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Vessel based solutions for the acquisition of geotechnical data in subsea site investigations

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This extended abstract describes a presentation that was given at the Society for Underwater Technology/ASEG 1st Joint Technical Seminar, 25 March 2010, Perth. It discusses the role and technical capability of multi-purpose support vessels in providing solutions in performing comprehensive geotechnical site investigations. There is a growing awareness of the benefits to be gained in being able to integrate geotechnical results with the geophysical data during the later acquisition phases of seabed investigations. This presentation highlights the growing trend to want to integrate and be able to easily access the various existing desk top study findings and the geophysical data sets right through to the geotechnical phase offshore. This is being made easier by the current and future adoption by oil and gas operators of seabed survey GIS data models. Having data accurately stored in a universally recognized format by means of GIS will make it much easier to display and use seabed visualisation systems to get the best benefits of data integration.

Introduction

Geotechnical site surveys on subsea developments test our ability to acquire geophysical and geotechnical data safely, efficiently and without damage to the environment, offshore contractor's equipment, the oil and gas operator's subsea assets, and their good reputations. Key to this is the sound management of the many planning aspects of the various operations; taking into account risk mitigation, efficiency, environmental considerations, the offshore operators' ultimate needs with relation to the seabed data. At all stages there is a need to be able to make use of every bit of information that is available. This gives rise to the requirement of being able to effectively manage data sets in an efficient and integrated manner. This is of great benefit to operators at all stages, from looking at their preliminary site assessment data to choose a suitable location, to deciding what structures are best to be considered, down to what their ultimate foundation designs and engineering requirements may be in their subsea developments.

The solution to achieving full integration of the many diverse seabed data sets lies with everyone promoting information sharing. This includes the custodians of the information and the manufacturers and users of the systems and software that log, process and store survey data. This requires us to have recognised industry standardised formats that can easily enable the flow of digital data between the more commonly used information systems and platforms.

The growth in the use of broadband internet, high speed communication systems etc. help us to share information more easily. Being able to do this both onshore and offshore gives us the ability to better understand and manage offshore programs while they are actually in progress. There have also been developments in the capabilities of PPP (precise point positioning GPS) systems; GIS (geographical information systems) and our ability to use 3D visualisation systems to display and examine spatial data sets. This gives us the platform to share a multitude of data sets to better enhance our ability to meet our objectives with a better understanding, efficiency, safety and improved risk mitigation. Visualisation is a fast means of transferring and understanding information to give us better use of our survey data bases for the benefit of all.

Geophysical data sets

To name the many different survey data sets we start by looking at the early phase of seabed site surveys, phase 1, which entails acquiring information that might include bathymetry (e.g. LIDAR, swathe or multibeam sonar); surface characterisation (side scan sonar or acoustic backscatter and snippets); seismic (reflection and/or refraction); magnetics; resistivity; and visual data from cameras.

Survey data in shallow and deep water is acquired from survey vessels either using surface/hull mounted or towed sensors (see

Fig. 1. *DOF Subsea's bathymetric survey vessel, Geograph.*

Fig. 2. *Hugin autonomous underwater vehicles about to be launched.*

Figure 1), or from AUVs (autonomous underwater vehicles). Data acquisition rates during geophysical surveys where the vessel is fitted with multibeam sonar, shallow seismic profiler, and side scan sonar in shallow water can acquire 170 line km/day at 4 knots and 65 line km/day at 1.5 knots with a deep tow, exclusive of any delays such as for line turns, deployment, etc. The deep water surveys are therefore not efficient using such an approach.

In deep water an AUV such as the Hugin (see Figure 2) can be used to acquire more than 113 line km/day in water depths down to 3000 msw, inclusive of launching and recovery, data downloads, battery recharges etc. The longest dive to date is 69 hours. Besides AUVs being significantly more efficient they are able to provide extremely high quality data.

Geotechnical data sets

The 2nd phase, a geotechnical seabed investigation, takes place from a large geotechnical vessel. Geotechnical survey data is obtained in a phase 2 survey and entails acquiring information with geotechnical tools (see Figures 3 and 4 for examples) such as marine drillship rigs; seabed sampling systems; box and grab coring systems; visual systems; and cone penetration testing systems.

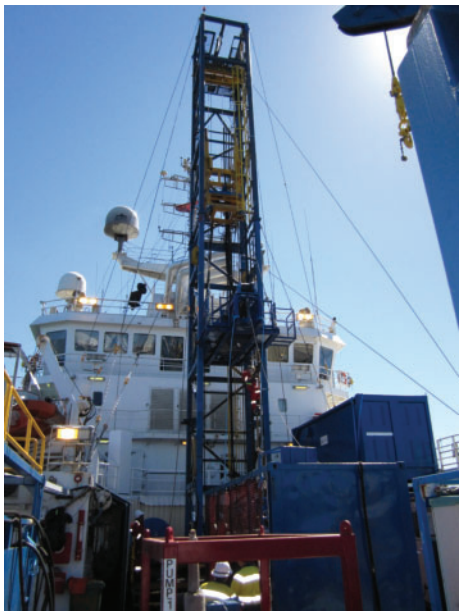

Fig 3. *The geotechnical drill rig mounted over the Geosea's moonpool.*

Fig. 4. *Cone penetrometer testing being launched off side of the Geobay.*

For deep water site surveys large dynamic positioning 2 vessels, such as DOF Subsea's Skandi Bergen, are an alternative to using a drill ship. These are used as the platform for remote seabed sampling systems. These vessels can operate safely with a large weather window, using an integrated dynamic positioning with survey sensor systems that are stable and efficient.

