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A Novel Platform for Drilling in Harsh High-Latitude Environments.

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Abstract

This Paper describes the Extendable Draft Platform (EDP), which has a deeper draft than a conventional drilling semi and a novel construction and deployment method. It then compares the vessel motions behavior of the EDP with a 5th generation drilling semi for a specified high latitude location with a particularly harsh environment including long period swell conditions. Using the motions limits at which the 5th generation semi must curtail drilling operations, the motions for both platforms are assessed and the applicable seastates at which the motions are exceeded are noted. By performing multiple calculations for specific wave conditions defined by a wave scatter diagram, the percentage of time per year that drilling operations can be performed for that location is derived. In this manner the drilling downtime relating to vessel motions for each platform type is inferred. This paper then assesses how the benefit of improved platform motions, achieved through a deeper draft, could assist the drilling industry as it searches for hydrocarbons in these increasingly remote and environmentally challenging areas.

This paper concludes with an assessment of the readiness of such new initiatives being available to the drilling market in the future.

Introduction

The Extendable Draft Platform (EDP) is a column stable Deep Draft Floater (DDF) platform. The EDP column design is based on the "Classic" Spar concept combined with a heave plate rather than the pontoon arrangement of a conventional semi submersible vessel. The function of the heave plate is to trap a mass of water and thereby reduce heave motions.

Its ultra deep draft has been shown to provide superior global motions performance when compared with a conventional draft or deep draft semi submersible platform.

There are two main applications for the EDP, as a Drilling and Production platform or as a Mobile Offshore Drilling Unit (MODU).

As a Drilling and Production platform, its superior global motions performance enables it to support wells with dry trees and Steel Catenary Risers (SCR's) for the import and export of production fluids even in ultra deepwater water (10,000ft).

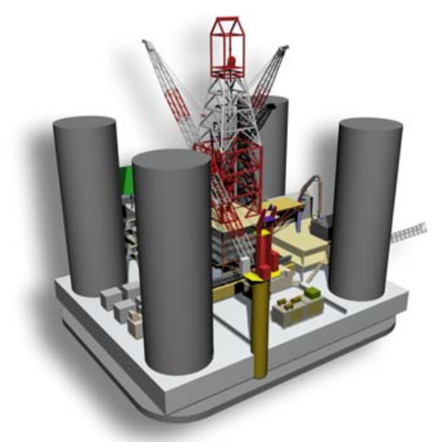
As a MODU, and the subject of this Paper, the EDP's superior global motions performance enables it to continue drilling operations longer during severe weather, when compared with a conventional draft or deep draft semi submersible platform.

The Eirik Raude is an up-to-date 5th generation conventional draft semi submersible MODU, owned and operated by Ocean Rig. In terms of global motions performance and operational uptime, it is a good example of the current state-of-the-art for a MODU.

This Paper compares the global motions performance of and EDP with that of the Eirik Raude for a specific harsh environment location and estimates the difference in operational up-time.

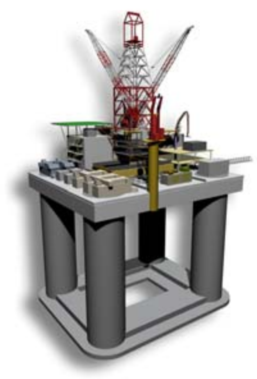
The Extendable Draft Platform (EDP)

The EDP is a deep draft floating platform constructed and deployed in a similar manner to Technip's TPG 500 production jack-up platforms. In the case of the EDP, the deck is constructed at quayside level directly above the lower heave plate and with the columns elevated in the air.



EDP in construction and transit configuration

This construction configuration enables the topside facilities to be completed onshore and enables a rapid deployment offshore. The EDP is wet towed to its deepwater site where the columns are lowered, together with the heave plate, by a combination of controlled ballasting and by the use of its mooring winches. Once the columns are fully lowered they are mechanically locked to the deck, which is then lifted clear of the water by de-ballasting of the columns.



