TOOLS FOR MITIGATING AND MANAGING VDL LIMITATIONS IN CHALLENGING AUSTRALIAN SOIL AND ENVIRONMENTAL CONDITIONS.

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ABSTRACT

Australian continental shelf drilling faces some of the most challenging soil types combined with severe weather. Carbonate soils present significant risks to jack-up drilling operations during both installation phases (punch-through risk) and operation phases due to cyclic degradation of the soil strength.

This paper will present learnings and specific tools that were developed for the Yolla Field, offshore Victoria, Australia where the above challenges were compounded by pre-existing spudcan craters and close proximity to a production platform. These tools allowed for effective VDL management planning for drilling operations, and emergency planning for extreme weather events.

KEY WORDS: Jack-Up, Variable Deck Load, VDL, MetOcean, Operations Planning, VDL Contours

NOMENCLATURE

ABS	American Bureau of Shipping
AG	Advanced Geomechanics
BMC	Baker Marine Corporation
BPT	Ball Penetrometer Test
CoG	Centre of Gravity
CPT	Cone Penetrometer Test
GLND	GL Noble Denton
LCG	Longitudinal Centre of Gravity
MLE	Mid-Life Enhancement
ND	Noble Denton Marine Assurance and Advisory, DNV GL – Oil & Gas
TCG	Transverse Centre of Gravity
JV	Joint Venture
PCPT	Piezocone Penetrometer Test
VDL	Variable Deck Load

INTRODUCTION

In 2012 Origin Energy Resources limited, operator of the Yolla Field offshore Victoria, Australia, undertook a rig selection exercise and subsequent analyses to allow a jack-up drilling rig to drill two offshore wells at the Yolla Platform on the BassGas Joint venture (Permit T/L1).

The BassGas JV is a joint venture between Origin Energy Resources Limited (Operator) 42.50%, AWE Limited (via subsidiaries) 35.00%, Toyota Tsusho Gas E&P Trefoil Limited 11.25% and Prize Petroleum International Pte. Ltd 11.25%. The project consists of offshore wells in Tasmanian waters, with gas and liquids extracted using an offshore platform and transported via pipelines to the Lang Lang onshore processing plant in Victoria. Gas is then transported via the Victorian Principal Gas Transmission Pipeline for sale to the domestic gas market.

The Yolla Platform is located in 82m of water depth in Bass Strait, offshore South Australia (see Figure 1). The area is subject to frequent severe storms, which increase in number and intensity in the Australian winter months, peaking in the month of September.

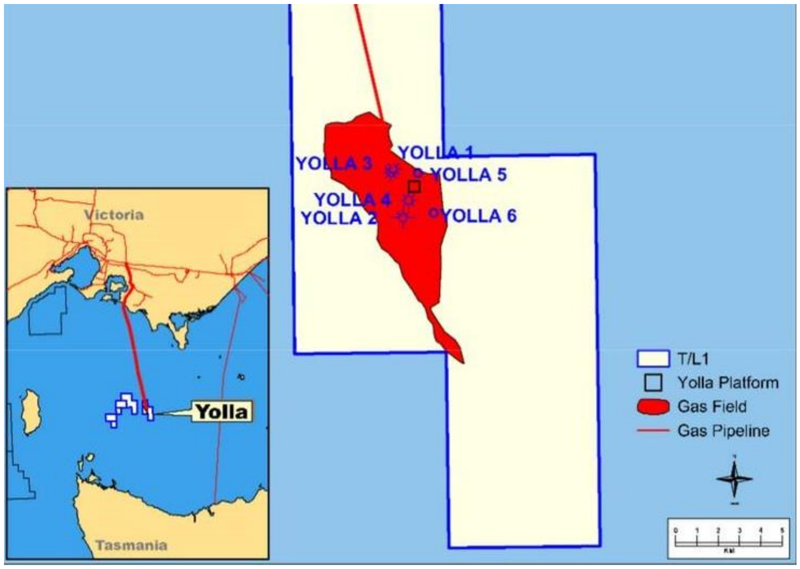

Figure 1 – Yolla platform location

To be able to site a jack-up drilling rig at the Yolla platform a number of challenges had to be considered and procedures to manage these agreed by all parties. The key initial challenges and associated restrictions are:

- Complex layered seabed soil conditions; layers of carbonate soils, of varying, but low, strengths leading to large leg penetrations and the potential for rapid penetrations during installation. Further, the associated risk of cyclic degradation during extreme weather – requiring consideration of cyclic load effects and leg-load control measures thus restricting the choice of a potential jack up drilling rig and/or the allowable variable loading.
- Pre-existing spudcan craters –limiting the choice of rigs available to those rigs with similar leg and spudcan geometry to the Ensco 102 rig that had previously been installed at the location. See Figure 2.
- Potential for large depth ground deformation around the platform mudmat – presenting risk to the foundation support of the Yolla Platform. See Figure 2.

This paper outlines the efforts made by Origin Energy, supported by DNV GL (Noble Denton Marine Assurance and Advisory) and Fugro AG (Advanced Geomechanics) to address these constraints and mitigate the geotechnical risk such that rig installation and the planning of effective drilling operations could happen.

The following topics will be addressed:

- Geotechnical challenges presented by the Yolla location;
- The process for selecting a Jack-up rig considered suitable for emplacement at the Yolla location;
- Site specific assessment of the selected Jack-up "West Telesto" including modifications to the foundation assumptions in agreement with AG;
- Restrictions on target preload due to the possibility of punch-through;
- Restrictions on elevated condition VDL for storm survival to account for the expected cyclic degradation of the soils;
- The development of tools to manage the VDL restrictions as a function of the CoG of the elevated weight.

