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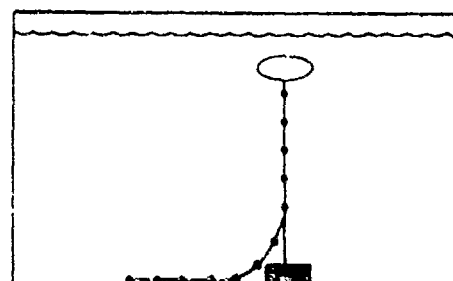
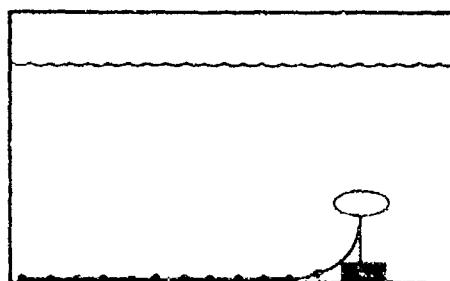
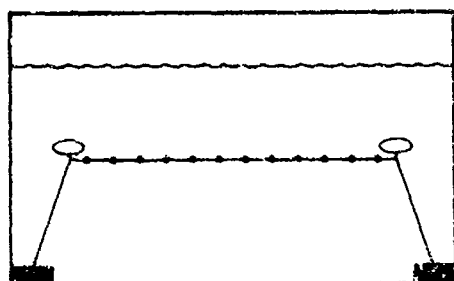
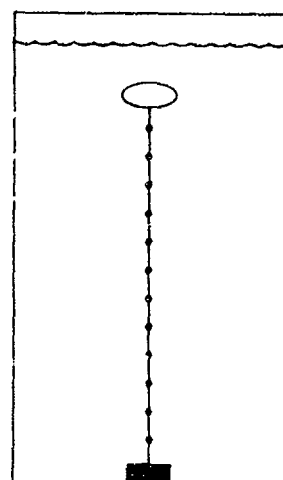
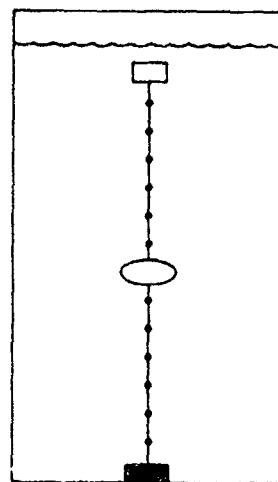


The Moored Acoustic Buoy System (MABS)

Robert F. LaPlante
Raymond W. Hasse

OCEAN SCIENCES & TECHNOLOGY DEPARTMENT

4 April 1975



NAVAL UNDERWATER SYSTEMS CENTER
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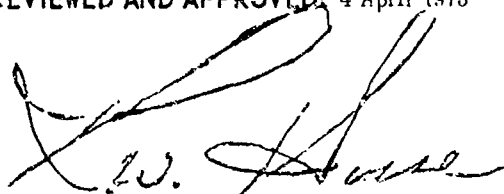
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PREFACE

This report was prepared under NUSC Project No. 012345,
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REVIEWED AND APPROVED: 4 April 1975

A handwritten signature in dark ink, appearing to read 'R. W. Hasse', is written over the printed name.

R. W. Hasse

Associate Director for Sonar Research

The authors of this report are located at the New London
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durations so that deployments of up to 7 months are possible with a maximum of 14 days of continuous recording. The outputs of as many as 13 hydrophones can be recorded simultaneously from the acoustic array. The present MABS inventory consists of three instrumentation pressure vessels, four flotation buoys, three tape recorders (two different types), many array cables, and a complement of auxiliary gear.

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THE MOORED ACOUSTIC BUOY SYSTEM (MABS)

INTRODUCTION

The Moored Acoustic Buoy System (MABS) is a bottom-moored programmable acoustic data recording system. It consists of a subsurface instrumentation buoy in conjunction with a family of lightweight hydrophone arrays designed to measure a variety of underwater acoustic signals. The MABS equipment can be used in any water depth. It can be laid on the ocean bottom or suspended at any attitude from vertical to horizontal in the water column. Recent developments in lightweight synthetic-cable technology have been incorporated into the design to make MABS deployable from the most modest of ocean-going ships in a wide range of sea states with a minimum of support equipment and personnel. To date, MABS systems have been used in 19 deployments and retrievals in the Atlantic and Pacific Oceans and in the Caribbean and Mediterranean Seas.

