Data Comparison of the SeaBat7125 and 8125 Multi-beam

Survey specifications such as the Land Information New Zealand (LINZ) require a specified number of hits on a given target size and a specified overlap in Special Order areas. In practice, the surveyor has two options to increase the number of hits: reduce the range to increase number of hits or slow down the vessel to increase sounding density. A multi-beam echosounder (MBES) with an equi-distance possibility increases the number of hits at the sides of the swath. This article describes a comparison survey with two SeaBat MBESs: one with equi-angle mode and one operated in equi-distant mode.<P>

With beams formed in equi-angle mode, sounding spacing is most dense at nadir and decreases towards the edge of the swath, whereas in equi-distant mode nadir density is maintained across the entire swath.

Land Information New Zealand (LINZ) is the National Hydrographic Authority of New Zealand. The LINZ specifications, which are built on the IHO S-44 specifications, specify a minimum target size to be detected and they also define a minimum number of hits on that target in order to assure detection in the reduced data set.
The availability of equi-distant beam-forming significantly increases productivity, especially in survey operations where a number of soundings per grid cell is specified. The increased density in the outer beams maintains a high number of soundings across the swath and can significantly reduce the amount of overlap required, thus reducing survey time and costs.

Having developed a new multi-beam echosounder (MBES) system, RESON wanted to compare the performance of this system in a field test with their SeaBat 8125 MBES.

Coverage and Object Detection

The ability to detect and delineate an object is determined by a combination of:
•receiver (across-track beam width)
•projector (along-track beam width)

•sample rate (depth resolution)
•water depth
•ping rate
•vessel motion
•vessel speed.

These parameters are examined in more detail below.

Beam Width
A multi-beam system uses a combination of a narrow (1°) along-track projector beam and multiple receiver beams in the cross-track plane. Both the SeaBat 7125 and 8125 have a nadir beam width of 0.5°, spreading to 1° at ±60° steering angle as the effective aperture decreases.

One sounding per receiver beam is generated, the number of beams varying according to system and operating mode.

Narrow receiver beams provide spatial resolution and, as one sounding per beam is generated, a combination of a large number of narrow receiver beams provides the best opportunity to detect a target.

The along-track (projector) beamwidth contributes to the spatial resolution but also directly affects the along-track sounding density, which, in turn, may restrict vessel speed under certain conditions.

Sample Rate
The receiver sample rate (assuming a short enough pulse length is used) defines the range resolution of a system, which is considered to be its ability to discriminate depth differences.

Water Depth and Ping Rate
The ensonified footprint on the sea floor from which a single sounding is derived increases with water depth.
The need to wait for the acoustic round-trip time prior to the next acoustic transmission is directly related to water depth and swath angle, the two of which determine the maximum slant range.

The SeaBat systems in general are designed to ping as fast as possible for any given range scale.
The water depth and consequent ping rate combined with vessel motion and speed are the determining factors in the eventual along-track sounding density.

Vessel Motion and Speed

Whilst the operator has little controlover vessel motion, vessel speed is an important factor. The LINZ specifications require three hits along track and three across track for a given target size. Since the ping rate is related to the water depth and slant range, the operator has two choices: either to reduce the range scale to increase the ping rate or to decrease vessel speed to increase sounding density on the sea floor. Both of these approaches have time and cost implications.

Decreasing the range scale will truncate the swath, resulting in reduced coverage and a need to decrease line spacing, and decreasing vessel speed simply increases the time taken to perform the survey.

Vessel motion, particularly pitch and yaw, also have a significant effect on sounding density.

Comparison Surveys

In order to illustrate the advantages of using equi-distant beam spacing for this type of operation, compari-son surveys were carried out offSanta Barbara (CA, USA) in early September 2007 using a standard SeaBat 8125 and 7125 in two areas with a depth of 12 and 50m.

Shallow-water Area

The area chosen for this survey is off Santa Barbara harbour and is mostly flat mud. There is a rock-dump protected pipe running diagonally through the area from north-west to south-east.
The area is 500×500m and the water depth varies between 9.5 and 15m.

