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

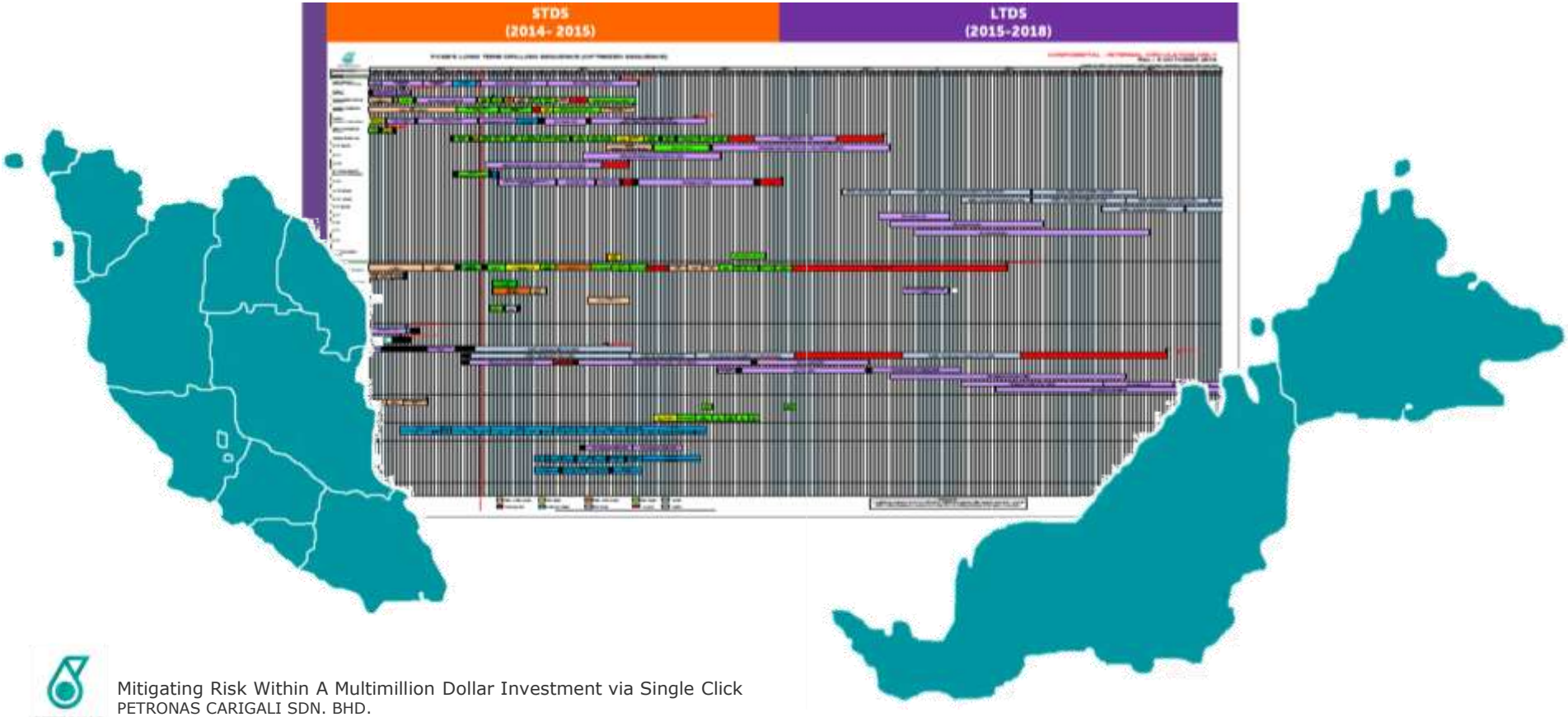
Presentation Outline

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


LeTourneau Super 116C

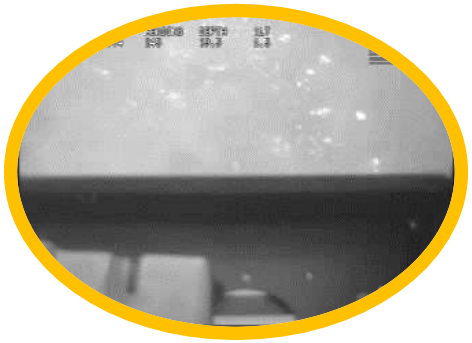

PPL Pacific Class 400


Gusto MSC-CJ46-X100-D

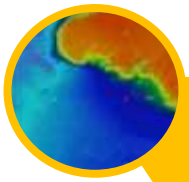
Rig Class/ Type	Keppel FELS B Class	Keppel FELS Super B Class	Baker Marine Services Pacific Class 375	PPL Pacific Class 400	LeTourneau Super 116C	Gusto MSC-CJ46-X100-D	Friede & Goldman L-780 MOD II	Friede & Goldman JU-2000E
Design operating conditions								
Usable leg length (m)	140	131	131	140	128	125	112	146
Spudcan diameter (m)	14.4	16.0	16.9	16.9	14.0	13.7	12.1	18.0
Spudcan area (m^2)	152.6	162.6	231.6	231.6	143.6	150.0	103.8	254.0
Lightship Weight (MN)	36.5	35.1	52.7	47.3	36.5	34.9	18.3	58.4
Max preload (MN)	78.3	80.1	90.0	91.8	62.3	70.0	41.7	130.0
Max preload pressure (kPa)	513	492	389	396	434	467	402	512
Rig	Naga-4, Ensco 105, COSL Boss	Deep Driller 3	AquaMarine, Maersk 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)



Continental Slope, Shallow Water Flow, Gas Hydrates, Shallow Gas

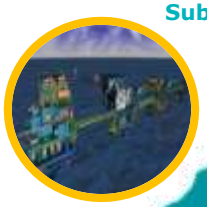
Complex Buried Channel

Obstructions on Seabed i.e. Coral, Pipeline, Footprint/Crater Interaction etc.

Crustal Layer Punch-through

Seabed Instability

Subsidence



Shallow Gas

Jack Up Incident

Scour

Deep Penetration

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.

