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BOTTOM TOPOGRAPHY VEHICLE FEASIBILITY REPORT.(U)

MAY 68 H T LOESER

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(9) Technical memo.,

U. S. NAVY UNDERWATER SOUND LABORATORY
FT. TRUMBULL, NEW LONDON, CONNECTICUT

(6) BOTTOM TOPOGRAPHY VEHICLE FEASIBILITY REPORT

(10) BY

H. T. LOESER - NAVAL ARCHITECT

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BOTTOM TOPOGRAPHY VEHICLE

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BOTTOM TOPOGRAPHY VEHICLE

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ABSTRACT

1.0 Introduction

The objective of the bottom Topography Vehicle system is to provide a vehicle for measuring relatively small variations of the bottom in rugged terrain at depths to 20,000 feet at sea in any area of the world, except areas covered by ice. Since the tolerances on vertical definition are particularly tight, this vehicle system requires advanced state-of-the art technology.

ABSTRACT

2.0 Description of Approach to Design

2.1 Basic Requirements

The requirements of the vehicle are set forth in a memo from Code 2111.5 (A. W. Ellinthorpe) to Code 2300 (M. Milligan) Ser. 2111-45 of 19 Feb. 1968.

Briefly paraphrasing this memo, the parameters are:

2.1.1 Develop design of a system for acquisition of a statistical description of the amplitude irregularities of the ocean floor.

2.1.2 The vehicle will operate in track areas where large scale bottom variations are known.

2.1.3 The geographical areas of chief interest are rough: The midatlantic ridge is a prime example.

2.1.4 Depth capability should be at least 20,000 feet; a 15,000 feet limit would be a significant limitation; a 10,000 feet limit would make the vehicle practically useless.

2.1.5 The resolutions sought are as follows: About 2 feet horizontally, and about 0.2 feet vertically.

2.1.6 The pitch, roll, yaw, and heave of the vehicle must be kept small.

2.1.7 The heave motion can be taken into account if it can be measured independently.

2.1.8 If optical means are used for sensing the bottom, the vehicle must be no more than about 20 feet from the bottom; if acoustical means are used, the vehicle must be no more than 200 feet off the bottom.

2.2 Survey of Existing Capabilities

The first approach to the solution of the acquisition of the bottom topographical information was to canvass the oceanographic community to determine if this capability or near capability existed. The initial results of this survey are given in Appendix I. At the early stage of the investigation at which the survey was made, optical methods were considered necessary, since then, the advantage of acoustic methods of contouring have changed the requirements to those given in Paragraph 2.1 above. Similarily, the operating depth has been increased to 20,000 feet as noted.

Briefly, the result of the survey showed that no one had performed a survey of the nature required. In addition, the only people with a demonstrated capability approaching our needs was Scripps Inst. of Oceanography's Marine Physical Laboratory with their Deep Tow.

Direct communication with the persons involved and a trip to their laboratory resulted in several significant findings.

1) The towed vehicle had proven quite satisfactory for their needs

2) The towed vehicle was good in roll stability but pitched. This pitching action did not affect the performance relative to their application. However, it was apparent that it would be significant in the topography application.

3) The problems of data transmission and control had been satisfactorily solved.

It was apparent that no easy solution to the problem existed and although several companies were interested in helping us develop the system, none was especially qualified. Therefore, work continued on a further definition of a system for performing the work.

2.3 Comparison of Vehicle Types

2.3.1 General - Several types of vehicles were considered for this application. They are:

Manned Submersible

Unmanned Acoustically Guided Submersible

Unmanned PreProgrammed Submersible

Unmanned Tethered Self-Powered Submersible

Towed Body

A discussion of these types follows:

2.3.2 Manned Submersible - The overriding consideration in regard to this type of vehicle is depth. Those manned submersibles which can operate to 20,000 feet have such limited horizontal range as to be useless for this application. Those with sufficient horizontal range, such as the Aluminaut, cannot operate at that depth. NOTE: The Aluminaut is expected eventually to be able to operate at her design depth of 15,000 feet.

Other consideration such as the high cost of operating these submersibles, the difficulty in providing surface support facilities all over the world also weigh heavily against their use.

An additional, significant, consideration is the hazardous manner in which the submersible would be operated when fulfilling its mission. A mission in which the submarine operated so close to the bottom in terrain as rugged as is postulated would be extremely hazardous if not foolhardy at this stage in their development.

2.3.3 Unmanned Accoustically Guided Submersible - An example of this category is the SFURV vehicle operated by the Applied Physics Laboratory of the University of Washington. Its maximum operating depth is 12,000 feet with an endurance of 5 hours at six knots. The principal advantage claimed for this type of device is that it is not affected by impulses carried down a towline from a pitching, rolling and heaving ship.

This type of vehicle has several disadvantages in the proposed application. One disadvantage is that it presently is depth limited. Two factors control the depth limitation, construction of its pressure hull and range of its acoustic command system. Both of these disadvantages may be overcome; however, this will require considerable time and effort.