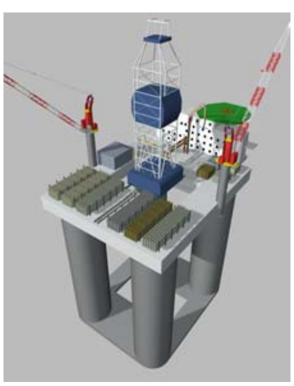
EDP in operating condition

Thereafter the EDP acts in a similar manner to a deep draft semi-submersible platform but with a deeper draft than can be achieved by using other onshore topside integration techniques.

The EDP's motions are equivalent to those of Technip's Spar platform and the EDP is able to use the same riser and mooring technology developed for the field-proven Spar platforms. It also shares the Spar's simple ballast system with no need for active ballasting.

When the EDP operates as a MODU it is moored, with the moorings designed to resist the design hurricane storm conditions and hence, like the spar, drilling operations can be performed using a dry Blow Out Preventer (BOP). This can save considerable time in terms of a round trip required to retrieve and repair a faulty seabed BOP stack. The dry BOP also enables a slimmer drilling riser design. The fact that the EDP is not fitted with a DP system means that it is best suited to development drilling in one location or area rather than exploration drilling where mobility and transit speed are vital characteristics.

The EDP MODU has a large payload capacity, which is not limited by its configuration, draft or construction method. Studies have been performed for platforms with payloads as high as 50,000 tonnes. As a result, the EDP is able to support large drilling riser loads in deepwater and store large quantities of drill pipe, casing and tubing.



The EDP configured as a MODU

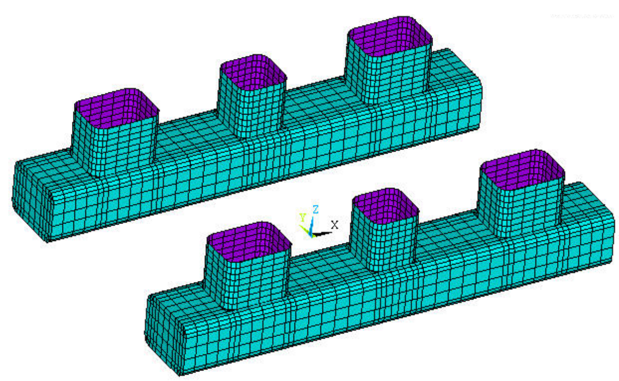
The Eirik Raude 5th generation semi

The Eirik Raude is a state-of-the-art 5th generation conventional draft semi submersible MODU, owned and operated by Ocean Rig.

The Eirik Raude 5th generation semi

The Eirik Raude is a Bingo 9000 design semi-submersible vessel with an operating draft of 24m (78ft) and a payload capacity of around 12,000 tonnes. She is fitted with a Class 3 DP system which provides station-keeping over a water depth range of 500-3000m (10,000ft). In water depths of 70-500m she has an 8 line mooring system assisted by her thrusters (POSMOOR ATA). She has six fixed-pitch variable speed azimuthing thrusters each capable of generating 100 tonnes of thrust. The extreme weather design conditions are a maximum wave height of 32m (Hmax), an average wind speed (one minute sustained) of 51.5m/s and a maximum current speed of 1.5m/s (tidal) and 0.8m/s (wind).

The hull form of the Eirik Raude comprises of twin longitudinal pontoons each supporting three columns with a main deck of 79m x 67m (260ft x 220ft). This dual pontoon configuration is well suited to transit, when a design speed of 7 knots in a Beaufort Storm 6 condition is specified.



The hydrodynamic model of the Eirik Raude hull form

Normal drilling operations on the Eirik Raude are curtailed when vessel motions exceed either 5m (16.5ft) of double amplitude heave or 3 degrees of pitch/roll. These limits reduce when a BOP is being landed to 2m (6.6ft) of double amplitude heave or 2 degrees of pitch/roll.