The surveys were run at between 6 and 6.5 knots with the sonar operating on the 35-m range scale, giving a ping rate of 10Hz (Figure 4). This translates to an along-track distance between successive soundings of approximately 0.5m.

Equi-angle Data

The area was surveyed with a SeaBat 8125 on 4 September 2007. The 500×500m area was surveyed using 14 north-south lines at a spacing of 38m providing overlap of approximately 10%.

A grid model with a 1×1m cell size was generated in PDS2000 and the data were imported. The colour table indicates hits per cell, ranging from 0 (red) to 100 (blue). It can be seen that the majority of the cells have 10–50 hits and that the outer edges of each north-south line have fewer hits than the centre section.

The LINZ specifications call for three hits across AND along track. Terramodel was used to examine individual soundings in detail and results showed that, in a 1×1m cell in the outer section of the swath, the three hits along-track criterion is met but the sounding distribution across track does not meet the criteria.

Taking the inner section of the same swath area, the along-track density remains similar but the across-track density is significantly higher with approximately six across-track soundings in the same 1-m cell.

Of a total swath of approximately 40m, only the centre 30m meets the LINZ criteria.

In order to increase the across-track sounding density, the overlap between successive lines could be in-creased. The area surveyed was 500×500m and was covered by 14 lines, each of three minutes duration, giving a total of 42 minutes. Increasing overlap to achieve the required number of hits would increase the number of lines to 17 and the time to 51 minutes, an increase of approximately 20%.

It should be noted that the LINZ overlap specification for Special Order areas calls for 200% coverage, which would double the time required from 42 to 84 minutes.

SeaBat 7125 Equi-distance Data

The same area was surveyed on 5 September 2007 with SeaBat 7125 operating in equi-distant mode with 512 beams. The 500×500m area was surveyed using 10 north-south lines at a spacing of 48m providing an overlap of approximately 10%.

In the case of SeaBat 7125, the entire swath, typically 50m, meets the LINZ criteria.

Deep-water Area

The area chosen for deep surveys is a flat area of mud, approximately 3 miles south of Santa Barbara. Water depth in the area varies between 48m in the north and 55m in the southern part.

The surveys were run at a reduced speed of approximately 4 knots due to weather. Observed vessel motion was similar to that in the shallow water area.

The sonars were operated on different range scales due to the sector coverages. The 8125 was operated on the 120-m range scale producing a ping rate of 3Hz and the SeaBat 7125 on the 150-m range scale with a ping rate of 3.4Hz.

The area was surveyed with a SeaBat 8125 on 4 September 2007 (Figure 7). The 500×500m area was surveyed using five north-south lines and one east-west crossline at a spacing of 110m providing an overlap of approximately 10%.

A grid model with a 2×2m cell size was generated in PDS2000 and the data were imported. The colour table (Figure 8) indicates hits per cell, ranging from 0 (red) to 25 (blue). It can be seen that the majority of the cells have approximately 10 hits and that the outer edges of each north-south line have fewer hits than the centre section.

On 5 September, the same area was surveyed with the SeaBat 7125 and the same process was used to gener-ate a hit count model (Figure 9). Note that, due to the increased sector coverage, line spacing was increased to 185m.

From the SeaBat 8125 swath of approximately 170m, only the centre 80m had sufficient density to meet the across-track requirements.

In order to meet the criteria, line spacing would need to be reduced from 110m to approximately 80m, with the resulting increase in survey time.

The entire useable SeaBat 7125 swath met the requirements.

Conclusion

The adoption of more stringent survey specifications, particularly those regarding target detection, place much greater demands on survey planning and operations than ever before, which translate directly into the time and, of course, cost of such operations. The results are summarised in Table 2.

Advanced features available in the SeaBat 7125, such as equi-distant soundings, narrow beams and high beam density, all contribute to improving efficiency with the resulting cost savings.
In the shallow-water survey area, using SeaBat 7125 and the LINZ specifications resulted in an increase in efficiency of approximately 20%.
In the deep-water area, again with SeaBat 7125 and LINZ, an increase in efficiency of approximately 25% may be expected.