In addition, its direction instrument is caged gyro which is accurate for only relatively short periods of time, after which its reading is meaningless. The direction of the vehicle may be inferred from the tracking system which has a maximum range of 15,000 feet, and is highly dependent on sound conditions; however, this method is limited in its use and not reliable. A magnetic compass will be affected by any magnetic material aboard and by stray magnetic fields from equipment. Its reliability is highly dependent on the final design of the vehicle.

The vehicle in contouring the bottom will of necessity change its depth to follow the shape of the bottom surface. A vehicle such as this will, therefore, be assuming various dive and rise angles which, in effect, are as troublesome as disturbances from a surface tow line.

Other disadvantages are: difficulty in launch and retrieval, and delay in receipt of data until retrieval of vehicle.

2.3.4 Unmanned Pre-programmed vehicle - This type of vehicle has most of the disadvantages of the acoustically guided submersible with the added disadvantage that no control of the vehicle is possible if it departs from its preprogramed path. In addition, no variations can be made to this path if so desired.

2.3.5 Unmanned Tethered Self-powered submersible - This type of vehicle may receive its primary power either from self contained batteries or from its tether. While incurring the penalty of an attachment to the ship, this type, however, reaps a number of advantages.

The problems of launch and retrieval are greatly simplified. Data may be sent up the tether in real time, so that immediate evaluation is possible. Commands may be given to the vehicle reliably at great depths, the surface ship fathometer may be used as an aid to piloting the vehicle over the terrain.

However, this type still has the problem of dive and rise angle while contouring as well as the disturbing influence of the ships motion. In addition, it has problems similar to the manned and unmanned free submersibles in that the structural hulls for obtaining buoyancy and strength to withstand the pressures at 20,000 feet are difficult to design construct and maintain.

2.3.6 Towed Body - The use of a towed body solves most of the problems discussed above and appears to offer the best solution at this time.

The towed body may be lowered to 20,000 feet. It is not depth limited because it does not have to be self-buoyant.

It has an indefinite endurance because it receives its power and propulsion from the tow line.

It has no navigation problem because its track is the same as the ships track within the requirements of the system.

It provides the operator with real time data.

Its location including depth is controlled directly from the surface without the requirements for actuators on the vehicle.

Because it is towed, it is possible to give the vehicle an oblate spheroid shape which permits it to contour without requiring a rise or dive angle. This shape also permits it to accept disturbances from the surface without causing it to pitch or roll. It is necessary to carefully engineer this vehicle; however, good results may be expected if it is done properly.

The launch and recovery problems are minimized because the vehicle is attached to the tow line.

The closest prototype to the towed vehicle system required for this job is the Deep Tow vehicle built for and operated by the Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego, California.

This vehicle operated at about 1-1.5 knots at about 15-16,000 feet although its collapse pressure is 19,000 feet and its cable length is over 25,000 feet.

Therefore, it may be stated that considerable experience with towed vehicles for bottom surveys exists.

3.0 Problem Areas

3.1 General

Several problem areas in the Topographical Survey Vehicle system are inherent in the tight specifications, great depth, open waters and rough bottom terrain to which this system must comply. These problem areas may be stated as follows:

A) Provide an echo sounder having a beam angle 0.3 degrees to give a horizontal resolution 2 feet, and an accuracy within 0.2 feet when 200 feet from the bottom.

B) Determine depth changes of vehicle within less than 0.2 feet at a depth of 20,000 feet (1/100,000 scale)

C) Avoid pitching and rolling motion while contouring the rough bottom

D) Determine pitch and roll angle within 0.3 degrees

E) Avoid contact with the bottom in rough terrain where 1000 foot cliffs are expected.

F) Determine instantaneous speed of vehicle.

G) Resist sea pressure - 10,000 PSI

H) Provide data converters, multiplexers and required electronics to send data to the surface.

I) Display the data aboard ship in usable form for the operation

J) Provide suitable control for the operator to control the depth of the vehicle.

3.2 Primary Bottom Sensor

The primary sensor can be a narrow beam high frequency projector using a frequency of 1.0 megaherz. This projector is approximately two feet in diameter and one and a half feet high. It will be able to form a narrow beam and to resolve the distance to the bottom within 0.2 feet as required above.

A gyro-stabilized platform for this projector was considered. However, the size, weight and power drain of such a platform increases the cost and complexity of the system by several orders of magnitude. It is therefore proposed to continue the investigation without this platform and to make the vehicle as inherently stable as possible, compensating for small motions by sensing them at the vehicle and correcting the data as required.

The high frequency of, and the importance of narrow beam performance to the primary sensoring means that careful attention must be paid to the accustic window through which the beam penetrates the shell of the vehicle. A brief investigation indicated that a 1 millimeter thick membrane would provide a window with acceptable loss.

3.3 Differential Depth Gage

3.3.1 General

To make the data from the bottom sensor meaningful it is necessary to know the vertical position of the vehicle relative to some known horizontal datum within the accuracy of the bottom sensor and to keep this instrument from drifting more than about 0.75 feet in several thousand seconds, i. e. 30 to 45 minutes.

Only two references are available at these depths, echo sounding to the surface and pressure due to depth of water. Both of these are subject to variations in the water column above them. Echo sounding at that depth does not have the required accuracy. Therefore, the feasibility of the program depended on finding depth gages which could give the required accuracy.

