International Hydrographic Review, Monaco, LVIII (2), July 1981

A STUDY OF FUTURE DEPTH RECORDER REQUIREMENTS

by Dr. Lloyd C. HUFF (*)

Paper presented at the NOS Hydrographic Survey Conference, January 1980, Gaithersburg, Maryland, and published in the "Proceedings of the NOS Hydrographic Survey Conference".

ABSTRACT

A discussion of the needs and requirements of the National Ocean Survey with respect to future hydrographic survey depth recorders. A summary of the functional specifications recommended by the study team is also presented.

*
* *

In April 1979, the Director of the National Ocean Survey (NOS) directed the establishment of an NOS study team to conduct investigations to determine the functional specifications for a replacement shallow water depth sounder.

At the initial organizational meetings of the team, efforts were made to establish a philosophy for the study and a methodology for conducting it.

Somewhat in keeping with the recent popular "All you wanted to know about..." books, the study team members each contributed lists of questions, the answers to which they felt were essential to anyone who wanted to specify a hydrographic survey depth sounder. These questions were condensed into basic topics which were divided among the study team members for investigation and resolution. The bulk of the team meetings were devoted to detailed discussion on the various topics as the members reported their findings, frustrations, and future direction. This framework proved to be highly successful. Individual members worked up certain issues for which they had the technical background and

(*) Engineering Development Office (OA/TE2), NOAA, Rockville, Maryland 20852, U.S.A.

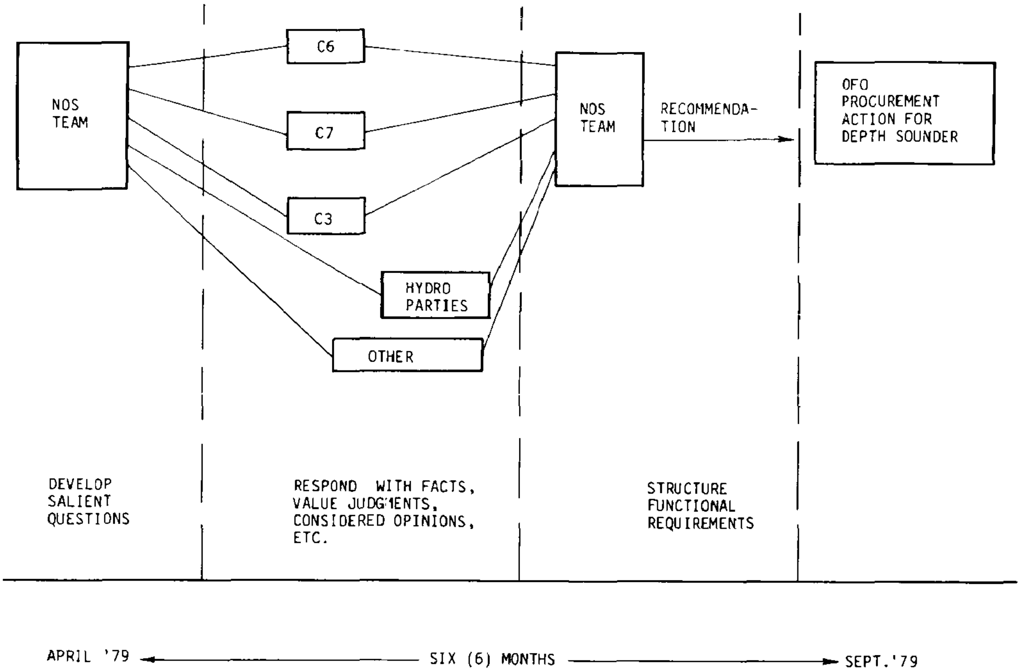

FIG. 1. – Study team process schematic.

experience; they then presented the issue, discussed it, and strived to achieve a consensus from the entire study team. In this way positions, both pro and con, on the issues were discussed relative to the advantages, disadvantages, and general consequences or system impacts of espousing a particular recommendation.

Figure 1 shows the process in schematic form. The team developed salient questions and sought answers from a variety of sources, who responded quickly with value judgments, considered opinions, etc. Many NOS hydrographers responded to a questionnaire that was developed to obtain their input to the study.