SYSTEM DESCRIPTION

Basically, MABS is both a concept and a realization. Thus, the system appears in a variety of forms with various capabilities. The basic concept was to produce a rapidly deployable, programmable, self-recording, multi-channel system that can be deployed for periods up to 7 months, is highly reliable, and requires little if any ship outfitting.* Figure 1 depicts a variety of configurations in which MABS can be deployed.

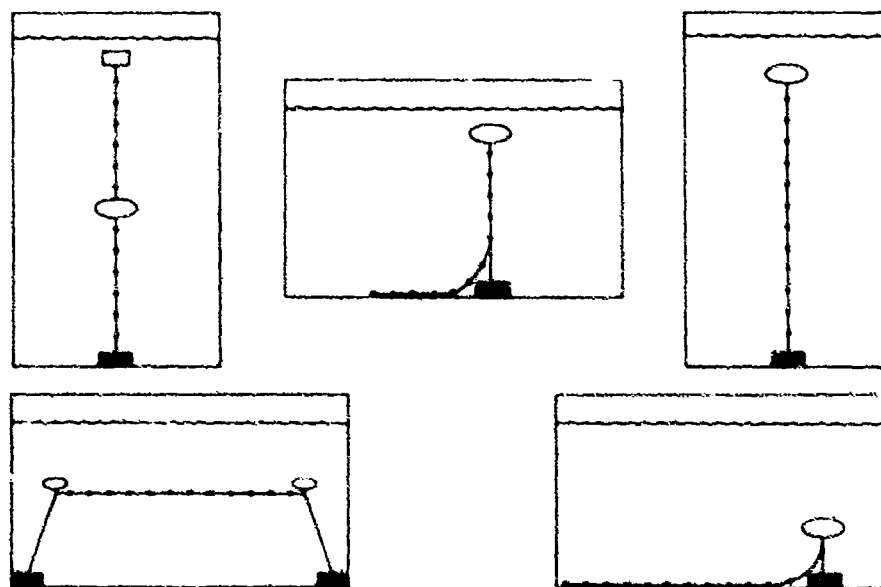


Figure 1. MABS Array Configurations

*For further information on MABS and its earlier development, see P. C. King and R. C. Swenson, Moored Acoustic Buoy System (MABS): Specifications and Deployments, NUSC TR 4457, 5 January 1973 (UNCLASSIFIED).

The major components of the basic MABS equipment are the instrumentation pressure vessel (IPV), battery pack, flotation buoy, electromechanical cable, hydrophones, acoustic telemeter, acoustic transponder/releases, recovery package, and anchor.

Figure 2 shows the MABS II buoy, consisting of the IPV, battery pack, syntactic foam flotation unit, acoustic telemeter, and recovery-aiding light and radio beacons. Figure 3 depicts the similarly constructed MABS I buoy. The MABS II flotation buoy is 7.5 ft in diameter by 3.5 ft high and is constructed of high-density syntactic foam protected by a rubber bumper around the rim. The flotation buoy serves a dual purpose in providing both buoyancy and protection to the IPV. Twelve hundred pounds of buoyancy provides enough reserve buoyancy to recover the system should the IPV completely flood. The buoy was designed to fit through most shipboard A-frames and also to fit inside standard van trailers for ease of transport.