A diligent search turned up three candidates. These are:

1. Vibratron - United Control, Redmond, Washington
2. Quartz Pressure Transducer - Bisset Berman, San Diego, California
3. Differential Pressure Gage - MPL-Scripps I.O. San Diego and USN/USL

3.3.2 Vibratron

The vibratron works on the principle of a vibrating wire stretched between two points one of which is a diaphragm subject to water pressure on one side. As the pressure increases, the diaphragm deflects, changing the vibration frequency of the wire. The pressure is read indirectly by counting electronically, the number of cycles of the wire in a given period. These instruments are capable of extreme accuracy. For example, Mr. Pederson of APL who has used this instrument claims an accuracy for this instrument which is greater than required for this project. The instrument is subject to drifting due primarily to temperature vibrations. Various devices have been used to overcome this difficulty. The device is a stock item costing about $900 each. With circuitry and case the cost of the instrument might reach $1500.

3.3.3 Quartz Pressure Transducer

This instrument has been built by the Bissett Berman Marine Division in San Diego. It operates on the basis of a condenser formed by two quartz cylinders an inner cylinder which is not under pressure, and an outer one which is. The pressure on the outer cylinder changes the diameter and thus the capacitance of the condenser. The condenser forms part of a resonating circuit and its changing capacity changes the frequency of the circuit. This may be measured very accurately. The resolution of this instrument is specified at ±0.001% which for 20,000 feet becomes ±0.2 feet which is the precision required. The drift due to the temperature is less than that specified for the vibratron.

3.3.4 Differential Pressure Gage

The Marine Physical Laboratory, S.I.O. has built and tested a differential pressure gage which works on the principle of trapping a sample of sea water at a reference pressure, and then obtaining differential pressure readings based on that sample. They claim resolution within the desired precision of this project. USL has obtained plans of this device and is investigating it.

3.4 Vehicle Dynamics

3.4.1 General

The vehicle for carrying this equipment has imposed on it a peculiar set of requirements. It must remain steady in pitch and roll while moving in directions which vary from straight down to forward to straight up: i.e. The water flow past the body can swing in a 180° arc, but the body must not rotate. In addition, it must achieve a vertical orientation for its bottom sensor to operate correctly and it must align itself with its forward motion so that the collision avoidance sonar may operate correctly.

3.4.2 Hydrodynamic Shape

The most natural shape for meeting the requirements of varied flow direction is a circular body. This body presents the same shape no matter which direction the flow comes from. In addition to water flow forces, other dynamic forces of the tow line gravity and body inertia are at work.

For the vehicle to seek a vertical orientation, its center of gravity must be below its point of support. This may be done by proper location of the bridle or tow line termination.

In order to align the body with the forward motion, it must have a greater drag aft of its C.G. than forward. This conflicts with the earlier requirements for a point symetrical body.

The first apparent solution is to separate the two requirements by putting the fins for forward alignment on the bridle where they may orient the body without affecting its hydrodynamic symmetry. However, it may be better to put a small fin on the trailing edge of the body to avoid the mechanical complications of the bridle fin.

3.4.3 Vortex Generation

The body must also be designed to avoid the vibration due to vortex shedding from the main body and also the tow cable. USL experience indicates that the vibration of the cable may be eliminated by fairing on the lower 100 feet of cable.

The elimination of vortex vibration of the main body will be a matter of proper design and test. Since this is tied in with the rest of the hydrodynamic design, the body design must be handled as a unit.

3.5 Orientation Instrumentation

The need for accurate information on the orientation of the downward looking echo sounder was pointed out in Para. 3.2. To obtain this information, two pendulums are needed, one to sense roll and the other to sense pitch angle. Such an instrument is manufactured by Humphrey Instrument Co. The instrument is accurate to $\pm 0.2^{\circ}$ of angle and has a 1/3 second period. This type of instrument should not present a difficult problem. For test purposes, a magnetic compass will indicate how steady the vehicle holds a bearing.

3.6 Collision Avoidance

3.6.1 General

An essential capability of the system is to operate in rugged bottom terrain. The criteria for collision avoidance is that the system has the capability of avoiding collision with a 1000 foot vertical cliff immediately in the path of the vehicle.

3.6.2 Collision Avoidance Sonar

The method of avoiding the terrain is to monitor the bottom ahead of the vehicle in two ways. First, by the use of a fathometer from the surface ship towing the vehicle. This will give the operator a picture of what the vehicle is going to traverse. By means of an indicator on the recorder, the location of the vehicle could be given to show the operator the kind of terrain the vehicle is about to encounter.

The second method of monitoring is the use of a forward looking collision avoidance sonar. The echo sounder looks forward of the vehicle and indicates any object within range. A forward range of 300 to 500 feet is considered adequate for this application. The readout of this instrument will be presented to the operator.

The collision avoidance sonar has not been selected. However, this item is not considered to be critical.

