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Jack Up Rig Selection for Multi-environment Offshore Drilling in East Kalimantan and Attaka

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Abstract. East Kalimantan and Attaka is a mature oil and gas blocks located in offshore East Kalimantan, Indonesia covering vast geographical area with vary water depth ranging from 14 feet as the shallowest and more than 1,000 feet as the deepest. The original concept of field development utilizes Tender Assisted Rig (TAD Rig) for development drilling with fixed platforms specifically designed specifically for TAD Rig operation. An initiative to utilize a Jack Up Rig (JU Rig) was taken as a smaller satellite platform was built to develop marginal reserve in deeper water depth.

Pertamina Hulu Kalimantan Timur (PHKT) as current operator commenced a continuous drilling campaign started at 2020 as a future development program of the asset. With current challenging industry environment, operating two type of mobile offshore drilling unit (MODU) as previous modus operandi was not a wise option. A process was implemented to select an appropriate MODU type. The evaluation was lead to the selection of a suitable JU Rig for all platform environment in East Kalimantan and Attaka with capability for operation in wide range of water depth as the main criteria. The selection method was based on geo-hazard identification and assessment with the priority to ensure safe operation and avoid catastrophic accident, which can lead to loss off asset, personnel safety, and environmental damage.

This paper describe the procedure in selecting a proper JU Rig that meet the requirement of multi-environment platform in East Kalimantan and Attaka. This initiative has been successful to provide optimization in drilling operation and cost efficiency for the company. Despite all the challenges encountered during execution, the operation was successful in safe manner without any incident.

Keyword(s): Mobile Offshore Drilling Unit**,** Jack Up Rig, Tender Assisted Rig, Rig Selection, Geo-hazard

1 Introduction

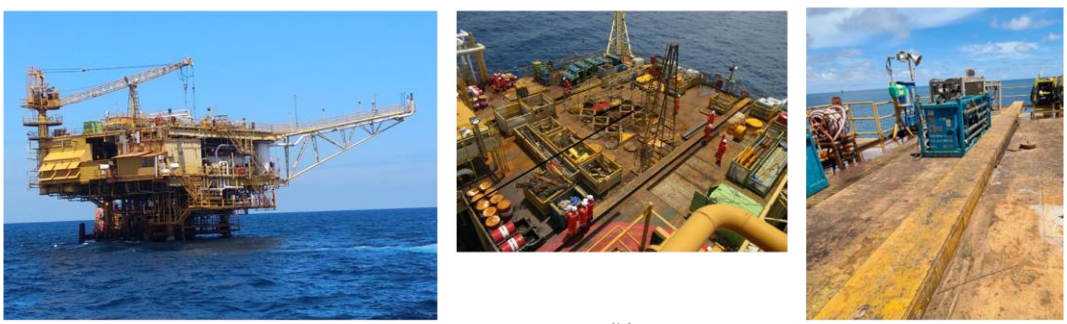
1.1 East Kalimantan and Attaka

East Kalimantan and Attaka Blocks are an oil and gas working area located in offshore East Kalimantan, Indonesia. Discovered in 1969, the asset is currently operated by PT Pertamina Hulu Kalimantan Timur (PHKT). The working area lies in vast geographical area covering more than 3,000 km square area. With variety of offshore environment from shelf area near shoreline to deep water transition, the water depth is ranging from 14 feet as the shallowest to 1,000 feet as the deepest (Figure 2a).

1.2 Drilling Unit Used at Previous Development Drilling

TAD is one type of Mobile Offshore Drilling Unit (MODU), which has been widely used in South East Asian region since 70s (Figure 2b). TAD rig have several benefits compare to JU rig in shallow or shelf water opeartions, such as simple moving operation (Rohani, 2014), ability to drill in multiple wells from one area, and relatively less dailly rate (Anders, 2022). The superiority of TAD Rig over the JU rig become the basis of development drilling concept in East Kalimantan and Attaka as it can deliver cost efficient drilling solutions for the company.