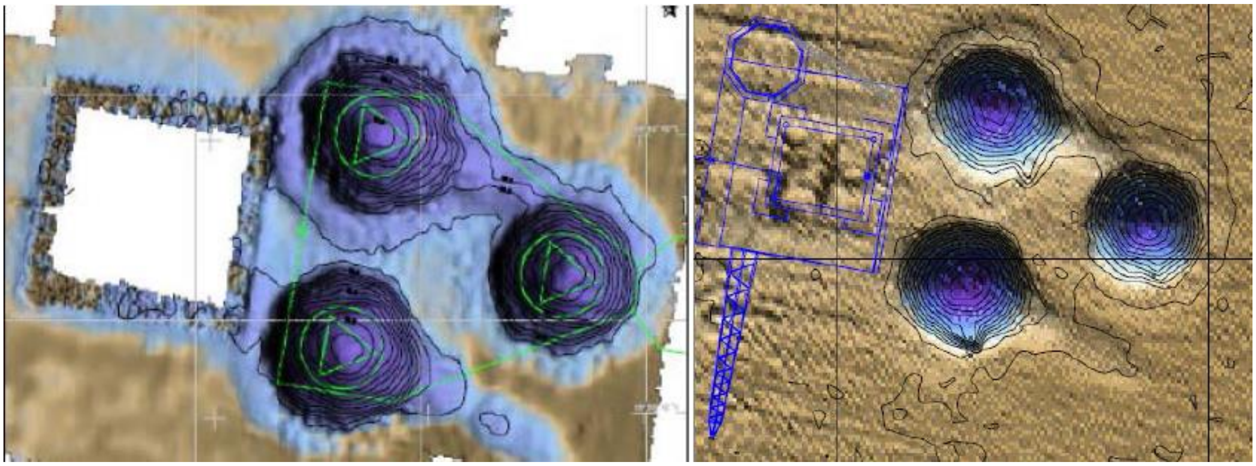

Figure 2 - Yolla Platform bathymetry plot showing the craters left by the Ensco102 jack-up drilling rig.

SITE AND SITUATION

SITE GEOTECHNICS

Five separate geotechnical site investigations have been performed in the past, the most recent were undertaken at the Yolla location in 2013 and comprised of sampling and piezocone penetrometer tests (PCPT) within each of the Ensco 102's footprints and also a number of tests outside the footprints. Various offshore and onshore laboratory tests were performed on the retrieved soil samples.

The geotechnical information showed that the soils at Yolla were susceptible to significant degradation when subjected to cyclic loading. The effects of the foundation disturbance caused by the previous jack-up installation added to the complexity of the site. The location also presented a significant risk of punch-through occurring during the preloading operation or in the elevated mode as a result of storm loading. It was therefore necessary to identify the maximum preload that could be achieved whilst having acceptable margins against punch-through. This limiting preload (90MN per leg at spudcans) was such that the resulting foundation capacity (accounting for AG's-recommended reductions to account for cyclic degradation of the soil) was less than that required to support the standard storm-survival VDL given in the Jack-Up's Marine Operations Manual (2,995tonnes) under storm loading conditions. It was therefore necessary to determine allowable VDL limits as a function of elevated weight CoG, and graphical tools were developed for this purpose.

SNAME [1] includes reference to accounting for cyclic degradation using factors applied to soil rotational stiffness and horizontal bearing capacity for Clay soils. However, for this location and foundation type, further assessment was needed and AG conducted further studies (see also [2] & [3]) which concluded it was necessary to apply further reductions to fixity on Bow leg and Moment capacity on Port leg than that calculated using the SNAME approach. It was agreed by all parties (DNV GL, Origin and AG) following workshop discussions to follow the AG approach. However it was later found that AG-recommended reductions to Bow leg fixity and Port leg foundation moment capacity to account for cyclic degradation, were mostly offset by subsequent soil consolidation subject to minimum consolidation times that were dependent on penetration achieved after preload.

The soil in the top 30-40m of depth comprises predominantly clayey carbonate mud and carbonate mud. The worst case leg location for soil strength and resistance to punchthrough was identified as the Starboard Crater. More information on the complex geotechnical analysis needed is contained in the companion two papers (Refs. [2] and [3]). The outcome of these assessments was used to optimise the tools that were used to perform drilling operations planning.

RIG SELECTION

For a jack-up to operate at the Yolla location several key technical specifications and conditions had to be met:

1. Duplicate the dimensional and operability parameters of the Ensco 102, a KFELS MOD V A design jack-up, which drilled the original Development wells Yolla 3 and Yolla 4.
   a. Suitable leg length to operate in the water depth with 24 metres spudcan-tip penetration below seabed and 21.22m airgap.
   b. The cantilever can extend over the well bay area and reach all well-slots.
   c. The leg spacing is compatible with the existing spudcan footprints so that the spudcans can be installed in the existing spudcan craters.
2. Pass the SNAME T&RB 5-5A criteria (the industry standard for site qualification of jack-ups) and have sufficient foundation bearing capacity to operate at Yolla for the 50-Year storm conditions.

The challenges for a jack-up operating at Yolla are primarily the weak soil strength conditions, which create stability issues during preloading, and also soil strength cyclic degradation in the 50-year storm conditions.

Extensive studies were undertaken to select a suitable rig to operate safely while on location. Three rig types were initially highlighted as suitable in meeting the first three conditions above (1a. to 1c.); the BMC375, BMC400 and JU2000E type jack-ups.

DNV GL (at the time trading as GL Noble Denton (GLND)) then completed a SNAME T&RB 5-5A site specific, cyclic loading and punch-through assessment of the rig types using 50-year , all-year environmental extremes for the Yolla Location, with confirmation of soil condition/stability under cyclic loading (performed by Advanced Geomechanics). All three rig types were prequalified, however with restricted survival and operational Variable Deck Loads (VDL).

