

Helicopter-Borne Nearshore Survey System, a Valuable Tool in Difficult Survey Areas

Cheryl Burke Pollock

U.S. Army Corps of Engineers
Coastal Engineering Research Center
Waterways Experiment Station
Vicksburg, MS, 39180 U.S.A.



ABSTRACT

POLLOCK, C.B., 1994. Helicopter-borne nearshore survey system, a valuable tool in difficult survey areas. *Journal of Coastal Research*, 11(3), 959-966. Fort Lauderdale (Florida), ISSN 0749-0208.

Because the U.S. West Coast can present hazardous conditions in which to conduct field monitoring studies, new techniques must be developed to aid in data collection. The U.S. Army Corps of Engineers (USACE) Portland District has developed a bathymetry collection system which can operate in high energy wave conditions or dangerous environments inaccessible to other types of survey methods. The new system is capable of traversing steep grades, passing safely through the surf zone, operating on land, over structures, or in water with remarkable accuracy. A marked lead line suspended from a helicopter is used as a survey rod. A survey crew on shore uses a total station and a level to measure and location of the helicopter and the depth of the seabed.

The USACE Portland District has been using this system since 1960. In the summer of 1990, this Helicopter-Borne Nearshore Survey System (HBNSS) was compared for accuracy and repeatability to the USACE Coastal Research Amphibious Buggy (CRAB) at the USACE Waterways Experiment Station, Coastal Engineering Research Center (CERC) Field Research Facility in Duck, North Carolina.

ADDITIONAL INDEX WORDS: Bathymetry, profiling, Total Distance Station, helicopter surveying.

INTRODUCTION

Bathymetric surveying can be difficult and hazardous near coastal structures, in regions of high seas and surf, or over drastically varying topography. Using the HBNSS, safe and reliable measurements can be made of coastal seabeds and structure relief.

In 1960, the USACE Portland District developed the HBNSS (CRAIG and TEAM, 1985). The purpose of the system is to measure bathymetry (seabed elevations) to depths of -12 m and relief of rubble mound structures along the Pacific coast. The survey helicopter is fitted with a 26-meter weighted cable graduated like a surveyor's rod. A shore-based surveyor's level is used to read elevations, and horizontal positioning is obtained using a shore-based electronic total distance station (TDS) aimed at a cluster of prisms mounted on the helicopter. Because of the maneuverability of the helicopter, this survey system can operate safely and accurately in most hazardous regions during severe wave events and in most weather

conditions, although heavy fog or winds in excess of 50 km/hr will prevent operation of the helicopter. Bathymetric and structure relief data gathered via HBNSS have been used to compare shoreline and nearshore bathymetric change and to aid in design and documentation of structure placement and stability. A video prepared by the USACE Portland District and CRAIG and TEAM (1985) gives a detailed discussion of this system and its equipment.

DESCRIPTION

The HBNSS requires a helicopter crew, a helicopter equipped with an undercarriage-pulley system tailored for travel of the survey cable, a prism cluster (Figure 2), the survey cable, a land crew, a TDS, a surveyor's level, and range poles. The land crew is composed of four members: TDS operator, level reader, data recorder, and a person to assist and evaluate the angle of the cable. The survey cable consists of three parts: a weak link leader cable with a 27-kg main weight, the graduated cable, and the travel cable with an 18-kg counterweight (Figure 2).

Range poles and the TDS are set up on the



Figure 1. The CRAB and HBNSS survey systems operating side-by-side.

beach along the profile line. The helicopter supporting the cable system moves offshore to the end of the profile line (Figure 3). Line of sight on the range poles and radio communication with the TDS operator help the pilot to position the helicopter at the appropriate distance offshore while remaining on line. The pilot lowers the helicopter until the main weight reaches the seabed and the cable tension goes slack. The level operator continuously views the graduated portion of cable through the level as the cable is lowered. At the instant the cable goes slack the level operator reads the elevation to the nearest tenth of a foot and relays this information to the data recorder. At the same time, the TDS operator has the TDS aimed at the prism cluster mounted on the helicopter and takes a reading of the horizontal location of the helicopter, also providing the information to the data recorder. After the position and depth have been hand recorded, the pilot, notified by radio, raises the helicopter so that the weight clears the water surface and moves forward

on the range line toward the beach to the next point, where the process is repeated.

Time Efficiency

The distance between points is determined by density requirements of the survey. Each point requires 5 to 10 seconds to read instruments and record data. The greater portion of the time is spent maneuvering the helicopter between points. Approximately 60 points can be surveyed along a 900 to 1,600 m long profile line in 20 minutes. Time required between lines range from the few minutes necessary to reposition the helicopter to the time required to move the TDS and level to a new position, if needed. In comparison, the CRAB which travels at 5 km/hr requires approximately 45 minutes for each profile line. Time required between lines is again a function of CRAB travel time and distance between lines and/or time required to reposition the TDS (BIRKEMEIER, 1991).