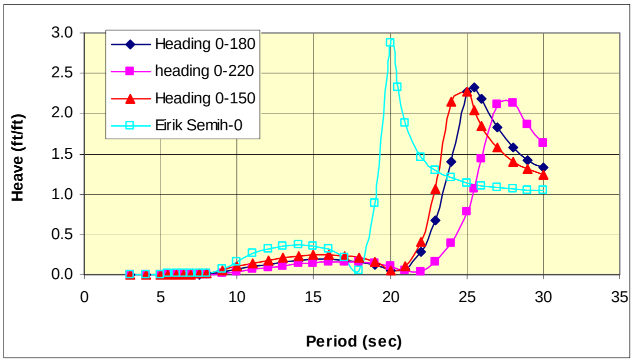
Equivalent EDP MODU designs

Three EDP platform designs were evaluated with equivalent main deck size and payload capacity to the Eirik Raude. The three EDP platforms varied in terms of draft with 45m (150ft), 55m (180ft) and 67m (220ft) being assessed.

Comparison of motions

Hydrodynamic models of the Eirik Raude and the three EDP platforms were then created and their motions performance compared.

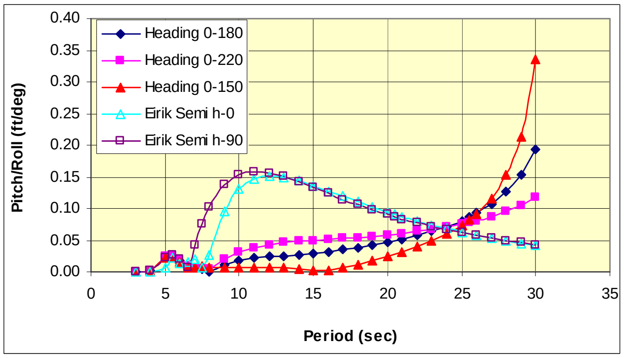
As expected the heave response of the EDP is superior to the Eirik Raude due to its greater draft as shown by the heave RAO's presented below.



Comparison of heave RAO's

The ROA's of the Eirik Raude indicate she will heave more in short period waves (10-15s) and has a resonant peak response at a 20s wave period. The EDP by contrast has a smaller response in short period waves and has a resonant peak response of at least 25 seconds which increases with draft (150, 180 & 220ft drafts shown). This improved heave response is particularly important when drilling in areas of the world exposed to long period wave energy, eg high latitudes.

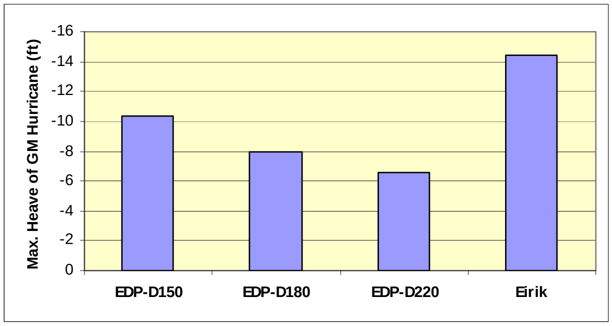
A similar situation is shown when comparing the pitch responses of the two platforms.



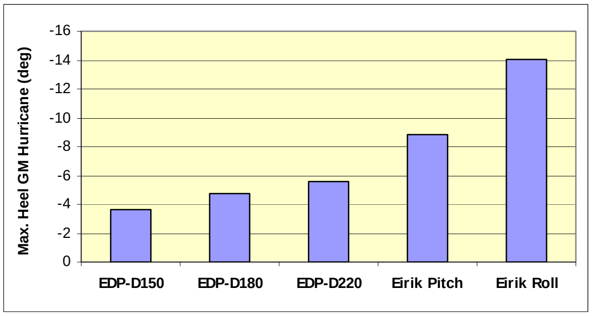
Comparison of pitch RAO's

Here again the EDP experiences significantly less pitch motion when compared with the Eirik Raude across the wave spectra of interest (although in this case the EDP pitch response does not improve, but deteriorates, with increasing draft).