3.6.3 Winch Requirements for Avoidance

The operating speed of this system is approximately 1.0 knot. This corresponds to 1.69 ft/sec. The time available for inhaul in the case of avoiding a 1000 feet cliff if inhaul is started 250 feet from the base is 250 ft/1.69 ft/sec. or 150 seconds. Since the amount of cable which must be hauled in is about 1000 feet, the inhaul speed should be 1000/150 = 6.6 ft/sec. or 400 ft/min. This is within the capability of winches built for oceanographic purposes. With advance warning provided by the ship's fathometer, the operator could be prepared for such occasions and would not need maximum hoist speed.

3.7 Speed Indicator

In order to provide a horizontal base line for the data, it is necessary to know the speed of the vehicle. The average speed is the speed of the ship. However, the ships speed made good over the bottom depends on current, in addition, the bottom vehicle may be varying in speed in some cyclical fashion. Since this affects the data, it is necessary to determine the actual speed of the bottom vehicle. This may be done in several ways. A doppler sonar system may be used to sound the bottom and detect the doppler shift of the return or a water velocity meter may be placed aboard the vehicle to determine its speed through the water. This could be similar to current meters now in use.

3.8 Encapsulation of Equipment

The vehicle will be subject to the very high water pressure found at 20,000 feet. To attempt to make the vehicle watertight would create a very difficult problem to solve.

Therefore, the outer configuration will be made of fiberglass and only the individual electronic or instrument packages will be housed in pressure containers. These containers may be relatively small and easy to fabricate. They will be connected with external connectors.

3.9 Cable

The tow cable is one of the major items governing the performance of the system. It is, however, not possible to design the cable until the weight and drag of the vehicle are known.

Nevertheless, several points may be discussed. At least 30,000 feet and possibly as much as 40,000 feet of cable will be required depending on the weight and drag of the vehicle and the weight and drag of the cable. This will require high tensile steel on the order of 250,000 PSI to 300,000 PSI breaking strength. The specific gravity of steel is about 7.9. Since the specific gravity of sea water is about 1.02, the weight of steel in sea water is about 6.9×62.5 #/ft^3. A one sq. inch wire would therefore weigh $\frac{6.9 \times 62.5}{144}$ #/ft=3.00 #/ft. Therefore, it could support about 100,000 feet of itself in water. However, when operating at sea a good factor of safety is required. In addition, the steel must support the copper conductors and the towed body. It appears that with a steel armored cable the best factor of safety obtainable is $\frac{100,000}{20,000} = 5.0$. However, when the copper and towed body are considered, this factor of safety will probably be halved.

When this point is considered, the problems of cable life and wear become important. This is especially dependent on the sheave sizes used for handling the cable. Conversely, if we must use existing traction winches, it is important to keep the cable diameter to a minimum. This means, of course, keeping the size and weight of the vehicle to a minimum.

The pertinent coefficients are:

T = weight of vehicle - pounds IN WATER

D = drag of vehicle - pounds

W = weight per foot of cable - #/ft

d = diameter of cable - inches

The ratios being considered at this time for a 1.0 knot speed are:

T/D	10 to 12	TERMINAL VEL > 12'/sec
T/d	2,000 to 2,500	
W/d	.4 to 1.2	
T/W	1,500 to 6,000	

Although this appears to be a wide range of values, preliminary calculations indicate that with these values the trail distance will not be so great as to require complicated maneuvering by the surface ship and the tow staff angle will be close enough to the vertical to permit vertical motion without pitching the vehicle.

The use of high W/d and T/D values will permit the system to be used at slightly higher speeds and should be used if possible.

3.10 Ship Board Handling Equipment

At this time, insufficient information is known to discuss the shipboard handling requirements. At present, the objective is to make the system compatible with existing equipment aboard AGOR's.

3.11 System Control

The system will be controlled from a console which will have on-off switches, and data display, and recording and controllers as follows:

1. Power to winch - lower-stop-hoist
2. Power to system - on-off
3. Depth of vehicle - digital to 1/100 feet, 7 digits
4. Distance from Vehicle to bottom - digital to 1/100 ft - 6 digits
5. Ships fathometer - continuous recording with 4 hours visible
6. Roll angle - indicator
7. Pitch angle - indicator
8. Speed - indicator
9. Dist to ahead object - indicator
10. Spare locations for future use
11. Spare control space for adding controls to equipment such as to modify reference depth of depth indicator

or adjust tow staff. Approximately six controls should be provided for.

12. Bearing angle - indicator

4.0 Recommended Action

4.1 General

A review of the problem areas of the project shows that reasonable solutions appear to be available for all areas. However, before committing the project to procurement of a complete system, several areas deserve experimental confirmation of performance.

4.2 Hydrodynamic testing

It is recommended that several configurations similar to those shown in Appendix III be tested, first in model scale. These tests should then be followed up with at-sea tests of the most promising shapes. The test depth will depend on available facilities. A good test does not require full depth testing, however, that would be desirable.

4.3 Precision Pressure Meter Testing

Since this instrument is vital to the operation of the system, it is recommended that two and possibly all three types of meters be procured and tested in the laboratory to determine their resolution and drift. The most satisfactory instrument would then be selected.

4.4 Electronic Bread-Boarding and Test

To perform the above tests, it is recommended that the electronic package to be used be bread boarded and that a prototype system be installed in the Hydrodynamic test vehicle (para. 4.2). This will permit angular data to be obtained on the performance of the vehicle.

