Mitigating Risk for a Multimillion Dollar Investment with a Single Click

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Objective

To share with Geospatial Community, of how GIS help us to improve the way we work.

CASE STUDY :
Jack-up Suitability Mapping
Presentation Outline

1. Introduction
   i. Malaysia operations
   ii. Jack-up suitability: Rig classes
   iii. Potential hazards
2. Jack-up rig operation
3. Potential consequences
4. Geohazard assessment for rig location
5. Jack-up: Suitability mapping
   i. Objectives
   ii. Implementation strategy
   iii. Methodology
   iv. Maps
   v. Desktop implementation
   vi. Web based implementation
6. Enhanced W3
7. Inter & intra-departmental integration
8. Challenges
9. Conclusion
Introduction

Malaysia operations

- Petroliam Nasional Berhad (PETRONAS) manages extensive drilling operations and utilizes various jack-up rig classes for its various drilling campaigns.
## Introduction

### Jack-up suitability: Rig classes

#### Jack-up classes

- **Baker Marine Services Pacific Class 375**
- **Keppel FELS B Class**
- **Keppel FELS Super B Class**
- **Friede and Goldman L-780 MOD II**
- **Friede and Goldman JU-2000E**
- **PPL Pacific Class 400**
- **Gusto MSC-CJ46-X100-D**
- **LeTourneau Super 116C**

#### Design operating conditions

<table>
<thead>
<tr>
<th>Rig Class/Type</th>
<th>Keppel FELS B Class</th>
<th>Keppel FELS Super B Class</th>
<th>Baker Marine Services Pacific Class 375</th>
<th>PPL Pacific Class 400</th>
<th>LeTourneau Super 116C</th>
<th>Gusto MSC-CJ46-X100-D</th>
<th>Friede &amp; Goldman L-780 MOD II</th>
<th>Friede &amp; Goldman JU-2000E</th>
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<tbody>
<tr>
<td>Design operating conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usable leg length (m)</td>
<td>140</td>
<td>131</td>
<td>131</td>
<td>140</td>
<td>128</td>
<td>125</td>
<td>112</td>
<td>140</td>
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<tr>
<td>Spudcan diameter (m)</td>
<td>14.4</td>
<td>16.0</td>
<td>16.9</td>
<td>16.9</td>
<td>14.0</td>
<td>13.7</td>
<td>12.1</td>
<td>18.0</td>
</tr>
<tr>
<td>Spudcan area (m²)</td>
<td>152.6</td>
<td>162.6</td>
<td>231.6</td>
<td>231.6</td>
<td>143.6</td>
<td>150.0</td>
<td>103.8</td>
<td>254.0</td>
</tr>
<tr>
<td>Lightweight (MT)</td>
<td>36.5</td>
<td>35.1</td>
<td>52.7</td>
<td>47.3</td>
<td>36.5</td>
<td>34.9</td>
<td>18.3</td>
<td>58.4</td>
</tr>
<tr>
<td>Max preload (MN)</td>
<td>78.3</td>
<td>80.1</td>
<td>90.0</td>
<td>91.8</td>
<td>62.3</td>
<td>70.0</td>
<td>41.7</td>
<td>130.0</td>
</tr>
<tr>
<td>Max preload pressure (kPa)</td>
<td>513</td>
<td>492</td>
<td>389</td>
<td>396</td>
<td>434</td>
<td>467</td>
<td>402</td>
<td>512</td>
</tr>
</tbody>
</table>

#### Rig

- Nago-4, Ensco 105, COSL Boss
- Deep Driller 3
- AquaMarine, Muerks Convincer, Topaz Driller
- Pacific Perisai 101
- West Vigilant
- Naga-3
- GSF 136
- TASHA

#### Shape of brace

- △

#### Shape of spudcan

- △
Introduction

Potential hazards

- Ground Motion (Earthquake)
- Complex Buried Channel
- Crustal Layer Punch-through
- Continental Slope, Shallow Water Flow, Gas Hydrates, Shallow Gas
- Obstructions on Seabed i.e. Coral, Pipeline, Footprint/Crater Interaction etc.
- Shallow Gas
- Seabed Instability
- Subsidence
- Deep Penetration
- Scour
- Jack Up Incident
Jack-up rig operation

Managing risk is a must!

