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Geophysical Investigations for Offshore and Nearshore Structures

Mehrdad Tajabadipour[1], Masoud Dehghani[2]
[1]Ph.D Candidate, Department of Civil Engineering, University of Hormozgan
[2]Assistant Professor, Department of Civil Engineering, University of Hormozgan
([1]mehrdad.tajabadipour@yahoo.com)

Abstract- With human growing and demands for the offshore oil and gas, construction and development of the offshore structures are growing. The offshore geotechnical engineering is the application of scientific knowledge and engineering techniques to the investigation of seafloor materials and the definition of the seafloor's physical properties. Different site investigation and design methods are required for each sea. Geological survey is one of the requirements for identifying ground types (sediment types), describing their characteristics and for assessing their suitability for construction work. It makes use of modern, high-performance geophysical processes, and the results of which must be verified based on direct explorations (drillings). Due to the lack of accessibility to the seabed, geophysical processes are an extremely efficient method to get a general overview of the ground conditions in selected areas within a short period of time and therefore the sediment distribution and tectonic elements are detected in such a manner which enables e. g. the identification of areas with heterogeneous or problematic ground conditions. In this paper different methods of geophysical explorations for the offshore projects are examined and also marine x-band radar systems are well tested to provide information about sea state and bathymetry is investigate.

Keywords- *Marine Investigation, Geophysical Method, Marine X-Band Radar, Side Scan Sonar*

I. INTRODUCTION

After second half of the 20th century, the offshore structures construction and development are growing because of demand for the offshore oil and gas and developing interest in the offshore wind farms. The offshore oil and gas now provide approximately one third of the world's energy demand, there is a growing need for improved understanding of seafloor ecosystems to facilitate sustainable management of offshore resources. Human activities can cause a wide variety of impacts on the seabed environment. Thus, a reliable model of the seabed stratigraphy including quantification of engineering parameters for relevant layers is essential for engineering design of an offshore foundation. Often, preliminary design studies will be called for prior to any site investigation at the particular site, and estimation of the seabed characteristics must rely on regional knowledge. In any case, it is advisable to establish a site model that extends beyond the immediate location, as this allows for subsequent adjustments in the positions of facilities and indicates the spatial uniformity of seabed conditions across the region. Critical features such as faults, buried channels or other localized non-uniformities will need to be mapped.

Designing the offshore geotechnical engineering structures evolved from onshore practice, with areas of the foundation scale and installation methods separated from the original onshore principles during the last 30 years [1].

Generally, the offshore industry is very innovative with well-funded research that its results are rapidly and cautiously used in practice [2]. The offshore geotechnical engineering is an applied science that covers related problems in the offshore environment. The offshore industry progresses in the geotechnical aspects can be described as a few very large diameter piles groups are being used instead of many moderate-sized piles; deep skirts are used instead of the excavation of shallow soft sediments. They can change the effective foundation depth to the skirts tip levels penetrated several diameters into the seabed. Underwater embedment has increased the application of suction (or under pressure) skirted or caisson foundation installations. Special attention to the effects of cyclic loading on the offshore structures has been taken. Special design codes have been developed for proper design of the offshore structures (Randolph et al., 2005). The offshore wind energy is getting a more popular source of renewable energy, and it has been forecasted 16 GW of the offshore wind turbines to be installed by the end of 2014, and global total of 75 GW by 2020 [3]. The offshore wind turbines foundation approximately cost for 1/3 of the total cost of the offshore wind farm budget and in deep water (>25m), its cost accounts for 50% of the total project (Madsen et al., 2012). Acoustic systems are efficient tools capable of monitoring the environ-mental (physical and biological) evolution around ARs, whereas visual dive and ROV inspections can be limited by water turbidity. However, techniques such as single beam echo sounder and side scan sonar have spatial limitations and navigation and tow fish control difficulties. On the other hand, high-frequency multibeam echosounders offer the potential of detecting and defining the fine-scale distribution of reef units. These high resolution systems are able to achieve 100%

coverage of seabed geology and geomorphology over relatively broad spatial scales, offering an unprecedented level of resolution, overage, and spatial definition [4-5]. In recent years the application of acoustic-mapping methodology, in particular the use of acoustic ground discrimination systems used in conjunction with ground-truth sampling, has become common practice in monitoring and mapping seabed habitats [6-10]. Because acoustic data are less able to detect changes in the biological components of the seabed, classifications of different seabed ecosystems tend to be driven largely by physical criteria [11-12].

As it is well known, X-band radar can be used to extract valuable information about the sea state; the main mechanism is the interaction between the electromagnetic waves and the sea's short capillary waves, which in turn ride over longer gravity waves, and has been described and tested for many incidence angles and wavelengths [13-18]. In the last two decades various approaches have been developed and validated to estimate sea state parameters such as the Significant Wave Height (SWH), the wave spectrum, as well as surface currents and bathymetry [19-22]. Most of the systems employed to these purposes operate in the short pulse mode (i.e., pulse duration of about 50 ns) and are equipped with a 9-ft (about 2.74 m) antenna. These features enable them to attain a range resolution of about 7 m and an angular resolution of approximately 0.9° thus providing good results in sea state monitoring [22-24]. It is also well known that the non-uniform bathymetry and current fields typical of coastal areas can complicate the estimation of the hydrodynamic parameters (i.e., the direction, the period and the wavelength of the dominant waves) with respect to offshore situations [19].

A refraction/reflection near-field model was then used to understand near-field effects and in particular to highlight the presence of reflected waves. This is perhaps the most important result of the work reported here, and it might potentially evolve into an important feature of X-band radar sea monitoring systems, since reflected waves may significantly complicate the harbor activities (e.g., berthing operations), as they interfere with the oncoming waves thus creating a confused sea [26,27].in this paper different methods of geophysical explorations for the offshore structures especially, oil and gas platforms, and wind turbines are reviewed and discussed.