The NOAA ship *Whiting* contributed to the study by assisting in the determination of acoustic noise characteristics of a Type 1 launch. The NOAA Ship *Rainier* and the Naval Postgraduate School assisted by making available early results of the multiple beamwidth and multiple frequency tests. Many individuals within NOS assisted by providing input and critical reviews on portions of the study report.

The study was scheduled for completion in September 1979; however, this date was not met. The complete report which documents and supports the recommendation is forthcoming within a short time following this conference.

One of the first topics to be discussed during the studies was "Why is a replacement necessary?" There were several factors which indicated that a replacement may be necessary. Primary among these was the aged condition of the present systems, many of which were purchased 8 or more years ago. Another important topic addressed was "Why not just purchase a newer version of the Ross or Raytheon units which NOS is presently using?" To this question came the answer that there were multiple non-trivial reasons why NOS should strive for a system with operating and performance capabilities that could only be achieved with systems which had multiple frequencies and/or beamwidths.

NOS charting responsibilities, present and future, require improvement in present survey systems and techniques for acquiring and processing sounding data in support of changing uses for nautical charts, as well as scientific and engineering research and development.

NOS has established the need to modernize and update the coverage of their chart series. As a means of meeting these needs, NOS is introducing automated techniques in data handling, processing, compilation, and production in order to reduce the time interval between data acquisition and dissemination of new charts to the using public. The basic purpose of the shallow water depth sounder is to provide accurate data for use in both nautical charts and bathymetric maps. Nautical charts serve to instruct mariners as to the dangers to surface navigation, particularly within coastal waters. To construct nautical charts, the most shallow depths recorded by a depth sounder are emphasized to stress the navigational hazards. Bathymetric maps, however, are intended to instruct one in the physical shape on the bottom. To construct a bathymetric map, both the peaks and deeps recorded by a depth sounder must be given equal importance in representing bottom features.

The survey requirements on data for both these nautical and bathymetric purposes are closely allied with regard to shoaling features. In either instance, the field hydrographer should further develop an area, as prescribed by the hydrographic manual, when there are reasonable indications that shoal features might exist which have not yet been directly under the survey vessel. Regardless of whether a sounding represents a peak or deep, the accuracy, both vertical and horizontal, of the information supplied to a cartographer remains the same for the production of a bathymetric map.

Therefore, high resolution data which are appropriate for bathymetric mapping of an area also satisfy nautical charting needs. Higher resolution of the bottom acoustic return is one of the reasons why the hydrographic community has been moving towards greater and, in some cases, exclusive use of narrow-beam high frequency sounders. It achieves high resolution data through negative impact on survey efficiency.

It appears that NOS, having primarily emphasized that a sounder should accurately measure the depth of water directly beneath the transducer, may have reduced its capability to locate shoal features and items of relatively small cross-sectional areas such as rock pinnacles, wrecks, etc., in a reasonable amount of time.

Most narrow-beam echo sounders have one basic limitation in that they give no information on either side of the launch track line. This shortcoming, which may be significant in the proper development of an area, can be overcome by operating a broad-beam system in conjunction with the basic narrow-beam echo sounder. This allows for much greater information to be obtained about the bottom while obtaining a high resolution delineation of the bottom required by the hydrographer. In the proposed dual frequency depth sounder, additional potential information is obtained because the broad-beam transducer is also a lower frequency than the narrow-beam sounder.

Historically, depth sounder recorders were designed so that echoes from a sequence of transmission pulses could be conveniently correlated by a trained observer to obtain a rapid visual check on data confidence and to recognize any individual echoes that varied significantly from the normal, as well as patterns within the echoes that were characteristic of certain bottom features. This sort of subjective interpretation of echo information requires presentation of the total echo returns.