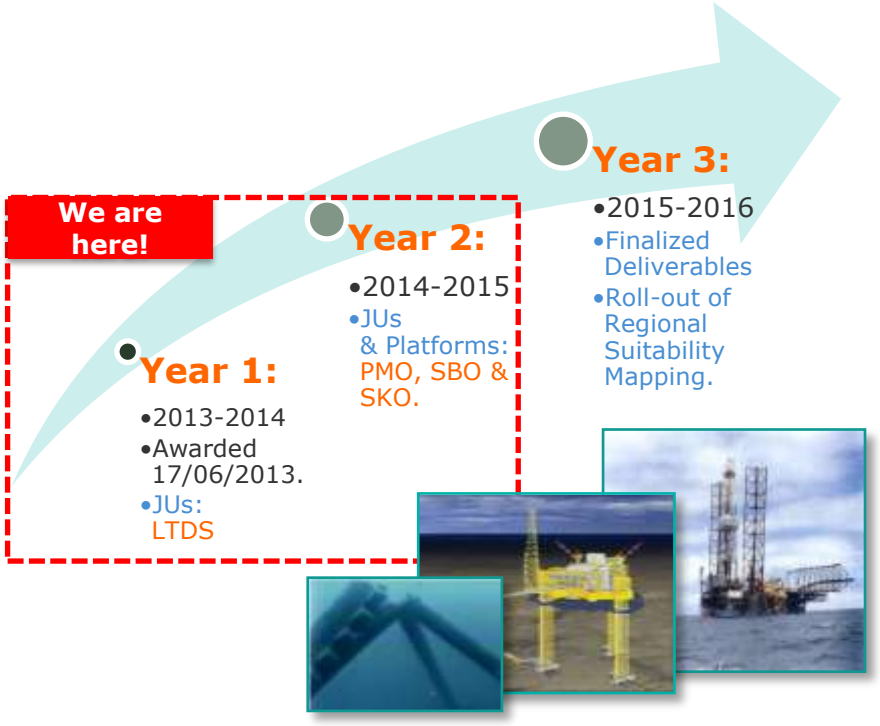
Jack-up suitability mapping

Implementation strategy

Project organization chart

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

Roadmap



Methodology

General approach

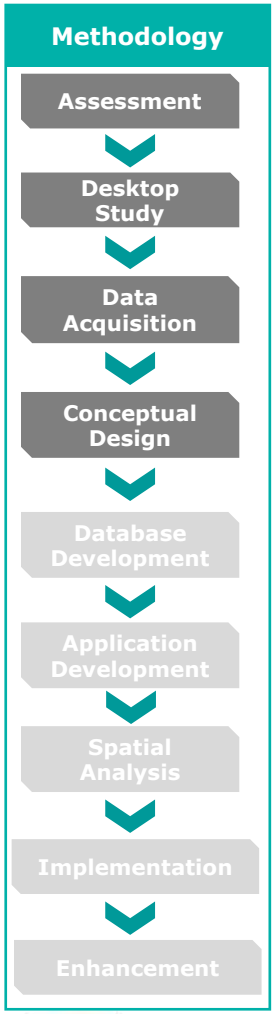
Explore the Past…

Understand the Present…

Shape the **Future!**

Methodology

Step by step



Step 1

- 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.

Step 2

- 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**.

Step 3

- 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

Perform geospatial integrity check.

Step 4

- Conceptual model

Hazards Model
Developed 3D conceptual block model for both:

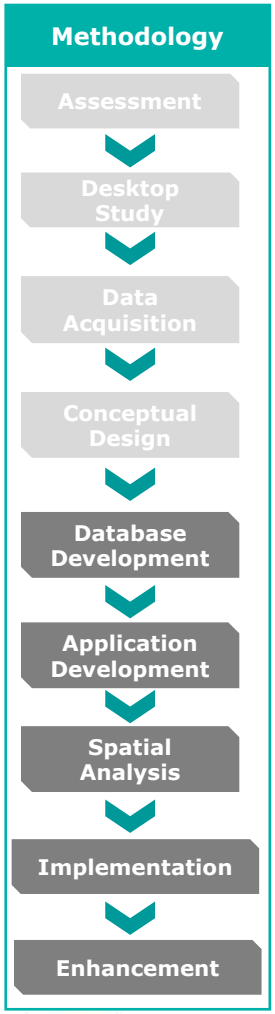
- Jack-up
- Platform

GIS Data Model
Develop GIS data model for both:

- New
- Enhance existing

Methodology

Step by step



Step 5

- 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.

Step 6

- Application development

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

Spatial Analysis

- Perform spatial analysis using GIS.
- Use multilayer ranking analysis.

Step 7

- 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.

Step 8

- 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

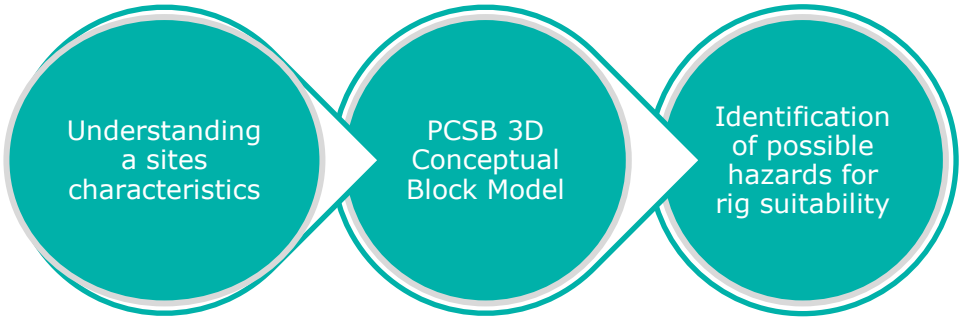
Data acquisition

- 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

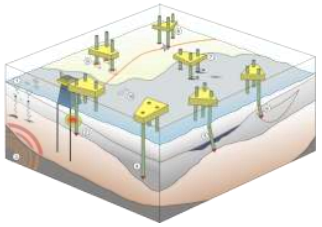
- Comprises:
  - A general description of possible risk for rigs.
  - Designed to assist engineers and drillers identify possible hazards.

Application of Conceptual Block Model



Examples

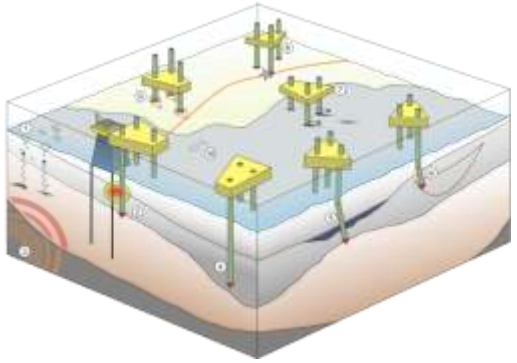
1. "There is a clay crust everywhere in that area."
2. "Extensive gas bubbling has been witnessed there."
3. "A rig was damaged due to sliding into footprints in that area."
4. "The soft clay layer is very deep in that area."
5. "The RPD suddenly increased midway through preloading."



