rise.

We clearly wanted a drillship optimized for drilling, making hole operations, and installation of completions and Christmas-trees.

When drilling in very deep water depths, the drilled depth is shallow, compared to the total depth: Unproductive handling operations take a higher proportion of time than productive making-hole operations. Rather than going to a "dual derrick" configuration, we developed a "dual handling" concept. In DP mode and deep water, it can operate 2 strings as long as 10,000 ft and separated by only a few feet, even when rotating. Again, the capital cost is high for operations that cannot take full advantage of the equipment.

Our "dual handling" concept focuses on reducing handling time, by allowing non productive handling operations "in the background".

POWER PLANT

The vessel is designed with a dual and even triple redundant dynamic positioning system (compatible with NMD 2 / NMD 3 notation). Again, economics are taken into account, resulting in 2 engine rooms, each with its own cooling water, fuel oil and auxiliary systems. 2 separate pump rooms and auxiliary engine rooms are located next to the engine rooms. Power is generated by 6 medium-speed, 4,860-kW diesel generator sets, 3 per engine room. The electric power is fed from 2 separate switchboard rooms to the consumers. Redundancy is also provided in the cable routing. The vessel will be able to operate with one engine room out of order during a 10-year-return-period storm if it is allowed to select its optimum heading. Engine rooms are located in aft with one main exhaust (split internally into 2 parts) on port side to minimize deck occupancy. The aft location ensures that the exhaust gases do not interfere with the drilling operations on the vessel, as they are downwind.

Redundancy is also provided for the drilling systems by having 2 drilling switchboards. One is starboard and one on port, next to the moonpool to minimize cabling length. A power-management system is installed to ensure that sufficient power is available.

RISER STORAGE

The vessel has an open riser hold designed to store 10,000 ft of 70-ft risers. The open riser hold allows fast and safe riser handling and reduces the need for overhead cranes inside the vessel. It also contributes to reduce the vertical center of gravity compared to storage on the main deck.

A dedicated riser-handling system is installed over the open hold. The forward deck crane ensures redundancy, should the riser-handling system fail.

ACCOMMODATIONS

Table 1: Maximum motions for substructure analysis

	Maximum Drilling	Standby *	Natural Periods
Roll	2.4 degrees/16.8 s	8.9 degrees/20.0 s	23.2 s
Pitch	4.5 degrees/8.8 s	6.4 degrees/13.1 s	7.9 s
Heave	6.1 m/9.3 s	9.9 m/12.1 s	8.4 s

*** Risers disconnected from the BOP**

The accommodation block is upwind of all the hazardous areas and designed for a total complement of 130 persons. Lifeboats are located besides the accommodations block to allow safe and easy emergency egress away from the hazard. The raised catwalk is extended to the muster platform aft of the accommodations, allowing drill-floor personnel to directly reach the lifeboats or accommodations without first descending to the main deck.

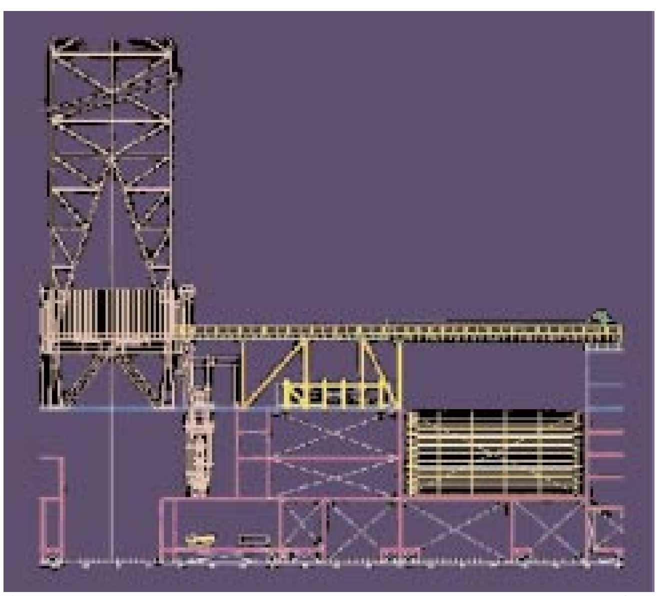
DERRICK, SUBSTRUCTURE, DRILL FLOOR

The vessel is designed to accommodate a single derrick suitable for dual-handling operations. Triple pipe or casing stands can be made up in the powered mousehole independent of drilling operations, and placed in the setback prior to any drilling operations. As a result preparation time for drill pipe, risers or casing is reduced by 60%.