The benefits in deep water investigations of using remote seabed drilling rigs are that they can combine other survey tasks such as AUV work with seabed deployed drilling systems; there is a deep water efficiency over surface drilling rigs; can provide excellent depth accuracy; the remote handling of the seabed drill string has health, safety and environment advantages.

Precise point positioning GPS

It is important to have accurate decimeter level position accuracy in three dimensions (x, y, z) which is possible with global GPS systems such as the Veripos Ultra PPP GPS. Accurate Seabed Sampling Results with decimetre spatial high accuracy provides a reliable framework for visualisation giving seamless 3D and 4D representation of data in true geographical position and to scale.

Integration of geophysical and geotechnical information

Figure 5 shows an example of a screen image on ESRI's GIS of integrated geophysical and geotechnical information. The integration of geophysical data entails being able to access and compare information such as:

- Seabed bathymetry
- Lists of seabed hazards
- Seabed geomorphology
- Subsurface seismic layers
- Limited geotechnical information

The integration of the geotechnical survey data entails accessing and comparing the

- Refined geological model geomorphology
- Ground conditions and variations

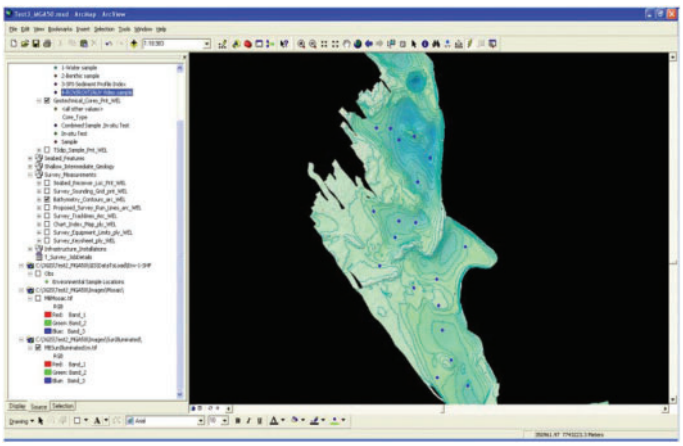

Fig. 5. *A GIS screen display of integrated geophysical and geotechnical information showing relief contours and core locations.*

- Detailed *in-situ* soils and rock information
- Geotechnical parameters needed for foundation design
- Geotechnical hazards

In doing the integration it is important to be able to get a clear picture of all the geotechnical investigation objectives such as the:

- Thickness and properties of seabed layers
- Complexity of geological model
- Presence and distribution of hazardous layers
- Variability

Benefits of using GIS and integrated data quality control

With GIS and good survey quality data it is possible to maximise the understanding of geohazards. The use of GIS helps minimise the dangers of misunderstanding multiple data sets in having data viewed in isolation, with a lack of standardisation, or having data of unknown accuracy. In an offshore industry that has a shortage of experienced geophysicists and interpreters these are real problems, as is having the geotechnical survey team divorced from the 1st phase geophysical and shore based expert office teams.

Some benefits of data visualisation

By using a visualisation package such as Fledermaus IVS during the planning stage as well as the data acquisition stages, the following benefits can be achieved:

- Helps speed up the whole process of sharing information and the interpretation of existing information
- Comparison of multiple surveys over time: bathymetry data comparisons – quality, changes, artefacts, reliability and volumes of sediment movement
- Comparison of multiple data sets: bathymetry/backscatter/seismic data comparisons – overlays and interpretation
- Reprocessing raw x, y, z data with similar bin sizes to achieve a comparable comparison
- Provide 3D and 4D visualisations
- Determine seabed slopes
- Create 3D fly through visualisations
- Better study the seabed features and conditions by means of multiple views

Conclusions

The improved vessel based solutions available to us through better communications and technology provide the following benefits:

- High speed broadband Internet technology and high quality video enables a 'Telepresence'
- More use will be made of 3D and 4D visualisation in risk mitigation, positioning and mapping
- Standardisation in GIS geodatabase file structure specifications will enable better data sharing adoption by oil and gas companies of the OGM's (International Association of Oil & Gas Companies) Seabed Survey Data Model
- Remotely operated systems in geoscience activities in deep water is growing
- Console based geoscience activities can be run using onboard and shore based resources
- The 'digital download' generation's entry into our industry will speed up the impact of new technologies offshore

The graphic capabilities of modern 3D visualisation systems will open up all sorts of future benefits towards 'making the ocean transparent' to show us what lies on and below the seabed.