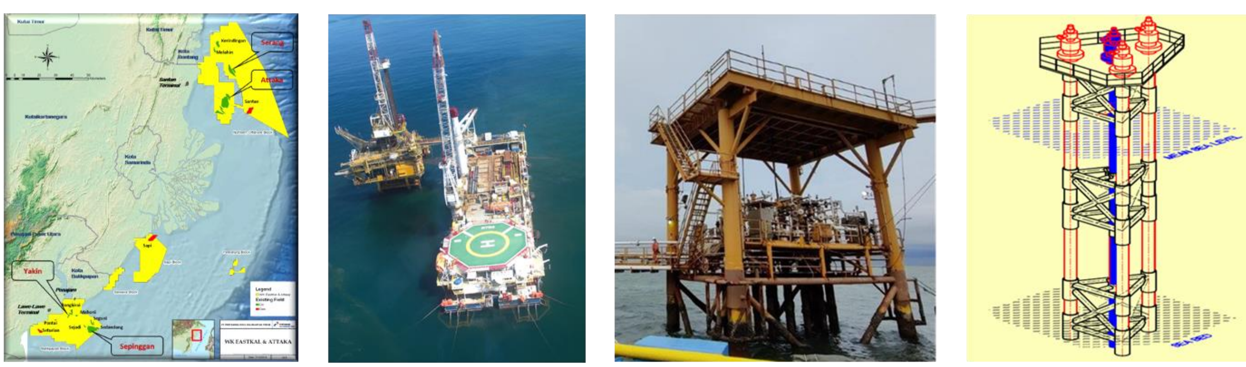
Following the concept, all jacket platforms in the field were initially designed specifically for TAD Rig operations, which generally characterized by relatively large platform with well bay deep in the platform center and rig skidding beam built on the top deck (Figure 1). In 1997, following 3D seismic acquisition in Yakin Field, a Soft Pile Structure (SPS) was developed as a less expensive structure to develop marginal resource in very shallow water depth of 18.5 feet (Kuntjoro, 1999) (Figure 2c).



(a) (b) (c)

Figure 1. (a) Santan Jacket Platform as typical platform initially designed for TAD Rig, (b) Well day deep in the platform center, (c) Rig Skidding beam on the top deck

In 1999, a satellite wellhead platform called Stacked Template Structure (STS) concept was utilized to drill additional delineation well in Sepinggan (Palar, 1999). The structure is designated for a JU rig as a cost effect option in water depth up to 140 feet (Figure 2d). Following the successful implementations in Sepinggan Field, more STS satellite platform was built for JU rig operations in several area. As JU rig operation become more common in the area, an initiative was taken to use small JU rig with shallow draft for drilling in SPS Plaform at Yakin Field. The small JU rig commonly refers to draft less than 20 feet and cantilever reach out less than 45 feet.



(a) (b) (c) (d)

Figure 2. (a) East Kalimantan and Attaka Block, (b) TAD Rig Operation at Santan Platform, (c) Soft Pile Structure (SPS), and (d) Stacked Template Structure (STS)

1.3 MODU Utilization for Current Drilling Campaign

At PHKT era, a continuous development drilling campaign was programmed as further development of the asset. The challenge was to select one type of MODU that suit to all platform environment in the area. Operating two type of MODU at the same time in East Kalimantan and Attaka as previous company did was not a beneficial option in current challenging situation of oil and gas business.

- Projects Economics
  The benefit of operating single rig is one time mobilization and demobilization cost, which will be shared among all wells drilled. Efficient mobilization cost is significant to improve the economics of marginal project especially in mature field.
- Operation Sustainability
  Due to limited number of well candidate, operating more rigs requires more resource to support the operation but in a short period. It is easier to plan and manage operations at low level but in long and sustain period than busin but in a short terms.