Figure 2. Helicopter, undercarriage, and survey cable.

Accuracy and Repeatability

In July 1990, a field study evaluated the HBNSS for accuracy and repeatability under the Monitoring of Completed Coastal Projects Program's Siuslaw River work unit. The Coastal Engineering Research Center Field Research Facility's CRAB survey system was used as a control. A detailed discussion of the CRAB system (including its ac-

curacy and reliability) is presented in BIRKEMEIER and MASON (1984). Additionally, CLAUSNER *et al.* (1986) present a similar field comparison of the CRAB with other nearshore survey systems. In the previous comparison study, a Zeiss Elta-2 TDS provided the horizontal and vertical position of the CRAB. During the July 1990 study, a Geodimeter 140T self-tracking TDS replaced the Zeiss. The Geodimeter 140T increases the number of



Figure 3. Helicopter, range poles, and total station on profile line.

points that can be reasonably collected along a line, yielding an almost continuous profile. This increased the quality of the CRAB survey and the likelihood that positions of soundings taken using the HBNSS would closely coincide with those of the CRAB.

The July 1990 field test was designed to evaluate the HBNSS's ability to survey a known profile, stay on line, and produce repeatable results.

Test-day conditions were characterized by small, long-period waves and moderate to low longshore currents. Repeatability tests included five repetitive surveys on two profiles of diverse topography. For these tests, the reference profile shape was determined by two repetitive surveys by the CRAB. Therefore, accuracies are relative to the accuracy of the CRAB. Figures 4 and 5 show the envelope of four HBNSS surveys superimposed

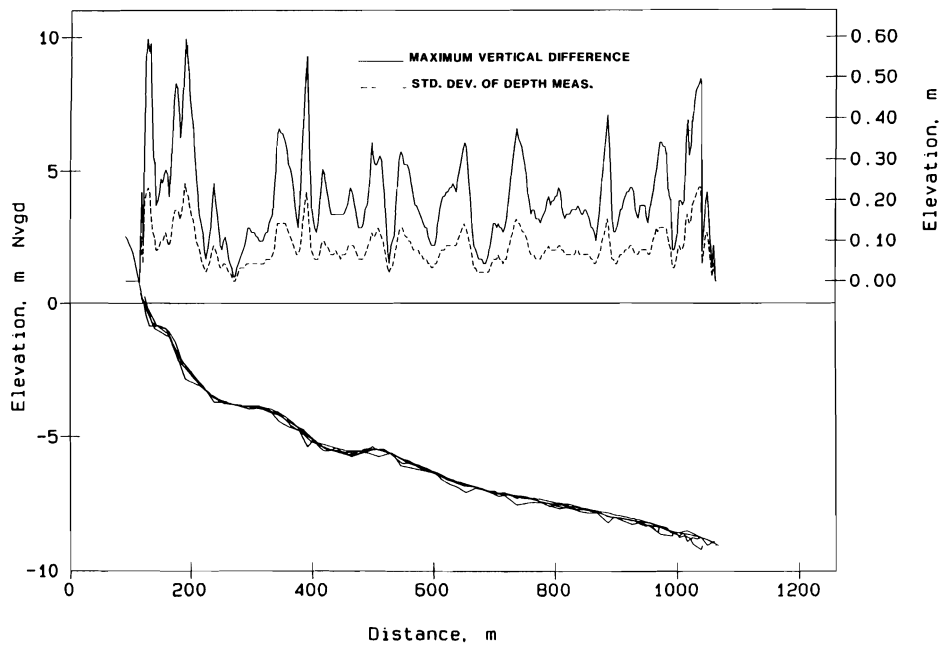


Figure 4. CRAB survey and four HBNSS surveys of line 100.