II. GEOPHYSICAL INVESTIGATION TECHNIQUES

A Geophysical investigation is required to understand the nature or characteristics of the seabed. Seabed features and seabed obstructions can be revealed and the main stratification boundaries and faulting within the soil column identified.

A. *Bathymetric mapping*

Bathymetric mapping is used to quantify the water depth and thus provide a visual 3D image of the seabed. This type of investigation gives important information about the seabed slope at the proposed location, but can also lead to detection of palaeo-slope failures or debris flows, geological features such as volcanoes, scarps from faulting and seabed obstructions. The most common types of bathymetry measurements are echo sounding and swathe bathymetry.

B. *Swathe Bathymetry*

A swathe bathymetry system usually comprises a beam that sweeps from side to side as the vessel sails ahead; resulting in a large number of spot measurements as it sweeps that cover virtually the entire area (Fig.1). Systems are usually hull-mounted, generally reliable and able to recover data at up to 7/8 knots in 5/6 sea state (30 kHz) and even 7/8 (14 kHz). Systems are available for both shallow and deep water but it is important to select correct frequency for task with the usual constraint that deeper water requires lower frequency (due to signal attenuation being frequency dependent) with consequential lower resolution. The higher resolution higher frequency systems have been mounted on AUVs and ROVs to get closer to the target zone. Footprint may be up to twice the water depth/tow height. Up to now, the ability of systems to record a backscattered signal response (to provide reflectivity index and hence relate this to sediment type) has been less successful, and it is claimed that the processing development described above will raise the credibility of the technique. There has been an instance in the Gulf of Mexico where a low frequency system failed to record the 'true' seabed as it was a thick soupy mud and recorded the top of underlying material as the seafloor. Developers will need to give more attention on the QC side, improve visualization methods and pursue the use of high frequency systems on AUVs for maximum usefulness in deep water.

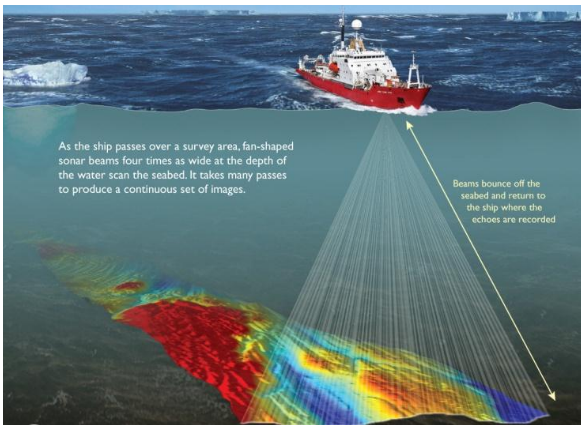

Figure 1. Swathe Bathymetry in offshore investigation

C. *Echo Sounding*

A conventional single-beam echo sounder is similar to echo sounders available on all ocean going vessels. However, in order to provide the accuracy necessary for survey work, this single-beam equipment is heave compensated to automatically correct for prevailing sea state. The equipment must be calibrated to the correct seawater sound velocity. The results produced are spot measurements of depth, usually at distances of about 25–50m apart. Spot measurements are continually made along each track line and are used to produce seabed contours of the area surveyed. The frequency range (typically 30–300 kHz) is chosen to be too high to penetrate the seabed sediments, thus ensuring a clear reflection at the seabed (Fig.2).

More accurate bathymetric data may be obtained from multi-beam echo sounding, which uses a fan of narrow acoustic beams and is thus more efficient in terms of time and cost. Multi-beam echo sounders may be mounted on the vessel. Water depth data from the echo sounder is then combined with Global Positioning System (GPS) data, giving the position of the instrument in order to evaluate absolute bathymetry.

D. X-Band Radar System for Bathymetry

Marine X-band radar based systems are well tested to provide information about sea state and bathymetry. It is also well known that complex geometries and non-uniform bathymetries provide a much bigger challenge than offshore scenarios.

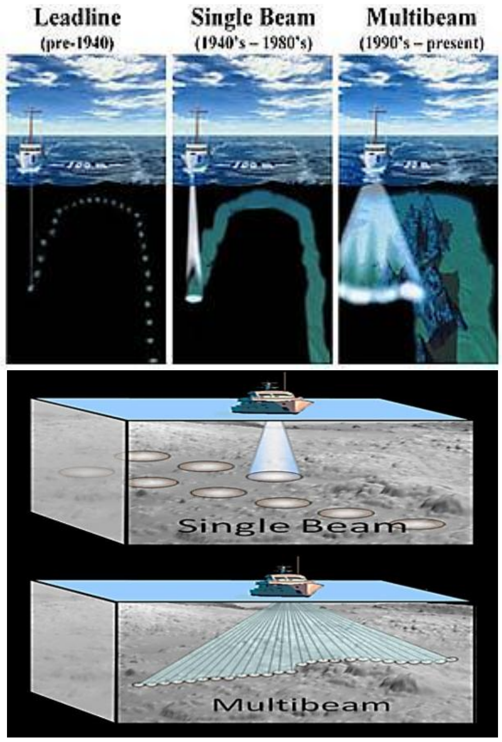

Figure 2. Different echo sounders

The strategy employed to retrieve the sea state from nautical radar data typically involves the processing of a temporal sequence of Nt partially overlapping consecutive radar images. Starting from the 3D spectrum of the radar sequence and by going through a number of operations to take into account the physical processes and to filter out the distortions [22], it is possible to extract the wave spectrum and the hydrodynamic parameters, as well as the surface currents and the bathymetry. The commonly used procedure is based on the assumption that the former quantities do not vary significantly in the scene; this assumption is normally only true for deep offshore areas, where the physical parameters can be reasonably assumed to be spatially homogeneous [23-25]. In many instances such as in the case considered here, the data do not meet this requirement due to the non-uniform surface currents and bathymetry fields; the retrieval of the sea parameters requires therefore a local estimation procedure.

