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MOST Project -3

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LEVEL II

⑥ SUBMARINE CLASSIFICATION

by

HELICOPTER

(Equipped with High Resolution FM Sonar)

by

⑩

R. L. Waldie

U. S. Navy Electronics Laboratory

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SUBMARINE CLASSIFICATION

Introduction:

COMINPAC has recently conducted a short series of tests to determine the submarine classification capability of the small boat AN/SQS-19 sonar (high resolution minehunting sonar) presently installed on the USS COVE (MSI). The purpose of the tests was to demonstrate submarine classification by means of visual aspect as well as aural Doppler modulation produced by the submarine's propellers on the FM sonar target echoes. The test results were sufficiently successful that ADM Veth, COMINPAC, suggested to ADM Thach, ASWFORPAC, during a meeting of their combined staffs in Long Beach, California on 16 March, that such a device installed on a helicopter might be useful to ASWFORPAC. As an attendee at that meeting, I was requested to comment briefly on the technical feasibility of such an installation, and to present any background information pertinent to the suggestion. Later I was requested by ADM Thach and staff to forward to their headquarters the following information:

- a. Tape recordings of actual runs on submarines which would demonstrate the type of propeller Doppler modulation to be expected; and
- b. A proposal outlining how a helicopter might be effectively equipped with such a sonar giving size, weight, speed, cost, etc.

This proposal, although somewhat delayed due to press of other business, fulfills that request.

Background:

Visual Aspect: Portrayal of visual aspect of a submerged submarine on a sonar PPI has been demonstrated numerous times in the past at ranges of 1,000 yards or less. Striking results were obtained in 1951 by the AN/SQG-1 attack sonar installed on the USS WITEK, and later in 1958 by the AN/SQS-19 installed on a MSB. Both used 5° hydrophone beams and range resolution of the order of 10 yards. Little interest was displayed by the Navy in either case because the ranges of good aspect portrayal were less than 1200 yards.

Propeller Doppler Modulation: During engineering tests of the AN/SQG-6 attack sonar (FM sonar) developed at NEL in 1952-53, extensive investigations were conducted of the phenomena of Doppler modulation of target echoes by the submarine's propellers at speeds as low as 2 knots. It was demonstrated that the modulation was strongest when observed while echo ranging on the submarine from the bow or stern quarters. The phenomenon was rarely observed when the submarine was at beam aspect. During the investigation, actual amplitude patterns were

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constructed showing how the screw Doppler signal strength varied with aspect of the submarine. Such target echoes were characterized by

- a. Amplitude modulation
- b. Dual frequency echoes produced by frequency shift due to the rotating propeller blades.

The results of these investigations were summarized in NEL Report 571 which is attached as enclosure (1). A sample tape recording depicting the modulation of the echo upon rotating propeller blades is contained in enclosure (2). The screw doppler is most strikingly demonstrated when the FM sonar acoustic beam is made to track the submarine by manual control instead of scanning automatically in azimuth. Also the effect is enhanced if the echo is passed through a narrow (100 cps.) band pass filter. Both of these techniques are demonstrated on the tape in enclosure (2).

All work was stopped on this project in 1954 because the Navy showed little interest in the technique, again due to its short range. The subject of a helicopter borne FM sonar for short range submarine classification was discussed by myself and Mr. R. O. Burns, OP-07T in 1958, but nothing specific was done. Again in 1961 this possibility was discussed with Captain J. Wallace, BUSHIPS Code 688, during a visit to NEL. The possibility had been brought to Captain Wallace's attention by a proposal made to CNO by Captain H. B. Smith who had been in charge of MINEVDET, Key West, during the Operational Evaluation of the AN/SQS-19.

Possible Helicopter Equipment: The interest briefly outlined above has stimulated us to investigate the feasibility and value of installing a high resolution FM sonar on a helicopter. Results of this investigation indicate that a highly effective FM sonar could be used having the following desirable characteristics:

- a. Excellent visual target aspect portrayal out to 1,000 yards.
- b. Aural portrayal of propeller Doppler modulation.
- c. Stabilized towed body capable of being towed up to 10 knots at depths as great as 160 feet.
- d. Weight of electronics - 150 lbs.  
(Two packages 15 in. x 18 in. x 24 in.)
- e. Weight of towed body and transducers - 250 lbs.  
(Dome 30 in. in diameter with 12 in. depressor wings on either side.)