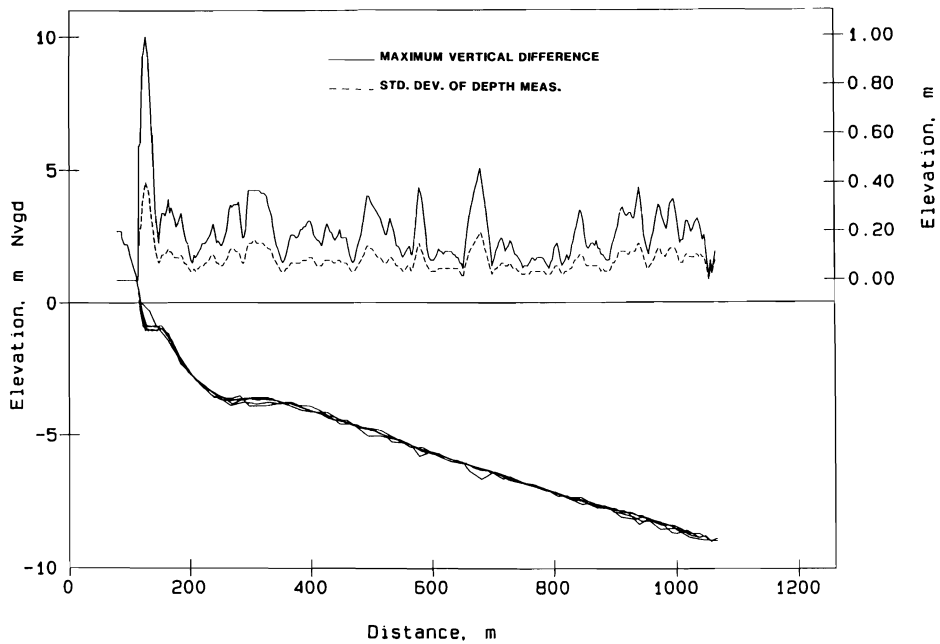


Figure 5. CRAB survey and four HBNSS surveys of line 200.

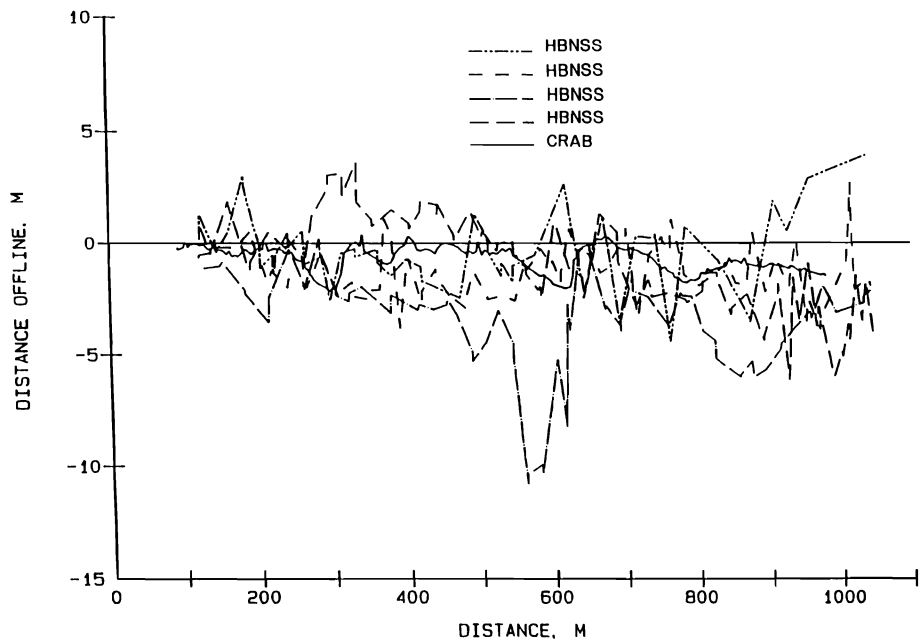


Figure 6. Distance off line of CRAB and four HBNSS surveys.

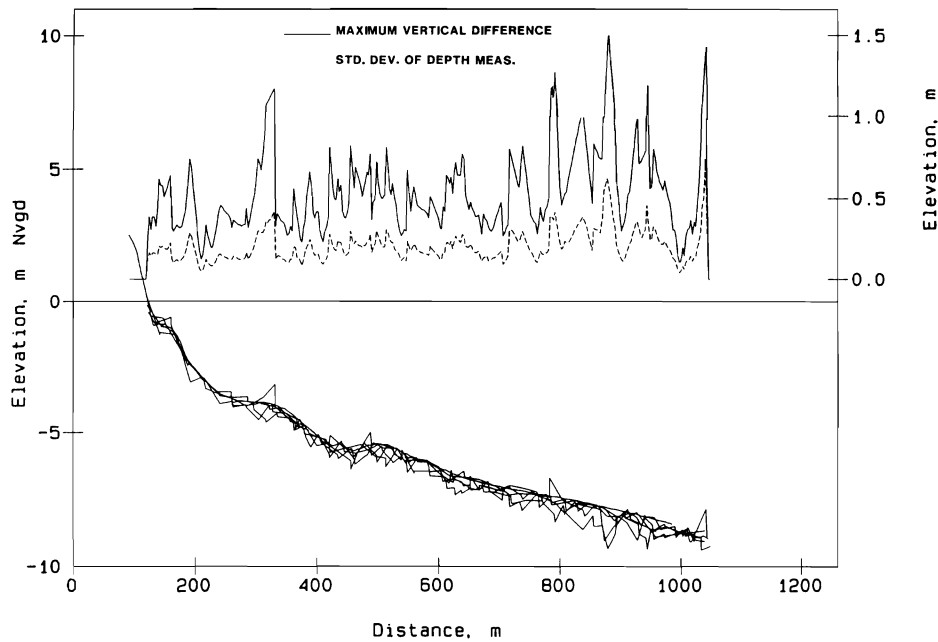


Figure 7. Profile Comparison of TDS automatic tracking method and CRAB profiles.