WEIGHT COMPARISONS OF NEW BUILD JU2000E UNITS

DNV GL based their site qualification analysis on the principal weights from the Marine Operations Manual for a "base-case" JU2000E design jack-up with details confirmed with the rig owner as correct and representative of the company’s fleet of JU2000E design Jack-up rigs. This rig was the basis for Yolla Stage 2 Final Investment Decision.

During early engagements with Rig owners it became clear the existing fleet of jack-ups were unavailable due to long term contracts in the Middle East and North Sea. These existing JU2000E design jack-ups were qualified to operate at Yolla under a restricted survival VDL of 2,000 tonnes, a value that was operable but tight. The more recent, and potentially available JU2000E’s constructed in the Singapore and Chinese shipyards experienced a growth in hull weight above that of the previously qualified jack-ups of the same design. The main difference between the "base-case" JU2000E and the more recent JU2000E’s is the hull lightship weights as shown in Table 1. The hull lightship weight of the Singapore built JU2000E's is about 2,000 tonnes heavier, the Chinese built JU2000E's also have a weight increase, but less than the Singapore built JU2000E’s. The ABS Verification Certificate of the incline and buoyancy testing, indicated the selected rig “West Telesto” is approximately 1,000 tonnes heavier than “base-case” rig assessed. The weight increase is dominated by upgrades to the leg jacking systems.

Table 1: JU2000E - Weight Comparison

	"Base-Case" JU2000E	**JU2000E "X"**	**JU2000E "Y"**	**JU2000E "West Telesto"**	**JU2000E "Z"**
Build Location	***China***	Singapore	Singapore	China	China
Build Year	***2009***	2013	2012	2012	2014
Hull Lightship Weight (tonnes)	***9,164***	10,596	10,378	9,885	10,307
Cantilever & Drill Floor (tonnes)	***2,628***	3,056	3,023	2,854	2,590
Sub total	***11,792***	13,652	13,401	12,739	12,898
Weight of legs & spud can (tonnes)	***4,923***	5,033	5,227	4,997	4,980
Total	***16,715***	**18,685**	18,628	17,736	**17,878**
(difference)	***Base Weight***	**+(1,970)**	**+(1,913)**	**+(1,021)**	**+(1,163)**

RE-ASSESSMENT OF THE JU2000E YOLLA SITE QUALIFICATION

DNV GL were asked to review the SNAME 50-year return storm survival and 1-year return operating cases for the Yolla location based on the latest hull lightship weights. This would consist of re-analysing the JU2000E site qualification by:

a) Considering revised hindcast data to determine an updated 50-year return metocean criteria based on measured metocean data collected at Yolla;
b) Reviewing the impact of JU2000E weight increase on 50-year return survival, and 10-year & 1-year return operational VDL; and
c) Developing a matrix qualification tool to evaluate various weights under various environmental loadings.

It was item c) that led to the development of tools for managing VDL limitations governed by satisfaction of SNAME requirements for 50-year return storm survival or passing all SNAME unity checks for a 10-year & 1-year return operational loadcase.

SITE-ASSESSMENT ANALYSIS METHODOLOGY

INTRODUCTION

The analyses were carried out in general accordance with the methods and criteria given in SNAME T&RB 5-5A (Ref. [1]), with loading and response analyses performed using DNV GL's jack-up analysis program JUSTAS. An environmental load factor ($\gamma 3$) of 1.15 was applied to the environmental loads as applicable to independent environmental extremes. In accordance with the SNAME methodology, the default kinematics reduction factor was applied in the calculation of wave and current loads by means of the reduced wave height, Hdet.

A marine growth profile of 12.5mm was included in this assessment and was assumed present over the entire submerged leg in accordance with the SNAME default.

Storm headings from 0° through 345° in 15° increments (relative to the longitudinal centre-line of the jack-up) were analysed using directional metocean data.

DYNAMIC ANALYSIS

Dynamic effects were determined using the simplified random-wave time-domain dynamic analysis methodology implemented in JUSTAS. This methodology is based on the 'SIPM' MPME method given in SNAME T&RB 5-5A ([1], Commentary, Figures C7.B.2, C7.B.4, C7.B.5). Although recent best practice for Site-specific assessment of Jack-ups suggests use of the Winterstein-Jensen method for dynamic analysis (see C.2.3 of [4]), the SIPM method was maintained for use in the Yolla MLE project to maintain compatibility with results that were generated in its early stages (2011).

For the purposes of the dynamic analysis, used to determine the Dynamic Amplification Factors (DAF's), the wave loading was computed from a qualified random wave trace composed from the summation of Airy waves at random phase. The DAF's were computed from time-domain analysis for environmental headings at 15 degree intervals from 0-345 degrees.

Wave / current forces were calculated using the Morison equation and equivalent hydrodynamic coefficients for the truss legs calculated using the method of, and the hydrodynamic coefficients given in, SNAME. Total damping equal to 7% of critical damping, as specified by SNAME, was included to cover fluid, structure and foundation damping.

Based on the estimated spudcan penetrations, linearised fixity was considered using initial vertical, horizontal and rotational stiffnesses calculated from SNAME.

The Bow leg was modelled as having pinned foundation (as recommended by AG) due to cyclic degradation of the soil from a maximum storm loading predicted to arrive from the Stern. The Port and Starboard leg foundation rotational stiffnesses were calculated following the SNAME method with linearised rotational stiffnesses for the dynamic analyses taken as 80% of calculated initial (small-strain) value.

GLOBAL QUASI-STATIC NON-LINEAR ANALYSIS

The loading in the final quasi-static analyses comprised:

- Wave-Current loading determined using applicable higher order wave theory (Stokes 5th in this case) using Hdet = τ x Hmax with the kinematics reduction factor, τ, set to 0.86 in accordance with the SNAME requirements.
- Inertial load applied at hull level = (Amplitude of wave load)*(equivalent SDOF DAF - 1).
- Wind loads applied to hull and legs above and below the hull.