2 Methods

2.1 MODU Requirements

The record of MODU utilization in East Kalimantan and Attaka before current operator is listed below:

Water Depth	Field	Platform Type	Rig Type	Remark
8 - 12 feet (Swamp)	Sapi, Bangkirai	Monopod, Mini SPS	Semisubmersible swamp barge	Outside of this paper discussion
15 – 350 feet (Offshore)	Seturian, Sepinggan, Yakin, Attaka, Melahin Kerindingan, Serang and Santan	Jacket Platform and SPS	Tender Assisted Rig	Specific Jacket Platform required for TAD Rig
	Sepinggan, Seguni, Sejadi, Sedandang, and Attaka	STS and SPS	Jack up	For SPS platform, JU rig with shallow draft is required.

Table 1. MODU Utilization in East Kalimantan and Attaka before PHKT

Evaluation on TAD Rig utilization as original concept shows no sufficient platform load capacity to support rig equipment and operational load. The de-rating load capacity of the platform is mainly due to the metal loss on the platform structure, as the platform get old. The TAD rig was also less preferable due to unsuitability for STS platform. The procurement would also be challenging compare to other type of MODU due to availability of the rig in the region. The decision was to assess a JU rig type suitable for all offshore platform environment.

2.2 JU Rig Selection

The following chart summarizes a geohazard-based selection process to select the JU Rig type. The geo-hazard identifications is critical in all JU rig operations particularly in the area with no previous JU rig operations. . Fail to identify the hazards would cause catastrophic accident which lead to loss of asset, personnel safety, and environmental damage.

Figure 3. A Geo-hazard based Rig Selection Process

2.3 Geo-hazard Identifications and Mapping

The following table briefly explain the potential geo-hazard encountered during placement of a JU rig in all area of East Kalimantan and Attaka. Set of site surveys were carried out to evaluate bathymetry, seabed feature, sub-seabed condition, and geotechnical aspects in relation geo-hazards. In virgin soil with no previous JU Rig experiences, the recommendation is to have the most recent survey before location acceptance.

Potential Hazard	Description
Punch Trough	All fields with no previous JU rig operations are considered having a punch trough risk which can cause structural failure of the leg. The risk is more critical when the rig is positioned with very close distance to the platform. Any little movement due to rapid leg penetration can cause collision to the platform.
Coral Layer	In the fields located in northen area, such as Santan, Serang, Kerindingan and Attaka, the presence of coral layer under the seabed soil is common. The hard and localized coral layer within leg penetration can cause high Rack Phase Different (RPD) between the cords. Uncertainty in final location may also arise.
Close Stand off to Platform	For a large jacket platform as in Santan and Kerindingan, the JU rig need to be placed in extremely close distance to the platform to reach all well slots determined. Approaching the platform to low distance has high risk of collision which can lead to a catastrophic incident. Any little movement due to sliding, current, or event boat malfunction is dangerous for the platform safety.
Uneven Seabed	Most of platform was initially intended for TAD Rig operation where no consideration on the seabed profile around the platform during the initial selection of platform location. Slope on the seabed combined with minimal penetration can cause the spud can moving from its previous position. This is critical especially when placing the JU rig near to the platform required such as in Santna and Kerindingan Field.
Old JU Rig Footprint	The recommendation is to install the spud can in exactly the same old footprint location or with safe distance to prevent uncontrollable penetration and sliding towards the footprint when pining the leg. However, it is unlike to pin all the legs at the center of the old foot print as he different size of spud can and distance between legs due to different rig size as the last rig operated in STS and SPS platform was a smaller JU rig.
Underwater Structure	In platform designated for TAD rig, there is often no consolidated plan between seabed profile, underwater pipeline location, and future JU approach making challenging to find proper JU rig approach direction. The condition is mainly applied in large platform complex as in Sepinggan and Attaka.
Shallow Water	Some SPS Platforms in Yakin Field have water depth less than 20 feet when the lowest tide. Hence, a JU rig with excessively deep draft will have no capability to float. This become one of the main concern in selecting suitable JU rig.
Insufficient Leg	The concern of the leg length is mainly in Serang Field where water depth is more than 350 feet and no previous JU rig experiences, hence uncertainty on leg penetration. It is important to ensure the JU rig has sufficient leg length to accommodate leg penetration, air gap, and allowable remaining leg above hull.