The amount of information one might glean from a fathogram depends on the size and shape of the footprints, pulse length, transmission frequency, and the resolving ability of the graphic recorder. There are several commonly observed features of bottom echoes. These include groups of echoes, each having the same length as the outgoing pulse, but with distinct arrival times, in which case part of the echoes might break into short crescent-shaped sequences. The crescent sequences are interpreted as being a series of echoes from highlights on the bottom. When an echo sequence breaks up into more or less well-defined crescent sequences followed by fainter patchy returns, a trained observer can estimate the roughness of the bottom. Higher roughness elements reveal themselves by more prolonged crescents. Reading fathograms for this extra information can provide a hydrographer in the field with the impetus to further develop an area around a track line that has shown reasonable indications of shoaling.

On the other end of the scale of information that can be gleaned from a fathogram lies a vast area related to deposits that are intermediate between muddy water and muddy seabeds and occur as a dense, soupy layer above the bed. This phenomenon is well known in harbors and ports that are located at the mouth of a river. The first echo return comes from the surface of the fluid mud followed by a stronger and longer echo return that comes from underlying cohesive mud. In this instance, the character of the fathogram trace is heavily dependent on the frequency of acoustic transmission and the pulse length. Since the floating mud tends to have a featureless upper surface, the shape and size of the footprint are of little importance. Errors in true depth that occur from using this first echo might have been acceptable for nautical charts because they defini-

- SIMULTANEOUS DUAL FREQUENCY OPERATION OF NARROW BEAM, HIGH FREQUENCY AND BROAD BEAM, MEDIUM FREQUENCY
- ALL SOUNDINGS IN UNITS OF METER WITH A RESOLUTION OF 0.01 METER

MEDIUM 20-30 kHz	30-45°,	-10dB BEAMWIDTH
HIGH 100 kHz	7.5-10°,	-10dB BEAMWIDTH

FIG. 2. – Major characteristics of proposed depth recorder.

Scale No.	Depth range (meters)	Pulse length (millsec)	Pulse rate PPM	Automatic chart speed cm/min
1	0-20	0.12	600	16 cm/min
2	15-35	0.12	600	16 cm/min
3	30-50	0.12	600	16 cm/min
4	40-80	0.25	300	8 cm/min
5	70-110	0.25	300	8 cm/min
6	100-140	0.25	300	8 cm/min
7	120-200	0.50	150	4 cm/min
8	180-260	0.50	150	4 cm/min

FIG. 3. – Depth recorder scale characteristics.

tely cause mariners to exercise greater caution. The errors are, however, intolerable for bathymetric maps because the featureless top of the fluid mud masks the real features of the bottom.

A survey of sediment types over the 1980-84 primary survey areas in the Pacific, Atlantic, and Gulf coasts was conducted using the bottom type annotated on nautical charts and from published literature. It was found that there is a complete cross-section of bottom types in the 1980-84 priority survey areas, from sand-gravel bottoms to very low density mud and grass-covered areas. There are large, mud-covered areas where potential low-density layers exist on all three coasts. It was concluded that the replacement depth sounder required both high resolution capability and the presentation of total echo returns. The former is for use by an on-line computer or automatic data logger, and the latter is to preserve information that may be obtained from the fathogram by human scrutiny.

- PROBABILITY $\geq$ 0.95 OF DETECTING A BOTTOM WITH SCATTERING STRENGTH $\geq$ -45 dB/m^2
- FALSE DIGITIZATION ON NOISE WILL OCCUR ON NO MORE THAN ONE DEPTH SCAN OUT OF ONE THOUSAND DEPTH SCANS

BOTH OF THESE APPLY TO ALL RANGES BETWEEN 0.3 AND 260 METERS UNDER BROAD BAND NOISE CONDITIONS AT THE TRANSDUCERS OF

57 dB RELATIVE TO 1 MICROPASCAL IN A 1 Hz BAND AT THE MEDIUM FREQUENCY

30 dB RELATIVE TO 1 MICROPASCAL IN A 1 Hz BAND AT THE HIGH FREQUENCY

FIG. 4. – Performance specifications.

RECORDER

- LINEAR RECORDING ON DRY ELECTROSTATIC PAPER IN

  SEVEN (7) SHADES OF GREY

- LARGE SCALE RECORD

  0.1 METER DEPTH RANGE/MILLIMETER OF CHART

  SPAN (UP TO DEPTHS OF 50 METERS)

- SELF GENERATED CHART SCALE (41 LINES)

- AUTOMATIC ANNOTATION OF OPERATOR CONTROLS

- ANNOTATION OF CHART WITH POSITION NUMBERS

- FOUR DIFFERENT DISPLAY MODES

FIG. 5. – Chart paper recording characteristics.