The above loads were all increased by the SNAME environmental load factor ($\gamma 3$) of 1.15.

Hull sagging moments of 25% of the theoretical maximum were applied, as permitted in SNAME (Commentary Section C5.3.3), and large displacement (P delta) effects were included in the analyses. After completion of the global analysis, the leg bending moments at the hull were increased to account for leg out of verticality (SNAME Section 5.4).

Whilst linearised spudcan fixity was included in the dynamic calculations on the Port and Starboard legs (Bow leg was assumed pinned to account for cyclic degradation of the soil under storm loading, in agreement with AG), the final quasi-static extreme global response analyses were carried out using the non-linear fixity (rotational stiffness reduction) procedure of SNAME (Section 6.3.4.1). Using this procedure, the level of fixity (rotational restraint) at the foundations was taken as a function of the vertical, horizontal and moment loads at each footing under the factored gravity, dynamic and environmental loadings. Since the response of the unit (and therefore the footing loads) is a function of the foundation stiffness, an iterative procedure was required to determine the correct fixity, noting that a reduced foundation moment capacity was assumed on Port spudcan as recommended by AG, to account for cyclic degradation of the soil, with the level of reduction dependent on the storm return period (Bow leg is still treated as having pinned foundation). This was achieved using JUSTAS, which began the analysis with a fixity value equal to the linearised elastic stiffness of the foundation. The program then iterated, modifying the stiffness and jack-up response until equilibrium was achieved.

UTILISATION CHECKING

The following Utilisation Checks (UCs) were determined using the factored loads obtained from the analyses and resistances determined using the appropriate SNAME T&RB 5-5A resistance factors:

- Overturning
- Preload Capacity
- Windward leg sliding Capacity (first pass)
- Leg Strength
- Rack-chock holding system strength
- Leg and holding system utilisation checks

In addition the following checks were determined using the foundation reactions calculated by JUSTAS and the vertical-horizontal capacity plots determined in the geotechnical analysis:

- Foundation Bearing Capacity
- Windward leg sliding Capacity

Both the 100% and 50% variable deck load conditions were considered, the latter typically producing the more critical UC's for windward leg foundations (sliding) and overturning.

VDL AND COG GRAPHICAL TOOLS

A parametric study was undertaken to investigate the effects of the variables (a) to (d) listed below, to determine combinations that resulted in a limiting utilisation check, generally using the analysis methodology described above. In this study it was found that the limiting utilisation check was foundation bearing capacity. The VDL and CoG combinations that resulted in footing reactions just meeting the factored foundation bearing capacity envelope determined the allowable VDL v/s CoG envelopes.

The variables captured in the analyses were:

a) VDL or combined elevated weight (i.e. sum of hull lightship and VDL),
b) LCG of the combined elevated weight,
c) TCG of the combined elevated weight,
d) Environmental loading intensity (50-year all-year extremes and 1-year all-year extremes).

CENTRE OF GRAVITY LIMIT PLOTS

Figure 3 shows the rig diagram with the centre of gravity reference used in this study. The LCG (+ve aft of bow) is the longitudinal centre of gravity with regard to bow (Frame 0) for the combined elevated weight (i.e. hull lightship plus variable load). The TCG (+ve stbd) is the transverse centre of gravity from the hull centre line for the combined elevated weight. It is worth noting that the drilling loads are considered to be part of the variable load and contribute to the overall centre of gravity position.

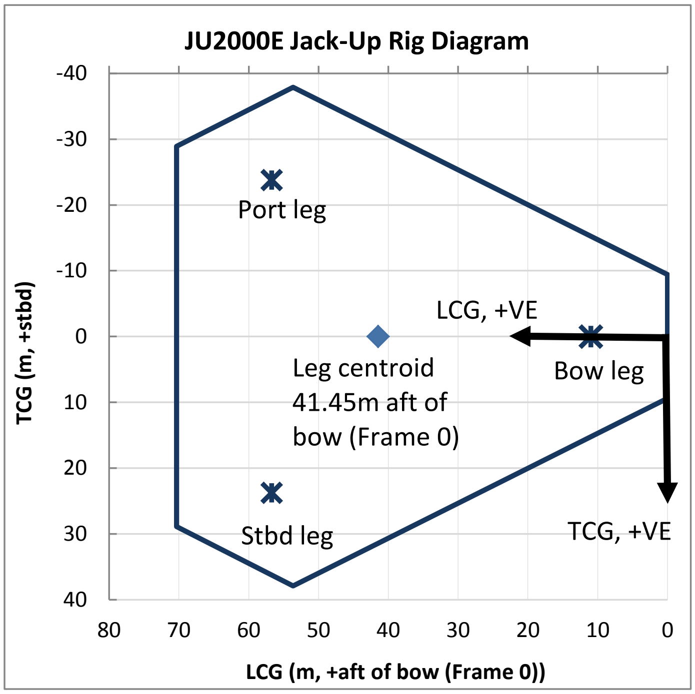

Figure 3 - West Telesto Rig Diagram with CoG Reference

LIMITING VDL ENVELOPES WITH LCG FOR TCG = 0M

Results of site-specific assessments to determine rig utilisations for a range of VDL / elevated weight LCG positions were plotted as limiting VDL envelopes (where limiting VDL is governed by a foundation bearing capacity utilisation = 1.0) as a function of elevated weight LCG.

