MARINE GEOSCIENCES

SEAFLOOR ENGINEERING STUDIES

SURVEY PLANNING & IMPLEMENTATION

GEOPHYSICAL/GEOTECHNICAL/HYDROGRAPHIC

CLIENT & QC REPRESENTATION

EQUIPMENT AND SOFTWARE
INFRASTRUCTURE

Seascape Technical Resources interfaces with various client organizations such as; oil & gas firms, consulting engineers, pipeline companies, governmental entities, universities, seismic survey companies, dredging companies, utilities, environmental companies, and others active in the coastal and offshore regimes, domestic and international.

Though most requirements are associated with the field operations, other needs may lie in the areas of project planning, identifying field data acquisition needs and appropriate systems and methodology, preparation of RFP’s, review of proposals, selection of contractors, project management, data reduction, analysis and reporting. The needs may be in the field and at the client company location.
Areas of Field Operations
MULTIDISCIPLINE SURVEYS

- Mitigation of risks from natural or man-made seafloor hazards
- Regulatory compliance (archaeological, integrity management, shallow hazards…)
- Establish design criteria for pipeline, cable, template, etc.

By operating several data acquisition systems simultaneously a wide range of survey objectives can be accommodated quickly, minimizing survey costs to client companies. The data from the various instruments can be processed and interpreted in the field and preliminary reports provided to the client to allow on-site evaluations and survey plan modifications as needed. Or the data is shipped back to the home office for processing, interpretation and reporting.
Multidiscipline survey techniques will provide data not only for depth of cover but can identify the conditions of the pipeline trench, backfill material, surrounding surficial soils, seafloor scour along the pipeline, debris and proximity to other pipelines. Accurate position information is recorded along with the systems data.

By simultaneously operating several systems, a quick determination of conditions that may have impact on an existing or planned pipeline installation can be realized. A typical system suite includes:

- Positioning - DGPS
- Subbottom Profiler – Chirp
- Echo Sounder – Dual Frequency
- Sidescan Sonar – Dual Frequency
- Magnetometer – Low noise
Pipeline Depth-of-Cover survey techniques – Shallow Water Operations

Four primary approaches are utilized to measure depth of soil cover over an existing pipeline;

a) Physical probing from the water surface or by diver
b) Gradiometer array
c) Pulse induction system
c) Chirp subbottom profiler

The following discussion details the subbottom profiler utilization as it is considered the most effective and least costly survey method of the three. In addition, when other complimentary survey equipment is utilized, additional important data is available to the operator

Figure 1 illustrates typical data provided by a sidescan sonar, subbottom profiler and echo sounder when operated over a pipeline. Additionally a magnetometer is utilized to assist in determining the exact location of the line.
**Accuracy – Depth of cover**

Typically a dual frequency echo sounder (30 kHz – 200 kHz range) and a subbottom profiler are utilized to determine depth of cover. The higher frequency system inherently is the most accurate due to a narrow beam width, shorter pulse length and wavelength provided. Specifications for the ODOM Hydrographic 200 kHz published accuracy as .01m 1% water depth. In the case of depth of cover we are concerned with the window between the seafloor surface and the top of the pipe which will normally be less that 10 ft. In this case the accuracy would be better than .01m (.4 in.) + 1% of 10ft. (1.2 in.) or 1.6in. maximum error.

The sediment within the depth of interest is water saturated and acoustic velocities are considered identical to that of the water column.

To assure accuracy of measurement, acoustic velocity profiles are taken and bar checks made to calibrate the echo sounder to minimize system index errors and draft variations.
Pipeline Depth of Soil Cover

Collage of Sidescan Sonar, Chirp Subbottom Profiler and Echo Sounder records surveyed perpendicular to the pipeline route.

Fig 1
With reference to fig. 1, we can observe the depth of the pipeline from the seafloor to be 9 ft. However, due to scour or lack of backfill we also can see the pipeline is 6 ft. from the bottom of the trench. It would be difficult, at best, for a diver to determine where the actual seafloor surface is in respect to the trench bottom and the pipeline.

