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EARTH RESOURCES TECHNOLOGY SATELLITE

DRIFT BUOY PROGRAM

FINAL REPORT

21 JANUARY 1974

PRINCIPAL INVESTIGATOR: ROBERT KEE GSFC ID: DE 011

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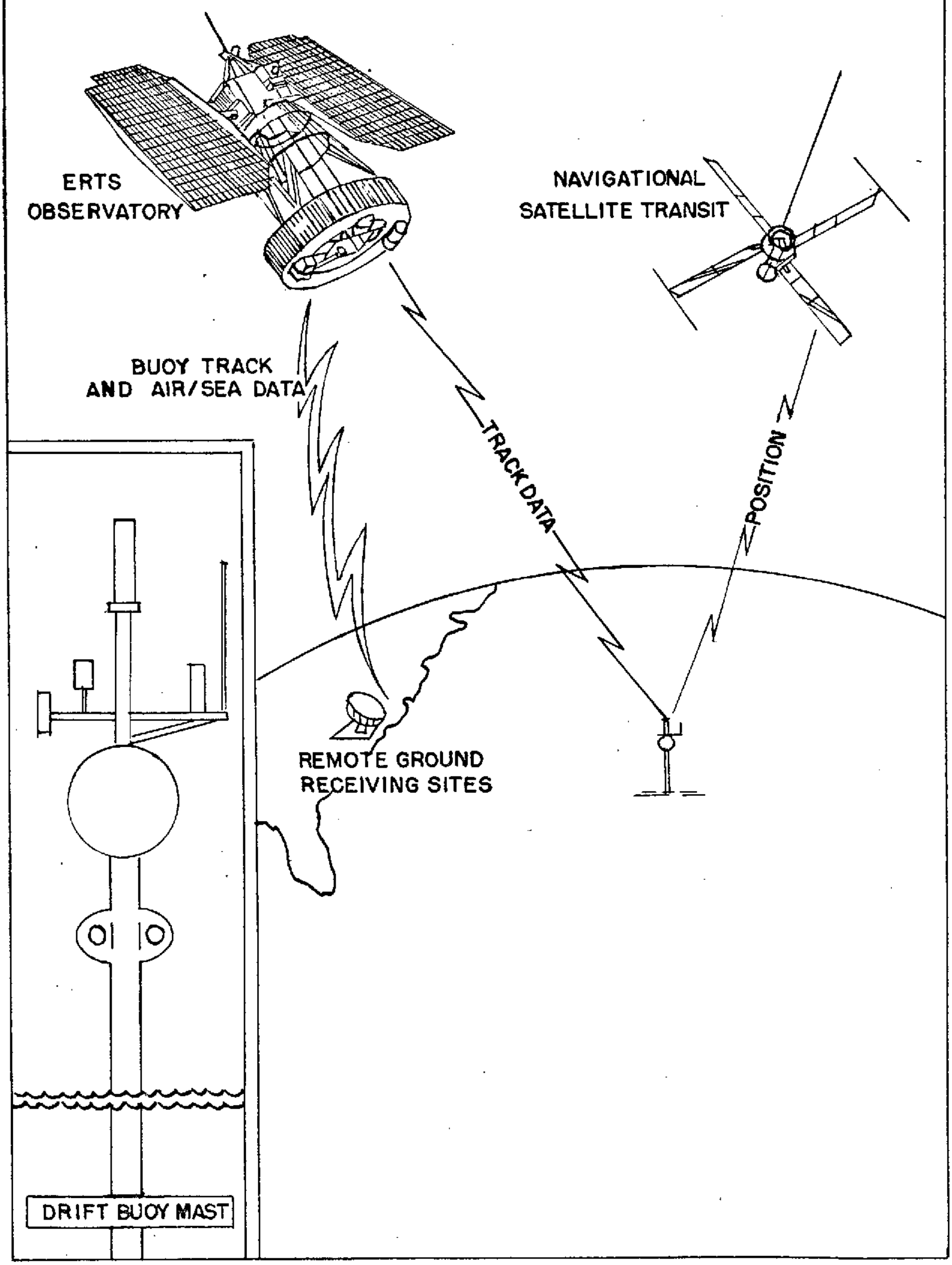
Naval Oceanographic Office
Washington, D. C. 20373

EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS)
DRIFT BUOY PROGRAM



I. INTRODUCTION

In 1970 the Naval Oceanographic Office (NAVOCEANO) began developing a satellite-interrogated drifting platform for use in tracking ocean currents and for studying associated oceanographic and meteorological properties. A highly successful oceanographic experiment involving satellite-tracked buoys, ships, and aircraft was conducted with the Interrogating, Recording, and Locating System (IRLS) during September 1970. Results from this experiment demonstrated the feasibility of using drifting platforms such as the NAVOCEANO IRLS buoy for remote sensing of Lagrangian current measurements.

The second phase of the drift buoy program began in July 1972 with the Earth Resources Technology Satellite (ERTS). The objectives of the ERTS drift buoy program were to (1) develop and improve surface drift prediction techniques, (2) evaluate the potential of satellite-tracked drifting platforms, and (3) gain a better understanding of circulation patterns in specific strategic ocean regions, particularly the relationship between surface drift and subsurface thermal structure.

To accomplish these objectives, two 60-day at-sea experiments were planned in 1973; ship and aircraft support were made available by NAVOCEANO.

Equipment failures precluded at-sea experiments, therefore this report is limited to the technological aspects of the program, problems encountered, and results achieved.

II. DESCRIPTION OF THE ERTS DRIFT BUOY SYSTEM

A. Buoy Location Subsystem

The ERTS Data Collection System (DCS) did not provide the location capability required by the drifting buoy program. A low-cost location subsystem using existing Transit satellites was designed, developed, and interfaced with the Data Collection Platform (DCP) in the buoy. The location subsystem consisted of a transit receiver, doppler counting logic and a memory. Doppler data derived from the Transit satellite was transmitted by the DCP to the ERTS, received through the DCS, and computed for the buoys geographic location. The location subsystem is described in detail in Chapter 2 of enclosure (1) by Operations Research, Inc., the sub-contractor for the subsystem.

B. Sensor Subsystem

This subsystem included sensors, interfaces, analog-to-digital converters, and a 64-bit shift register as memory. All sensor data were digitized and stored in the register, which was interfaced with the DCP for transmission upon command. Sensors for the measurement of wind speed and direction, air and water surface temperatures, barometric pressure, and wave height were included.