Table 3. Risk Identification and Mapping of All Fields in East Kalimantan and Attaka

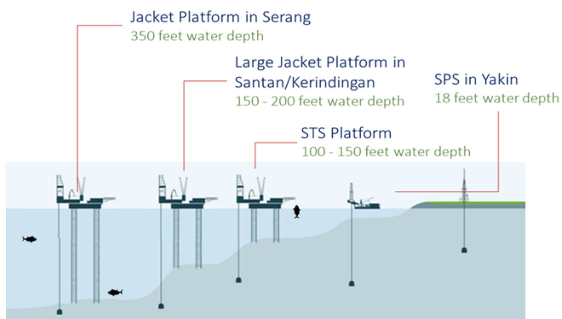
2.4 JU Rig Specific Requirement

To simplify the rig selection process, attention now can go to several fields that considered representative for all PHKT locations in terms of challenges (Figure 4a). A specific requirement on JU Rig was then formulated and highlighted as critical provision on the scope of work part in the procurement document.

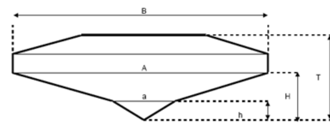
Aspect	Specifications	Descriptions
Draft	Maximum draft at load line is 17 feet	SPS platform at Yakin Field has water depth 18.4 feet at the lowest tide. The maximum draft will dictated the minimum water depth the rig can be operated.
Leg Length	Minimum leg length available below hull is 400 feet.	A jacket platform at Serang Field has water depth 350 feet. A requirement of 400 feet leg length below hull is with the assumption maximum leg penetration is 50 feet

Cantilever Envelope	Maximum cantilever outreach in longitudinal direction is 70 feet	A large jacket platform in Santan and Kerindingan need 70 feet cantilever skid out to reach the farthest well slot. Cantilever load capacity de-rating due to longer cantilever out need to be reviewed base on the drilling load.
Spud Can	Tip geometry at the bottom and pressurized jetting system (Figure 4b)	The tip is significant to give better performance of spud can foundation when reaching initial leg penetration especially in sloping seabed or near the old JU footprint. Working leg by jetting is also anticipated according to geo-hazards.

Table 4. JU Rig Specific Requirement Based on Risk Identification



(a)



(b)

Figure 4. (a) Representative Fields for Geo-Hazard Challenges, and (b) Tip Geometry on Spud Can

2.5 Rig Sourcing

A survey on some potential rig provider in the region results in the provision of specific model of JU rig to satisfy the demand of all fields. The following matrix summarizes the process with three examples.

	Location			
	SPS in Yakin	Large Jacket Platform in Santan / Kerindingan	STS Platform	Jacket Platform in Serang
Rig A Draft: 20 feet Leg Length: 517 feet Cantilever Envelope: 70 x 40 feet	Not Suitable	Suitable	Suitable	Suitable
Rig B Draft: 16.2 feet Leg Length: 400 feet Cantilever Envelope: 45 x 24 feet	Suitable	Not Suitable	Suitable	Not Suitable
Rig C Draft: 15.4 feet Leg Length: 503 feet Cantilever Envelope: 70 x 40 feet This rig was selected	Suitable	Suitable	Suitable	Suitable

(a)

(b)

Figure 5. (a) Matrix on JU Rigs Suitability, and (b) Selected JU Rig

3 Result

Beside the selection of drilling unit, there are challenges encountered on the operational said mainly in all rig move sequences (Figure 6a). Two cases are highlighted as situation with highest risk:

3.1 Moving Operation to Santan and Kerindingan Platform

Santan and Kerindingan Field share similar offshore environment such as water depth, uneven seabed and rocky sub-seabed soil. The platforms are also typical, which is relatively large platform with well bay located deep in the center. To be able to reach all well slots determined, the JU rig need to be positioned with 6 to 10 feet gap between rig hull and platform edges with maximum cantilever outreach of 70 feet.