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- f. Weight of winch and cable - 250 lbs.  
(Winch approximately two cubic feet.)
- g. Total weight of combined equipment - 650 lbs.

Most important, all of this equipment has been developed and tested, but in two distinct systems, one by BUSHIPS and one by BUWEPS. If the operating forces considered it worthwhile, it is very feasible to combine parts of the two systems to produce an equipment incorporating the characteristics outlined above. It could be accomplished as follows:

Sonar: The AN/SQS-19 sonar, evaluated and service approved by OPTEVFOR, could be procured, packaged in two modules, weighing a total of no more than 150 lbs. Other than the re-packaging, the equipment would be built to present approved specifications. The hydrophone beam widths would be narrowed from 5° to 2° in the horizontal plane. The 2° hydrophone has already been built by NEL for another purpose and this design could be furnished to the contractor as necessary. Parameters of this sonar are outlined in enclosure (3).

As mentioned above, this sonar would give excellent visual aspect portrayal on the submarine out to 1,000 yards. At 500 yards it would delineate a submarine with the same clarity as that accomplished by the new minehunting classification sonars (British 193, AN/SQQ-14, AN/SQQ-16, etc.) on a cylindrical bottom mine at 100 yards. Enclosure (4) is a photo of such a mine shown on the AN/SQQ-16 display at a range of 100 yards. It would also have the capability of providing aural Doppler modulation from the submarine's propeller when such modulation was present. It must be emphasized that such a sonar represents only an interim solution to the classification problem for use at short range. However, within the range limitations outlined above, it would be extremely effective as a classification device.

Towed Body, Cable and Winch: BUWEPS (RUDC-63) is at present developing under contract with Raytheon the AN/AQS-8 mine detection and classifying sonar for use with a helicopter. It is scheduled for first tests this summer at the Mine Defense Laboratory in Panama City, Florida. In our opinion, this sonar (like the AN/SQQ-16 and AN/SQQ-14, designed for minehunting) is too complicated for the submarine classification task. Also, it must first undergo a complete technical and operational evaluation before consideration can be given to procurement. However, the towed body and stable platform have been developed and successfully tested at the David Taylor Model Basin. The transducer mounted in the towed body is gyro stabilized. The AN/SQS-19 transducers could be easily installed in this body on the gyro stabilized mount. I have discussed this possibility with BUWEPS personnel who are cognizant of the AQS-8 development and they are enthused with the idea. They indicate a

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second towed body could be procured in short order without delaying in any way the AQS-8 program. They say that they have on hand at present a spare winch and stabilized transducer mount which could be made available. We believe that this towed body, would most effectively fulfill the requirements for the helicopter submarine classification sonar employing the modified SQS-19.

Estimated Costs and Schedules:

Sonar:

Estimated cost: \$40,000.00

Estimated delivery after letting contract: 6 months

Towed Body, Cable and Winch:

Estimated Cost: \$35,000.00

Estimated delivery after letting contract: 6 months

Total Procurement Costs: \$75,000

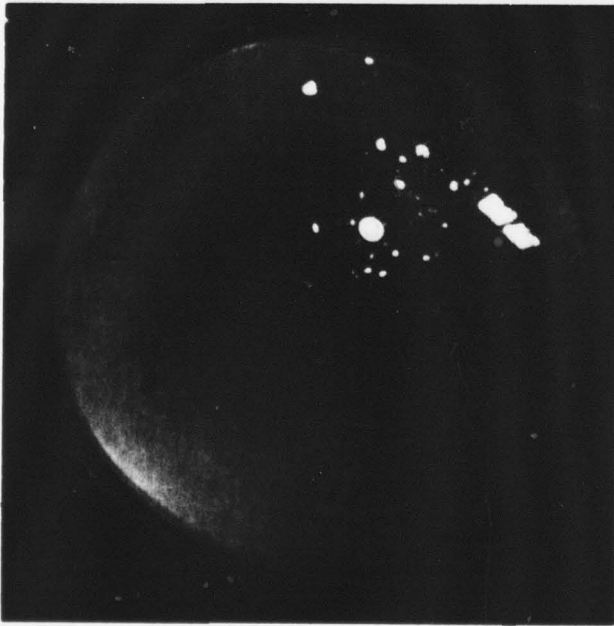
The above cost and schedules are based on the premise that a government laboratory, possibly NEL, would let the contracts through the Navy Purchasing Office of Los Angeles and provide technical guidance to the contractors. Cost estimates are based on similar sonars we have purchased within the last two years. Cost estimate of the towed body is based on the fact that BUWEPS already has a winch and stabilized platform which they promise to provide if such an installation is desired by the Operating Forces.