C. ERTS DCP Link

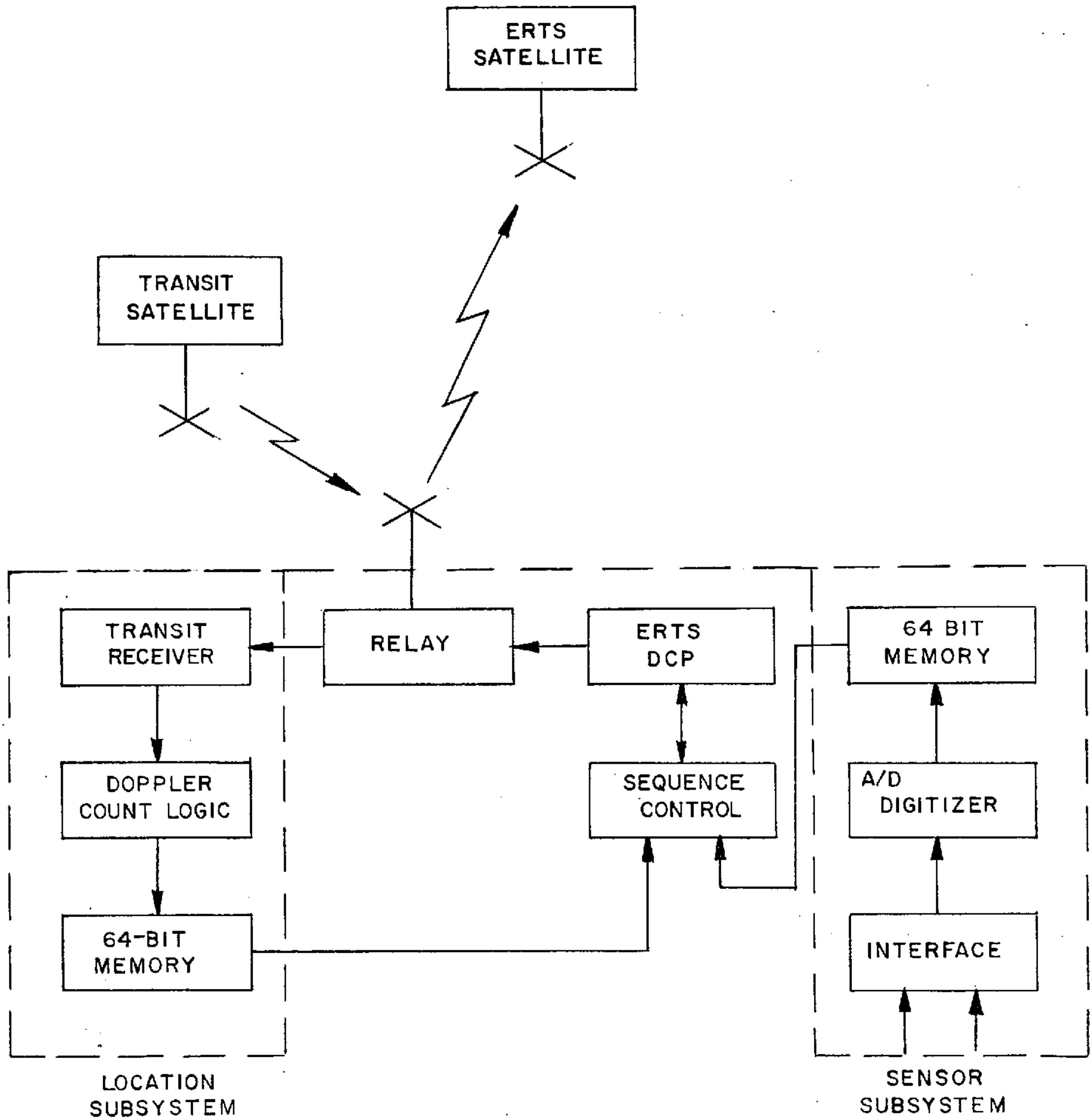
In the area of the planned experiments, the ERTS satellite was in communication range once every 12 hours. Doppler data were up-dated whenever a Transit satellite was in range of the buoy on the average of once every hour and were stored until the ERTS satellite was in range for transmission by the DCP.

Because the DCP was limited to transmission of only one frame of 64 bits every 90 seconds, one frame of location data (64 bits) and one frame of sensor data (64 bits) were alternately transmitted. At 90-second intervals, a minimum of 2 frames of each type of data was received every 12 hours by the Ground Data Handling System (GDHS) at NASA's Goddard Space Flight Center.

A simplified functional block diagram (figure 1) described the DCP transmission sequence.

D. Buoy Hull

The Buoy hull (figure 2) was a spar configuration constructed from high-strength, corrosion-resistant aluminum type 6061-T-6 with a length of 42 feet from antenna top to damping plate bottom. Atop the structure were mounted a spiral antenna,



