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Report on the SHARPS system used on the *Queen Anne's Revenge*

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INTRODUCTION:

In August 1997, Richard Lawrence, Director of the North Carolina Division of Archives and History Underwater Archaeology Unit, contacted me about using the ECU Maritime History Program's Sonic High Accuracy Ranging and Positioning System (SHARPS) on a shipwreck site tentatively identified as the *Queen Anne's Revenge* (*QAR*). The device is an acoustical mapping system using the speed of sound to measure distance. The objective for using SHARPS on the *QAR* was to determine its practical application as a mapping tool relative to other techniques. For several weeks two students and two staff members (Ryan Harris, Wayne Lusardi, Steve Sellers, and Steve Brodie) under my supervision experimented with SHARPS in Minges Pool at ECU and learned how to operate the system software. SHARPS was deployed on the *QAR* site on October 14 after preparing the site the previous day.

DESCRIPTION:

The Program's SHARPS system was built in 1993 by Marquest, Inc. It consists of three stationary transceivers and a diver operated trigger transceiver that are connected to a control box on the surface by coaxial cables. The cables are deployed from spools stored in two large shipping boxes. The system is designed to use an IBM PC-AT computer to collect and store data transmitted to the control box. We used a BSI portable computer, and an IBM clone, during site operations. The SHARPS system operates on a DOS based software package with limited menu functions. It includes programs to check the system's operating condition, calculate the speed of sound in water, track and collect targets, and allow editing of collected data

In operation, SHARPS uses trilateration with slant ranges, or direct distance measurements, to locate target points. Three stationary transceivers are set up in a net around the site and a fourth mobile transceiver is carried by the diver. The stationary transceivers, designated A, B, and C are set up to create a Cartesian XYZ coordinate grid. The A and B transceivers create a baseline on the X axis while C describes the Y axis. The SHARPS software also accepts transceiver elevations or depths in order to supply a vertical Z coordinate for three-dimensional data collection. The diver with the mobile transceiver, or trigger, places the transceiver's tip on the target point and presses the trigger to emit a sound pulse. As the pulse travels away from the target at a known speed, the three stationary transceivers record the signal. The program software uses the speed of sound and the time it takes for the sound pulse to travel between the diver's transceiver and each stationary transceiver to calculate the distance in metric units between the transmitter and three receiver units. The tracking program then iterates the three measurements to find the best fit convergence point. This point is the XYZ coordinate for the target within the grid created by the A, B, and C transceivers. The process is repeated for each target point the diver "shoots".

The diver trigger has two operating modes and both were used on the QAR. The diver can, at their discretion, press the trigger to generate a signal or the transceiver can operate in a continuous pinging mode. In continuous mode, the pulse rate is set by the computer operator who also decides which data points to collect on the computer. During three initial pool experiments, switch problems were experienced in the diver trigger which caused the trigger to operate intermittently. This problem, however, did not significantly hinder data collection. Experience showed that with the transceiver operating in continuous mode, the computer operator could toggle the data collection on and off just as easily as the diver pulling the trigger underwater.

Surface to diver communication equipment is invaluable for coordinating the activities of the diver and computer operator when using the SHARPS system. Communication is used in all stages, from deploying cables and transceivers, to specifying data collection points and then confirming that data on each point that has been collected.

During the pool experiments several data files were collected and later used in the graphics editor program of the SHARPS software. These files allowed us to practice with the program and learn how to manipulate data. We downloaded SHARPS files into AutoCAD Release 13 for final editing and adding titles and text.

FIELD USE ON THE *QAR:*

Two days, October 13 and 14, were set aside to experiment with the SHARPS system on the QAR site. The system was deployed from the UNCW research vessel *Seahawk*, a 29 foot boat with a protected cabin and large work deck. A Honda generator powered the computer and control box. Participants included Frank Cantelas, Steve Sellers, Ryan Harris, and Cathy Fach from ECU, Richard Lawrence from UAU, and Gerry Compeau, Captain of the UNCW research vessel.

When we arrived north-south and east-west baselines were in place on the site, crossing near the center of the ballast pile. The ends of the baselines were fastened to PVC pipes which were hydro-jetted into the bottom to provide anchors. The pipes create datum points at the four cardinal points of the compass. A fifth pipe, placed just northwest of where the two baselines cross, is the central site datum near the middle of the ballast pile. After an initial dive to inspect the ballast and datum pipes, we decided to divide the site into quadrants for mapping purposes. The ballast pile has enough vertical relief to create shadows for the acoustical signal generated by the diver trigger. In order for SHARPS to operate accurately the diver trigger must be in line-of-sight with all three stationary receivers. If even one transceiver is blocked, the operating software will not collect the point. Mapping the site in quadrants alleviated some of these problems.