RECORDER

- THERE WILL BE FOUR DISPLAY MODES FOR THE DEPTH

  INFORMATION AS FOLLOWS :

  1. DIGITIZED POINT RECORD OF HIGH FREQUENCY ECHOES;

  2. DIGITIZED POINT RECORD OF MEDIUM FREQUENCY ECHOES;

  3. DIGITIZED POINT RECORD OF HIGH FREQUENCY ECHOES AND ANALOG PRESENTATION OF TOTAL ECHOES FOR MEDIUM FREQUENCY ECHOES;

  4. ANALOG PRESENTATION OF TOTAL ECHOES FOR MEDIUM FREQUENCY ECHOES.

- THE CHART WILL BE DIVIDED INTO TWO SECTIONS, ONE FOR

  DISPLAY/SOUNDING INFORMATION AND THE SECOND FOR

  DISPLAY OF OPERATING STATUS AND VESSEL HEAVE INFORMATION.

FIG. 6. – Chart paper recording characteristics.

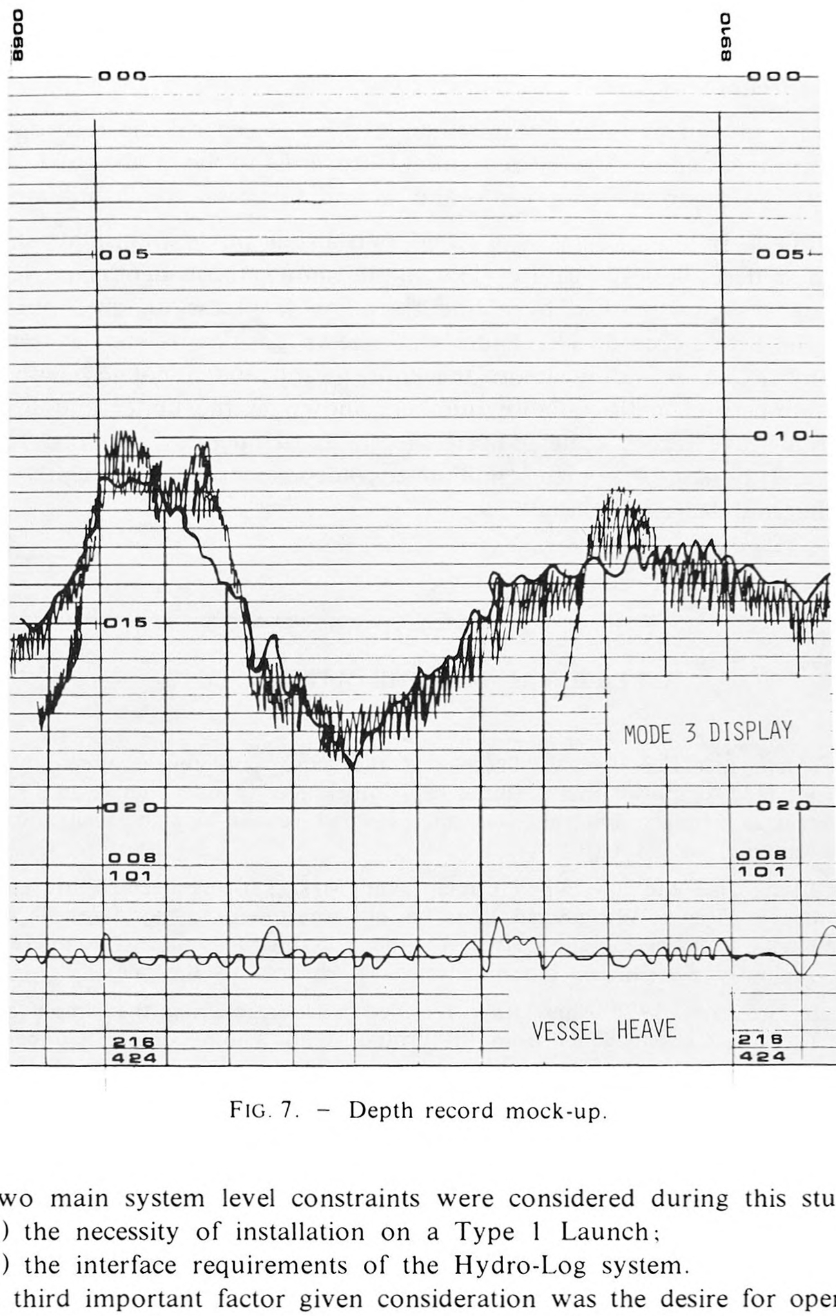

FIG. 7. – Depth record mock-up.

Two main system level constraints were considered during this study :
(1) the necessity of installation on a Type 1 Launch;
(2) the interface requirements of the Hydro-Log system.
A third important factor given consideration was the desire for operating a launch vessel heave measurement system in conjuction with the depth sounder.

With what was deemed to be proper consideration for the physics involved in acoustic depth sounding, the NOS operating environment, and the market availability, the team recommendation is being made for a depth sounder with the characteristics outlined in figures 2 through 6. The soundings will be made in units of meters with resolution of 0.01 meter and an accuracy $\leqslant 0.1$ meter + 0.25 percent of measured depth.

The sounder will operate with eight scales as shown in figure 3. The specification for the performance is given in figure 4 as two probabilities : real detection and false detection. The system performance was evaluated under the assumption of bottom scattering. This is more conservative than the assumption of bottom reflection.

Figures 5 and 6 outline requirements to be placed on the recorder portion of the depth sounder. A digitized point record is to be a digitized dark line starting at the digitized depth value and extending down for 1 millimeter.

Figure 7 is a mock-up of a fathogram using mode 3 display showing a peak and a deep bottom feature. The figure shows those depths passed to the Hydro-Log as being marked by a line extending from the digitized point record through the heave record. The figure also shows position reference points being marked by a line extending across the entire graph and annotated with position control numbers. The three-figure numbers shown at the upper and lower portion of the heave record scale indicate the status of operator controls. The heave scale would remain 0.1 meter/millimeter independent of the depth scale on which the sounder is working.