Each radar image within the temporal sequence is partitioned into Ns uniform spatial patches, thus producing Ns temporal subsequences and by using a FFT (Fast Fourier Transform) algorithm, Ns 3D spectra. Each spectrum is then high-pass (HP) filtered to compensate the power decay which affects the radar signal along the range direction. We denote this set of filtered signals with $\{F_I^J(\overline{K},\omega)\}_{j=1,\ldots,N}$,$\overline{K}=(K_x,k_y)$ being the wave-vector and ω the angular frequency. The local joint estimation of the bathymetry and surface current is then carried out by applying the NSP algorithm to each spectrum of the set. The NSP algorithm like most similar systems exploits the dispersion relation of the gravity waves to extract the sea signal from the overall noisy data [7]. The analytic expression of the dispersion relation for the sea gravity waves is given by equation (1):

$$\omega(\overline{K}) = \sqrt{gk\, tan\, h(kh)} + \overline{K} \times \overline{U} \quad (1)$$

Where g is the gravity acceleration,$\overline{U}$=(Ux,Uy) is vector of the sea surface current, h is the depth and $K=|\overline{K}|=\sqrt{K_x{}^2+K_y{}^2}$ is the wave-number.

The relation above rules the propagation of the gravity waves and, moreover, it defines the ω – k domain over which the energy of the sea waves is concentrated [30]. It is worth noting that any change of $\overline{U}$ or h turns into a shift of the spectral support of the sea signal. Therefore, these quantities play a key role in the analysis.

The joint estimation of the surface currents and the bathymetry performed by the NSP procedure is founded on the maximization of the following Normalized Scalar Product (Equation (2)):

$$V^j(\overline{U},h) = \frac{\left(\left|F_I^j(\overline{K},\omega)\right|, G^j(\overline{K},\omega,\overline{U},h)\right)}{\sqrt{P_{Fj} \times P_{Gj}}} \quad (2)$$

where $\left|F_I^j(\overline{K},\omega)\right|$ is the power spectrum in the jth patch, $G^j(\overline{K},\omega,\overline{U},h)$is a (real) characteristic function accounting for the local support of the dispersion relation (Equation (1)), while P_F^J and P_G^J are the image power spectra $\left|F_I^j(\overline{K},\omega)\right|$ and $G^j(\overline{K},\omega,\overline{U},h)$, respectively. The bathymetry and the surface currents fields can thus be computed starting from the local estimates. Such information is of course extremely useful for various coastal and offshore applications, but it is also an essential tool to correctly estimate the wave field since, as it is well known, the depth and the current map are required to define a band-pass (BP) filter to separate the energy of the global sea signal from the noise background in the radar spectrum.

The required sea-wave spectrum ,$F_w(\overline{K},\omega)$ can be obtained from the filtered image spectrum , $\widetilde{F}_I(\overline{K},\omega)$by resorting to the radar Modulation Transfer Function (MTF), which mitigates the distortions affecting the radar echoes and caused by both the acquisition geometry (e.g., shadowing and tilt modulation) and the electromagnetic (e.g., the Bragg) scattering mechanisms [25].

E. Seafloor mapping

One of important tools for sea floor mapping is side scan sonar. Side scan sonar systems provide graphic records that show two-dimensional (map) views of seafloor topography and identify objects on or above the seafloor. It can help identify the type and distribution of sediment and surface forms such as sand waves this old but extremely useful technology has not advanced much recently. The new digital system of Klein (http://www.l-3klein.com) provides better data at long range and this enables the higher frequency units (500 kHz) with their finer resolution to obtain good data out to 60 or 70 meters across track. Side-scan sonars provide an acoustic "oblique photograph" of the seafloor. By ensonifying a swath of seabed and measuring the amplitude of the back-scattered return signals, an image is built up of objects on the seabed (Fig.3) and information on the morphology (the different material and features comprising the seabed surface) is obtained.

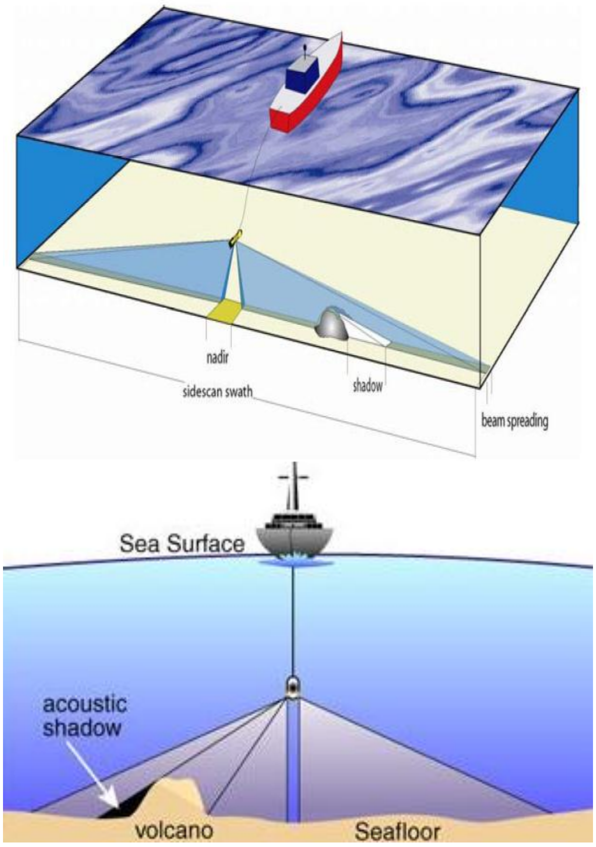

Figure 3. side scan sonar

The acoustic waves transmitted by the sonar interact with the seafloor and most of the energy is reflected specularly (Fig.4). The distance travelled from the transducer to the target of the seafloor is called the slant-range. It is not to be confused with the horizontal distance between the sonar's nadir and the target (ground-range). The total distance ensonified across-track is called the swath width, which is two times the selected range. The angle between the incoming wave and the seafloor is called the angle of incidence. The grazing angle is 90° minus the incidence angle, i.e. the angle between the incoming wave and the local normal to the seafloor (Blondel and Murton, 1997).