Deployment of the SHARPS system began in the late morning on October 14. The northeast quadrant contained very discrete and identifiable cannon and anchors and was chosen as the first mapping area. Transceiver A, placed on the central datum near the ballast pile, could be used in all quadrants while the other two transceivers would be moved around as mapping progressed. For mapping the northeast quadrant, transceiver B was placed on the east datum to create an east-west baseline between A and B, while transceiver C was placed on the north datum. This baseline did not overlay the established baseline because the central site datum was not located where the north-south and east-west baselines crossed. It was positioned in the northwest quadrant.

A late start and intermittent cable problems limited the time available to use the SHARPS system on October 14. In the roughly five hours during which SHARPS was used several system problems were solved and two data files collected from the northeast quadrant. The other three quadrants were not mapped. The first data file was collected by Steve Sellers as the diver trigger operator with Richard Lawrence designating targets. Ryan Harris operated the computer, Kath Fach handled surface operations, and Frank Cantelas coordinated data collection. Data 1 file contained point data such as the muzzle and cascabel on a cannon and each end of an anchor shank. This information can show spatial orientation and relationships among large linear artifacts on the ballast pile. During post processing, this data was found to be suspect. Table 1 lists the XYZ coordinates for each point collected in this file with their associated artifact described under comments. A graphic representation of these points is shown in Figure 1. In this drawing “transA” is the center site datum and also the origin point for the Cartesian grid created by the SHARPS system. The location and orientation of some of the cannon and anchors determined by SHARPS did not agree with their actual positions as observed on the site and recorded by more traditional methods. Although some of the SHARPS points appear accurate, there was no time available to resolve discrepancies.

Data File 2 was collected by Richard Lawrence as the diver trigger operator with Cathy Fach assisting. On this dive, the diver trigger was set on continuous transmit mode and the outline of artifacts were “painted” to provide a graphic outline. This technique worked very well to portray major artifacts shown in Figure 2. It also revealed anomalous and inaccurate data points which generally appeared far from the actual mapping area. These points are shown as a dispersed dot pattern west of anchor A2 in Figure 2.

Once data is collected the SHARPS software has limited ability to edit and manipulate data files. Each target point is assigned a number with a corresponding XYZ coordinate. The graphical editor allows the operator to manually delete individual targets and change the orientation of the Cartesian coordinate grid. To further manipulate data and print final graphics, files were imported into AutoCAD Release 13.

CONCLUSIONS:

SHARPS is a complicated recording system that requires time and experience to use successfully. Dive time on the QAR included 1 hour and 45 minutes for SHARPS setup (not including the first day’s dive to reconnoiter the site), 2 hours and 53 minutes to collect two data files, and 7 minutes for breakdown. Roughly 25 hours were spent processing the collected data. For the people involved in using the system, *QAR* was the first practical field application of SHARPS.

Numerous observations were made regarding the system’s use including:

- The system hardware should be tested on the boat before deployment on the site. We were plagued by intermittent cable problems and had to replace a cable during the dive to create Data File 1.
- The DOS based software was last updated in 1993. The operating manual is brief, not very thorough, and would benefit by discussing practical applications of the SHARPS system.
- The system must be deployed and removed from the site each day because the cables must be connected and disconnected on the surface. If the connectors were changed to Marsh Marine Plugs (which can be disconnected underwater) the cables and transceivers could be left in place on site. It would also resolve the problem of trying to replace the transceiver in exactly the same spot each day.
- Acoustical shadows or line-of-sight problems can create erroneous target points. Generally the system cannot collect a target point unless all three stationary transceivers receive a signal from the diver trigger. The rough vertical relief of the QAR site causes many acoustical shadows. This problem could be alleviated by attaching a plumb bob to the trigger’s transceiver tip with a short string to raise the transceiver tip above the obstacles. The Z coordinate for the target would be adjusted accordingly to account for the length of the plumb bob. Acoustical shadows were also caused by the trigger operator and stray divers traveling through the area.
- The main site datum, where Transceiver A was positioned creating the origin of the SHARPS Cartesian grid, was not placed directly on the north-south baseline. This skewed the SHARPS grid in relation to the baseline site grid as

demonstrated by the northwest cant of the baseline in Figure 3. This figure was created by the web for Windows program using distance measurements between the four site datums. Placing the center site datum on the baseline would eliminate problems encountered when trying to match the two baselines.