A PERSONAL MEMOIR WITH A TWIST

I first met Captain I.V. TEGNER at the 1962 Conference, after which we corresponded. Again we met at the 1967 Conference. In due course, in 1973, we met again in Monaco but this was after he had retired to Cap d'Ail and I had joined the staff of the IHB.

Then came the day when Captain and Mrs. TEGNER decided to return to Copenhagen to live. We invited them to our apartment to say farewell and he arrived with a parcel containing two Australian boomerangs and a woomera. They were obviously the genuine hand-made article. He told us the tale.

In the early 1920's his father received a letter, bearing the simple address "Mr. TEGNER, Copenhagen", from his brother with whom contact had been lost since he went to Australia many years before. The brother's one request was to make contact with the family before he died. He gave no address ! The family detailed off the young Lieutenant TEGNER to go to Australia and make contact with his uncle.

With a dilly bag and a burberry he set off and, for reasons he did not tell me, proceeded on a 'hunch' to Queensland and to a town called Maryborough. There, in the electoral rolls, he found a TEGNER living at Mount Molloy, a small mining town inland from Cairns. He persuaded a bullock driver to take him along on his routine supply journey and, after literally swimming flooded streams, he reached Mount Molloy and found Uncle TEGNER, old and part blind, with a faithful friend, an Australian aboriginal "tracker".

After two weeks, his mission achieved, young TEGNER took his leave for the long journey back to Denmark. As he left, the old aboriginal handed him two real boomerangs and a woomera, the stick used to lengthen the arm for spear throwing.

From that day on, these artifacts went everywhere with TEGNER, including Greenland and, presumably, Spain, hanging always, he told me, on the bulkhead of his cabin, until he was about to leave Monaco for Copenhagen. As he gave them to us he said, "I think it is time they went home !"

A.H.C.