Examples

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

PCSB 3D Conceptual Block Model

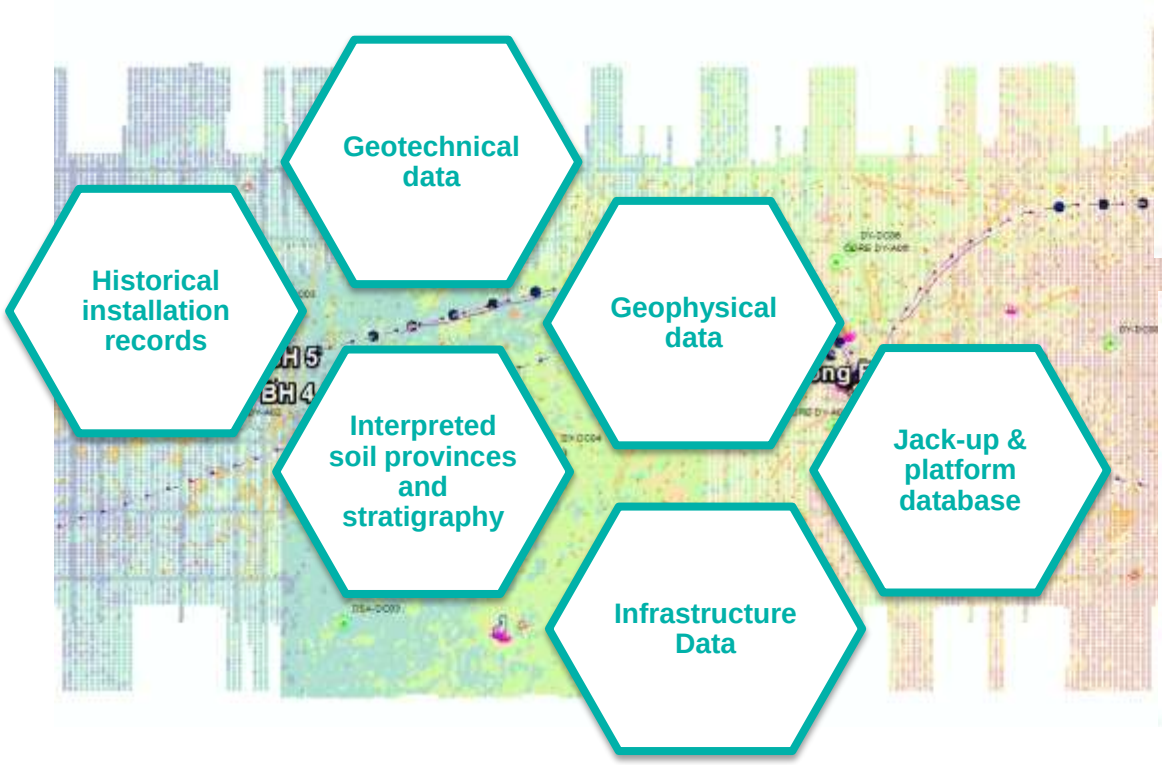


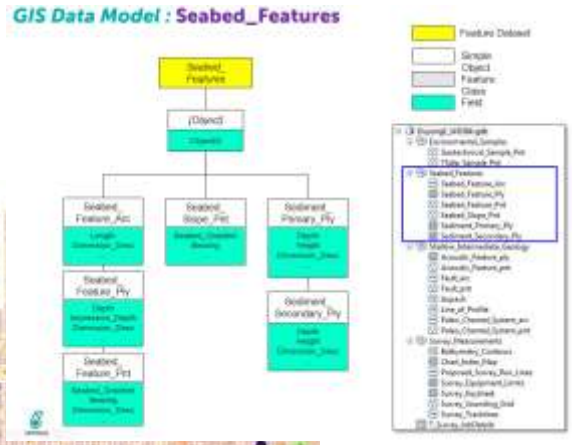
1. Shallow gas
2. Spudcan-pile interaction
3. Ground motion (Earthquake)
4. Thick soft clay layer
5. Crust (punch-through)
6. Buried channel(s)
7. Spudcan-footprint/crater interaction
8. Spudcan-pipeline interaction
9. Scour
10. Coral

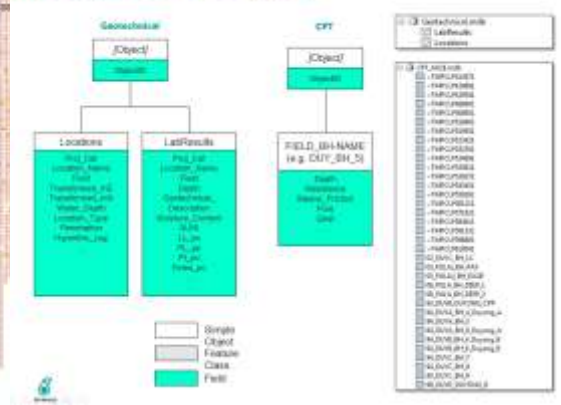
GIS data model

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.



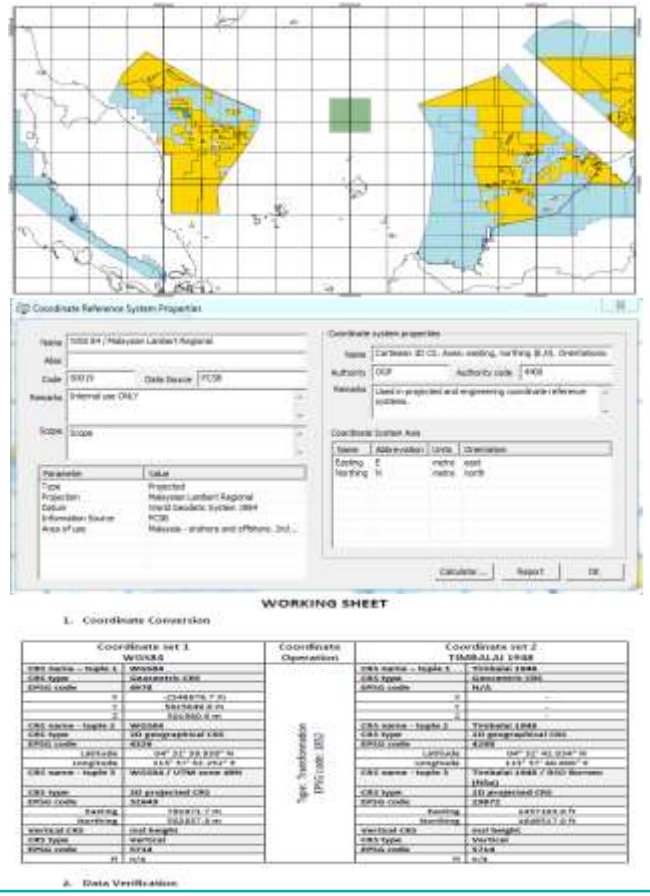




Geospatial integrity

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

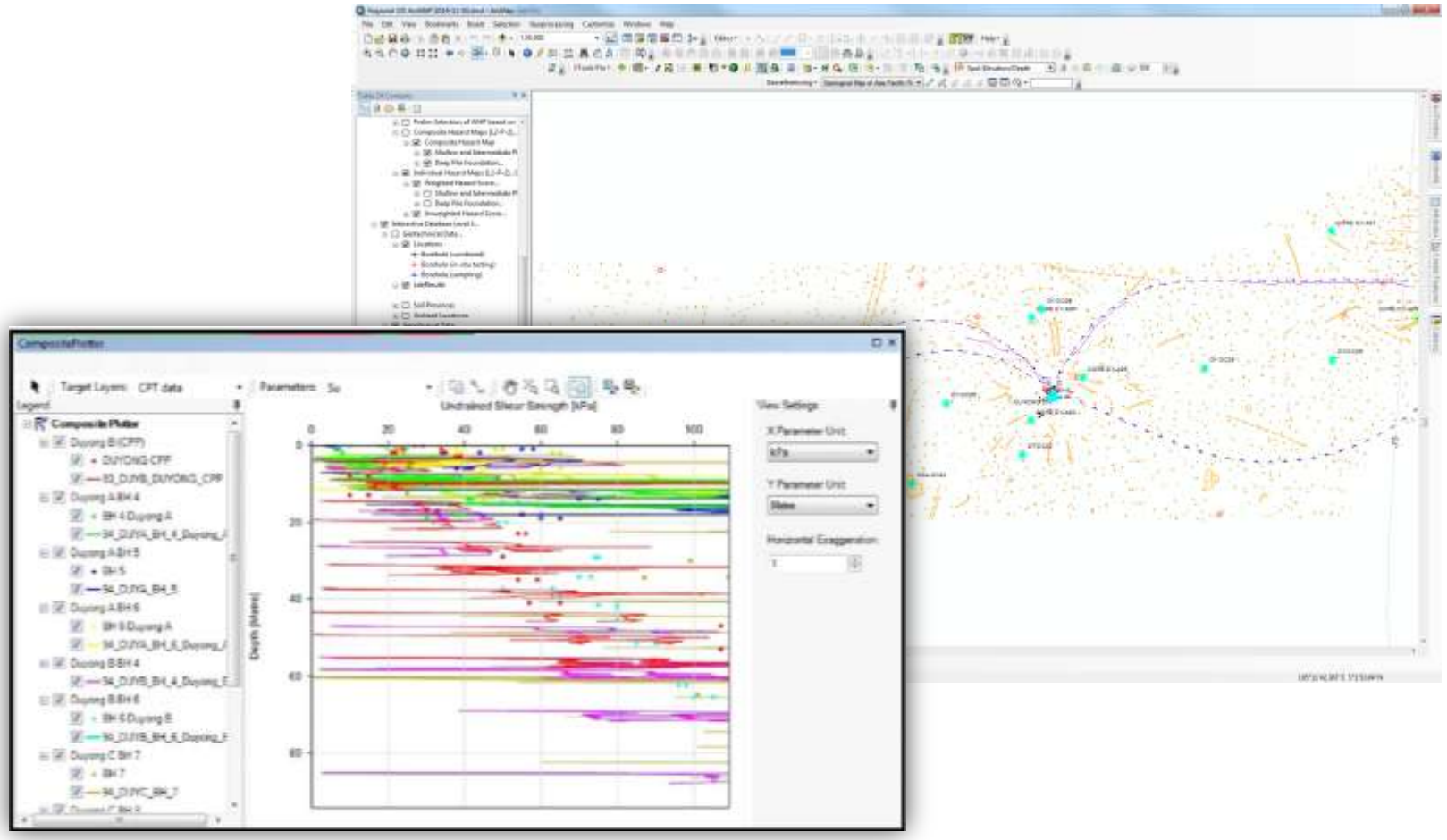
- Develop unique mapping solutions.
- Adopt single datum for all geo-spatial data.
- Adopt single map projection for Peninsula, Sarawak and Sabah.