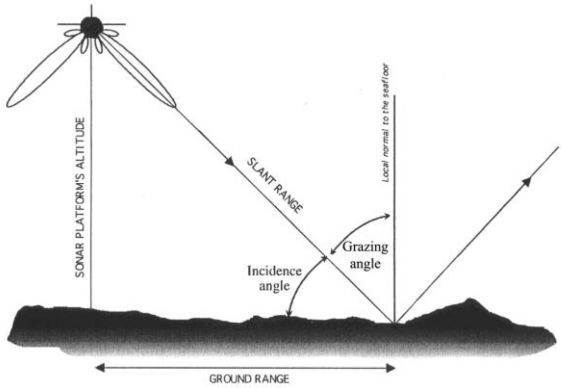

Figure 4. Geometry of side scan sonar and definitions of some basic parameters (Blondel and Murton, 1997)

The returning echoes from the seafloor are received by the transducers over a very short period of time (in the range of milliseconds), amplified, and transmitted up the tow cable to the recorder. The recorder further processes these signals, digitizes them, calculates the proper position for them in the record, pixel by pixel, and then prints these echoes on thermal paper, one scan at a time (Fish and Carr, 1990). In recent years, with the advent of digital data acquisition systems, recording on paper has become obsolete. Instead, data are stored digitally and can be used for further data processing. In a "typical" side scan sonar system, the beam is narrow in the horizontal plane and broad in the vertical plane (Fig.5). In a typical 100 kHz system this would be 1° in the horizontal and 40° in the vertical and for a 500 kHz system 0.2° in the horizontal and 40° in the vertical. The main axis of the beam is typically angled 10-20° down from the horizontal, so that most of the energy is directed toward the sea floor where it is needed. The narrow beam width is not only necessary for achieving a sharp image of the seafloor, but it helps in rejecting noise from extraneous sources. In the ocean, noise will be reaching the sonar from all directions but the response to all this disturbance will be controlled by the beam pattern. Thus most of the noise will be rejected, improving the sonar performance (Mazel, 1985).

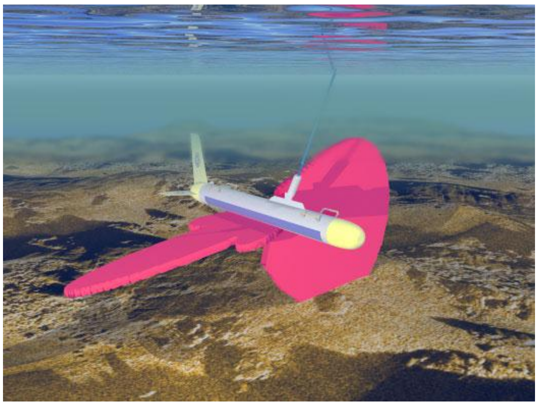

Figure 5. Typical beam pattern of a side scan sonar having a narrow beam width in the horizontal and a broad beam width in the vertical plane

The system is dependent on frequencies of the transmitting waves, with a trade-off between resolution and distance traveled. Higher frequencies sonar (500-kHz to 1-MHz) provide high-resolution images, but with short (100 m) Ranges, and low frequencies (50-kHz to 100-kHz provide long ranges (500 m), but with lower resolution. The intensity of the returning wave is dependent on both the topography and the material properties. The harder the object or material (e.g. gravel) on the seafloor, the darker the resulting image, as they reflect energy better than soft materials (e.g. muddy sands). Shadows show up as white areas due to the absence of reflected sound. When sand waves and ripples are large enough to produce shadows, there is an indication that currents are particularly high in that area and foundations would be subject to considerable scour. The resulting map of the variation in color, when combined with bottom samples or cores, produces a detailed map of seafloor features and interpreted sediment types (Fig.6).

The region ensonified by an outgoing pulse during one instant is called the sonar's footprint. The size and form of the footprint on the seafloor depends on the across-track distance from the sonar. It determines the resolution (The ability to distinguish between two distinct objects) of a sonar system.

The footprint is longer near the sonar due to the angle of incidence. The across-track resolution is related to the cosine of this angle which is equal to the sine of the grazing angle θ.

$$\delta y = \frac{c \cdot T}{2 \cdot \sin \theta} \tag{3}$$

Where c is the sound velocity in water and T is the pulse length (Lurton, 2002). The greater the distance from the sonar, the more the footprint approaches the actual pulse length in the water (Fig.7). The implication is that across-track resolution is better further away from the sonar (Mazel, 1985).

Equation 3 is only a nevertheless useful approximation of the real world. When $\theta \to 0$, this approximate solution is not valid ($\delta y \to \infty$), and the resolution becomes:

$$\delta y = \sqrt{h \cdot c \cdot T} \tag{4}$$

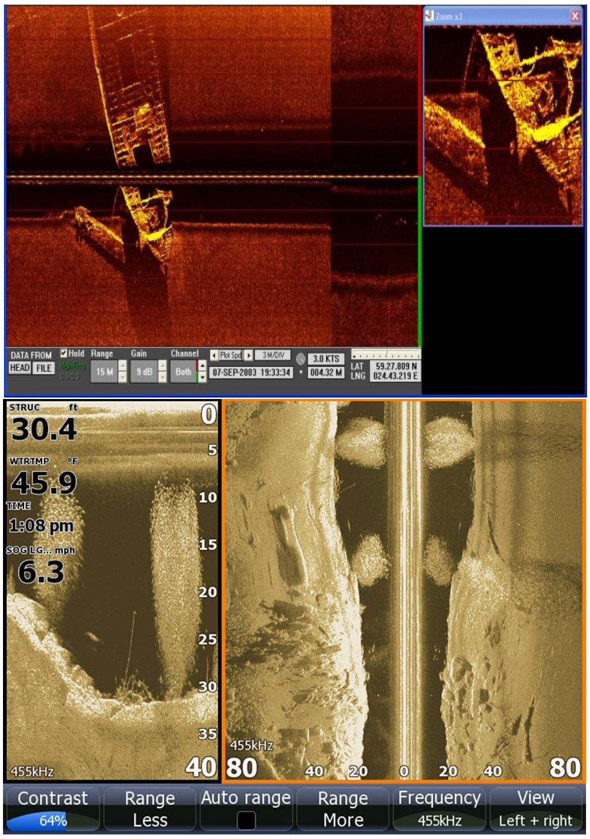

Figure 6. Example of side scan sonar image of seabed

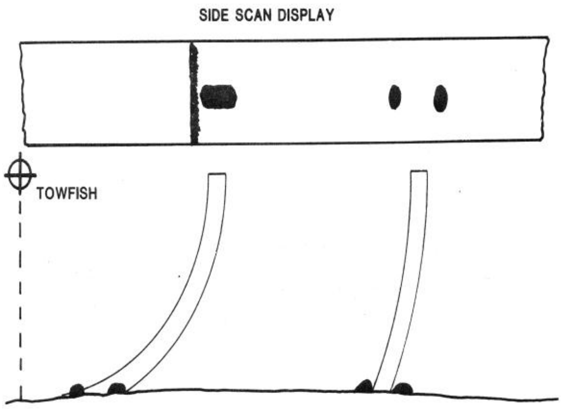

Figure 7. The across-track resolution of a sonar increases with range (Mazel, 1985).

With h being the sonar's altitude above the seafloor (Lurton, 2002).

Resolution in the along-track direction will be strongly dependent on the sonar's horizontal beam width. The beam widens with increasing distance from the towfish (beam spreading). Near the towfish, where beam spreading is not significant, two objects are clearly delineated as separate objects (Fig.8).

However, as the beam spreads out into the far region, the areas of ensonification widen. In these cases two separate objects on the seafloor may be imaged by the same sonar beam, thus appearing as one single object in the resulting sonar data (Fish and Carr, 1990). The along-track resolution can be estimated by (Flemming, 1976):

$$\delta x = r \cdot \sin \beta \quad (5)$$

Where r is the distance in across-track direction and β is the horizontal beam width.

In summary the resolution of side scan sonar is on the one hand inhomogeneous, both across-track and along track, and on the other hand varying along the ensonified swath (Fig.9):

- At small distances $\delta y >> \delta x$, across-track resolution is the worst, whereas along-track resolution is best.
- At large distances, $\delta y << \delta x$, across-track resolution is best, whereas along-track resolution is bad (Lurton, 2002).

Another performance constraint of side scan sonar is the need to ensure complete coverage of the ensonified area. The condition that needs to be fulfilled is the removal of gaps between ensonified areas from two successive pings (Lurton, 2002). Complete coverage depends on transducer length L, vessel speed v and ping rate f_p, which can be calculated by sound velocity in water and the selected range R:

$$f_p = \frac{c}{2 \cdot R} \quad (6)$$

With given transducer length L (approximately 40 cm for the used Klein and EG & G towfishes) and ping rate (determined by the selected range), complete coverage is achieved when a maximum vessel speed v_{max} is not exceeded:

$$v_{\max} = L \cdot f_p = \frac{L \cdot c}{2 \cdot R} \quad (7)$$

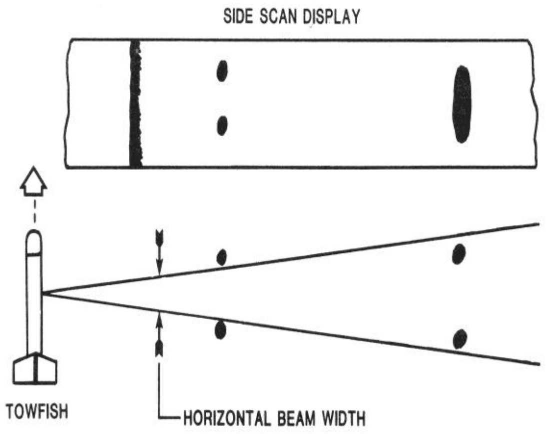

Figure 8. The along-track resolution is dependent on beam spreading and therefore best near the sonar (Mazel, 1985)

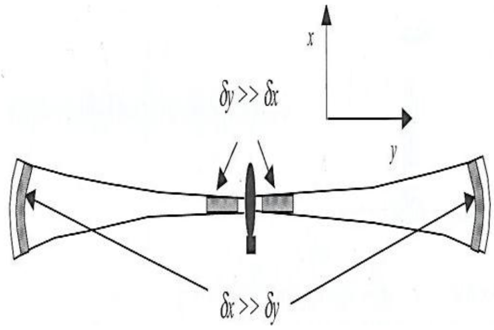

Figure 9. Evolution of the horizontal resolution of side scans sonar (Lurton, 2002)

Most of the energy arriving at the seafloor is scattered forward in the specular direction. A small portion is lost in the ground, and a small portion (several orders of magnitude smaller than the incident wave) is scattered back to the sonar. The backscattering is affected, in decreasing order of importance, by (Blondel and Murton, 1997):

- The geometry of the sonar-target system (angle of incidence of each beam, local slope, etc.)
- The physical characteristics of the surface (e.g. Micro-scale roughness)
- The intrinsic nature of the surface (composition, density, relative importance of volume vs. Surface diffusion for the selected frequency)

In the absence of large topographic variations, it is generally assumed that, in case of unconsolidated sediments, the grain size is the dominant factor in affecting the backscatter strength.Coarse sediments principally cause a higher back scatter than fine sediments do, as was shown by Davis et al. (1996) for sandy sediments (figure 10a). Nevertheless, backscatter is disproportionately affected by larger grain sizes. Addition of a few extra weight percentage of larger grain sizes (>4 mm) can strongly degrade the correlation (Goff et al. 2000; figure 10b).

Side scan sonar data becomes distorted during generation. These distortions are caused by towfish instabilities (Fig.11), speed variations in the survey vessel, and range data compression due to towfish altitude (slant-range distortion).