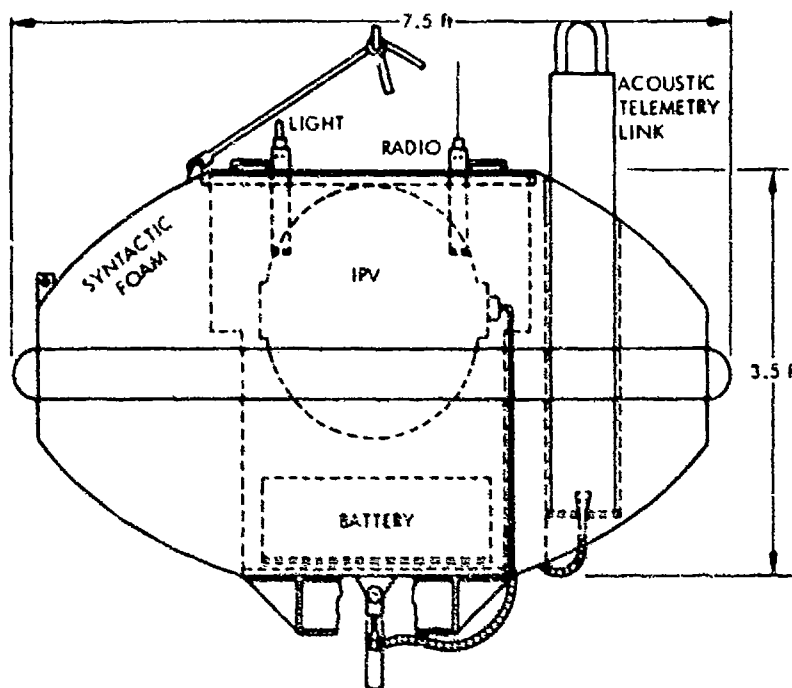


Figure 2. MABS II Buoy

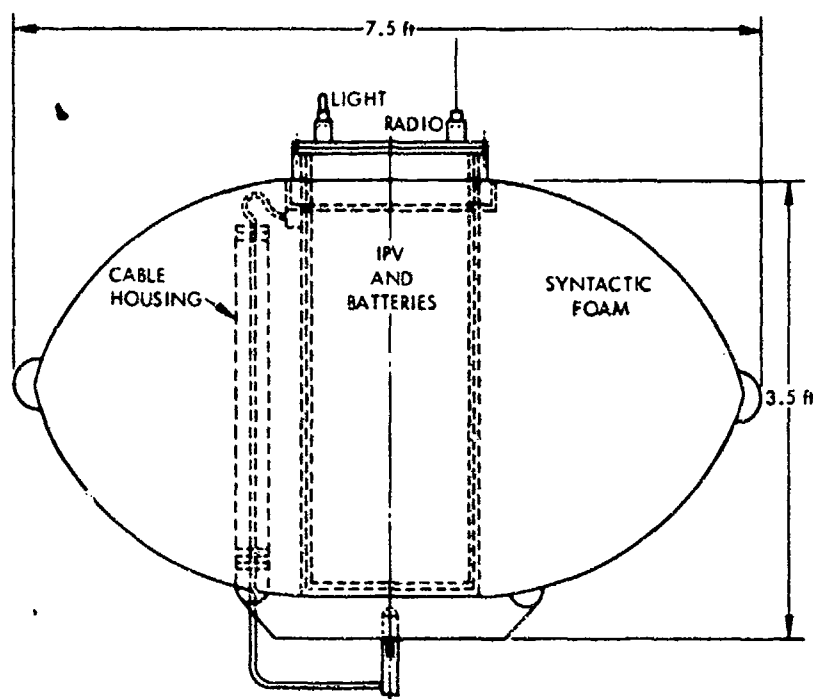


Figure 3. MABS I Buoy

The system electronics, logic circuits, and tape recorder are located in the 28-in.-diameter aluminum IPV. Two different types of tape recorders are incorporated into the MABS system and can be used interchangeably in MABS II. One, for long-time signal-amplitude measurements, has a total recording time of over 13 days. The other, with high cross-channel stability for coherence-type measurements, has a total recording time of 16 hours. With selection of suitable duty cycles, recording times can be extended to 7 months. Also in the IPV is an IRIG B time-code generator that controls the system timing and is recorded on one track of the tape recorder, providing a continuous accurate record of time on tape. The logic and timing circuits provide a wide range of programming options for data collection (see table 1). Data can be sampled continuously or at intervals from 10 sec to 9 hr for periods of 10 sec or more. Random noise and sine wave calibrations can be recorded automatically with every data sample or less frequently as desired.

Table 1. General Operating Characteristics of MABS

A. Programming Options

Time interval between samples

- 1) Continuous
- 2) 10 to 60 sec in 10-sec increments
- 3) 1 to 10 min in 1-min increments
- 4) 10 to 90 min in 10-min increments
- 5) 1 to 9 hr in 1-hr increments
- 6) adjustable to requirements

Length of sample

- 1) Continuous
- 2) 10, 15, 30, or 60 sec
- 3) adjustable to requirements

Delayed start (MABS II only)

1 hr to 90 days

B. Calibration: Random Noise and Sine Wave, Automatically at Any Interval Desired

C. Total Record Time With Astro-Science Mars 2000 Recorder

1-7/8 IPS*: 8 hr

15/16 IPS : 16 hr

D. Total Record Time With Precision Instruments 5114 Recorder

15/160 IPS: 328 hr

E. Maximum Deployed Time

7 months

*Inches per second (IPS)