DCP SEQUENCE

Figure 1

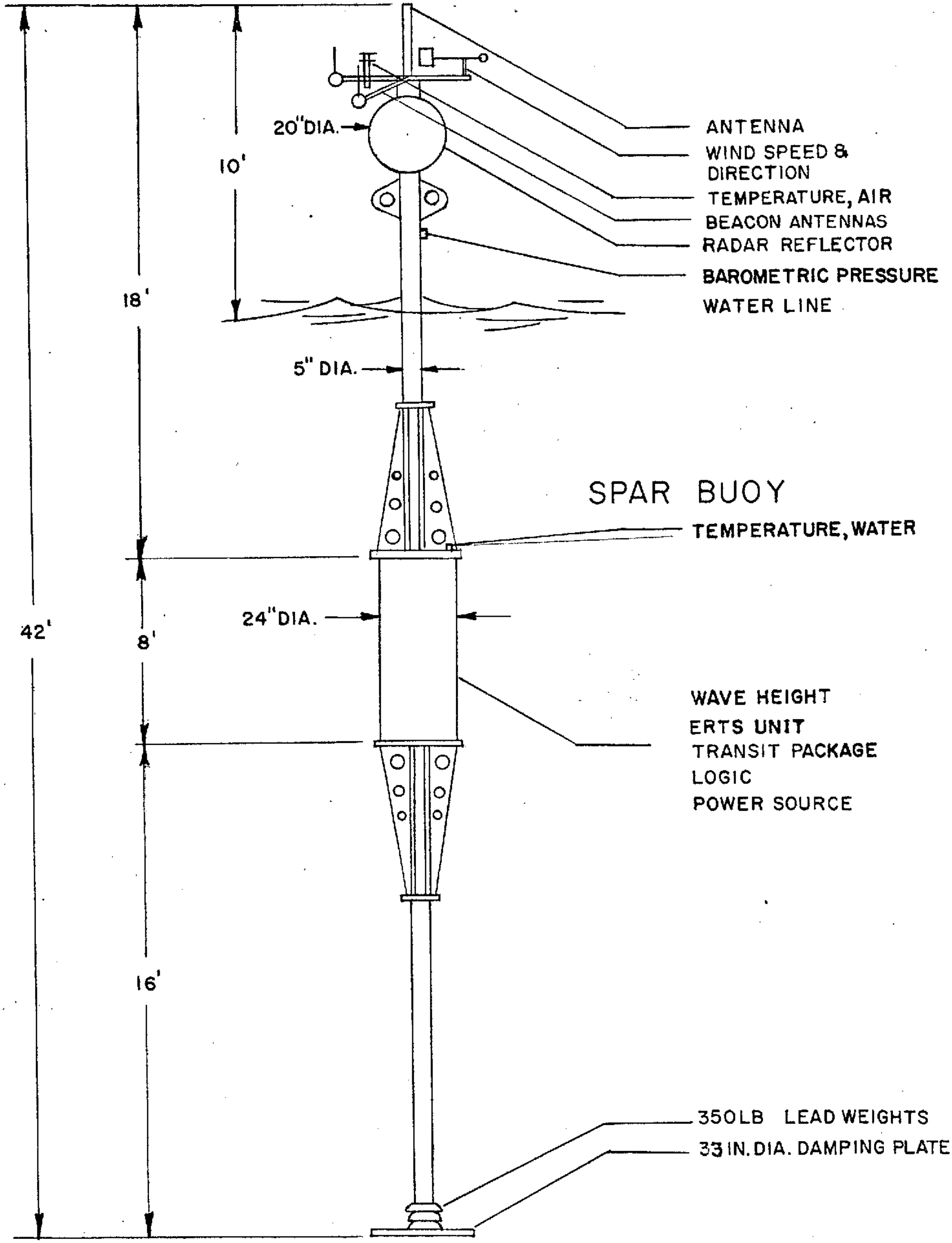

ANTENNA
WIND SPEED & DIRECTION
TEMPERATURE, AIR
BEACON ANTENNAS
RADAR REFLECTOR
BAROMETRIC PRESSURE
WATER LINE
20" DIA.
10'
18'
5" DIA.
SPAR BUOY
TEMPERATURE, WATER
24" DIA.
42'
8'
WAVE HEIGHT
ERTS UNIT
TRANSIT PACKAGE
LOGIC
POWER SOURCE
16'
350LB LEAD WEIGHTS
33 IN. DIA. DAMPING PLATE

Figure 2

navigation light, anemometer, temperature sensor, two back-up radio beacon antennas, and a radar reflector encapsulated in urethane foam. The buoys center section contained power sources, the ERTS unit, the transit package, and logic circuitry. A 33-inch diameter plate was mounted on the bottom of the spar buoy to provide heave stability and to support the lead ballast. The spar buoy is ideal for drift measurements by satellite, because it presents minimal surface area to the wind, and its vertical stability results in a steady antenna radiation pattern. This buoy has been successfully tested in previous tracking experiments with the Nimbus B satellite in tethered and drifting modes.

III. SYSTEM DESCRIPTION

The system's various components and their operating sequence are described in figure 3.