In terms of actual motions in a defined storm environment, such as the 100-year storm in the Gulf of Mexico (GoM), these are shown in the diagrams below:



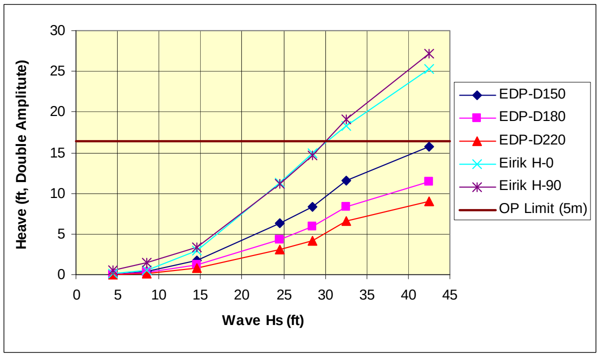
Comparison of heave motions



Comparison of pitch motions

It is noted that the Eirik Raude has a better pitch than roll performance since its longitudinal pontoons are more prone to beam seas and in practice uses her thrusters to head into the incident waves. It is also noted from these two diagrams that an optimal draft of EDP would be around 180ft (55m) which provides a heave and pitch response around one half that of the Eirik Raude.

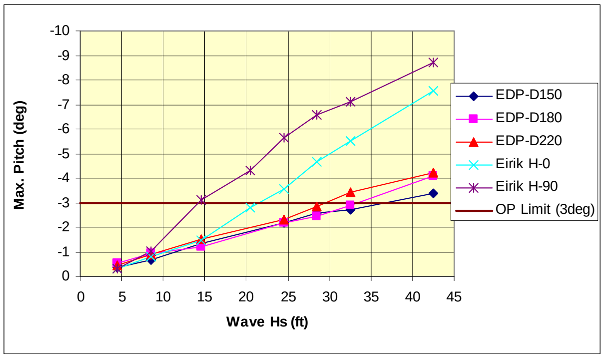
In terms of limiting sea states for normal drilling operations, the following diagrams indicate the relative performance of the different hull forms based on the same limiting motions criteria:



Limiting seastate comparison in heave

This diagram indicates that the Eirik Raude has to suspend drilling operations, when the double amplitude heave reaches 16.5ft (5m), with a significant wave height (Hs) of 30ft (9m) whereas the EDP does not reach the same motions limit until a significant wave height of 45ft (14m) for the 150ft (45m) draft version, or higher as the EDP draft increases. It should, however, be borne in mind that drilling operations may already have been suspended due to other reasons than vessel motion, such as high wind speeds associated with the wave conditions.

When pitch motions are considered, the seastate limits are even less.



Limiting seastate comparison in pitch

This diagram indicates that the Eirik Raude has to suspend drilling operations, when the pitch reaches 3 degrees, with a significant wave height (Hs) of 22ft (7m) whereas the EDP does not reach the same motions limit until a significant wave height of 33ft (10m), for the 180ft (55m) draft EDP. In fact this difference will increase if the environmental conditions of wave, wind and current are not co-linear and the asymmetric nature of the Eirik Raude's hull form, and its response to quartering seas, starts to take effect.

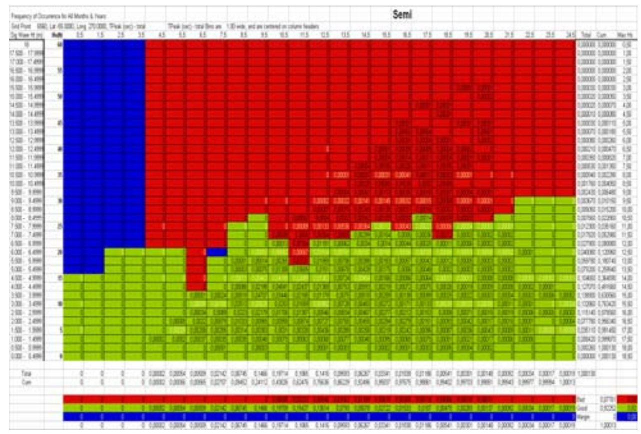
Unfortunately limiting seastates are of little value in terms of assessing drilling downtime and more sophisticated calculations are required.