Placing the rig with high accuracy is challenging due to the difficulty to maintain the rig position during reaching initial penetration caused by uneven seabed and rocky sub-soil.The following strategies were implemented as mitigations to minimize the probability of collision to the platform:

a. Securing The Platform

As common practices, prior to rig arrival, all wells and pressurized equipment need to be isolated and depressurized to 100 psi remaining pressure. The objectives of these measures is to minimize impact in case of collision occurred as worst-case scenario anticipated.

b. Positioning Method

Rig manuever utilized anchor whinches combined with the assistance of the 3 towing boats. The lead towing boat connected to the bow side had minimum bollard pull 150 Ton to ensure it has sufficient power to pull the rig when unplanned movement toward the platform occurred due to current (Figure 6b). The boat stayed connected to the rig until preloading completed.

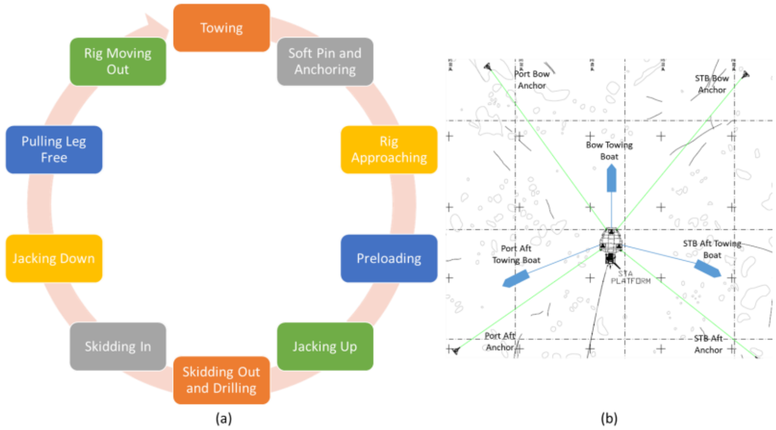


Figure 6. (a) JU Rig Moving Operation, and (b) Anchors and Towing Boat Configuration

c. Achieving Initial Penetration

In Santan Field, Port and Bow Leg located in slope has high tendency to slide in opposite direction following the seabed contour. To maintain the rig position, all anchor tension was increased to 18 ton and boat power to 50% during pinning down to obtain initial penetration (Figure 7a). While in Kerindingan case, the Port Leg was continuously sliding to the port direction following the seabed slope. The same strategy was applied to hold the rig in position by increasing the tension of starboard aft and starboard bow anchor to 18T to give opposite force to direction of sliding (Figure 7b).

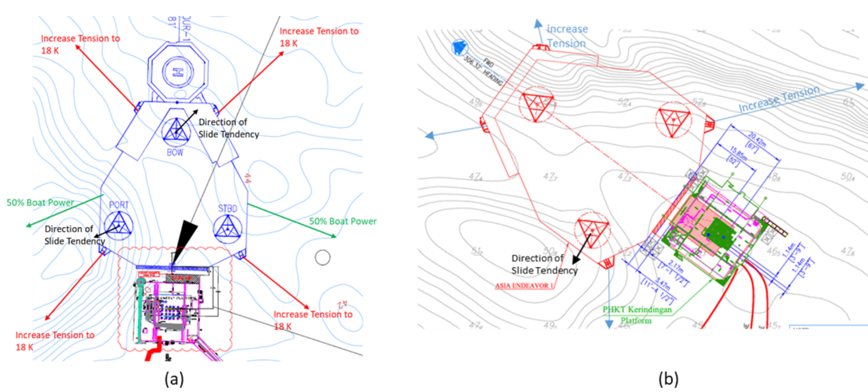


Figure 7. Adjusting Anchor Tension and Boat Power at Santan (a) and Kerindingan (b)

