A CONTRACTORÂ€™S FLEXIBLE APPROACH TO ART. 76-RELATED SURVEYS

Off-the-shelf Surveying Beyond 200 Miles

The unique opportunity now open to Coastal States to extend their maritime boundaries seawards has led to great interest in the particular marine geophysical and hydrographic survey techniques required to collect additional data in support of continental shelf extension. Criteria laid down in the United Nations Convention on the Law of the Sea (Art. 76, UNCLOS) emphasise each nation being able to "â€¦establish the outer limits of the continental margin wherever the margin extends beyond 200 nautical milesâ€¦" (www.un.org/Depts/los/index.htm). We describe Gardlineâ€™s experience with specific reference to surveying the continental margin of the Republic of Namibia.

The objectives associated with UNCLOS-related survey activities are somewhat different from oil & gas prospecting or hydrographic survey, requiring a more innovative and holistic approach on the part of the contractor, making the best use of existing resources, skills and techniques gained from years of experience in the offshore industry.
During 2004, Gardline Geosurvey Ltdâ€™s 64-metre vessel, M. V. *Sea Surveyor* (Figure 1) undertook 110 days of fieldwork on and around the continental margin of Namibia. This work was carried out under contract to the Brazilian consultancy Mar, Ambiente, Geologica e ServiÃ§Ãos Ltda (MAG), in partnership with Empresa Gerencial de Projetos Navais (EMGEPRON), a Brazilian state-owned company linked to the Brazilian Navy. This company was representing the Namibian government in the preparation of their case for extension of continental shelf to the UN. The photograph in Figure 2 shows the well-attended mobilisation ceremony in Luderitz prior to the vessel sailing for the cruise; speaking is the Honorable Hifikepunye Pohamba, Namibian Minister of Lands, Rehabilitation and Resettlement. Whilst we cannot give exact details of the survey area, a general overview is shown in the map below (Figure 3).

Methodology
The scope of work was defined by MAG before the start of the project. There followed a period of constructive dialogue between MAG and Gardline to arrive at the best technical solution to meet Namibiaâ€™s objectives within budgetary constraints. As a contractor, Gardline worked to provide technical and operational solutions using its many years of practical surveying experience and equipment knowledge to the best advantage of the project in hand. Whilst much of the work was carried out using tried and tested methods, some aspects of the survey required the use of more innovative approaches to ensure requirements were met. Essentially, the survey required the collection of multi-beam bathymetric data, single and multi-channel reflection and refraction seismic data, and potential field data (magnetic and gravimetric, by Austin Exploration Inc. Texas, USA) all from a single survey vessel, across a wide area of ocean.
The project was undertaken in three phases. Firstly, the focus was on the collection of multi-channel seismic data. Secondly, the collection of hydrographic and single-channel seismic data to determine the foot of the continental slope and obtain shallow sediment information. Thirdly, seismic refraction data was collected to reinforce the velocity structure of margin sediments critical for the determination of sediment thickness (depth to the basement). All three phases included the simultaneous collection of multi-beam bathymetric data, 3.5kHz sub-bottom profiler data, and magnetic and gravimetric data.

Equipment
In addition to standard navigation and positioning packages, the following equipment was used on the vessel:

- Kongsberg Simrad EM 12S (13kHz) multi-beam echo sounder
- Kongsberg Simrad EM 502 (30/ 200kHz) single-beam echo sounder
- Knudsen 3.5kHz sub-bottom profiler
- SeaSpy Overhauser magnetometer
- LaCoste & Romberg gravity meter
- 1,310cu.in. Bolt airgun array source & 3,200m streamer
- 270cu.in. Bolt single airgun & 12 channel â€˜mini-streamerâ€™
- Sparton AN/SSQ-57SPC sonobuoys & WinRadio receiver.