The cellar deck features 2 accesses and 2 working areas, one aft for Christmas-tree preparation and handling and one forward for BOP storage. The BOP can be handled in one piece and can be serviced and tested on main deck and cellar deck.

THRUSTERS

The vessel is equipped with azimuthing thrusters aft, 3 retractable azimuthing thrusters amidships, and 2 bow tunnel thrusters. The 2 aft thrusters deliver sufficient propulsive power for a service speed of 13 knots. All thrusters protruding below the vessel base line are retractable to facilitate shallow-water maneuvers, and for smooth sailing at 13 knots using the minimum amount of fuel. All retractable thrusters can be inspected and maintained inside the hull of the vessel as the entire unit can be raised above the highest waterline by a dedicated retrieving mechanism. These thrusters can be retrieved all the way through the main deck and handled as necessary.



Open riser hold: The rig's open riser hold is designed to improve safety and ease of pipe handling. It accommodates 10,000 ft of 70-ft risers. In addition, the need for overhead cranes inside the ship is reduced. The open riser hold also lowers the drillship's center of gravity.

ADDITIONAL FEATURES

The design offers a large deck area on the aftship for drilling and company equipment. Provision of a raised deck for well testing increases this area. Workshops and stores are arranged next to the funnel. Aft of the stores and funnel the main deck is fitted with hinge structures for burner booms.

Hatches are provided throughout the main deck to allow lidding operations for all compartments where this is required. This also ensures that during construction of the vessel no special arrangements are to be made to install equipment with long lead times. The main deck forward of the derrick is used for storage of casing and drill pipes in racks.

The drill floor, mud return and pipe racks have a separate drain system dumping polluted water in a skimmer tank.

Table 2: DP capability

	Diameter (mm)	Power (KW)	Thrust (kN)
Azimuthing DP:			
Main Propulsion	3,400	4,500	720
Azimuthing DP	2,800	3,000	470
Tunnel	2,750	1,700	265

Table 3: Station Keeping

Thruster inoperative	Thruster power (MW)	Generator power (MW)
NMD-2 switchboard section failure		
1+6	15.2	23.4
2+7	15.2	23.4
4	18.4	18.8
5	18.4	18.8
NMD-3 engine room failure		
1+4+6	12.2	14.1
2+5+7	12.2	14.1

On the main deck aft, racks are provided for storage of completion and work-over risers. These risers can be lifted in the dragway by means of the aft deck crane. The aft dragway leads to the derrick via a ramp structure.

The design features 2 (or 3) offshore cranes servicing all the areas required. Sufficient space is available for installation of additional cranes if required.

STABILITY

Stability and longitudinal strength of the vessel was evaluated under some typical operating loading conditions as defined by Pride/Foramer for maximum drilling depths of about 3,000 m (2 sailing conditions, 2 casing conditions and 4 drilling conditions).

Foramer also defined 8 loading conditions for typical West Africa operations in 2,000 m water depth range. For these cases, less liquid mud and a smaller amount of drill pipes and risers are required. Furthermore, substructure loads are smaller.

The vessel was assumed to carry 1,100 tons of company equipment occupying 1,100 sq m. Enough mud for a complete well was included in the load.

MAXIMUM MOTIONS

The maximum roll, pitch and heave motions at the center of gravity of the vessel for the 3 environmental conditions are shown in Table 1.

DP CAPABILITY

Tables 2 and 3 display DP and station-keeping capability. The total installed thruster power is 21.4 MW.

In case of a NMD-2 failure, the electric installation is designed in such a way that not more then one fore thruster and one stern thruster can be out of operation at the same time.