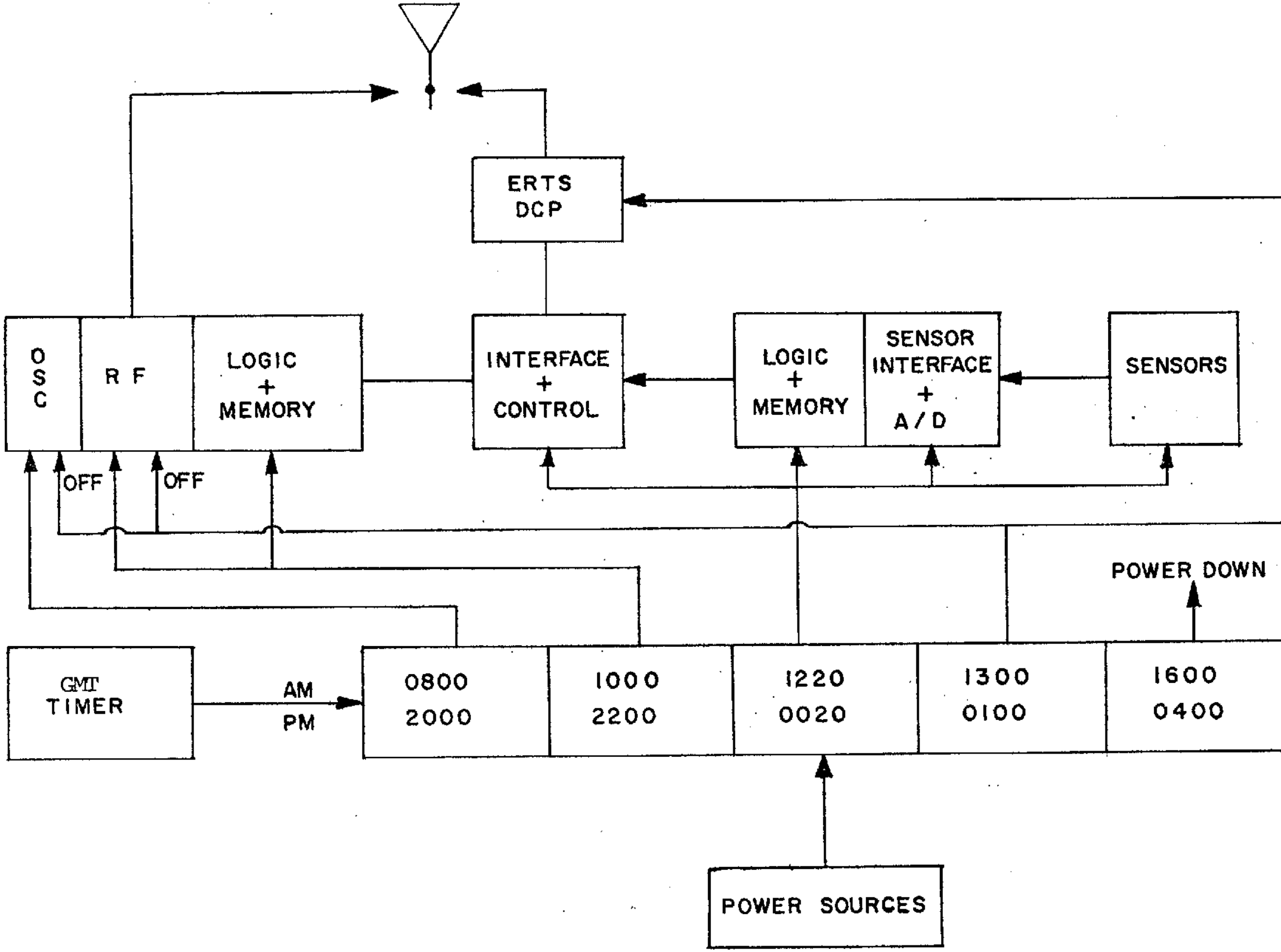
The primary power source was a bank of twenty four 1-volt 300-ampere-hour silver-cadmium cells. A separate 24-volt, 10-ampere-hour alkaline battery powered the DCP unit.

A timer controlled the power to each component to assure battery life for a 60-day unattended operation.

The sequence of operation repeated every 12 hours as follows:

Gmt

AM	PM	
0800	2000	The oscillator of the Transit receiver activated to stabilize for 2 hours.
1000	2200	RF, doppler logic, and memory energized for 3 hours to assure reception of doppler data from at least one Transit satellite. Doppler data from the latest satellite loaded into memory.
1220	0020	Sensors, averaging and control logic, and memory activated. Sensor data loaded into memory.
1300	0100	DCP unit energized. Transit oscillator and RF circuits deactivated. DCP interface alternately extracted data from each memory every 90 seconds for transmission to ERTS satellite for 3 hours.
1600	0400	Power to all components turned off.