Towfish instabilities are minimised by the towing configuration used by the Institute of Geosciences, Kiel University. Speed variations and slant-range distortions can be corrected by digital sidescan sonar systems (Fish and Carr, 1990). Speed correction can be done online during data acquisition by applying the calculated ship speed from GPS-data.

Raw sidescan sonar imagery presents important across-track geometric distortions (slant-range distortion). They occur because the sonar system actually measures the time for a transmitted pulse to travel from the transducer to the target and the same way back. Figure 11 shows the slant-range distortion: two targets close to the nadir (A and B) will be associated with nearly identical slant-ranges $R_1=cT_1$ and $R_2=cT_2$. Conversely, two targets at far range (C and D), at the same distance from one another, will be associated with very different slant-ranges $R_3=cT_3$ and $R_4=cT_4$ and therefore placed further apart.

Without slant-range correction, near-range areas are more compressed than far-range areas. Slant-range correction is a remapping of pixels from their apparent position to the true one and is computed from the elapsed time and the sonar's altitude. Assuming a flat seafloor, the correct distance on the ground is:

$$D_i = \sqrt{R_i^2 - h^2} \tag{8}$$

where R_I is the slant-range distance and h is the sonar's altitude (Blondel and Murton, 1997).

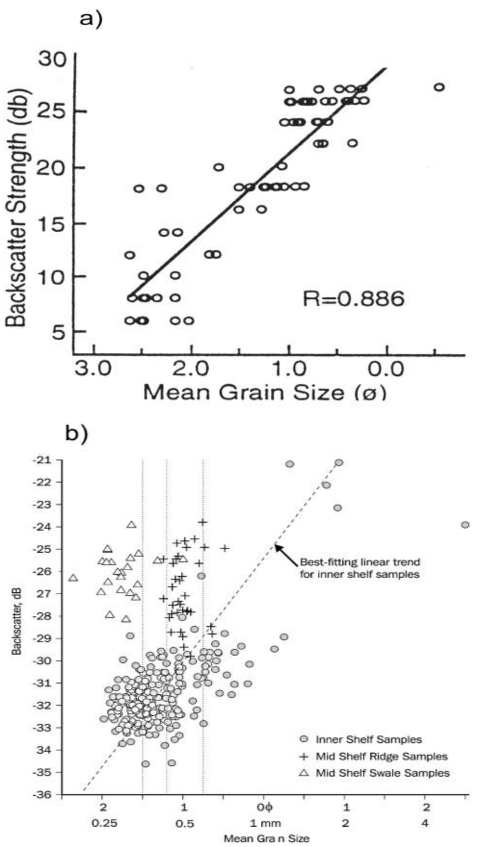

Figure 10. Relationship between mean grain sizes versus relative backscatter strength: a) based on data from the inner shelf of the Gulf of Mexico (Davis et al, 1996), b) based on data from the shelf of the New Jersey margin (Goff et al., 2000)

Slant-range correction assumes a flat seafloor across-track, thus errors are introduced, if the true topography significantly deviates from flat-bed conditions. Moreover, a reasonable bottom tracking is necessary to precisely calculate the slant-range correction. Bottom-tracking is the attempt to depict the first return from the seafloor, which yields the altitude of the towfish above the seafloor. Several methods of bottom-tracking are available.

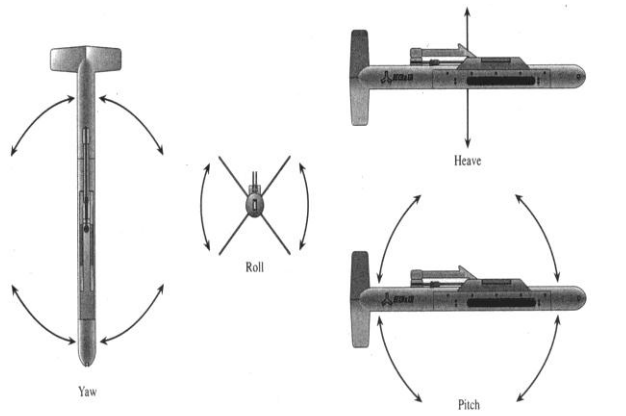

Figure 11. Towfish instabilities, which degrade the quality of the sonar data (Fish and Carr, 1990)

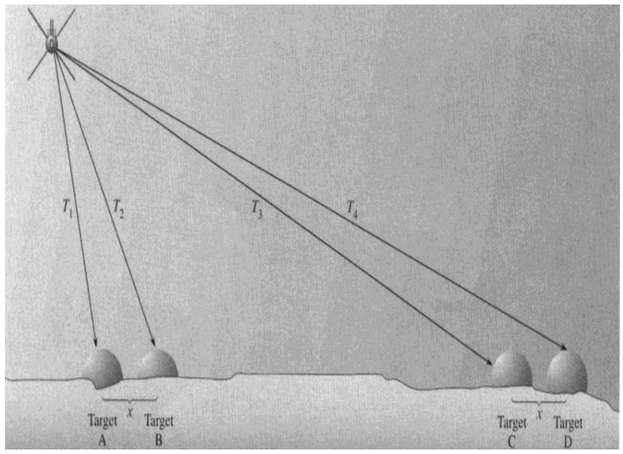

Figure 12. Slant-range distortion (Fish and Carr, 1990)

F. *Sub-bottom profilers*

Wide band digital sub-bottom profilers are now available which transmit an FM pulse that is linearly swept over the frequency range between 0.5 and 24 kHz (Fig.13).These 'chirp' systems transmit a signal burst of between 20 and 40 milliseconds. Received data is stored in an industry standard digital format enabling subsequent processing. Correlation with bottom sediment type in deep water environments (where they are being used for submarine cable route surveys is being developed. However, whilst there have been advances, it is considered that the capabilities of the chirp systems have been oversold as penetration is frequently lower than expected. There is a body of opinion that the technology of the early deep tow sources such as Huntec Boomer and Nova Scotia Research Foundation sparker was prematurely regarded as obsolete.