Coordinates verification

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

Application development

Composite plotter

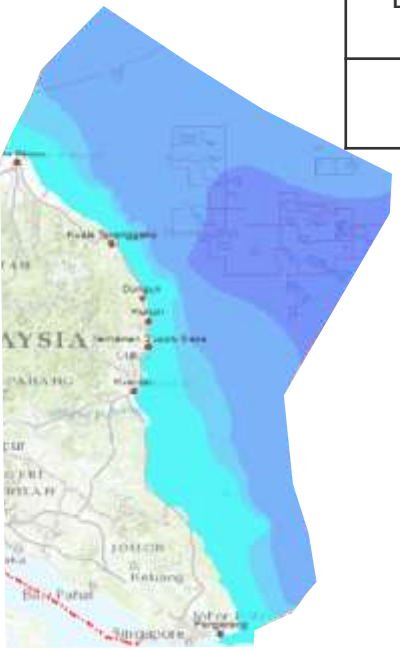


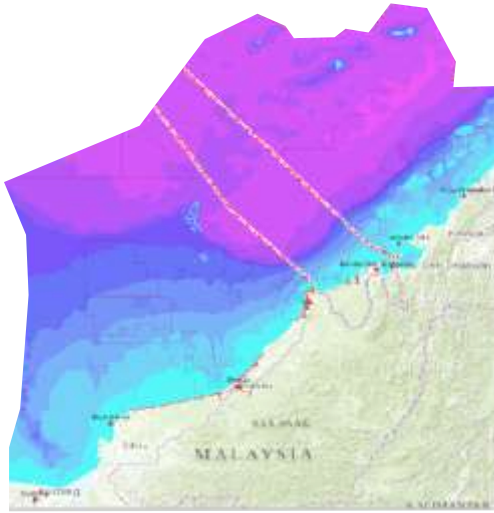
Multilayer ranking analysis

Level 1 mapping

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

Air Gap Classification	Remarks	Symbology
>21m	No restriction for jack-up rig entry	
Between 8m and 21m	Exploration and appraisal for green field	
< 8m	No entry of jack-up. Use TADR or semi-sub.	