Results of this field test were mixed. Efficiently operating a complex system such as SHARPS takes experience gained by trial and error. This first field application pointed out many problems which, when resolved, will shorten the time needed to deploy the system and collect data. Data File 2, presented as Figure 2, provided the best results. Although not everything in the northeast quadrant was mapped, it only took an 88 minute dive to map this area by "painting" the artifacts with the transceiver. During this period the divers spent much of their time avoiding acoustical shadows. SHARPS is certainly not a quick fix when considering the time needed to process and edit data after it is collected. Future application of the system on *QAR* will depend on the needs of the project, carefully weighing the benefits against problems experienced on the site.

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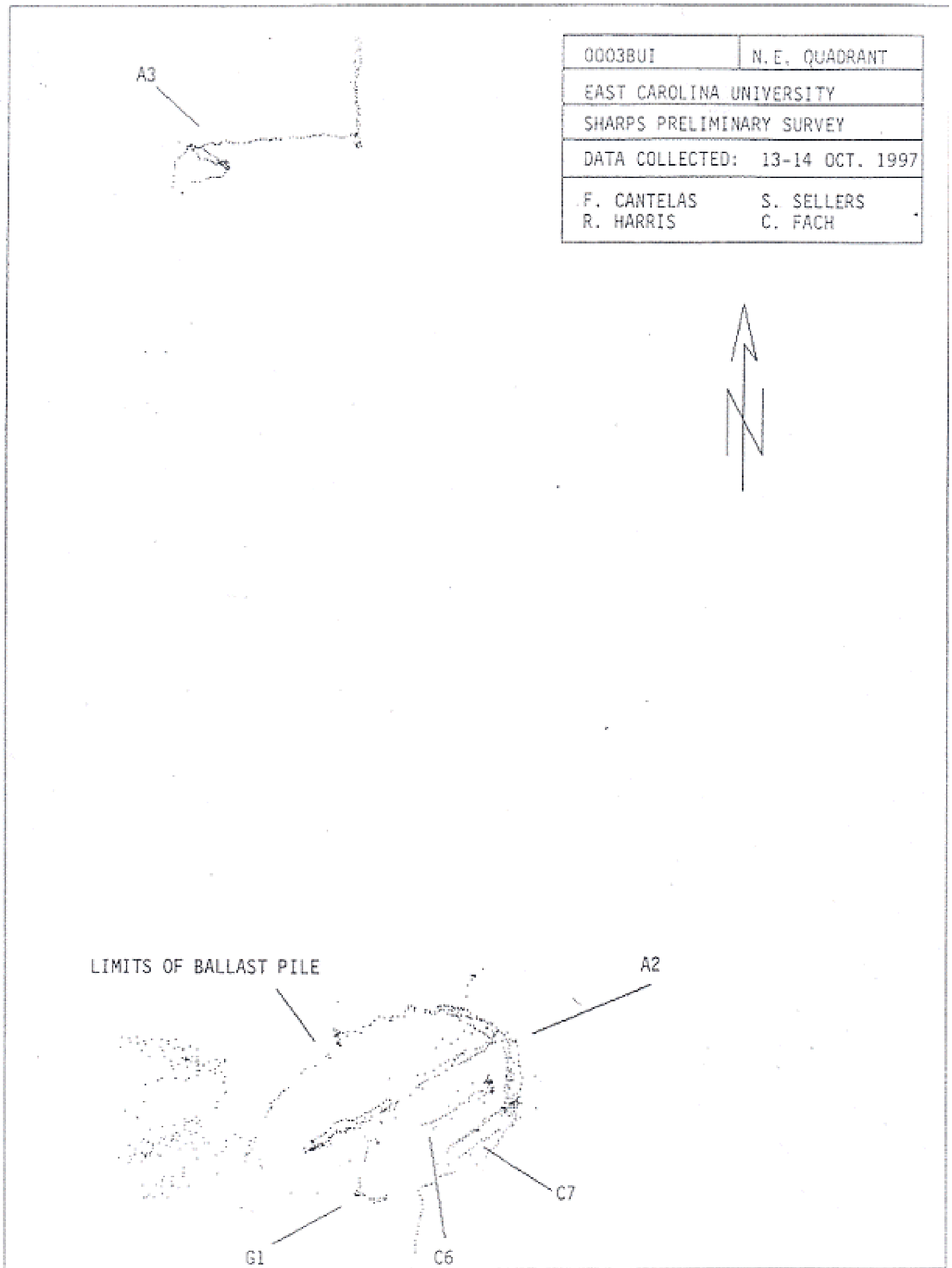
SHARPS PRELIMINARY SURVEY (TRIAL #1)	
EAST CAROLINA UNIVERSITY	
DATA COLLECTED: 13-14 OCT. 1997	
F. CANTELAS	S. SELLERS
R. HARRIS	C. FACH