Similarly, bread board circuits would be prepared for testing and depth indicators.

4.5 Design

In parallel with the above tests, it is recommended that the vehicle and control console design continue so that shortly after satsifactory conclusion of the testing, the design may be completed.

4.6 Procurement

It is recommended that the type of procurement of the system be decided when the testing and design are complete and confidence in the system is established.

H. T. LOESER
Naval Architect

APPENDIX I

NAVSO 5216/5 (REV 11-66)
S/N 0104-904-1761

UNITED STATES GOVERNMENT

DEPARTMENT OF THE NAVY

Memorandum

DATE: 29 JAN 1968

FROM : H.T. Loeser

TO : A. Ellinthorpe

SUBJECT : Acoustic Range Bottom Survey Vehicle

1. In accordance with your request to obtain information on underwater vehicles for performing a fine grain bottom survey of the acoustic range area, I explored the capability of several well known ocean engineering companies and oceanographic laboratories.

2. I posed the problem as follows:

2.1 Two areas about 20 miles long and 5 miles wide are to be surveyed.

2.2 A high confidence factor is required for a statistical 2 dimensional auto correlation of this area.

2.3 Resolution of bottom objects as small as 1" is required.

2.4 Vertical accuracy of the movement of the vehicle is required to be within one foot of an established horizontal.

2.5 The operating depth will be between 2000 to 8000 feet.

2.6 Sediment penetration is needed.

2.7 The survey information is needed by summer 1969.

3. I discussed this problem with the following people:

3.1 Ocean Science and Engineering Inc., Washington, D.C., W.R. Bergman, A.C. 301-657-4222

3.2 Woods Hole Oceanographic Inst., Woods Hole, Massachusetts, Mr. Frank Omohundro, A.C. 617-548-1400

3.3 Ocean Systems Inc., Arlington, Va., Mr. Allen Beiber, A.C. 703-525-2800

3.4 Grumman - Ocean Systems, Mr. W. Tullio, A.C. 516-575-0574

3.5 E. G & G, Cambridge, Massachusetts, Mr. Robert Henderson, A.C. 617-267-9700

3.6 Naval Civil Engineering Laboratory, Port Hueneme, California, Autovon 8-898-3300, Mr. D. Ciani Ext. 5923

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3.7 Electric Boat Division General Dynamics, Mr. R.B. Zeigler

3.8 General Motors AC Electronics Defense Research Laboratory, Goleta, California, Mr. S. Momsen, A.C. 805-968-1011

3.9 Westinghouse - Ocean Research and Engineering Laboratory, Mr. Mel Hiller, A.C. 301-765-5613

3.10 Kelvin Hughes America Corporation, Annapolis, Md., Mr. H. Butt, A.C. 301-267-8103

3.11 Lockheed Marine Laboratory, San Diego, California, Mr. R. Worthington, A.C. 714-298-8245

3.12 Alpine Geophysical Associates, Norwood, New Jersey, Mr. H. Miller, A.C. 201-768-8000

3.13 Bell Laboratory, Whippany, New Jersey, A.C. 201-386-3000, Mr. B.T. Bogert Ext. 2996

3.14 Lamont Geophysical Laboratory, Palisades, New York, A.C. 914-EL9-2900

3.15 Hudson Laboratory, Dobbs Ferry, New York, Mr. P. Rona, A.C. 914-693-5800

3.16 Scripps Inst. of Oceanography, LaJolla, California, A.C. 7140 453-2000, Dr. Mudie Ext. 1091

4. The responses to my inquiry were mixed. It is apparent that although the requirements for this survey are very stringent several reputable organizations feel they can accomplish the job. I am very much aware of the gap between promises and performance. However, it appears that the U.S. has a developing capability in this field.

A brief summary of my findings follows:

4.1 Ocean Science and Engineering

Their search and recovery department would be interested in managing the survey. They feel it is definitely within their capability.

4.2 Woods Hole Oceanographic Inst.

Their capability centers around the deep submersible ALVIN. They would propose to use this vehicle with a camera and sonar suit. Operating at about 1 knot, it would take about three days to make a one line survey the length of the range. If about ten runs were satisfactory, each range would require a month to survey. Operations have been running at roughly $100,000 per month. However, there is a possibility that by 1969 ONR will be providing the basic costs for the vehicle and support catamaran and crew. Therefore the user will only be required to pay the operating costs that is,cost of expendables, overtime transit etc. They are presently developing a data sensor package which will make recordings at 2 second intervals of depth, salinity, and speed of sound.

4.3 Ocean Systems Inc.

They feel they have the capability. They will review the problem and call back.

4.4 Grumman - Ocean Systems

Not prepared to do this type of job.

4.5 E. G & G

This company is interested they have experience in this type of work and will call back with a more definite idea of how to do it.

4.6 Naval Civil Engineering Laboratory

This laboratory is trying to develop or find this type of survey capability. However, they feel the requirements of this survey exceed the present state of the

4.7 Electric Boat Division General Dynamics

The ocean engineering capability of this company does not approach meeting the requirements of this job.