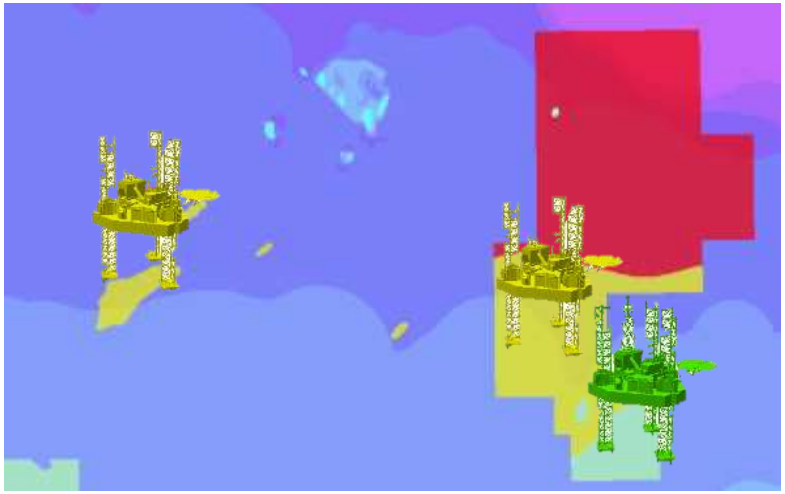




Example of application

Level 1 mapping

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



GO JU Entry

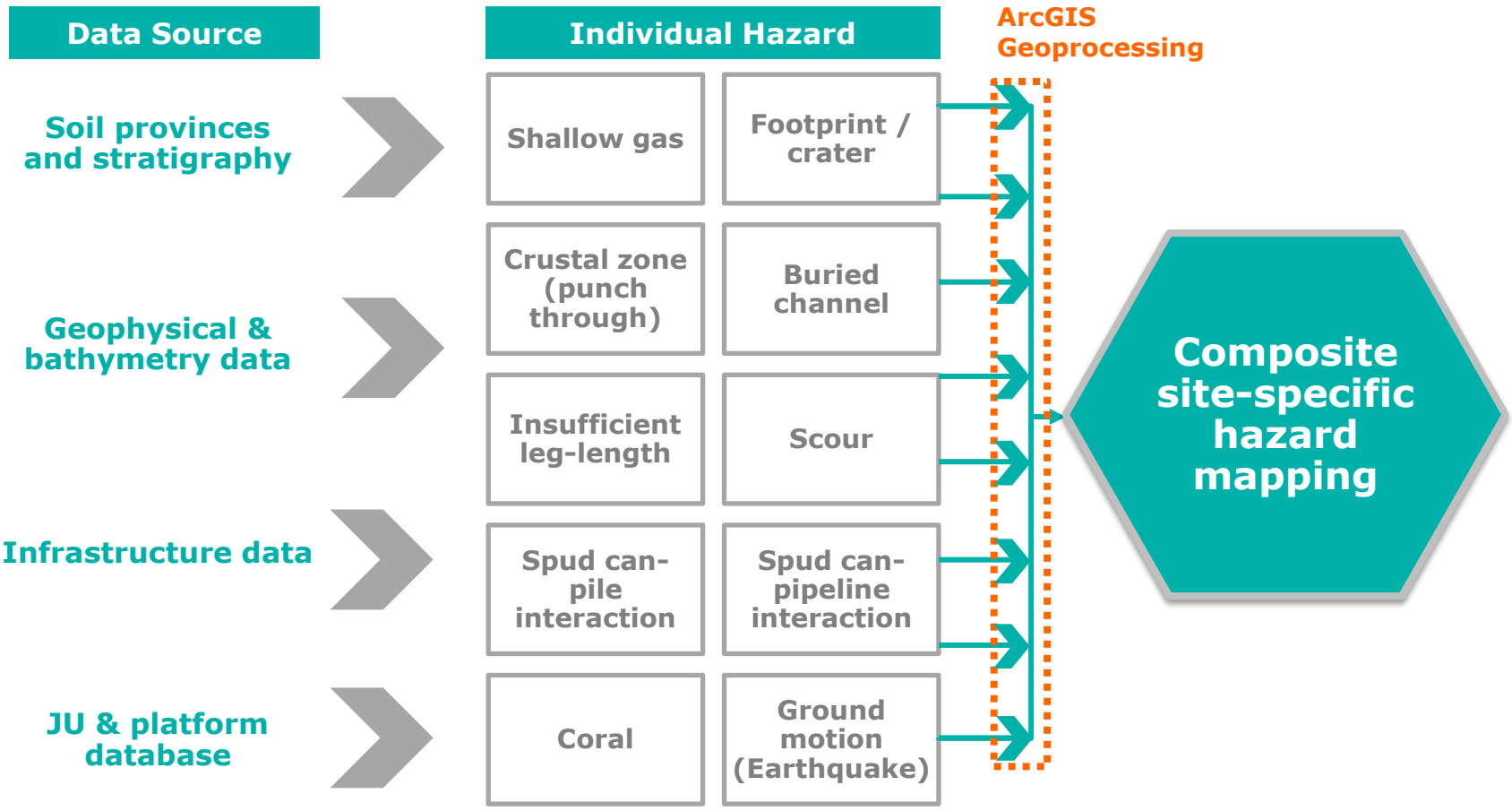
NO GO JU Entry

Use TADR/Semi-sub

Quick Screening for Jack Up Suitability

Multilayer ranking analysis

Level 2 mapping



Multilayer ranking analysis

Level 2 mapping

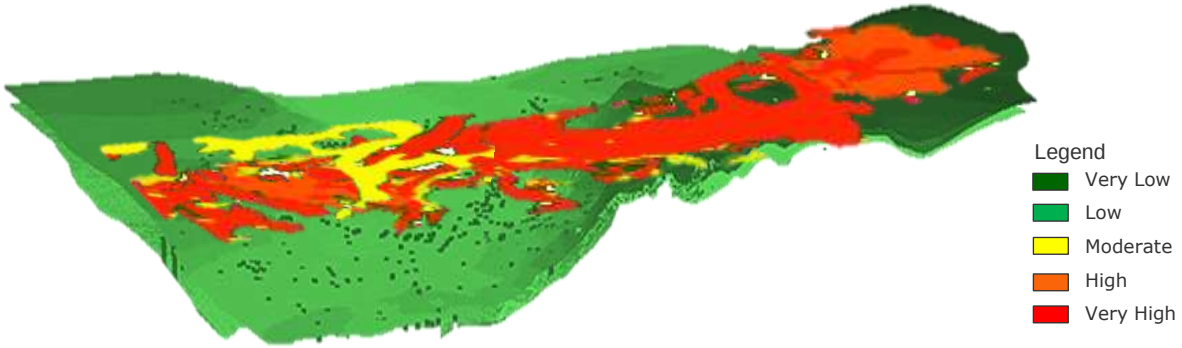
Weighted Hazard Score for a Specific Hazard (e.g. Shallow Gas) =
Hazard Weighting of a Rig Class (e.g. Keppel-Fels B Class) for Specific Hazard x Hazard Score

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

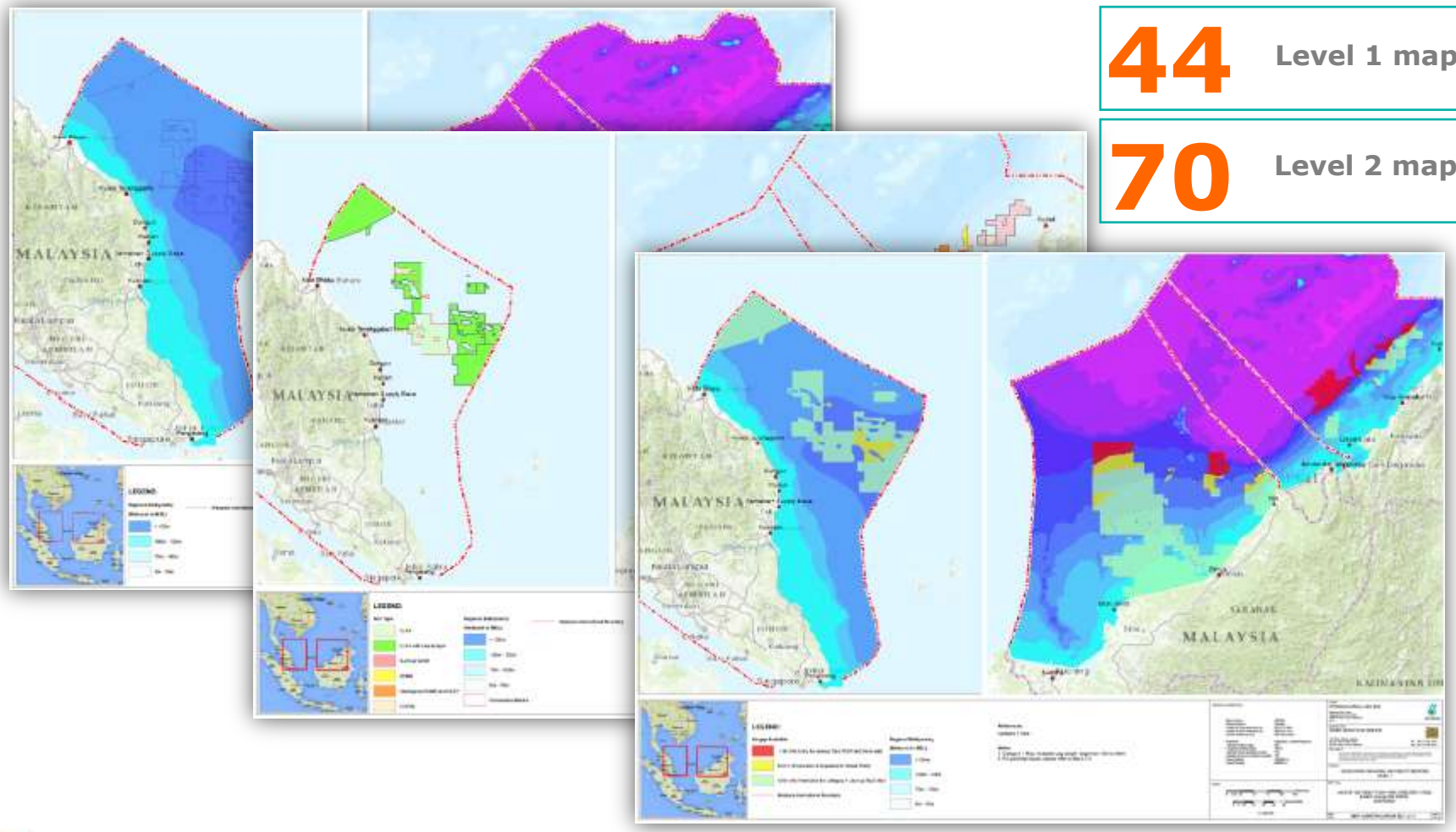
Composite hazard map



Composite Hazard Level	Minimum Geotechnical Work Scope Level	Minimum Geophysical Work Scope Level
Very Low	Program Type 3	Program Type 3
Low		Program Type 2
Moderate	Program Type 2	Program Type 1C
High		
Very High	Program Type 1A/ 1C	Program Type 1B

Maps

Printed copy for quick reference.