The tape recorders available for use with MABS are the Astro-Science Mars 2000 precision recorder and the Precision Instruments 5114 recorder. The specifications of the two recorders are summarized in table 2. All recorders are 14-channel units. The Mars 2000 unit was chosen for its wide bandwidth and rigid skew specifications, which are necessary for beamforming and coherence measurements. The Precision Instruments recorder is suitable for recording ambient noise, CW and explosive shot signals, and ship signatures for long periods of time. The MABS recorders can be used in a split gain configuration where each acoustic data channel is recorded simultaneously on two tracks at two levels with some overlap in dynamic range or with one data channel per magnetic tape channel. The split gain option provides the necessary extended dynamic range for high-amplitude transient data while facilitating data processing by maintaining constant calibration factors for each channel throughout the data. Thirteen hydrophone channels are normally available with MABS, with one tape channel reserved for time-code signals. With a split gain mode of operation for all hydrophones, a maximum of six hydrophones can be monitored.

Table 2. Specifications of Tape Recorders Used in MABS

Manufacturer and Model	Astro-Science Mars 2000				Precision Instruments 5114	
	1-7/8		15/16		15/160	
Tape Speed (IPS)						
Mode	Direct	FM	Direct	FM	Direct	Direct extended band
Total Record Time (hr)	8		16		328	
Bandwidth (kHz)	0.4-32	0-2.5	0.4-16	0-1.25	0.001-0.375	0.001-0.750
Dynamic Range (dB)	20	40	15	35	35	24
Dynamic Skew (min.)	+25		+50 2.5		--	--
Wow and Flutter (percent)	1		1.8		--	--
No. of Channels	14		14		14	14

Lightweight synthetic-fiber (Kevlar 29) electromechanical cables are utilized in the system. These cables are completely faired with a hairy type of fairing to reduce cable strain and vibration that might otherwise contaminate low frequency acoustic signals and ambient noise. The hydrophone cages are designed to be inserted into the cable without cutting the strength members or nonrequired conductors. The hydrophone assemblies are small, light, and reliable, employing pressure-insensitive electronics in a completely molded package that requires no pressure housing. Figure 4 shows the synthetic cable, hydrophone, and hydrophone cage before the hydrophone is inserted into the cable. Each hydrophone and cage can be incorporated

within the matrices of fiber strands and conductors of the cable in less than 3 hours. This operation can be done in the laboratory or aboard ship. The hydrophone forms a smooth bulge of increased cross-sectional diameter. The cable with the hydrophones can be wound easily around a winch drum and will pass through sheaves with little or no special attention during deployment and retrieval. With this arrangement, the hydrophones are readily available for testing and calibration as part of the total array, and pressure testing of the complete array before going to sea is easily accomplished. Additionally, the fiber cable, being light and easy to handle, requires little or no additional flotation along its length to support its weight as in the case of steel cables. Because it does not corrode, the cable requires no maintenance in use or storage.