d. Visual Observation

Dedicated watchers were assigned each on the starboard aft and port aft to manually measure the distance to platform edges with laser measurement as complementary of GPS based navigation provided by Navigation Company. Before preloading, personnel sent to the platform to validate the measurement from outermost well slot to the rig transom. With this plan, rig approaching activity is only permitted at daylight

e. Preload Strategy

In Santan field, preload was conduct with hull inside water as there is rapid penetration risk from Leg Penetration Analysis (LPA). Filling up the water into preload tank was done gradually in 20% increment and then give time for soil to react until the next increment. Individual preloading was implemented started at Bow Leg and then one of the Aft Leg depend on soil reaction during obtaining initial penetration. The aim of the measures are the ability to bring back the rig in level easier in case of rapid penetration occurred.

At Santan case, the JU rig is managed to be placed at the intended position with 9.8 feet standoff to the platform while in Kerindingan case the stand off is even lower at 6 feet (Figure 8), although the operation was longer than a routine rig move operation (Table 5)

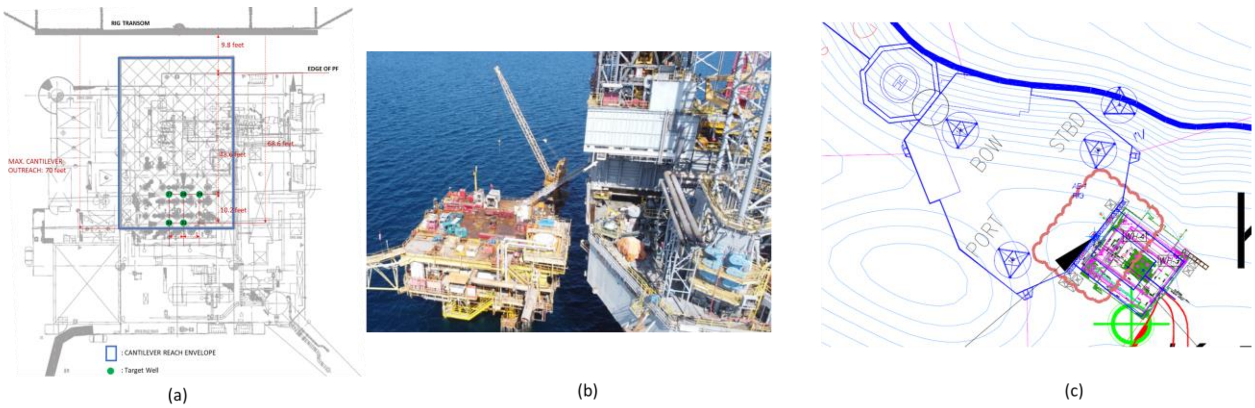


Figure 8. Actual Rig Poosition in Santan (a and b), and Kerindingan (c)

No	Operations	Actual Hours		Remarks
		Santan	Kerindingan	
1	Maneuver from 300 meter soft pin to 100 meters soft pin	6	4.5	
2	Deploy Anchors	5.5	7.25	
3	Final Positioning into STA PF	96	33	Operation delay in Santan Field due to working leg on hard coral layer
4	Preloading	60	45	
5	Recover Anchors	10	8	
6	Jack up	24	20	
	TOTAL (Hours/Days)	201.5 / 8.4	117.75 / 4.9	

Table 5. Actual Operation Time Frame

3.2 Moving Operation to Yakin SPS Platform

SPS platform in Yakin Field has very shallow water depth of 18.4 feet at the lowest tide while the JU rig at load line is 15 feet causing a challenge of JU Rig feasibility to afloat and transit. The physical collision of the keel to the seabed in case of ship stranding can lead to damage on the hull, making the integrity questionable. Ship stability during afloat also become a concern as all legs need to be totally pulled inside the hull combined with minimum draft. Limited gap between bottoms of the hull to seabed provide small space to adjust the hull during jacking operation. Increasing the draft during leg extraction provides more buoyancy due to higher hull displacement which is important to force up the spud can (Figure 9a). The following strategies were implemented to deal with challenges in Yakin Case.