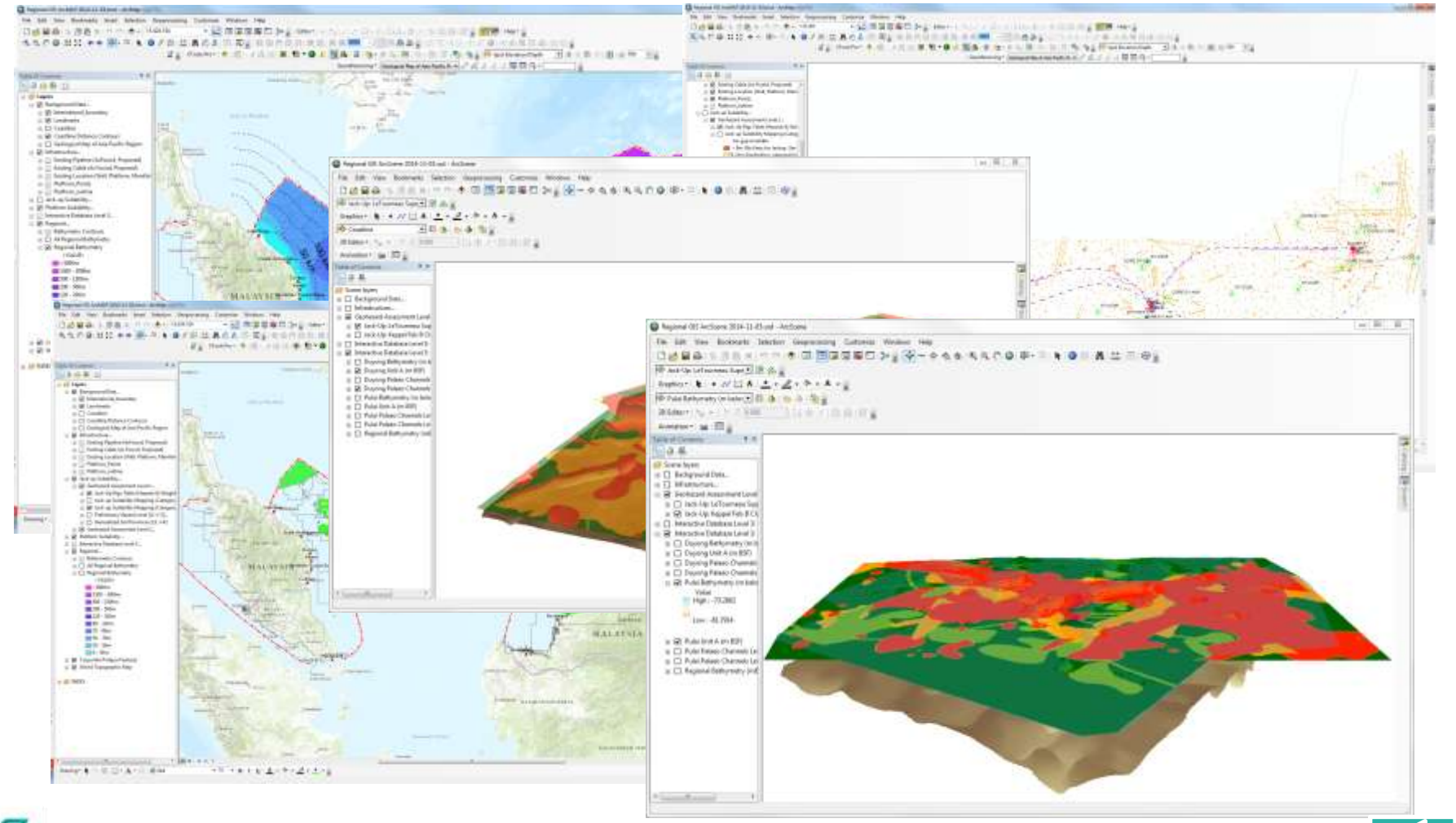


44 Level 1 maps

70 Level 2 maps

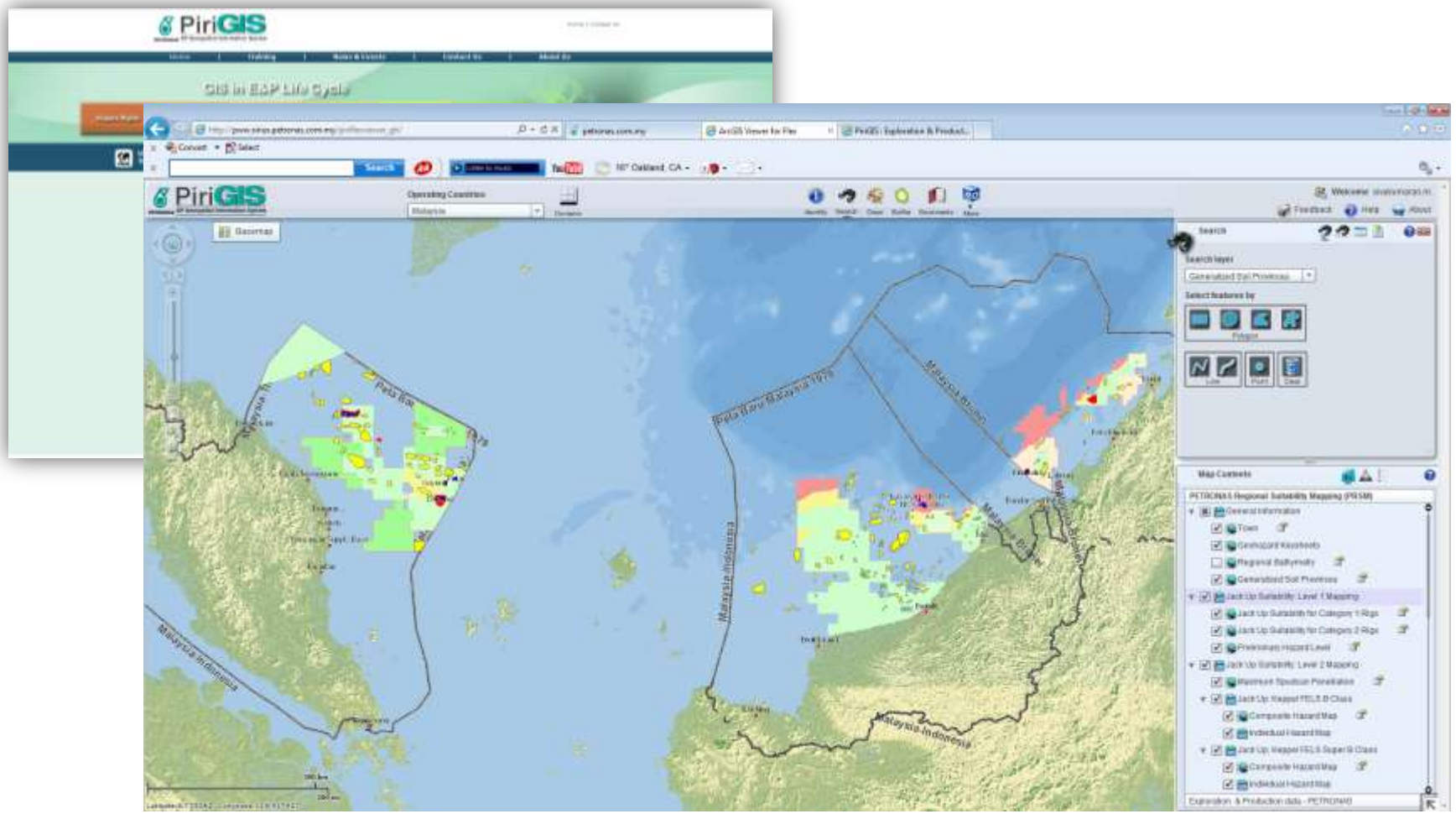
Desktop implementation

Regional hazards map and site specific map



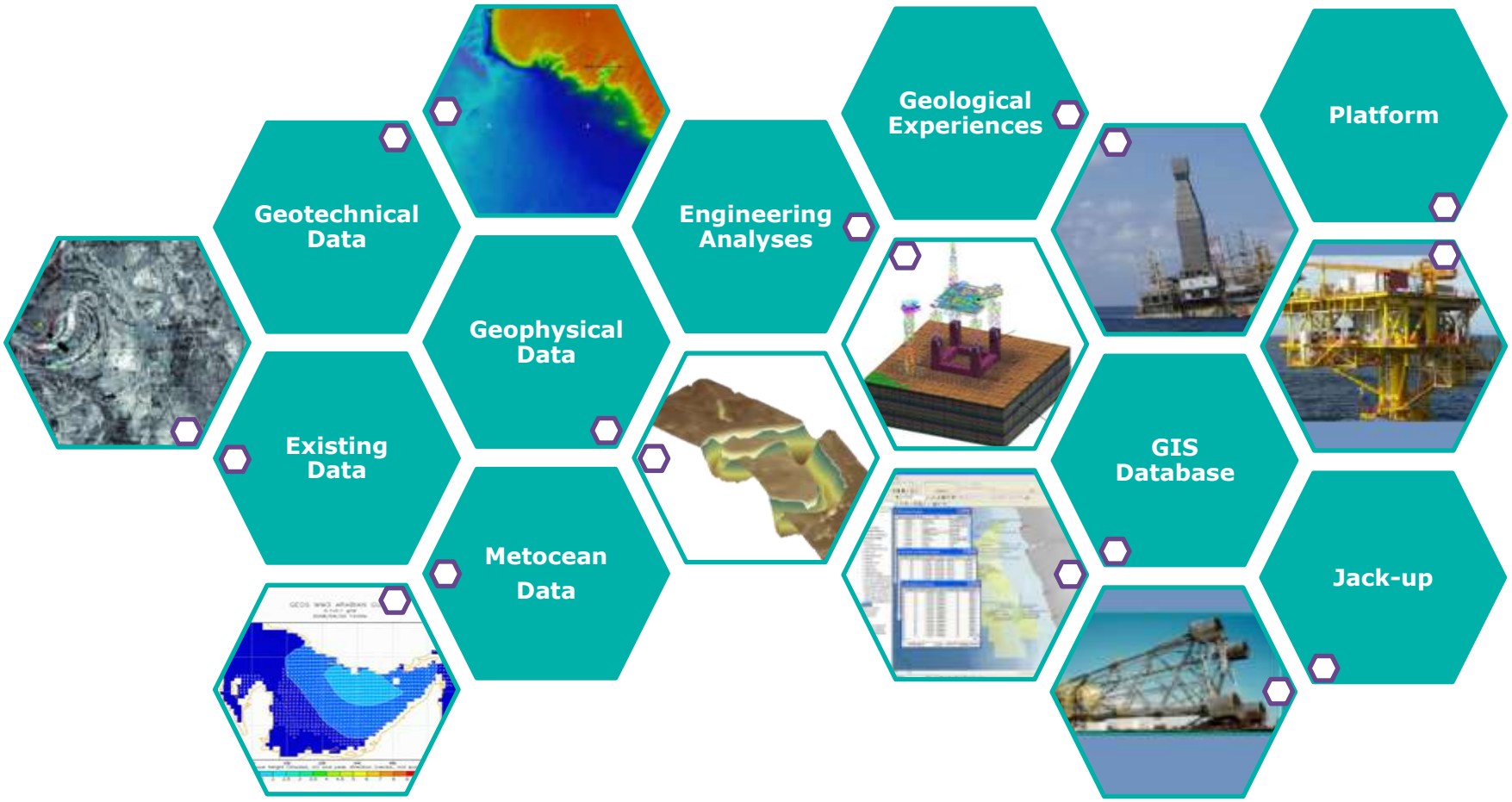
Web based implementation

Application enhancement



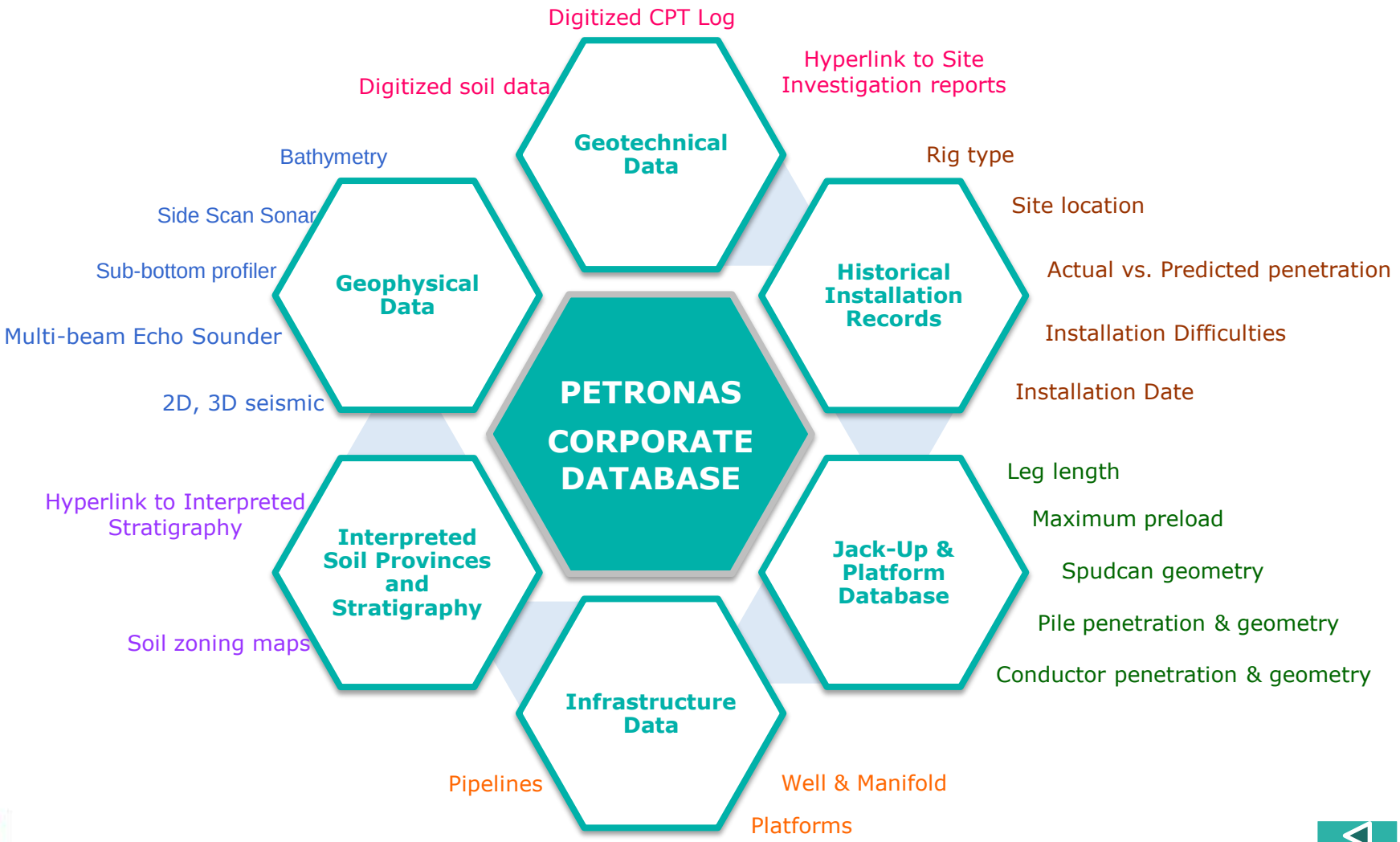
Inter & intra-departmental integration

Multi-disciplinary integration & interpretation