- Drilling is very challenging and costly. Geohazard risks add to the challenges if they are not managed appropriately.
- Sub-standard management contributes to time delays thus increasing project costs.
- May contribute to potential jack-up incidents.

Jack-up : How it works
Potential consequences

Punch through
Potential consequences

Gas blowout
Geohazard assessment for rig location

What are the barriers?

• To ensure safety of jack-up entry:
  • Requires geohazard assessment study. This compromises:
    • Geophysical and geotechnical investigation surveys.
    • Jack-up characteristics and configurations.

• Problems:
  • Legacy data not archives or managed in a suitable fashion:
    • Lack of integration between various departments.
  • Missed opportunities to optimize valuable data,
    • Proactively manage risks and optimize costs.
  • Risk often identified after rig is on location (or in tow).
  • Caused time delay and potential cost impact from inappropriate action to mitigate risk.
Jack-up suitability mapping

Objectives

• Generate regional jack-up suitability map for Malaysian waters:
  • Better identify and document geotechnical and geohazard issues affecting operations and installation of a jack-up rig.

• Establish site characteristics:
  • Suitability mapping,
  • Improve practices in foundation design procedures.
    • To include increased loadings and new rig designs.

• Increase technical standards within offshore industry.

• To improve intra-department integration.
  • Consolidate and manage all related data into a single repository.
Jack-up suitability mapping

Implementation strategy

Project organization chart

- Consortium:
  - Fugro, Asiangeos & SK Geotechnics.
  - Supports from industry players.
  - Academic advisory role for UTP.

Roadmap

- **Year 1:**
  - 2013-2014
  - Awarded 17/06/2013.
  - JUs: LTDS

- **Year 2:**
  - 2014-2015
  - JUs & Platforms: PMO, SBO & SKO.

- **Year 3:**
  - 2015-2016
  - Finalized Deliverables
  - Roll-out of Regional Suitability Mapping.

We are here!
Methodology

General approach

Explore the Past...

Understand the Present...

Shape the Future!
Step by step

**Methodology**

- **Assessment**
  Conducted 10 in-house studies and situational assessments. Findings:
  - Significant difference actual vs. predicted leg penetration.
  - Significant time lost due to rig standby and incident.
  - 30% due to foundation issues.
  - 70% due to rig suitability and operational matters.
  - Gaps identified among stakeholders.

- **Desktop study**
  Conducted in-house desktop studies. Findings:
  - No similar study previously conducted.
  - Use of **GIS to capture, store, manipulate, analyze and retrieve data from multiple sources and formats**.

- **Data acquisition**
  Assessed and retrieved 6 data types from various sources.
  - Geophysical data
  - Geotechnical data
  - Historical installation record
  - Jack-up & platform database
  - Infrastructure e-data
  - Interpreted soil provinces and stratigraphy

- **Conceptual model**
  Developed 3D conceptual block model for both:
  - **Jack-up**
  - **Platform**

**GIS Data Model**
Develop GIS data model for both:
- New
- Enhance existing

**Perform geospatial integrity check.**
Methodology

Step by step

- **Database development**
  - Conceptual into physical translation.
  - Data conversion and data loading.

- **Geospatial Data QC**
  - Perform geospatial data QA/QC for data loaded to corporate database.

- **Application development**
  - Develop specific application to display data formats via GIS.
  - Geotechnical data

- **Spatial Analysis**
  - Perform spatial analysis using GIS.
  - Use multilayer ranking analysis.

- **Implementation**
  - Produce regional hazards map and site specific hazards map for each category.
  - Level 1 mapping
  - Level 2 mapping
  - Level 3 mapping

- **Cartographic QC**
  - Perform QA/QC on final map.
  - Ensure standards are preserved.
  - Ensure geospatial integrity is preserved.

- **Enhancement**
  - Centralize database.
  - Integration with corporate database.
  - Ensure geospatial integrity is preserved.

- **Web based implementation**
  - Translate Level 1 & Level 2 mapping to web based mapping.
Geospatial integrity QA/QC

Data acquisition

- GIS used to perform visual geospatial integrity check.

- All data types undergo meticulous geo-spatial control. This includes:
  - Geophysical investigation surveys.
  - Geotechnical investigation surveys.
  - Jack-up rig and drilling parameters.