a. Minimum Draft

Effort was made to reduce the draft to the most minimum level possible by reducing the cargo load by minimize the number of DP and HWDP maintain on the deck, cut down ballast water, and store no bulk or chemical on boards. Barge Engineer calculated the cargo load very carefully in related to the vessel draft. This manage to reduce the draft from 4.6 meter to 4.3 meter (Figure 9b).

b. Rig Stability

The vessel stability strongly correlates with center of gravity determined by ship dimension and the actual load distribution. Generally the lower the centre gravity, the stable the vessel. The stability is commonly become an issue in transverse direction as the direction where the ship is more prone to tilt. In Yakin Case, the situation is challenging as the draft is minimum combined with all leg structures at maximum level above the hull moving the center of gravity upward (Figure 9b). Careful assessment on the rig show that the ship satisfy all the stability requirement set up for the vessel. Stability curve show that the range of stability is from zero to 33 degree (Figure 9c).

c. Tide Cycle

When pulling leg to move out the rig from the platform, the pulling force applied on the spud can is provided by buoyancy of the rig that is depend on hull displacement or ship draft. Due to limited water column, the opportunity to have high draft is only apply during high tide. Lack of buoyancy, will give less pulling force lead to difficulty releasing the leg. With this situation, timing is a critical thing on the operation. Period during high tide on the operation day was reviewed carefully to understand the perfect time window for pulling the leg (Figure 9d).

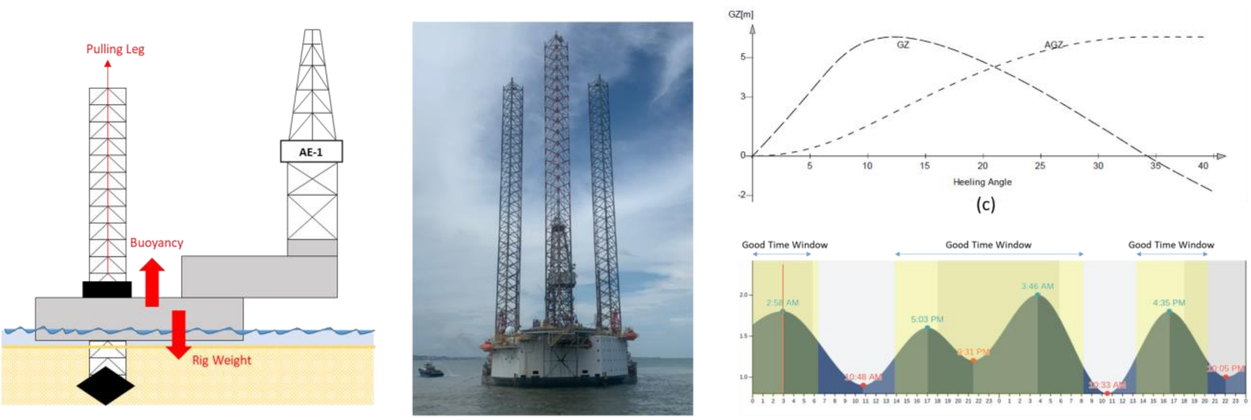


Figure 9. (a) Limited Buoyancy during Leg extraction, (b) Shallow Draft with high Center of Gravity, (c) Rig Stability Curve, and (c) Time Window on high Tide

4 Conclusion

Process of rig selection based on geo-hazards presented on this paper successfully determined the suitable JU Rig with capability to work in various water depth form 18 feet to 350 feet in East Kalimantan and

Attaka working Area. Even though the JU Rig with is available on the market, the operation is not simple. It requires careful planning with risk assessment and formulated mitigations before the job execution to ensure the operation is doable in a safe manner.

Despite all challenges encountered and delay during operations, the operation wen successful to bring the JU rig onto all desired platform safely and without any incident. This case can be a reference in the future drilling as an successful effort for MODU optimization which can be valuable as the oil and gas industry business environment become more challenging each year and drilling optimization is mandatory.

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