STATION KEEPING

The maximum excursion should not be more than 1% of the water depth. This means that for a water-depth of 10,000 ft the maximum allowable excursion will be 100 ft or approximately 30 m.

The vessel will be equipped with 6 x 4,688 kW generator sets (total 28.1 MW). The generator sets will be located in two (2) different engine rooms. During normal operations approximately 7.5 MW is needed for drilling and accomodations.

Table 4: Simulated downtime for West Africa and Gulf of Mexico

	West Africa		Gulf of Mexico	
	% Downtime (1-year weighted average)	% of Total	% Downtime (1-year weighted average)	% of Total
Running casing & riser (30%)	1.42	0.43	1.62	0.49
Drilling (44%)	0.00	0.00	0.19	0.08
Tripping (20%)	0.00	0.00	0.06	0.00
Connecting/disconnecting (6%)	0.00	0.00	0.01	0.00

Wave angle ranged from 120-180 degrees
Simulations were run heading into waves

The maximum available power for normal DP will therefore be approximately 20.6 MW.

During standby operation, it is estimated that approximately 2.5 MW is needed. The maximum available power during standby operations for DP (without any failure) is higher than the total installed thruster power.

NMD-2 and NMD-3 failure simulations are shown in Table 3.

ENVIRONMENTAL CONDITIONS

The simulation study was carried out for 3 environmental conditions:

- ENV1: Maximum drilling condition;
- ENV2: Standby condition with BOP disconnected;
- ENV3: West Africa.

SIMULATIONS

The criteria on which the station keeping capability were judged were maximum excursion, mean power consumption and maximum power consumption.

It was observed that for all the simulation runs the intact vessel is capable of station keeping within specified excursion and power. For these cases, the maximum excursion is not exceeding 1% of the water depth.

In standby condition and a heading into waves, the vessel is slowly moving away from its set point when thrusters T2 and T7 are out of order because of a switchboard section failure. This is allowed, because the riser is disconnected to the BOP. The power consumption does not eceeed available generator power.

In case of NMD-3 failure during drilling operation, the vessel is capable of station keeping with an optimum heading. At the moment of the failure, the drilling operations are stopped to ensure station keeping, because the riser is connected to the BOP.

In standby condition, the vessel is capable of keeping its set point with an optimum heading keeping within specified excursion and power.

To get an impression of the thruster power consumption offshore West Africa, a simulation was also carried out for the deep water drillship located at this location.

From the statistical analysis,it can be concluded the mean power consumption is approximately 1.55 MW with maximum of 2.21 MW in case of optimum heading and approximately 6.60 MW with maximum of 7.26 MW in case of heading into waves.

DOWNTIME

This vessel is designed for worldwide operation with emphasis on working in the Gulf of Mexico and West of Africa . For the downtime analysis two scatter diagrams were used, i.e. of area 15: Gulf of Mexico derived from 'Ocean Wave Statistics' (Hogben and Lumb, HMSO) and for West Africa derived from the environmental design criteria (reference to IML 97/441 provided by **Elf Exploration Angola**).

In determining the total downtime of the vessel, direction distribution in West Africa and experience from the DP simulations were used to estimate weight factors for the relative wave angles.

Downtime plots were made for 3 relative wave angles (i.e. 180°, 150° and 120° from astern).

The following situations, considering heading variation, were investigated:

- Heading into waves, heading variation is low, relative wave angle mainly from 180°.
- Optimum heading wave dependent, when current velocities are not too high. waves are determining the optimum heading. Governing relative wave angle is approximately 150°.
- Optimum heading current dependent, when high current velocities occur, the optimum heading is determined by the current. Therefore there is not one dominant relative wave angle.

CONCLUSION

The GUSTO 10,000 design gives a dynamically positioned drillship fully optimized for drilling operations up to 10,000 ft of water depth.

The excellent motion and DP characteristics bring the potential downtime to a minimum.

The drilling equipment is selected and sized according to the capacity required for typical deep subsea well programs. To reduce unproductive handling time, a "Dual Handling" concept has been designed and incorporated. ■