Enhanced W3 (Way We Work)

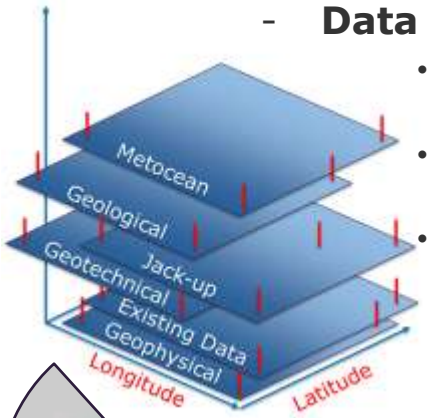
Integrated & intelligent data management



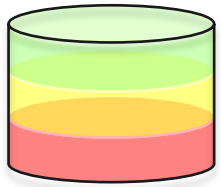
Challenges

Increases resilience, improves skill & capability.

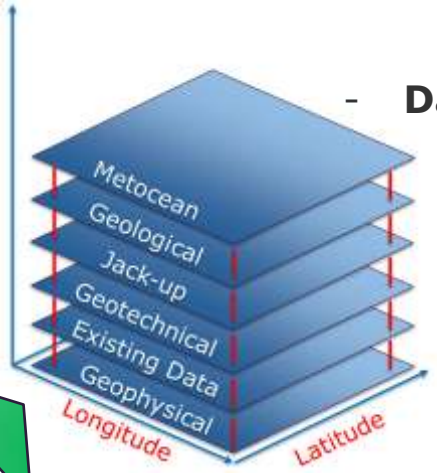
- **Data acquisition**
  - Data resides in various departments.
  - Vintage data; no/incomplete native files available.