4.8 General Motors Acelectronics

The DOWB is not yet fully tested and operational. They would use this vehicle if they did the job. At present, more information on the vehicle is needed by them before they could promise anything. They will consider the job.

4.9 Westinghouse - O R & E Laboratory

These people have what they consider an operational system which can do the job by towing a vehicle from a surface vessel. They will carefully consider the problem and discuss it later with us.

4.10 KelvinHughes

They do not perform surveys themselves but they do sell equipment. They will review their knowledge of the industry to suggest possible vendors of this service.

4.11 Lockheed Marine Laboratory

They have made 13 dives with Deep Quest. Its test depth is 8000 feet. They find they have very fine control. It is fitted out with a Ratheon doppler sonar log and Straza CT FM sonar which has a beacon ranging modification. They will call back.

4.12 Alpine Geophysical Associates

This company feels it can do the job. They will discuss it among themselves and call back.

4.13 Bell Laboratories

These people have never done a survey of this nature but suggested Westinghouse and Navoceano.

4.14 Lamont Geophysical Laboratory, Palisades, N.Y.

Mr. J. Ewing suggested calling Dr. F. Spies at Scripps Inst. of Oceanography. Also he heard that Navoceano had a device with this type of capability. He also suggested calling Mr. Peter Rona at Hudson Laboratories, A.C. 914-693-5800.

4.15 Hudson Laboratories, Dobbs Ferry, N.Y.

They have not taken bottom photographs. They used sidelooking sonar. They made a rough correction to surface ship position to determine approximately position of towed device. Their deep tow experience is not to the accuracy we desire. For high resolution bottom towed work they suggest we contact Dr. John Mudie at Scripps Institute of Oceanography.

4.16 Scripps Ins. of Oceanography

Scripps is using an accurately navigated towed vehicle called Deeptow they have not used a camera unit as yet. Their normal accuracy on recording depth is one fathom. However, by speeding up the recorder this may be improved to one foot in navigating relative to Beacons a representative accuracy is for 10 meters over a 5-10 mile course. The Deeptow can tow at about 2 knots. This device is described in the Journal of Underwater Acoustics. It we write a letter, we will receive additional information.

5.0 <u>Summary</u>

No one has performed a bottom survey of the type and to the accuracy desired by this project. The state of the art is improving, however. Therefore, it may be possible to obtain the information required almost as accurately as desired. Since sensors will be more accurate than the course keeping ability of a vehicle, additional data reduction may be required to convert the data to the desired baseline.

6.0 I will write Dr. J. Mudie for further information.

H.T. LOESER
Naval Architect

Copy to:
Code 2320
1100
2020

APPENDIX I
USN Tech Memo No.
2321-139-68

APPENDIX II

OUTLINE DESCRIPTION OF BOTTOM TOPOGRAPHY VEHICLE SYSTEM

1. System Requirements

1.1 General Requirements

This vehicle system is intended to be used for surveying the bottom of the oceans in water having a depth of up to 20,000 feet.

The principal purpose of the survey is to obtain a two dimensional, auto-correlation of the bottom surface. This, effectively means that the vertical variation of the bottom will be obtained as the vehicle moved over the bottom. The surveys will be made on whatever type grid is selected for operational reasons. However, for the purposes of this system, a quasi-orthoganal grid will be acceptable.

The areas which this system is intended to survey are extensive. For this reason, a relatively high transit speed and/or endurance is desired for making operational decisions. Similarly, continuous surveying is desirable without periodic stops for maintenance of the vehicle.

1.2 Specific Requirements of the System

(a) It shall be suitable for operation in any ocean not covered by ice

(b) It shall have a depth capability of 20,000 feet

(c) Its maximum speed will be at least 1 knot.

(d) It will carry a narrow beam echo sounder which will be used for accurately profiling the bottom. It is necessary that this projector be kept vertical or very nearly vertical at all times when it is in operation. Permissible motion of the projector is $\pm$ 1/6° ie. $\pm$10 min. of arc. Alternately, if the angular motion is slow, the maximum angle from the vertical is small ($\pm$ 10°). The motion of the projector may be compensated at the shipboard computer if the motion is known by installing an angle indicator on the projector or, if the projector is fixed to the vehicle, on the vehicle.

(e) The vehicle will operate between 250 feet and 10 feet of the bottom

(f) It will have a forward looking collision avoidance echo sounder

(g) The vehicle will be equipped with a differential depth gage or a very sensitive depth gage which will be sensitive to depth variations of 2.5 inches or less. If a differential depth gage is used, the gage must permit a vertical variation of 1000 feet before it required resetting.

(h) The collision avoidance system must be capable of avoiding a vertical cliff 1000 feet high in the part of the vehicle. This corresponds to an inhaul rate of 400 ft/min if the ship is proceding at 1 knot.

(i) The vehicle speed will be checked by a doppler sonar or current meter to determine if the vehicle is moving steadily over the bottom, and at what speed.

(j) The static and hydrodynamic balance of the vehicle and the nature of the tow cable and tow gear shall be such that ship movement in a state 5 sea will not cause angular motion of the bottom profiling echo sounder exceeding those given in item d above.