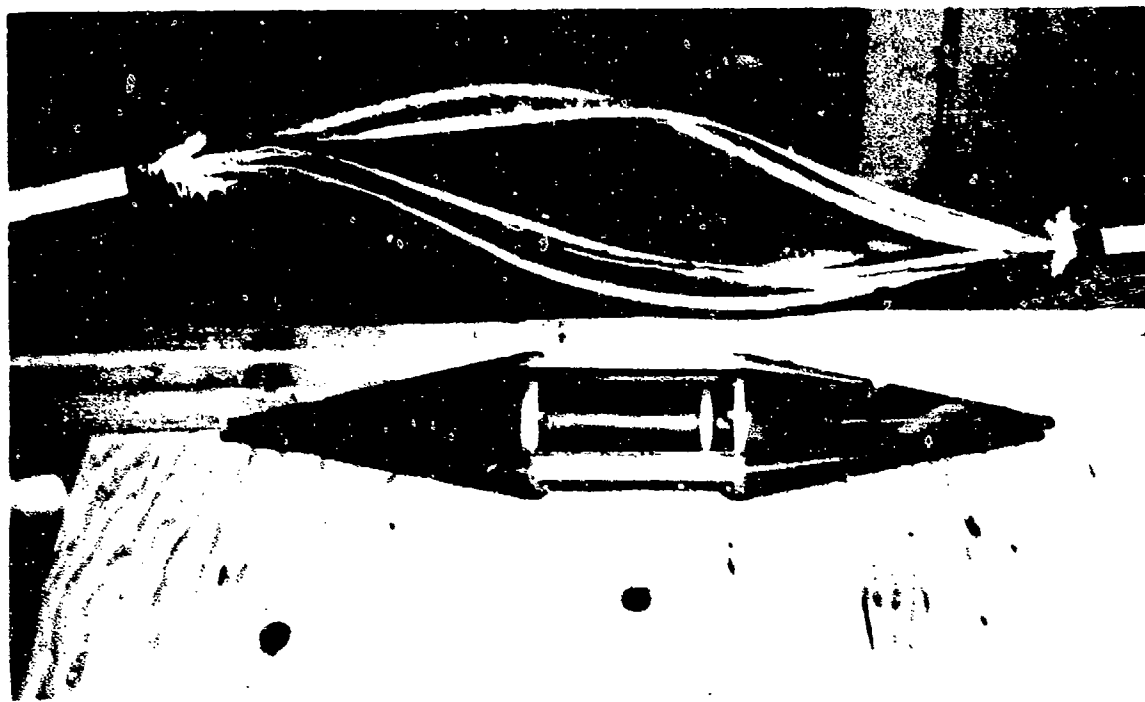


Figure 4. MABS Hydrophone and Cable

The power for MABS is supplied by a battery pack of lead-acid or silver-zinc batteries. The battery pack can be easily replaced for quick turnaround times.

The MABS equipment is capable of transmitting information about its status to a surface vessel or platform. Such information as battery voltage, buoy depth, system operation, presence of leaks in the IPV, and water temperature is available aboard the deployment vessel. A more complete list of interrogation options can be found in table 2.

Table 3. Acoustic Telemeter Interrogation Modes for MABS II

Mode	Command from	Action
1	Surface unit	Acts as a transponder
2	Internal logic circuitry	Interrogates bottomed transponders
3	Surface unit	Sends 5 min of data for five of the following parameters -- Depth, Water temperature, Signal level (at recorder), Battery voltage, Leak detector status, System mode or status, and/or other parameters.
4	Surface unit	Sends 5 min of data for five parameters with next data sample
5	Surface unit	Changes mode or status of programmer in buoy.

A dual, parallel, acoustic transponder/release system is used just above the anchor for recovering the system. In the transponder mode, these units assist in pinpointing the location of MABS. The parallel release provides 100-percent redundancy for the system release function.

DEPLOYMENT AND RETRIEVAL

The MABS equipment has been used most frequently in a vertical attitude. In this attitude, MABS is deployed anchor last to free-fall to the bottom with the buoy at the top of the array. Because MABS is a total, complete system prior to deployment, it is not necessary to stop the cable for sensor, float, or connector attachment, and there is little payout tension. Deployment and retrieval times are typically about 1-2 hours. The system is designed to be deployable from small ships in wind speeds to 20 knots and wave heights to 12 ft. It has been recovered in 40-knot winds. Little winching capability is required for MABS, and the only lifting capability required is for the IPV/flotation unit. Systems have been deployed and recovered 19 times in the last 3 years while operating from 5 different platforms.

TESTING AND CALIBRATION

Before it goes to sea, the MABS system is completely fabricated and the entire array is pressure tested in the pressure tank at NUSC. This process ensures the integrity of the complete system prior to deployment.

Various calibration procedures are used. A calibration is performed on each hydrophone at the Naval Research Laboratory, Underwater Sound Reference Division (NRL/USRD) Orlando before and after each exercise. Complete system end-to-end calibrations are also performed before and after exercises. These system calibrations consist of injecting a series of tonals and wideband noise signals at the input of the hydrophone preamplifiers and recording these signals on the system tape recorder. Additionally, calibration signals in the form of wideband noise plus a single tone are injected at the input of the IPV and recorded on tape at preprogrammed intervals while the system is deployed and operating.

SUMMARY

MABS is a versatile, reliable, easily handled, acoustic data gathering tool. It can be deployed and retrieved from a wide class of surface platforms without requiring specialized handling gear, numerous personnel, or large deck areas. With the option to interchangeably use two separate tape recorders with different capabilities, it can accomplish data gathering for a wide variety of underwater acoustic experiments.