Scatter diagram evaluations

In order to compare the difference in drilling uptime between the Eirik Raude and the EDP, a weather frequency assessment has to be performed. For this, a wave scatter diagram for a high latitude location has been selected with a particularly harsh environment. The location chosen was S55, 90W which is to the West of Cape Horn and which has a cocktail of large waves and long period swells, characteristic of other harsh environments in high latitudes.

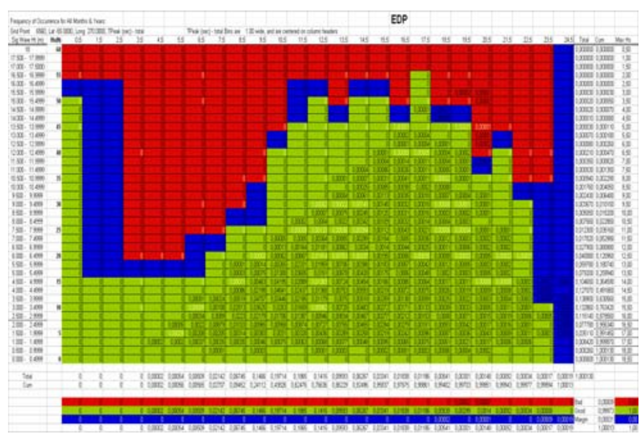
The wave scatter diagram is represented as a matrix with significant wave height (Hs) along the x-axis and wave period along the y-axis. The squares within the matrix then contain a fractional number, which represents the probability of that particular wave height and period occurring. If there is no number it implies that wave condition never occurs and where the number is large, this represents a frequent condition.

The scatter diagram analysis then involves calculating the platform motions for each square of the matrix and determining whether they exceed the limits required to perform normal drilling operations, ie 5m (16.5ft) of heave motion and 3 degrees of pitch and roll. If the motions are excessive and normal drilling operations must cease, the square is coloured red, whereas if the platform motions are within the limit for normal drilling operations the square is coloured green. When this procedure is completed the probabilities of all the red squares are summed and this gives the fraction of time that the platform motions exceed the specified limit for normal drilling operations. For example the diagram below shows the scatter diagram coloured up for the Eirik Raude motions.



Scatter diagram for the Eirik Raude – normal operations

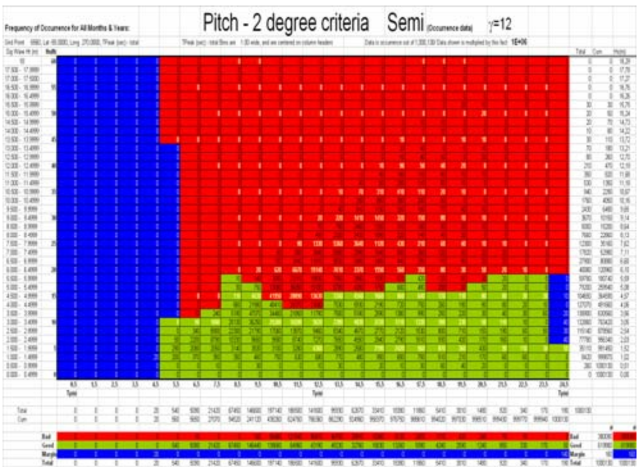
This diagram indicates that the Eirik Raude motions exceed the limits for normal drilling for 8% or 1month per year. The equivalent diagram for the EDP with a 180ft (55m) draft is shown below.



Scatter diagram for the EDP- normal operations

This diagram indicates that the EDP motions only exceed the same motions limits for normal drilling for 0.027% of the time or 2.4hours per year. Indeed the drilling downtime for the Eirik Raude is likely to be far in excess of this figure since the drilling operations will have to be shutdown prior to the motions limit being reached and there will be time taken to re-start operations after the motions are no longer excessive. This additional downtime will be in proportion to the number of times that operations have to be suspended. It should also be borne in mind that drilling operations may already have been suspended due to other reasons than vessel motion, such as high wind speeds associated with the wave conditions.