2. Subsystems

2.1 General

The Topography survey system is composed of the following subsystems which are briefly described below:

(1) Vehicle
(2) Survey instrumentation
(3) Communication
(4) Command system
(5) Data recording and analysis
(6) Retrieval and launching
(7) Cable stowage
(8) Maintenance

2.2 Vehicle:

The vehicle subsystem consists of the body or bodies in which the instrumentation is carried. It, of necessity, interfaces with most of the other subsystems and acts as a focal point of the total system.

Its features are:

(1) A hydrodynamic body which contains the required equipment. This body is to be hydrodynamically stable.

(2) Position and attitude sensors for use in survey data reduction.

(3) A collision avoidance system which looks forward to war of obstructions in the path of the vehicle.

2.3 Survey Instrumentation:

This instrumentation will obtain the information desired by the survey. It will consist of sensors, the back-up electronics and the pressure proof packages for containing this instrumentation.

The electrical output from the instrumentation will be fed to the communication system.

2.4 Communication:

The communication system will convey the signals from the sensors tc the survey ship and commands from the survey ship to the vehicle. These signals will probably be multiplexed. Therefore, the cable electronics and multiplexing and demultiplexing circuits will be part of this system.

2.5 Command:

The Command system will consist of the displays, command actuators and other equipment needed to accept the system operators commands and perform accordingly.

2.6 Data Recording, Analysis, and Display:

The data from the sensors will be conveyed via the communication system to the recording and analysis equipment. This equipment will record the data in permanent form for future analysis and also analyse such data as is required to be processed in real time.

2.7 Launching and Retrieval

This equipment will consist of the cranes, cradles, tractor winches, hydraulics, and other mechanical equipment which will accomplish the launching of the vehicle from the support ship, and its retrieval. It will also include equipment located on the vehicle if needed for this system.

2.8 Cable Stowage:

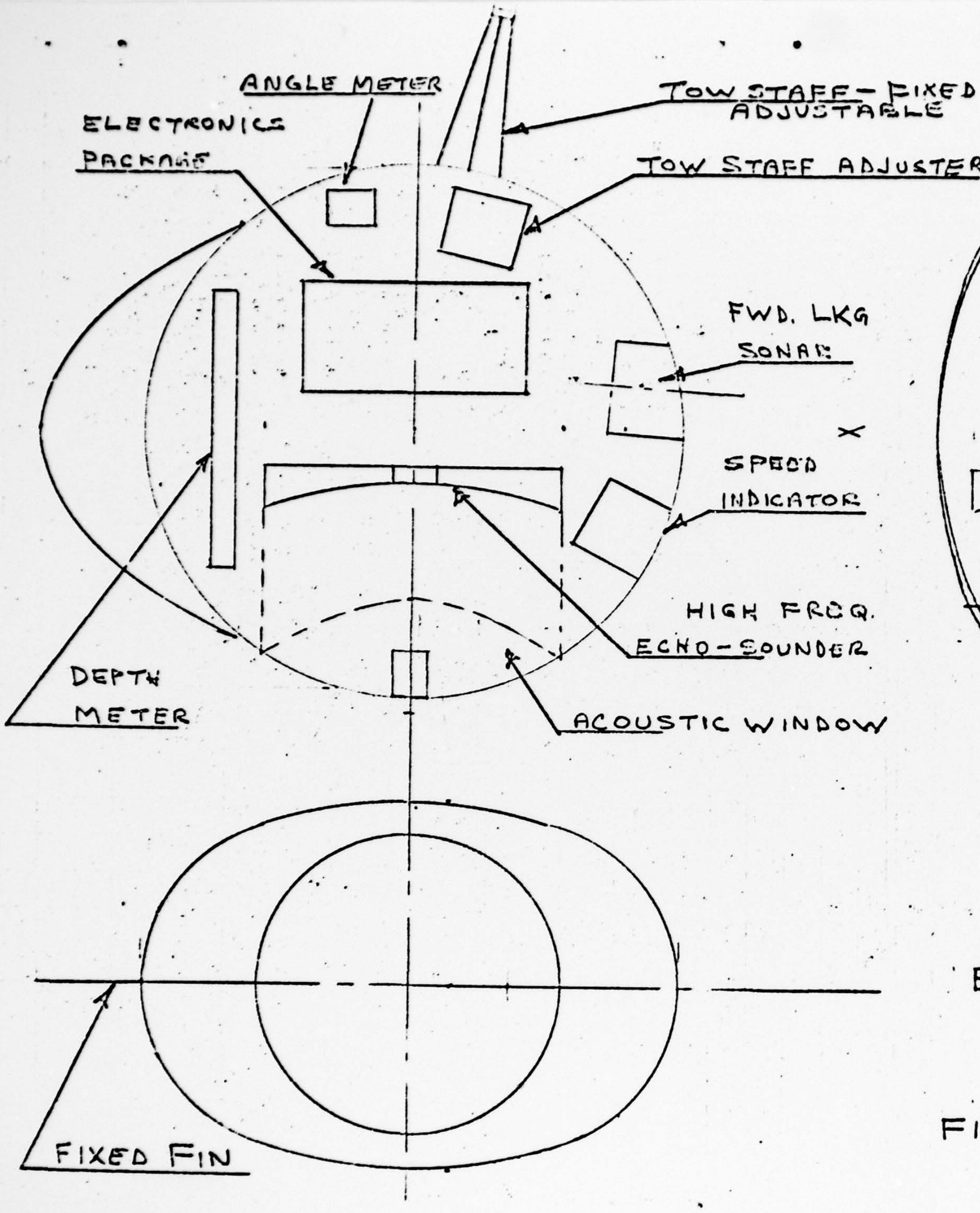
This equipment will include the guide sheaves, fairleads, and cable reels, or tanks used for stowing and unstowing the cable for a towed vehicle.