Utilizing the newest developments in synthetic cable and hydrophone array components, MABS is a weather-hardened, lightweight system that can be deployed in a variety of configurations (figure 1). The IPV unit is capable of deployment to depths from 100 to 12,000 ft with the array sensors at any depth below or above the IPV. Table 4 summarizes the important specifications of MABS II, one of the series of MABS equipments; table 5 summarizes the specifications of MABS I. Figure 5 depicts the combinations that are possible with the existing MABS hardware. This hardware includes four flotation buoys, three pressure vessels, three tape recorders, five arrays, and a complement of acoustic releases and other marine hardware.

Table 4. Specifications for MABS II

Component Descriptor	Pertinent Data	
<u>Buoy Module</u>		
Size: pressure vessel assembly	28-in.-diameter sphere 7.5-ft-diameter by 3.5-ft-high spheroid	
Weight of IPV	850 lb in air	
Maximum buoy depth	12,000 ft	
<u>Hydrophone Array</u>		
Cable type	Synthetic fiber or steel	
Hydrophone type	ITC model 8021 or 8014	
Hydrophone assembly size	2 ft long by 4 in. diameter	
Hydrophone assembly weight	3 lb in water	
<u>Tape Recorders</u>		
Manufacturer/Model	Astro-Science Mars 2000	Precision Instruments 5114
Dynamic range	40 db FM, 20 db direct	30 db direct
Dynamic range expansion	Yes, split gain	Yes, split gain
Tape duration	8 hr at 1-7/8 IPS 16 hr at 15/16 IPS	328 hrs at 15/160 IPS
Data tracks	14	14
Acoustic data channels	13	13
Record method	FM, direct	Direct
Frequency response	FM 3-1250 Hz at 15/16 IPS 3-2500 Hz at 1-7/8 IPS Direct 400-16,000 Hz at 15/16 IPS 400-32,000 Hz at 1-7/8 IPS	3-375 Hz or 3-750 Hz (extended band)
<u>Array Parameters</u>		
Maximum number of hydro phones	13	
Allowable sample lengths	10 sec minimum to continuous	
Interval between samples	10 sec to 9 hr or adjustable as desired	
Maximum active deployment time	7 months	
Maximum delayed start	90 days	
Interrogation modes	5	

Table 5. Specifications for MABS I

Component Descriptor	Pertinent Data
<u>Buoy Module</u>	
Size: pressure vessel assembly	16-in. by 44-in. cylinder 7.5-ft-diameter by 3.5-ft-high spheroid
Weight of IPV	300 lb in air
Maximum buoy depth	600 ft
<u>Hydrophone Array</u>	
Cable type	Synthetic fiber or steel
Hydrophone type	ITC model 8021 or 8014
Hydrophone assembly size	2 ft long by 4 in. diameter
Hydrophone assembly weight	3 lb in water
<u>Tape Recorder</u>	
Manufacturer/Model	Astro-Science Mars 2000
Dynamic range	40 db FM, 20 db direct
Dynamic range expansion	Yes, split gain
Tape duration	8 hr at 1-7/8 IPS 16 hr at 15/16 IPS
Data tracks	14
Acoustic data channels	13
Record method	FM, direct
Frequency response	FM 3-1250 Hz at 15/16 IPS 3-2500 Hz at 1-7/8 IPS Direct 400-16,000 Hz at 15/16 IPS 400-32,000 Hz at 1-7/8 IPS
<u>Array Parameters</u>	
Maximum number of hydrophones	6
Allowable sample lengths	30 sec minimum to continuous
Interval between samples	1 min to 1 hr or adjustable as desired
Maximum active deployment time	7 months
Delayed start	None
Interrogation modes	None