- Optimize capability of GIS to manage multiple coordinate reference systems.

- Use of independent system to check data before transfer to consortium.
PCSB 3D conceptual block model

- Comprises:
  - A general description of possible risk for rigs.
  - Designed to assist engineers and drillers identify possible hazards.

**Examples**

1. “There is a clay crust everywhere in that area.”
2. “Extensive gas bubbling has been witnessed there.”
3. “A rig was damaged due to sliding into footprints in that area.”
4. “The soft clay layer is very deep in that area.”
5. “The RPD suddenly increased midway through preloading.”

**Examples**

1. Punch through
2. Shallow gas
3. Spud can-footprint interaction
4. Insufficient leg length
5. Buried channels

PCSB 3D Conceptual Block Model

- Understanding a site's characteristics
- PCSB 3D Conceptual Block Model
- Identification of possible hazards for rig suitability

Examples

1. Shallow gas
2. Spudcan-pile interaction
3. Ground motion (Earthquake)
4. Thick soft clay layer
5. Crust (punch-through)
6. Buried channel(s)
7. Spudcan-footprint/crater interaction
8. Spudcan-pipeline interaction
9. Scour
10. Coral
GIS data model

GIS to host data from various types & sources

- Develop new GIS data model to store geotechnical data and risk map.
- Enhance existing Seabed Survey Data Model (SSDM) to suite project requirements.
Geospatial integrity

Data integration

Single Datum and Single Projection

Data integration – mixing datums and projections

- Use of multiple CRS’ within a limited geographical area.
- Choices based upon historical reasons.

Single map projection

- Develop unique mapping solutions.
- Adopt single datum for all geo-spatial data.
- Adopt single map projection for Peninsula, Sarawak and Sabah.

Coordinates verification

- Data converted and transformed to single datum.
- Appropriate geo-referencing of data.
- Adoption of international standards, IOGP.
Application development

Composite plotter
Multilayer ranking analysis

Level 1 mapping

air gap available = available leg length – (maximum leg penetration within the concession block + spot water depth based on bathymetry raster)

<table>
<thead>
<tr>
<th>Air Gap Classification</th>
<th>Remarks</th>
<th>Symbology</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;21m</td>
<td>No restriction for jack-up rig entry</td>
<td>Green</td>
</tr>
<tr>
<td>Between 8m and 21m</td>
<td>Exploration and appraisal for green field</td>
<td>Yellow</td>
</tr>
<tr>
<td>&lt; 8m</td>
<td>No entry of jack-up. Use TADR or semi-sub.</td>
<td>Red</td>
</tr>
</tbody>
</table>
Example of application

Level 1 mapping

Category 1 Jack-up (JU) vs. Category 2 Jack-up (JU)

GO JU Entry

NO GO JU Entry

Quick Screening for Jack Up Suitability

Use TADR/Semi-sub
Multilayer ranking analysis

Level 2 mapping

Data Source

- Soil provinces and stratigraphy
- Geophysical & bathymetry data
- Infrastructure data
- JU & platform database

Individual Hazard

- Shallow gas
- Footprint / crater
- Crustal zone (punch through)
- Buried channel
- Insufficient leg-length
- Scour
- Spud can-pile interaction
- Spud can-pipeline interaction
- Coral
- Ground motion (Earthquake)

ArcGIS Geoprocessing

Composite site-specific hazard mapping

Data Source

Geophysical & bathymetry data

Infrastructure data

JU & platform database

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Multilayer ranking analysis

Level 2 mapping

Weighted Hazard Score for a Specific Hazard = Hazard Weighting of a Rig Class for Specific Hazard x Hazard Score

Hazard Weighting for specific hazards: ranging from 0 to 1
Hazard Score: ranging from 0 to 10

Individual hazard maps

1. Shallow gas
2. Buried channels
3. Sliding
4. Insufficient leg length
5. Punch through
6. Spudcan-footprint interaction
7. Spudcan-pipeline interaction
8. Spudcan-pile interaction
9. Scour
10. Coral

Composite hazard map

<table>
<thead>
<tr>
<th>Composite Hazard Level</th>
<th>Minimum Geotechnical Work Scope Level</th>
<th>Minimum Geophysical Work Scope Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>Program Type 3</td>
<td>Program Type 3</td>
</tr>
<tr>
<td>Low</td>
<td>Program Type 2</td>
<td>Program Type 1C</td>
</tr>
<tr>
<td>Moderate</td>
<td>Program Type 2</td>
<td>Program Type 1C</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very High</td>
<td>Program Type 1A/1C</td>
<td>Program Type 1B</td>
</tr>
</tbody>
</table>

Legend

- Very Low
- Low
- Moderate
- High
- Very High
Maps

Printed copy for quick reference.