Figure 4 shows the limiting VDL envelopes with varying LCG position for a fixed TCG of 0.0m (no tolerances) for 50-year all-year and 1-year all-year environmental extremes. Both envelopes use an AG-recommended reduced foundation fixity condition (in comparison to that calculated using the approach recommended by SNAME T&RB 5-5A, [1]), with a pinned condition on Bow leg, and varying levels of foundation moment capacity on Port leg dependent on the load levels for the return-period of storm considered. The Port leg initial (small-strain) foundation rotational stiffness was left unaltered from the value calculated following the SNAME approach, and the Starboard leg foundation fixity & capacity was completely unaltered as per the values achieved following the SNAME method for all return periods of storm. The difference in foundation moment capacity assumption between Port and Starboard legs was due to the directionality of the storm environment at Yolla, which results in higher levels of storm loading and therefore cyclic degradation on Port leg.

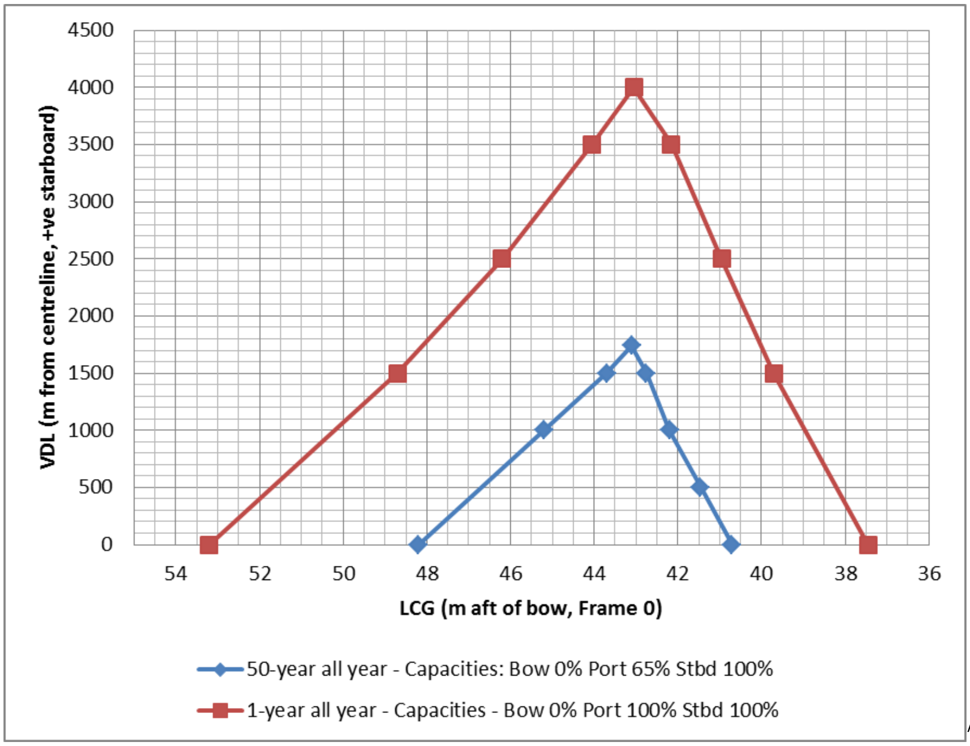

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Figure 4 - VDL envelopes for TCG = 0m

VDL envelopes determined using the foundation fixity and capacity values recommended by AG are compared with those determined using the standard foundation fixity and capacity from SNAME (ignoring cyclic degradation) in Figure 5 which shows the limiting VDL/LCG combinations for a fixed TCG of 0.0m (no tolerances) for the 50-year all-year environmental extremes only.

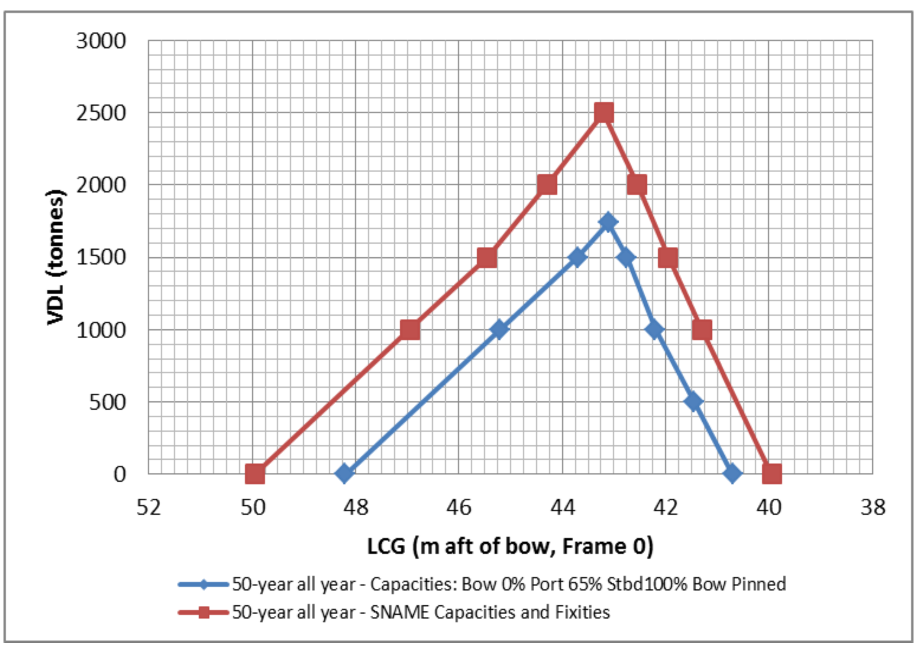

Figure 5 - Limiting VDL envelope for TCG = 0m, 50-year all year, Reduced Fixity and Capacity condition and SNAME fixities and capacities

VDL CONTOURS WITH ALLOWABLE LCG-TCG ENVELOPES

OVERVIEW

The “pyramid curves” (Figure 4 and Figure 5) showing variation of allowable VDL, for storm survival in the elevated condition, with elevated weight LCG were generated for a fixed TCG (= 0m without tolerances). If the TCG is allowed to vary, the “pyramid curves” become contours of allowable VDL for a range of LCG and TCG positions. These contour plots can be used by the rig to determine allowable VDL, and associated elevated weight CoG position, for the unit to satisfy SNAME criteria for a range of assumed storm conditions. **C**ontours of the allowable VDL with changing combinations of LCG and TCG are presented in Figure 6 to Figure 8.