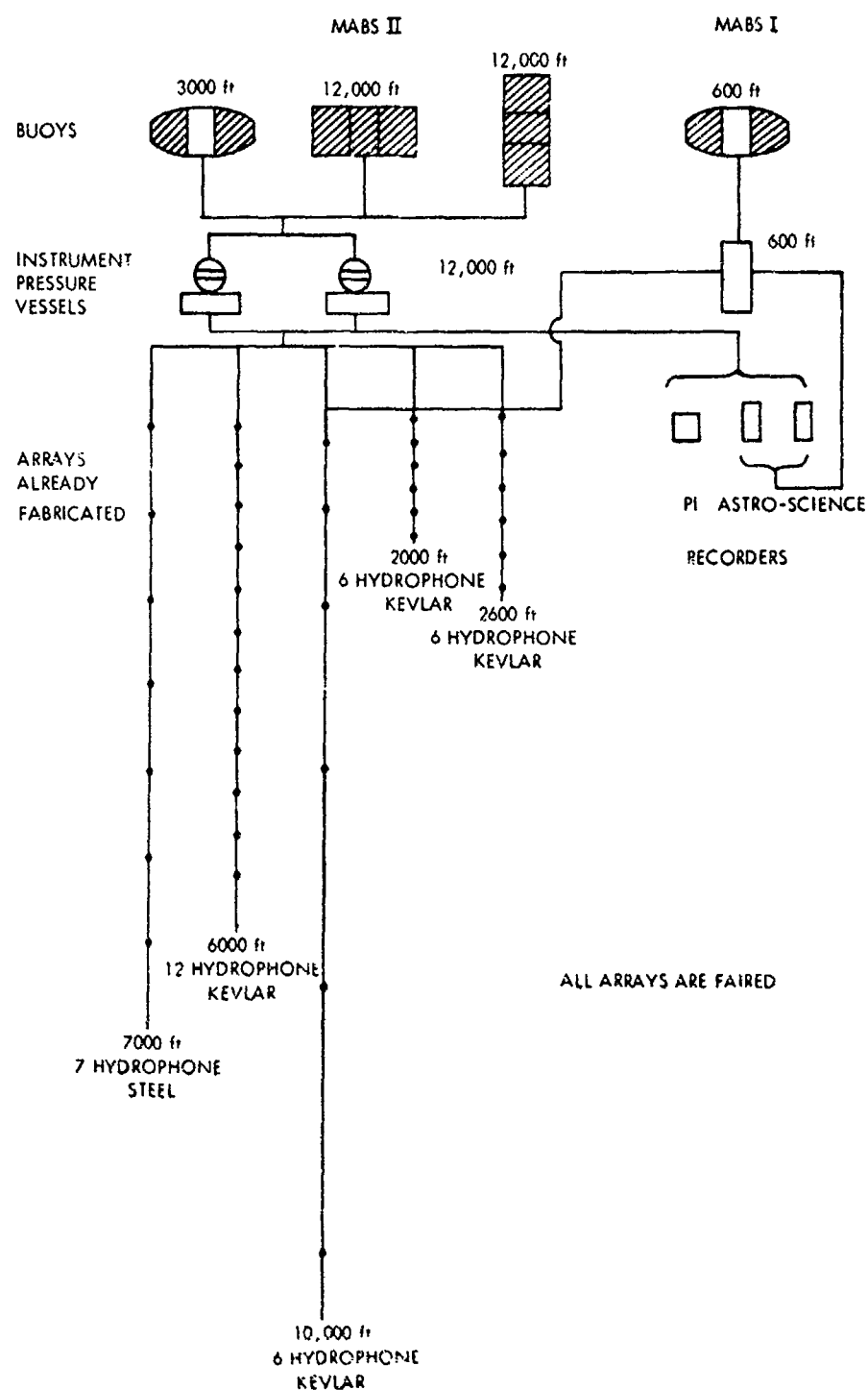


Figure 5. Possible Combinations of MABS Equipment

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NUSC TD No.4937	LaPlante, R. F., et al.	THE MOORED ACOUSTIC BUOY SYSTEM (MABS)	Naval Underwater Systems Center	750404	ADB003783; ND	U
USI 460-1-75	Weinstein, M. S., et al.	SUS SIGNAL DATA PROCESSING (U) INVESTIGATIONS CONDUCTED UNDER THE DIAGNOSTIC PLAN FOR CHURCH ANCHOR AND SQUARE DEAL SHOT DATA (U)	Underwater Systems, Inc.	750414	ADC002353; ND	U
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Unavailable	Unavailable	SUMMARY OF ENVIRONMENTAL ACOUSTIC DATA PROCESSING	University of Texas, Computer Science Division	761013	ADA032562	U
TTA83676285	Unavailable	ANALYSIS PLAN FOR NARROWBAND/ NARROWBEAM AMBIENT NOISE (U)	Tetra Tech, Inc.	761112	ADC008275; NS; ND	U
USI 564-1-77	Wallace, W. E., et al.	REPORT OF CW WORKSHOP. NORDA, BAY ST. LOUIS, MISS., 28-29 SEPT 1976	Underwater Systems, Inc.	770124	ND	U