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N.E. QUADRANT
EAST CAROLINA UNIVERSITY
SHARPS PRELIMINARY SURVEY
DATA COLLECTED: 13-14 OCT. 1997
F. CANTELAS
S. SELLERS
R. HARRIS
C. FACH
N
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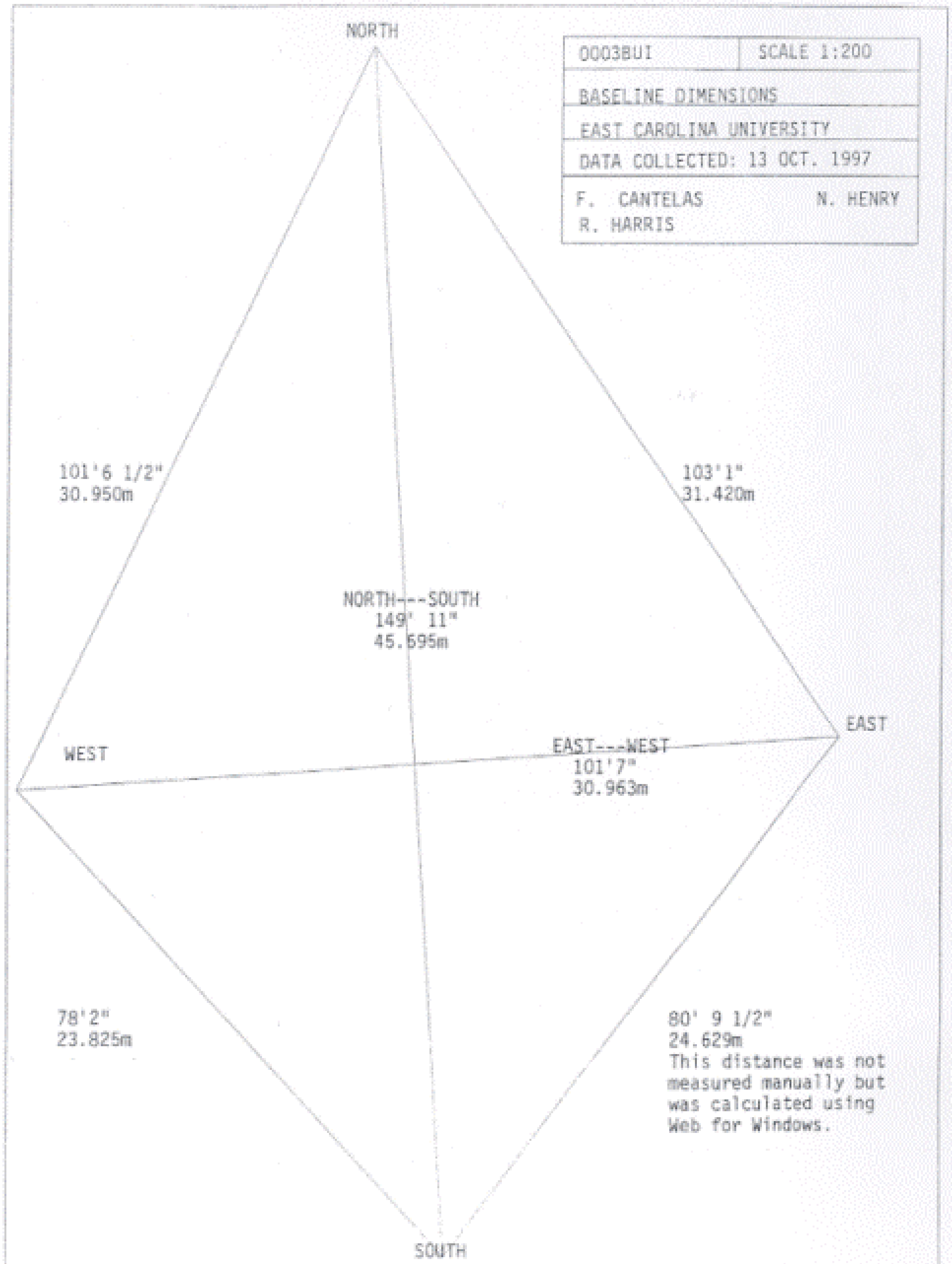
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SCALE 1:200
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EAST CAROLINA UNIVERSITY
DATA COLLECTED: 13 OCT. 1997
F. CANTELAS
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30.950m
103'1"
31.420m
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149' 11"
45.695m
EAST
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EAST---WEST
101'7"
30.963m
78'2"
23.825m
80' 9 1/2"
24.629m
This distance was not measured manually but was calculated using Web for Windows.
SOUTH