It can be seen that the distance from the allowable LCG to the leg centroid (for a fixed VDL value) is linearly proportional to the distance from the allowable TCG to the centreline. Along each of the contour envelopes, a limiting foundation bearing capacity utilisation check of 1.0 has been targeted i.e. the port leg and/or starboard leg bearing capacity is limiting for the contour lines converging on the centreline, and the bow leg limiting for the vertical contour line. Therefore three straight lines in the shape of a triangle can be obtained to define the allowable LCG-TCG envelope for a fixed VDL condition.

It is noted that some of the contour plots (for example, those in Figure 6) are offset from the TCG axis by approximately 0.3m towards starboard. This is attributed to the directional variation in the environmental forces and differences in the moment capacities between the three spudcans.

To cover the potential range of VDL values, four VDL conditions were assessed, including zero.

The limiting VDL contour plots for the unit when exposed to 50-year, all-year extremes are presented in Figure 6 and Figure 7 in the next section for AG-recommended reduced foundation fixity assumptions, and SNAME fixities & capacities respectively.

50-YEAR ALL-YEAR EXTREMES

Figure 6 and Figure 7 show the VDL contour lines with allowable LCG-TCG envelope for the 50-year all year extremes. Figure 6 shows contours for (AG-recommended) zero Bow leg foundation fixity and 65% and 100% of total foundation moment capacity for the Port and Starboard leg, respectively and Figure 7 shows contours for SNAME-calculated foundation fixities & capacities ignoring the effects of cyclic degradation.

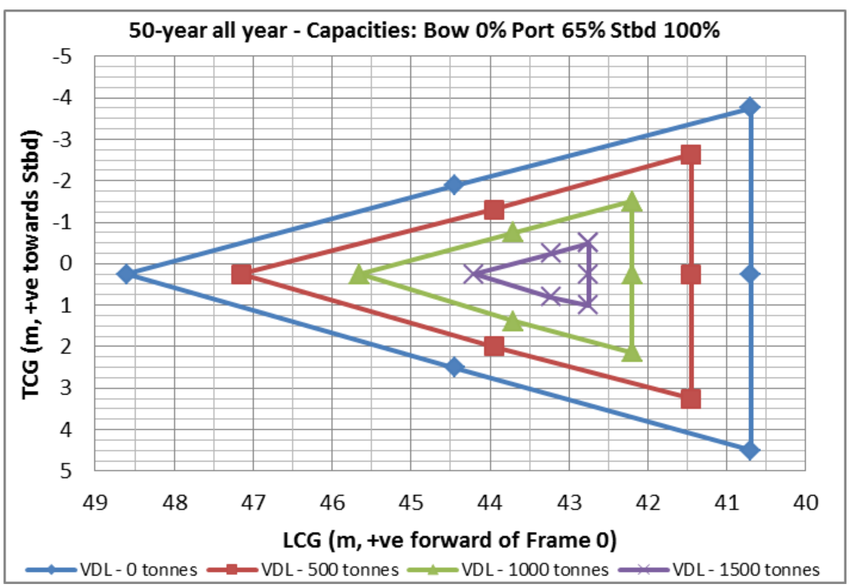

Figure 6 - VDL Contours with Allowable LCG-TCG Envelopes for: 50-year all-year Environmental Extremes with AG-recommended reduced foundation capacities

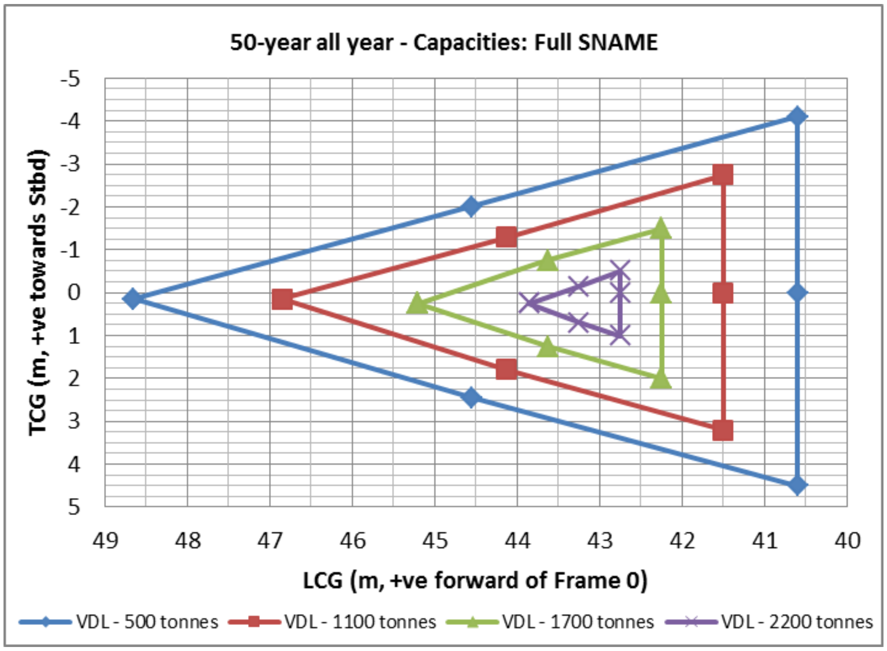

Figure 7 - VDL Contours with Allowable LCG-TCG Envelopes for: 50-year all year Environmental Extremes with SNAME foundation fixities & capacities

1-YEAR ALL-YEAR EXTREMES

Figure 8 shows the VDL contour lines with allowable LCG-TCG envelope for the 1-year all year extremes, zero Bow leg fixity and 100% and 100% of total foundation moment capacity (calculated using the SNAME method) for Port and Starboard leg, respectively.