Possible Means for Quick Fleet Tests:

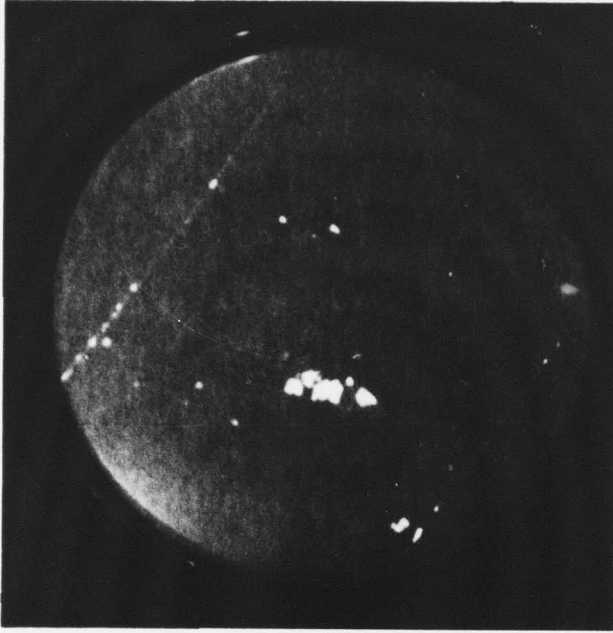
If ASWFORPAC, after considering this proposal, is interested in testing out the concept, it could be accomplished in the shortest time by implementing the following, direct approach. Assuming first that funds would be approved for purchasing the equipment, a helicopter would have to be temporarily assigned and the necessary modifications made for the installation. It is possible that a major portion of this installation and modification could be done by personnel from one of the helicopter squadrons. A project would have to be assigned and accepted by one of the government laboratories to provide technical guidance for the procurement of the equipment, installation and sea tests. If a sufficiently strong recommendation was made by the Fleet Commanders and approved by CNO and BUSHIPS, it is possible that the entire project could be accomplished within one year.

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**PPI**



**B-SCAN**



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**PPI AND B-SCAN INDICATOR PHOTOGRAPHS OF A MK-36  
MINE CASE ON BOTTOM OF SAN DIEGO BAY.**