  - Data in various coordinate reference systems.



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

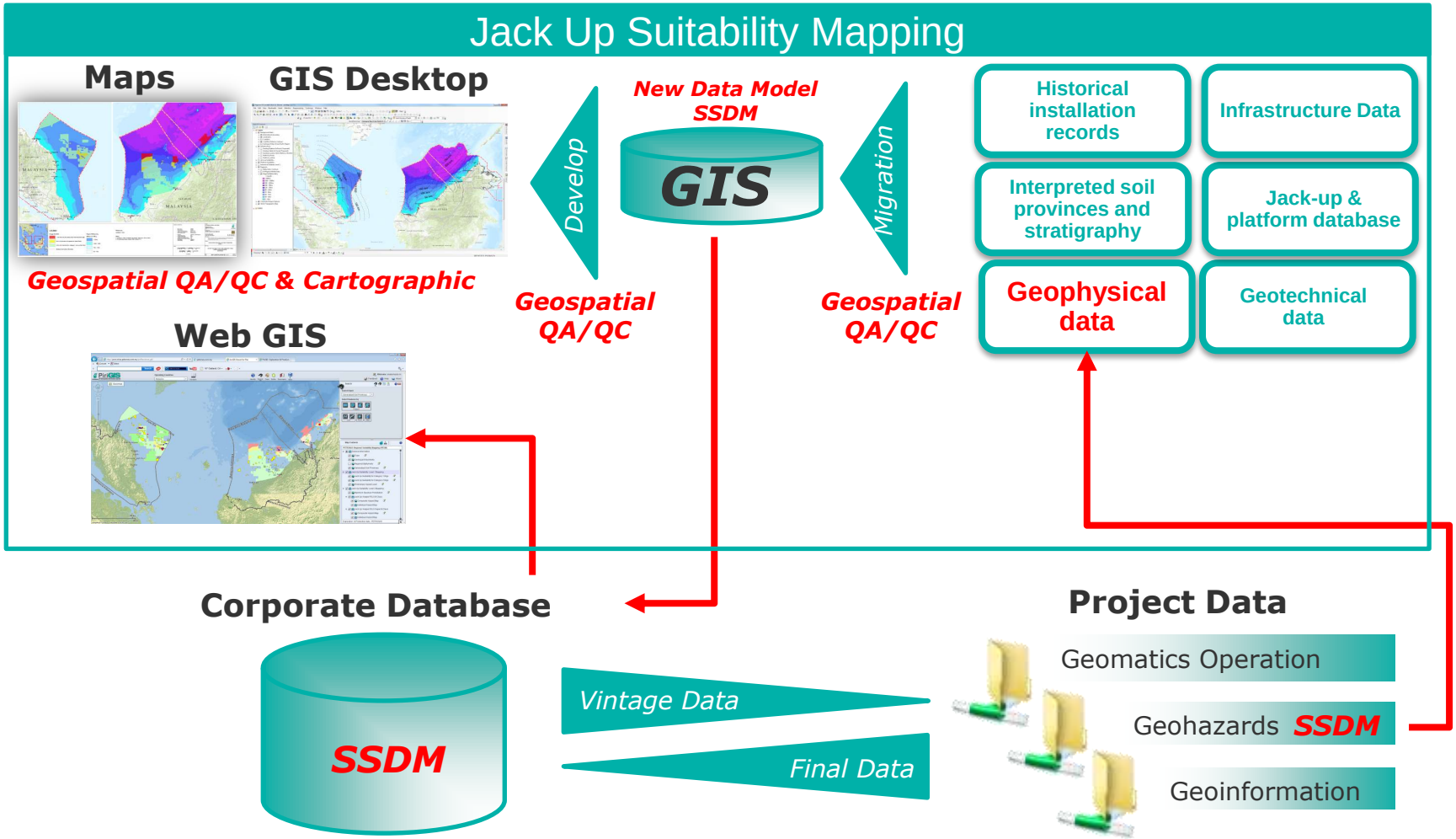


- **Data Integration**
  - Digitizing
  - Translation to GIS data files
  - Development of data model
  - Geospatial data quality



Conclusion

Information Workflow & Geomatics Role



* SSDM – Seabed Survey Data Model

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