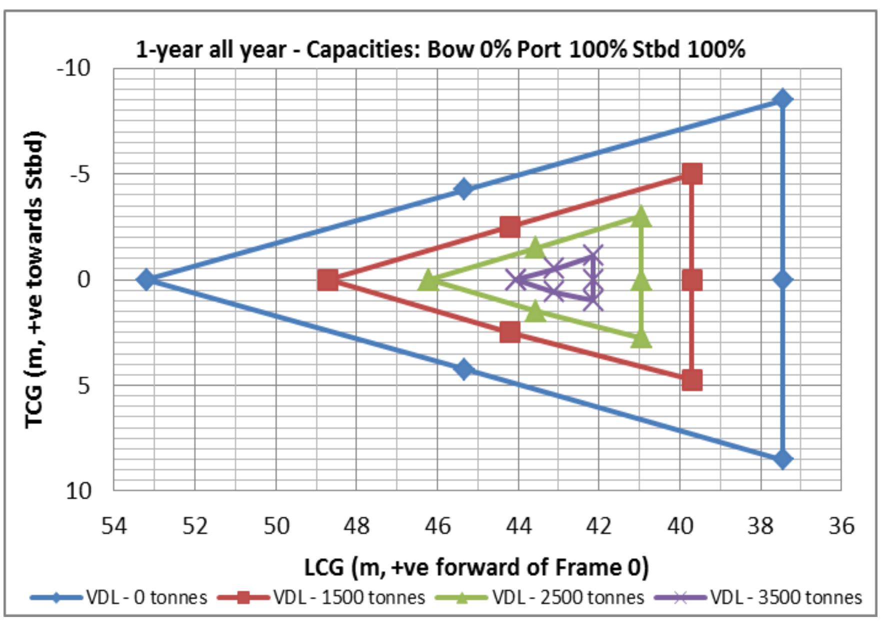

Figure 8 - VDL Contours with Allowable LCG-TCG Envelopes for: 1-year all year Environmental Extremes

OPERATIONS PLANNING

To allow the determination of realistic combinations of jack-up rig VDL, LCG and TCG to be evaluated for survival and operability cases, Seadrill provided the CyberMaster Rig Stability software. This software package is specific to a particular rig and incorporates weight and CoG data from the jack-up's ABS-certified Incline and Buoyancy Tests.

Originally the CyberMaster program was only available as a preliminary version for a China-built JU2000E. The CyberMaster program was used to develop Drilling Loads and relevant CoG data for all the well construction phases to meet the 1-year return storm case, along with the loads to be reduced to achieve the 50-Year return storm survival requirement.

This work indicated that a China-built JU2000E could qualify for the 50-year return SNAME extreme criteria on a seasonal basis from October to March.

Subsequently, the West Telesto CyberMaster rig stability program was received incorporating the revised and lower certified lightship weight. The previous work files for all the well construction phases were uploaded into the updated rig stability program, and then all cases were worked with Seadrill to ensure the loads, location on rig and other assumptions were correct.

Using the CyberMaster software each drilling sequence could be planned against the potential need to recover to an acceptable loading condition to survive any predicted storm. One such sequence is presented in Table 2 below. Using these steps it was possible to plot the anticipated weights and LCG/TCG values on the VDL Contours provided for the relevant environmental loading (either1-year, 10-year or the 50-year storm). Once plotted it was then possible to determine VDL components, and their location that needed to be moved or back loaded to be able to meet the relevant survival condition. This also incorporated cantilevering the drilling floor.

Table 2: Example Drilling sequence using CyberMaster software

	Drilling TD	9-5/8" Start	9-5/8" TD	50-Y All Year Storm
Cement	132 T	132 T	90 T	0T
Barite	125 T	125 T	125 T	0 T
9-5/8"	0	183 T	142 T	Back loaded
Drill Pipe	161 T HL No set back	115 T SB	141 T HL 115 T SB	No SB
OP - Max Allowed	75k lbs	Cantilever skidded back to 6m		
Mud Volume	1,600 bbls	1086 bbls	885 bbls	0 bbls
Mix water	0		629 bbls	0 bbls
Preload Tanks	458 T	458 T	458 T	0 T
VDL	2,522 T	2,486 T	2,514 T	1,100 T
LCG	42.32 m	42.43 m	42.87 m	43.13m
TCG	0.35 m	0.34 m	0.36 m	0.18m