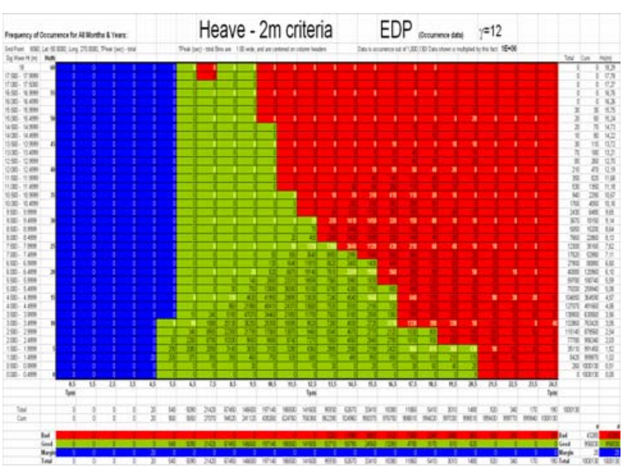
When the more critical drilling operation of running a BOP is evaluated the waiting-on-weather gets significantly greater. For running a BOP the limiting motions are 2m (6.6ft) of heave and 2 degrees of pitch and roll. The diagram below shows the scatter diagram for the Eirik Raude.



Scatter diagram for the Eirik Raude – running BOP

As can be seen the proportion of green squares reduces indicating a much lower frequency of acceptable vessel motions. For running a BOP, the Eirik Raude exceeds the motions limits for 38% or 4.5 months of the year.

The equivalent scatter diagram for the EDP with a 180ft (55m) draft is then presented below.



Scatter diagram for the EDP – running BOP

For the EDP, the motions limits for running a BOP are exceeded for only 4.3% or 0.5 months of the year (ie around a ten fold improvement over the Eirik Raude).

Conclusions

This paper has presented the results of a rigorous comparison of platform motions between a state-of-the-art 5th generation semi (the Eirik Raude) and an Extendable Draft Platform (EDP) for a specified harsh environment location (S55, 90W). These indicate that for the 5th generation semi the specified motions limits for normal drilling operations are exceeded for 8% or one month of the year compared with 0.027% or 2.4 hours per year for the EDP. For the more sensitive operation of running a BOP, the 5th generation semi motions limits are exceeded for 38% or 4.5months of the year compared with 4.3% or 0.5 months of the year. These periods of motion limit exceedance will relate to even greater system downtime due to shutdown of operations prior to the limiting seastate and the time taken to re-start operations after the motions are no longer excessive. This additional system downtime will be in proportion to the number of times that operations have to be suspended. It should also be borne in mind that drilling operations may already have been suspended due to other reasons than vessel motion, such as high wind speeds associated with the wave conditions.

In considering these results, it should be emphasized that the Eirik Raude has excellent motion characteristics for drilling operations, including running BOPs, in most areas of the world. Its shallow draft hull form with dual pontoons is an excellent configuration for transiting required during exploration drilling in several regions. However there are some locations where the extremely harsh environment exposes the shortcomings of the hull form and shows that additional draft has major benefits.

It is interesting to note that the significantly improved uptimes achieved by the EDP in ultra harsh environments do not act as a major incentive for drilling companies to invest in the EDP technology since there is little differential in day rate between drilling and waiting-on-weather in most current drilling contracts. The benefits thus lie with the operating companies who currently are financially exposed to weather risk in drilling operations.

The EDP technologies of a deep draft floater and of mechanical connections between structural members (ie column to hull) are established and the EDP design has been matured following a decade of development. However, it is possible that the EDP as a MODU, like many new technologies, may be first used as an enabling technology, perhaps in an ultra harsh area where only its superior performance will permit year-round drilling and production operations, where the consequence of waiting-on-weather associated with other designs makes a particular development financially non-viable. And as the oil industry continues its search for, and extraction of hydrocarbons in increasingly remote and environmentally challenging areas, the day of the first EDP is unlikely to be far away.

Acknowledgments

The authors would like to thank all Technip team members that have contributed to the development of the EDP concept.

Nomenclature

BOP = *Blow Out Preventer*
DDF = *Deep Draft Floater*
EDP = *Extendable Draft Platform*
GoM = *Gulf of Mexico*
MODU = *Mobile Offshore Drilling Unit*
SCR's = *Steel Catenary Risers*