Simultaneous acquisition of multi-beam bathymetry, high-resolution sub-bottom profiler, gravity and magnetic data with shallow seismic

and multi-channel seismic data optimised the use of available vessel sensors in a single-pass campaign. Use of expendable bathythermographs (XBTs) to measure sound velocity through the water-column enabled the vessel to regularly update the calibration of the multi-beam system without interrupting survey progress.
Fast-pace shallow seismic acquisition was achieved through development of a towing system for an air gun (270cu.in. Bolt gun) that allowed the acoustic source to remain at a constant and controlled depth at vessel speeds of up to 9 knots. This involved suspending the airgun below a hydrodynamic weight rather than the traditional float and removed the limiting factor of previous slower seismic acquisition speeds. When used in conjunction with a 12:1 channel-summed mini-streamer, an effective tool was engineered to collect high-quality seismic data, as seen in Figure 4.
As far as we are aware, the use of the Sparton sonobuoys for this project was one of the first commercial operations utilising this particular technology for seismic refraction surveying, these units being more commonly associated with academic research, military applications or even listening to Cetaceans. They represent a lower cost alternative to the use of Ocean Bottom Seismometer (OBS) units, both in terms of capital and operational cost, since the units are expendable, thus eliminating the need for vessel time for recovery. Sonobuoys do, however, have limitations: offset distance is constrained by range of the radio telemetry system and prevailing sea conditions, and also they are usually subject to export license control. Figure 5 shows an interpreted refraction profile from a single sonobuoy deployment recorded to 22km offset from the source during multi-channel seismic acquisition. This data was interpreted in conjunction with XBT profiles and simultaneous reflection seismic data to provide optimised velocity information to enable accurate time-depth conversion.

Time Advantage
Acquisition speed on the Namibian project was of prime importance in meeting the economic objectives, and a great deal of the surveying was carried out at a speed of 8 knots, allowing average daily acquisition of over 300 line km of geophysical and hydrographic data. During the course of the survey a tremendous amount of data was acquired:

- 27,900 line km multi-beam bathymetry data
- 27,900 line km 3.5kHz sub-bottom profiler data
- 27,900 line km gravity and magnetic data
- 3,600 line km multi-channel seismic data
- 22,400 line km single-channel seismic data
- 25 refraction seismic profiles.

Data Quality
It was important to comply with UNCLOS data objectives. The employment of a suitable ocean-going survey vessel and appropriate post-processing techniques made it possible to modify the normal survey industry specifications (shot interval and horizontal resolution for shallow seismic operations and data density for bathymetric surveying) while maintaining vertical resolution and accuracy of data. This enabled vessel speed to be kept high at all times, even during marginal weather that would normally impose periods of standby time. Data was regularly collected in Beaufort force-6 conditions with 3-metre swells for periods of up to a week, this part of the Atlantic being renowned for its long-lasting ocean swells. Sonobuoy data was supplemented with simultaneous reflection seismic data and XBT profiles to optimise the accuracy of the time-depth velocity conversion. Figure 7 shows a breakdown of the project time; notice the low (4%) weather standby time achieved and the almost insignificant 2% contractorâ€™s time, a testament to the work and dedication of both the crew and its shore-side support, as well as the reliability of the various systems used. All collected data was found by MAG and Gardline representatives to be acceptable and to fall within parameters defined for the survey.

Conclusions
No two UNCLOS surveys are the same; the objectives will always vary with the geological context of the continental margin and with the amount of additional data required for supplementing existing archives. The survey contractor needs to adopt a flexible approach to operations so as to enable collection of the minimum amount of data needed to achieve the objective within a clientâ€™s budgetary constraints. Added value can be achieved simply by adapting a mix of traditional hydrographic and geophysical methods using different technology and by responding to the individual clientâ€™s needs. This project made us look hard at the way we have worked in the past and to question the strict specifications crucial to some business sectors, but not necessarily universally applicable. We realised that whilst specifications and quality-assurance criteria were important to ensure the maintenance of data quality and integrity, it was important that they should be â€˜fit for purposeâ€™. Having said this, thought needs also to be given to the end user of the survey, the United Nations Commission on the Limits of the Continental Shelf. This body will ultimately see the data, albeit in a synthesised and ordered format and after months of work by MAG, as justification for the extension of Namibiaâ€™s continental shelf.

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