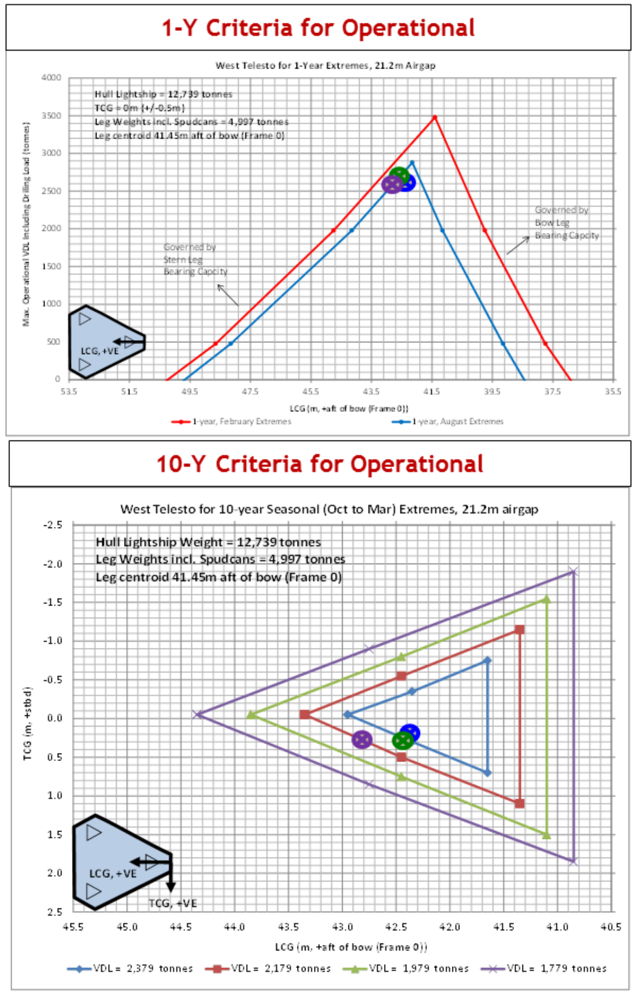

Figure 9 – Example Drilling sequence overlaid on the VDL Contours

Further to determining the weight movements needed to reach storm survival condition, a time requirement necessary to achieve this was also developed. This time requirement, together with the list of weight movements needed to achieve storm survival condition can be derived using the decision tree shown in Figure 10.

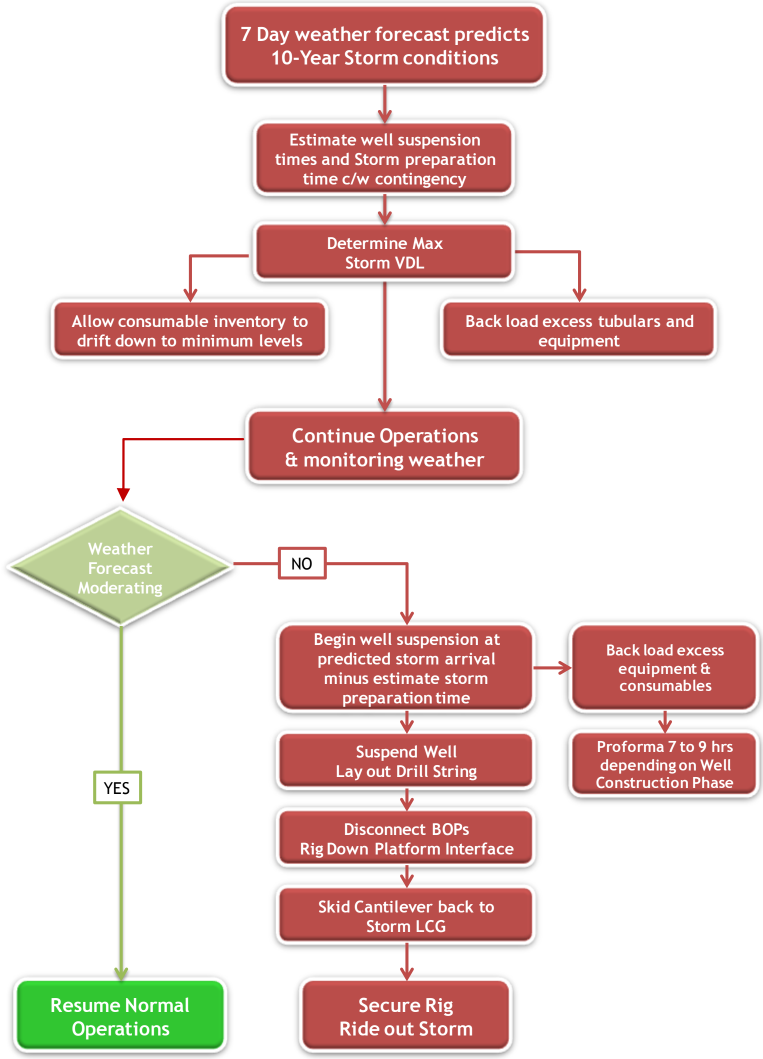

Figure 10 - Severe Storm Well Suspension Decision Tree Flow Path

CONCLUSIONS

The multi-disciplinary work performed to support the Yolla drilling project addressed and mitigated the identified risks resulting from soil strength. Had these mitigations not been evaluated it would have resulted in an onerous VDL limitation on the drilling operations. The operational VDL limitations were further compounded by weight growth of the available drilling rig.

By creating a novel means of representing the JU2000E rig weight limitations in storm sea-states it was possible to support effective variable deck load management during well planning phases. This was then assessed to determine which drilling sequences could pose operational limitations on weight management in the event of forecasted bad weather, and the weight reduction and positioning steps that would be needed to place the rig in an acceptable condition to ride out a storm. The VDL “pyramid curves” and contour plot tools developed were also a key enabler to not only the operational phases, but also to demonstrating risk mitigation strategies to wider project stakeholders.

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REFERENCES

[1] SNAME Technical and Research Bulletin 5-5A (August 2008), ‘Recommended Practice for Site Specific Assessment of Mobile Jack-Up Units’, First Edition, Rev 3.

[2] ‘Re-visiting Yolla – New Insights on Spudcan Penetration’, Erbrich C., Amodio A., Krisdani H., Lam S. and Xu X., Fugro AG Pty Ltd. Tho KK., Fugro Singapore Pte Ltd.

[3] ‘Re-visiting Yolla – Managing Storm Stability; Geotechnical Assessment’, Amodio A., Erbrich C.T, Murgavel V., Fugro AG Pty Ltd., Moyle I., Origin Energy Pty Ltd.

[4] ISO 19905-01:2012(E) (August 2012), ‘Petroleum and natural gas industries – Storm-survival assessment of mobile offshore units, Part 1: Jack-ups’.