However the move towards digitization of high frequency profiler data has produced benefits enabling cleaner signals, higher resolution and processing to ultimately achieve quantification of the soil type.

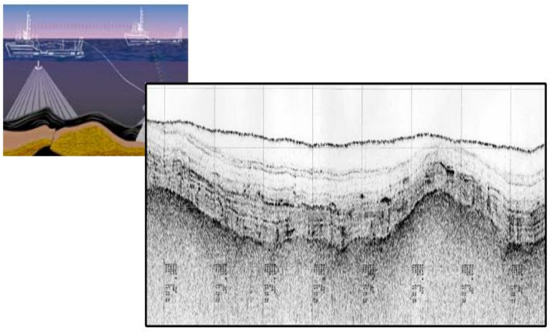

Figure 13. Sub-bottom profilling

The function of a sediment profiler is to record echoes from interfaces between sedimentary layers that correspond to differences in acoustic impedance. The movement of the support platform will allow reconstruction of a vertical cross-section of the sedimentary environment obtained as an image of boundaries between layers.

For the same transducer geometry, higher frequencies give narrow opening angles and lower frequencies gives wider opening angles.

The transducer dimension design is based on the desired beam pattern. The beam pattern is a dimensionless and a relative parameter of the transducer. It is a function of the operational frequency, aperture angle, and size and shape characteristics of the vibrating surface. The mathematical expression 'sinc function' for the normalized directivity pattern that gives the transducer sensitivity of the plane circular piston transducer is :

$$D(\theta)=\left[\frac{2J(Ka\sin\theta)}{ka\sin\theta}\right]^2 \quad (9)$$

Here J is the Bessel function of first order, k the wave number, a is the radius of the transducer, and θ is the aperture angle. Where y-axis represents the directivity response and x-axis = kasinθ

III. CONCLUSION

In the infancy of the offshore industry, the soil exploration program was performed simultaneously with construction. The soil boring served as a construction guide, rather than a design tool. Today, soil investigations are done months to perhaps years ahead of construction. The information is used to evaluate the type of structure best suited for the site and to complete the sophisticated designs. Offshore investigations involve both direct and indirect methods. Direct methods are those which provide actual physical evidence of the materials, such as soil borings, drop cores and in situ testing. The indirect methods are those which sense remotely, such as electromechanical and geophysical profiling. Geophysical processes are an extremely efficient method to get a general overview of the ground conditions in selected areas within a short period of time and therefore the sediment distribution and tectonic elements are detected in such a manner which enables e. g. the identification of areas with heterogeneous or problematic ground conditions.

Side scan sonar and sub-bottom profilers are undoubtedly one of the most useful tools for imaging the seabed. The clarity of the image, especially from the latest systems, is extraordinary.

In recent years one of important method to provide information about sea state and bathymetry is marine X-band radar systems.X-band radar data analysis can detect the presence of wave's reflection form structures and importance of this possibility as a support to navigation and harbour management, as well as to other coastal monitoring activities is self-evident.

The authors have proposed an engineer before designing offshore structures geotechnical and geophysical investigation are performing and the results are interpret.

REFERENCES

[1] M.Randolph,M.J.Cassidy,S.Gourvenec,Challengs of The offshore Geotechnical Engineering. In Proceedings of the 16th international conference of soil mechanics and geotechnology engineering, Vol. 1, Osaka, Japan, pp. 123-176(2005).

[2] E.T.R.Dean, Theoffshore geotechnical eng-ineering, Principles and practice, Thomas Telford Limited, London, UK.Madsen S., Andersen L.V., Ibsen L.B., 2012. Instability during Installation of Foundations for The offshore Structures, Nordic geotechnical meeting, NGM Copenhagen, 9-12 May (2010).

[3] S.Madsen, L.V.Andersen, L.B.Ibsen, Instability during Installation of Foundations for The offshore Structures, Nordic geotechnical meeting, NGM Copenhagen, 9-12 May (2012).

[4] A.J.Kenny,I.Cato,M.Desprez,G.Fader,R.T.E.Schuttenhelm,J.Side,An Overview Of Seabed-Mapping Technologies In The Context Of Marine Habitat Classification. Ices J. Mar. Sci., V. 60, P. 411-418, (2003).

[5] G.Berman,D.F.Naar,A.C.Hine,G.Brooks,S.F.Tebbens,B.T.Donahue, R.Wilson, Geologic Structure And Hydrodynamics Of Egmont Channel: An Anomalous Inlet At The Mouth Of Tampa Bay, Florida. J. Coast. Res, V. 21, N. 2, P. 331 - 357, (2005).

[6] D.F.Naar,G.Berman,B.Donahue,N.Dewitt,A.Farer,B.Jarrett,M.Palmsten, B.J.Reynolds,D.Wilder,Preliminary Results From A Em 3000 Multibeam Class Survey Along The West Coast Of The Florida Carbonate Platform. Eos Trans. Agu, V. 80, N. 46, P. 519 - 520, (1999).

[7] G.R.Cochrane, K.D. Lafferty, Use Of Acoustic Classification Of Side Scan Sonar Data For Mapping Benthic Habitat In The Northern Channel Islands, California. Continent. Shelf Res., V. 22, P. 683 - 690, (2002).

[8] R.L.FosterSmith,C.J.Brown,W.J.Meadows,W.H.White,D.S.Limpenny, Mapping Seabed Biotopes At Two Spatial Scales In The Eastern English Channel. J. Mar. Biol. Ass. U.K., V. 84, P. 489 - 500 (2004).

[9] A.Jordan, M.Lawler, V.Halley,N.Barrett, Seabed Habitat Mapping In The Kent Group Of Islands And Its Role In Marine Protected Area Planning. Aquat. Conserv., V. 15, P. 51 - 70, (2005).