over one CRAB survey for test profile lines 100 and 200, respectively. The upper portion of the figures present the envelope of maximum vertical deviation and standard deviation along the profile between all four HBNSS measured profiles and the CRAB measured profile. These figures indicate that the HBNSS provides accurate and repeatable measurement of the true profile shape. For profiles 100 and 200 respectively, the absolute maximum vertical deviation is 0.6 m and 1.0 m, the mean vertical deviation is 0.1 m and 0.07 m, and the mean standard deviations are 0.06 m and 0.05 m. The larger deviations occur where points were missed over the bars and can be eliminated by increasing the density of sampling. Tests of vertical accuracy differences between a fathometer survey and a CRAB survey conducted by CLAUSNER *et al.* (1986), indicate maximum deviations of the fathometer to be 0.67 m and mean vertical deviation to be 0.27 m in regions greater than 300 m offshore.

Figure 6 shows the position of the CRAB and four helicopter surveys and profile line 100. For the most part, the helicopter remained within 6 m of the profile line and the CRAB within 3 m of the line. Greater deviation from the line for both the CRAB and the helicopter occurred farther offshore. The large deviation in the one helicopter survey reflects communication problems between the pilot and land crew. Accuracy increases with crew experience.

Possible Automation Improvements

Coupling the TDS with a data logging computer would allow the horizontal positions to be recorded automatically. The level would still be used to read elevations, but these values could be directly entered into the computer as they are taken.

A step further in automating HBNSS would be to attach a ring of prisms on the cable and use a tracking TDS such as the Geodimeter 140T linked to a data logger. At the instant the cable weight reaches the seabed, the TDS operator marks the data point. Horizontal positioning and depths would automatically be entered into the data file. Marked data points would compose the profile. This process could reduce the land crew to one member. As a side effort, this process was briefly examined during the experiment. Because the TDS was capable of tracking the prism ring, the TDS operator did not view the helicopter through the TDS scope, but with the naked eye. Marked points indicate when the helicopter terminated its de-

scend opposed to when the lead line became slack. Therefore, marked points lagged the actual event, reflecting a deeper than actual profile. Figure 7 shows a profile collected using the tracking TDS. Refinement of this method would certainly improve accuracy and reduce time and cost requirements during actual operation and in data reduction.

For both automation methods, a complete digital record (ASCII file) would be available at the end of each profile. This would circumvent the need to digitize hand recorded field data, thereby reducing potential for error. Additionally, the TDS and level would not need to be moved from the start of one profile line to the next if the lines are within instrument ranges.

SUMMARY AND CONCLUSIONS

The Helicopter-Borne Nearshore Survey System can be used to measure seabed and structure topography in hazardous regions where other survey vessels cannot operate safely. Soundings can be taken quickly and are accurate and repeatable. Developed in 1960 by the USACE Portland District, the system has been in use along the Pacific Coast since that time. In 1990, the HBNSS was tested at the USACE Coastal Engineering Research Center Field Research Facility for speed and accuracy. Using the CRAB as the standard, mean vertical error for the HBNSS is 0.08 m compared to that of a fathometer reported to be 0.27 m.

ACKNOWLEDGEMENTS

This study was conducted under the Monitoring of Completed Coastal Projects Program of the United States Army Corps of Engineers at the Waterways Experiment Station. Great appreciation goes to Mr. William Birkemeier and Ms. Wendy Smith who arranged and conducted the CRAB surveys and provided insight and attention to detail during the test and data analysis. Thanks also to the USACE, Portland District, especially Messrs Steven Chesser, Keith Team, Robert Craig, and to Mountain Air Helicopter Co. for their assistance in arranging and conducting the study. Permission to publish this paper was granted by the Chief of Engineers.

LITERATURE CITED

- BIRKEMEIER, W.A., 1991. *Personal communication*.
BIRKEMEIER, W.A. and MASON, C., 1984. The CRAB: A

- unique nearshore surveying vehicle. *Journal of Surveying Engineering*, 110, 1–7.
- CLAUSNER, J.E.; BIRKIMEIER, W.A., and CLARK, G.E., 1986. Field comparison of four nearshore survey systems. *CERC Miscellaneous Paper No. 86-6*, U.S. Army Engineers Waterways Experiment Station, Vicksburg, Mississippi.
- CRAIG, R. and TEAM, W. 1985. Surf zone and nearshore surveying with helicopter and total station. *Proceedings of U.S. Army Corps of Engineers Surveying Conference*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.
- USACE PORTLAND DISTRICT, 1985. USACE Video—“Helicopter System”.