The lower frequency echo sounder (24 kHz – 30 kHz) is able to penetrate a soft bottom to several feet, in the case in figure 1, the partially suspended surficial sediment (flocculent, fluid mud or fluff), a second somewhat more settled material at one foot depth, and a clay seam at 9 ft., are identified.

The subbottom profiler record clearly shows the clay seam but due to the lower operating frequency cannot resolve the softer material near the surface. The footprint of the transmitted pulse is much wider than that the echo sounder allowing it to map the pipeline from a greater horizontal distance. The acoustic pulse from the profiler is less subject to attenuation and can function more effectively in noisy sea conditions.

The sidescan sonar transmits a narrow beam in the azimuth and can be very effective in determining if the seafloor has been disturbed along the pipeline. The example shows that the trench has not been impacted by significant scour and that the pipe remains buried out to the limits of the record (approx 50 meter swath).
Multiple Acoustic Systems

When a single beam echo sounder is utilized along with a “Chirp” subbottom profiler, enhanced correlating data can be obtained. The SBES resolution is greater due to the higher frequency and pulse repetition rate. The “Chirp” can penetrate to greater depths and provide data in soils that can limit penetration of the SBES.
Water depth 6.2 ft.

4 ft. depth-of-cover  3.5 ft. depth-of-cover

4" Pipelines

Single Beam Echo Sounder
In areas where soil conditions between the pipeline and seafloor are disturbed (i.e. gas charged sediments, backfill, sea grass, shell, fine sand), the pipeline signature can be obscured. By using special filters and trace gain adjustments, pipeline detection can be enhanced. When the acoustic signature and frequency response of the seafloor sediments are analyzed, the minute amplitude variance from a pipeline can be detected and mapped more easily.
The systems can be operated in very shallow water depths using special tow and transducer mounting configurations. The limit of shallow water operation is limited primarily by vessel draft which is approximately 2 ft., in this example.

The primary limiting operational factor is excessive noise on the geophysical records caused by rough sea conditions.

Fig. 3

Chirp Subbottom Profiler rigged for shallow tow operations

Fig. 4

Sidescan Sonar rigged for shallow tow operations

Depending on sea conditions the sidescan sonar towfish can be operated from the bow or stern
PROBING

Probing as a method of determining depth-of-cover is difficult and inherently inaccurate due to vessel heave, angle of measurement and the inability to define the seafloor surface.

Diver probing improves accuracy but can be slow and expensive.

When taken from the survey vessel, probes can be a value-added asset, to assist confirmation of targets identified by acoustic systems where results may be mitigated by gas-charged surficial sediments, sand, shell or sea-grass.
Portable Gradiometer

In areas where a pipeline crossing point is difficult to determine using only the acoustic systems, this instrument when towed or attached to a pole can prove to be a valuable tool. An audible tone is generated when the sensor passes over a pipeline and has a range of several meters beneath the sea floor depending on soil conditions.

It can greatly reduce probing time.
The marine magnetometer produces a strong signature when a pipeline is crossed and is the most effective system in initially locating a pipeline. The acoustic systems can then be utilized to record more detail.

Simultaneous operation of a magnetometer, sidescan sonar, subbottom profiler and precision echo sounder can provide position data, depth of cover, seafloor sediment regime, and orientation of buried pipelines, cables, wrecks and debris.
Innovatum Smartrack Pipeline & Cable Tracking System (Gradiometer Array)

Sand, gravel, sea grass and gaseous surficial soils can limit the effectiveness of acoustic systems. A gradiometer array can provide XYZ data at pipeline crossings. However the accuracy in the vertical plane is limited to < .25m. When used in conjunction with a chirp subbottom profiler, optimum position and depth-of-cover data can be produced.

An array of horizontally mounted magnetic gradiometers is used to collect magnetic field gradient information at the pipeline location providing an accurate two dimensional target position. The array can be sled mounted for use in areas where vessel use is prohibitive in extreme shallow water. It can also be configured for operation from a small ROV.

Although the system can be used in an active DC or AC mode for small cables, Passive tracking is used for pipeline surveys, using the natural magnetic field of steel pipes.
**PULSE INDUCTION TECHNIQUE ALTERNATIVE**

Subsea electronics pod, search coils and power supply mounted on a tow sled. Allows for detection of pipeline and burial depth when acoustic signatures cannot be obtained with subbottom profiler.