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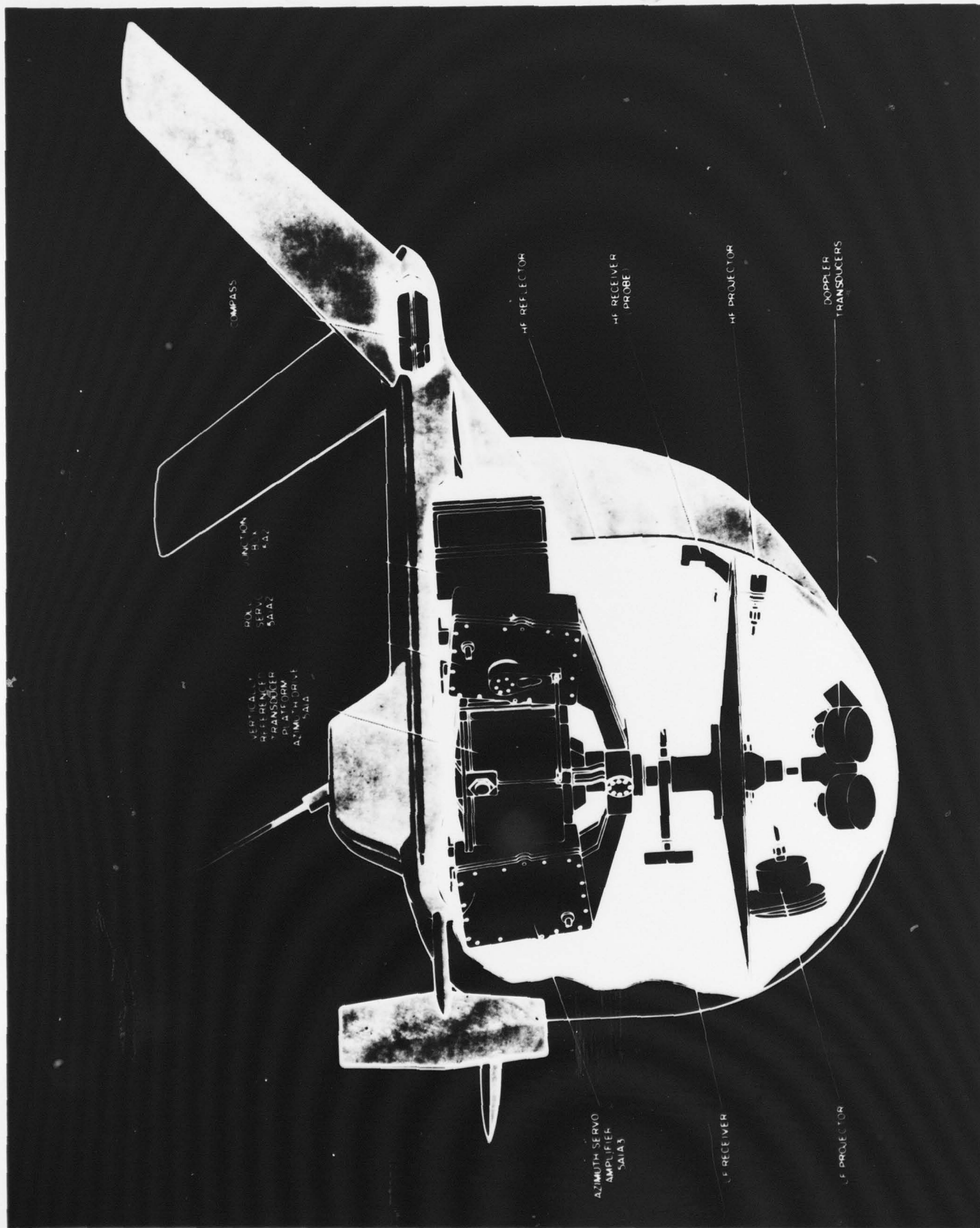
Parameters  
of  
Helicopter Classification Sonar

1. Mode of Operation: CTFM
2. Frequency: 70 kc  $\pm$  5 kc
3. Source Level: 100 db above dyne/cm<sup>2</sup>
4. Hydrophone Beam Pattern: 2<sup>o</sup> Horizontal  
15<sup>o</sup> Vertical
5. Projector: 40<sup>o</sup> Horizontal  
15<sup>o</sup> Vertical
6. Display, Visual: 7" PPI
7. Range Analyzer: 30 channels
8. Range Scales: 1000  
500  
250  
100
9. Azimuthal Scan Rates: (a) 15<sup>o</sup>/sec (1000 yd scale)  
(b) 30<sup>o</sup>/sec (all other scales)  
(c) Manual (all scales)
10. Aural Listening Band: (a) 500 - 2000 cps  
(b) 100 cps (Moveable through  
500 - 2000 cps band)

Enclosure (3)

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COMPASS

FUNCTION  
H.X.  
4A.

BOX  
SERVO  
SA1A2

VERTICAL  
TRANSDUCER  
TRANSDUCER  
AZIMUTH SERVO  
SA1A3

H.F. REFLECTOR

H.F. RECEIVER  
PROBE

H.F. PROJECTOR

DOPPLER  
TRANSDUCERS

AZIMUTH SERVO  
AMPLIFIER  
SA1A3

L.F. RECEIVER

L.F. PROJECTOR

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AN/AQS-8 Towed Body

The sketch illustrating the AN/AQS-8 towed body as shown in the photograph has a scale factor of approximately 9 to 1. Approximate dimensions of the towed body are as follows:

- (a) Dome Diameter: 30 inches
- (b) Maximum Body Length: 54 inches
- (c) Maximum Height: 50 inches

If the towed body were used with the AN/SQS-19 sonar all the transducers shown would be taken out leaving only the acoustic baffle plate to which the HF receiver (probe) is attached. The 2° hydrophone for the AN/SQS-19 would be mounted just above this baffle. The 40° projector would be mounted just below the baffle on the same shaft.

Enclosure (5)

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