[10] R.Freitas,A.M.Rodrigues,E.Morris,J.L.Perezllorens,V.Quintino, Single-Beam Acoustic Ground Discrimination Of Shallow Water Habitats: 50 Khz Or 200 Khz Frequency Survey? Estuar. Coast. Shelf Sci., V. 78, P. 613 - 622, (2008).

[11] V. E. Kostylev, B. J. Todd, B. J. Gordon, G. Fader, B. J. Courtney, R. C. Cameron, G. D. M. Pickrill, Benthic Habitat Mapping On The Scotian Shelf Based On Multibeam Bathymetry, Surficial Geology And Sea Floor Photographs. Mar. Ecol. Prog. Ser., V. 219, P. 121 - 137, (2001).

[12] F R.reitas, A. M.Rodrigues, V. Quintino, Benthic Biotopes Remote Sensing Using Acoustics. J. Expl Mar. Biol. Ecol., V. 285 - 286, P. 339 - 353, (2003).

[13] F.Ziemer, Directional spectra from shipboard navigation radar during LEWEX. In Directional Ocean Wave Spectra: Measuring, Modeling, Predicting and Applying, 1st ed.; Beal, R.C., Ed.; The Johns Hopkins University Press: Baltimore, MD, USA,pp. 80–84(1991).

[14] W.J.Plant, W.C.Keller, Evidence of Bragg scattering in microwave Doppler spectra of sea return. J. Geophys. Res., 95, 16299–16310(1990).

[15] E.Pugliese Carratelli, F.Dentale, F.Reale, Numerical PSEUDO-Random Simulation of SAR Sea and Wind Response. In Advances in SAR Oceanography from Envisat and ERS Missions, Proceedings of the SEASAR 2006 (ESA SP-613), Frascati (RM), Italy, 23–26 January 2006; Lacoste, H., Ed.; ESA Publications Division (ESTEC): Noordwijk, The Netherlands, (2006).

[16] E.Pugliese Carratelli, F.Dentale, F.Reale, Reconstruction of SAR Wave Image Effects through Pseudo Random Simulation. In Proceedings of the Envisat Symposium 2007 (ESA SP-636), Montreux, Switzerland, 23–27 April 2007; Lacoste, H., Ouwehand, L., Eds.; ESA Communication Production Office (ESTEC): Noordwijk, The Netherlands, (2007).

[17] M.P.Clarizia, C.Gommenginger, M .di Bisceglie C.Galdi, M.A. Srokosz, Simulation of L-Band Bistatic Returns From the Ocean Surface: A Facet Approach With Application to Ocean GNSS Reflectometry. IEEE Trans. Geosci. Remote Sens., 50, 960–971(2012).

[18] M.P.Clarizia, M .di Bisceglie, C.Galdi, C.Gommenginger, M.A. Srokosz, Simulation of GNSS-R Return for Delay-Doppler Analysis of the Ocean Surface. In Proceedings of the 2009 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2009), Cape Town, South Africa (2009).

[19] F.Serafino, C.Lugni,F. Soldovieri, A Novel Strategy for the Surface Current Determination from Marine X-Band Radar data. IEEE Geosci. Remote Sens. Lett., 7, 231–235(2010).

[20] F.Serafino, C.Lugni, J.C.Nieto Borge, V.Zamparelli, F.Soldovieri, Bathymetry Determination via X-Band Radar Data: A New Strategy and Numerical Results. Sensors, 10, 6522–6534(2010).

[21] C.M. Senet, J.Seemann, S.Flampouris, F. Ziemer, Determination of bathymetric and current maps by the method DiSC based on the analysis of nautical X-Band radar image sequences of the sea surface. IEEE Trans. Geosci. Remote Sens., 46, 2267–2279 (2008).

[22] G.Ludeno, A. Orlandi,C .Lugni, C.Brandini, F.Soldovieri, F.Serafino, X-Band Marine Radar System for High-Speed Navigation Purposes: A Test Case on a Cruise Ship. IEEE Geosci. Remote Sens. Lett., 11, 244–248(2014).

[23] F.Serafino,C.Lugni,G.Ludeno,D.Arturi,M.Uttieri,B.Buonocore,E.Zambianchi,G.Budillon,Soldovieri, F. REMOCEAN: A Flexible X-Band Radar System for Sea-State Monitoring and Surface Current Estimation. IEEE Geosci. Remote Sens. Lett., 9, 822–826(2012).

[24] G. Ludeno, S.Flampouris, C.Lugni, F .Soldovieri, F.Serafino, A Novel Approach Based on Marine Radar Data Analysis for High-Resolution Bathymetry Map Generation. IEEE Geosci. Remote Sens. Lett., 11, 234–238(2014).

[25] G.Ludeno,C.Brandini, C.Lugni, D.Arturi,; A.Natale, F.Soldovieri, B.Gozzini, F.Serafino, Remocean System for the Detection of the Reflected Waves from the Costa Concordia Ship Wreck. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., 3011–3018 (2014).

[26] N.W.H.Allsop, S.S.L.Hettiarachchi, Reflections from Coastal Structures. In Proceedings of the 21st International Conference on Coastal Engineering, Torremolinos, Spain, 20–25 June 1988; Edge, B.L., Ed.; American Society of Civil Engineers: New York, NY, USA,pp. 782–794(1988).

[27] D.Reeve, A.Chadwick,C.Fleming, Coastal Engineering: Processes, Theory and Design Practice, 1st ed.; SPON Press Taylor & Francis Group: Oxford, UK, (2004).

[28] M. Sheshpari , S. Khalilzad New Frontiers in the Offshore Geotechnics and Foundation Design, electrical journal of geotechnical engineering (EJGE) Vol. 21(2016).

[29] M.Randolph, S. Gourvenec ,Offshore Geotechnical Engineering, (2011)

[30] J.C.Nieto Borge, G.R.RodrÍguez, K.Hessner, P.I. Gonzáles, Inversion of marine radar images for surface wave analysis. J. Atmos. Ocean. Technol.,21, 1291–1300 (2004).