Surface display console incorporates windows based display and controls software. DSP provides sensor depth, pipe position and depth-of-cover information.

Though lacking the depth-of-cover accuracy of a “Chirp” system, the system can be effective for river crossings, bayous and areas of disturbed sediment. Disadvantages include slow survey speed and somewhat cumbersome to handle.
This sidescan sonar record was taken parallel to a buried pipeline. The trench and partially eroded backfill can be observed above the line with no apparent exposure or excessive localized scour.

Fig. 2
Sidescan records along with backscatter data recorded by the swath systems are utilized to assist in determining the character of the seafloor sediments for design and installation planning as well as detecting seafloor scour.

The C3D record below shows an exposed pipeline with disturbed surficial soils in the immediate area, a possible result of local currents.

The system combines the attributes of a sidescan sonar and multibeam echo sounder providing a 3D model with reflection amplitudes added.
GRAB SAMPLES

A Mini-Ponar is a portable, lightweight grab sampler. The samples can be used to help identify surficial soils characteristics and can be a valuable tool to assist in field interpretation of geophysical data. The samples can be bagged for later laboratory testing.
Soils samples acquired at locations chosen after preliminary interpretation of geophysical survey data can prove to be a valuable asset in the determination of soils regimes in a survey area.

Acoustic reflective horizons from a subbottom profiler or dual frequency echo sounder can often be correlated with soils samples to allow identification and mapping of sedimentary and stratigraphic sequences.

Backscatter data from the multibeam sonar and sidescan sonar data can help determine the lateral extent of the surficial sediments identified.
Reflectivity of seafloor sediment materials can be determined by recording acoustic images and sediment classification determined following data processing and correlation with ground truth data. Following data is proprietary to Questar Tangent. All bottom classification results attributable to the publication “Acoustic Seabed Classification.”

Data can be processed from sidescan sonar, multibeam sonar or single beam sonar. Algorithms used are particular to a specific survey objective and may utilize more than one system type.
Multibeam classification for environmental monitoring
Colorized backscatter mosaic overlain by single beam classification data – habitat mapping and arctic engineering

Classification interpolated for 50 kHz single beam echo sounder data for oyster habitat
Environmental monitoring utilizing backscatter data.

This technique may be applied during pipeline depth-of-cover surveys to help satisfy the requirements for Pipeline Integrity Management Programs.

4D surveys (XYZ & Time) may help monitor scouring or migration of surficial soils due to storm induced currents along pipeline assets. GIS database can be developed for specific survey data.
The advantages of a multidiscipline survey approach utilizing a suite of instruments are several.

Depth of cover can be determined quickly as the survey boat acquires data at approximately 3-4 knots. Accuracy of the high frequency echo sounder exceeds 1.6” in the material covering the pipeline. The sidescan sonar can provide information along the pipeline trench showing breaches or seafloor scour. Seafloor characteristics will be represented by acoustic reflectivity of the sidescan sonar, subbottom profiler, and echo sounder data. Accurate 3D position of the pipeline crossing location using the magnetometer, echo sounders, subbottom profiler, sidescan sonar and DGPS positioning. Using a gradiometer/pulse induction array, data can be obtained in problem areas; sand, gravel, sea grass, gaseous sediments. Economical since all systems are utilized simultaneously with one mobilization. Data recorded digitally for conversion to Client specified GIS format. A program can be designed and integrated into an “Integrity Management Programs” required by the D.O.T. Office of Pipeline Safety (49 CFR 192&195).
CONTRACT SURVEY PERSONNEL

Various professional contract personnel can be provided to satisfy various survey objectives on a worldwide basis.

Our personnel are experienced in:

Marine Geophysics          Civil Engineering          Marine Geology
Environmental Survey        Oceanography             Geotechnical Engineering
Hydrography                Quality Control           Project Management

Typical Projects Include:

Pipeline Route/Engineering Surveys  Pipeline Depth of Cover Surveys
Engineering Site Surveys          Seismic Exploration Surveys
Harbor Studies                   Foundation Investigations
Seafloor Hazard/Geophysical Survey  Erosion/Scour Studies

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