2.9 Maintenance

The required tools, space, workshop equipment, if not available on the support ship, and other facilities required for the maintenance of the system will be included under this category.

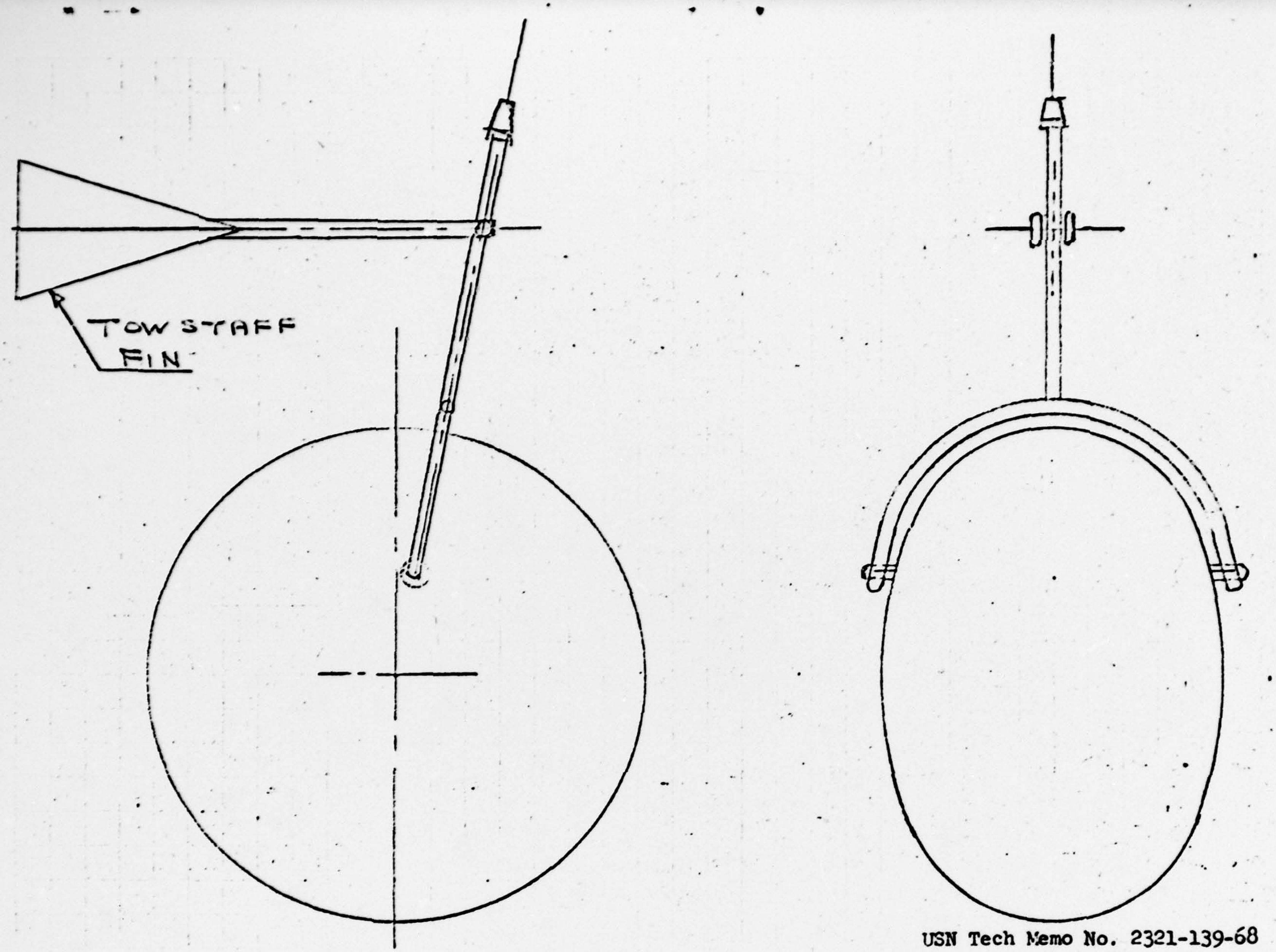
APPENDIX III

USN Tech Memo. No. 2321-139-68



BOTTOM TOPOGRAPHY VEHICLE
CONCEPT "A" SHAPE

FIG 1 APPENDIX III



BOTTOM TOPOGRAPHY
VEHICLE
HINGED BRIDLE
FIG 2 APPENDIX III