44 Level 1 maps
70 Level 2 maps
Desktop implementation

Regional hazards map and site specific map
Web based implementation

Application enhancement
Inter & intra-departmental integration

Multi-disciplinary integration & interpretation

- Geotechnical Data
- Geophysical Data
- Existing Data
- Metocean Data
- Engineering Analyses
- Geological Experiences
- GIS Database
- Platform
- Jack-up
Enhanced W3 (Way We Work)

Integrated & intelligent data management

PETRONAS CORPORATE DATABASE

- Geotechnical Data
  - Digitized CPT Log
- Historical Installation Records
  - Rig type
  - Site location
  - Installation Date
  - Actual vs. Predicted penetration
  - Installation Difficulties
- Jack-Up & Platform Database
  - Spudcan geometry
  - Pile penetration & geometry
  - Conductor penetration & geometry
- Geophysical Data
  - Side Scan Sonar
  - Sub-bottom profiler
  - Multi-beam Echo Sounder
  - 2D, 3D seismic
- Interpreted Soil Provinces and Stratigraphy
  - Soil zoning maps
  - Hydrocarbon provinces
  - Sedimentary basins
- Infrastructure Data
  - Pipelines
  - Well & Manifold
  - Platforms

Enhanced W3 (Way We Work) provides integrated and intelligent data management for various resources including:

- **Geotechnical Data**:
  - Digitized CPT Log

- **Geophysical Data**:
  - Side Scan Sonar
  - Sub-bottom profiler
  - Multi-beam Echo Sounder
  - 2D, 3D seismic

- **Interpreted Soil Provinces and Stratigraphy**:
  - Soil zoning maps
  - Hydrocarbon provinces
  - Sedimentary basins

- **Historical Installation Records**:
  - Rig type
  - Site location
  - Installation Date
  - Actual vs. Predicted penetration
  - Installation Difficulties

- **Infrastructure Data**:
  - Pipelines
  - Well & Manifold
  - Platforms

These resources are crucial for mitigating risks within multimillion dollar investments via a single click.
Challenges

Increases resilience, improves skill & capability.

- **Data acquisition**
  - Data resides in various departments.
  - Vintage data; no/incomplete native files available.
  - Data in various coordinate reference systems.

- **Data management**
  - Centralized & intelligently managed in a single repository.
  - Managing more than 17 stakeholders

- **Data Integration**
  - Digitizing
  - Translation to GIS data files
  - Development of data model
  - Geospatial data quality
Conclusion

Information Workflow & Geomatics Role

Jack Up Suitability Mapping

Maps
GIS Desktop
Web GIS

Corporate Database

GIS

New Data Model SSDM

Historical installation records
Infrastructure Data
Interpreted soil provinces and stratigraphy
Jack-up & platform database
Geophysical data
Geotechnical data

Geospatial QA/QC & Cartographic
Geospatial QA/QC
Geospatial QA/QC

SSDM

Vintage Data
Final Data

Project Data
Geomatics Operation
Geohazards SSDM
Geoinformation

* SSDM – Seabed Survey Data Model

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Conclusion

Moving forward and improving

KEY MILESTONES:

• First regional study in South-East Asia for jack-up suitability mapping.
• First PCSB 3D Conceptual Block Model:
  • Capture and create a geohazards inventory of features affecting rig installation and operations.
• Introduction of new GIS data model and enhancement of existing models for the integration of multiple data types from multiple sources as per project requirements.
• All data has been rigorously verified to ensure that its integrity and resolution are preserved.
• Analysis of platform suitability mapping.
  • Currently embarking at phase 2.
  • This includes data from Petroleum Agreement (PA) & Joint Ventures (JV) operations.
Thank you