OPERATIONAL SEQUENCE

Figure 3

A. Sensors

1. Temperature

Linear thermistor probes were used as sensors for air and water temperature. The air temperature probe, mounted 8 feet above the surface, was housed in a specially designed container to eliminate effects of solar heating and spray cooling. The water temperature probe was mounted on the top of the cylinder can 10 feet below the water surface. Each probe was encased in a Styrofoam-filled stainless steel tube to provide a long time constant for obtaining averaged temperature measurements.

2. Wind Speed and Direction

The wind speed sensor was a modified Bendix anemometer providing one magnetic-reed switch closure for each rotor revolution. Wind speed data were averaged over 30-minute spans.

The wind direction sensor was a potentiometer with 360 degree rotation. Instantaneous and averaged data were measured. Crossovers between 0° and 360° were counted and included in the averaged direction data.

3. Barometric Pressure

The barometric pressure sensor was a variable capacitance transducer with a pressure range between 900 to 1100 mb.

4. Wave Height

Wave height data were obtained from vertical and horizontal accelerometers and a pressure transducer with a 0 - 15 psi range. Because of the large amount of data required, wave height data were recorded separately on a strip-chart recorder.

B. Buoy Antenna

Of primary importance to the buoy telemetering link was the antenna for reception and transmission to and from two separate satellites. Major requirements were for an antenna with a hemispherical radiation pattern, low elevation angle, and not requiring a ground plane.

The antenna selected was a small lightweight spiral type recently developed by the Applied Physics Laboratory and produced by Chou Associates. Two "Chou" antennas were provided by the National Oceanic and Atmospheric Administration's National Data Buoy Center which was very interested in the antenna's performance and is expecting to use this type of antenna for their buoy application. The antenna was 3 inches in diameter, 16 inches in length and was well-suited for buoy application. A performance study of the "Chou" antenna is contained in enclosure (2).

C. Radio Beacons

Two self-contained radio beacons were used for locating the buoy in the event of failure of the Transit system.

A 173-MHz, 250-milliwatt transmitter modulated by 1000 Hz was turned on for 5 minutes and off for 10 minutes to conserve power. This beacon was for line-of-sight search from aircraft equipped with radio direction-finding gear.

The second beacon was a 27.575-MHz, 5-watt transceiver for surface search. This receiver required 100 mA at 12 volts and was also turned on for 5 minutes and off for 10 minutes to conserve power. The receiver detection circuit could be activated only by a legitimate interrogation signal modulated by two separate audio frequencies. Once the receiver detected an interrogation, the transmitter was locked on to provide a continuous tracking signal.

IV. AT-SEA EXPERIMENTS

The buoy system was shipped by air to Bermuda on 16 January 1973 for dockside testing before loading on the USNS LYNCH for the first implant scheduled for 26 January 1973. A procedure was established for obtaining a direct Teletype printout of the ERTS data at the NASA tracking station in Bermuda for expediting the dockside tests. The planned procedure was to test individual subsystems, then to merge all subsystems into the buoy for final satellite tests before loading on the ship.

High winds and heavy rains prevailed throughout the test period. High humidity adversely affected the DCP while it was being serviced. The DCP did not perform satisfactorily until it was purged with freon, sealed in a container, and dried with desiccants.

Additional problems appeared when the DCP was interfaced with the positioning subsystem. One of the DCP output lines had failed to drive the interface logic. The interface logic was modified and testing was resumed whereupon the received ERTS data revealed a further problem in transmission of the stored positioning and sensor data. Reconstruction of the received ERTS data in the binary format revealed that one bit had been shifted after every transmitted frame. This error was traced to a consistent spurious pulse being generated by the DCP. This pulse caused excess cycling of the stored data. The interface logic was remodified to ignore the spurious pulse, and the interface tests were successfully completed.

All subsystems were merged into the buoy for the final test on 30 January 1973 when an electronic timer was discovered to have failed. The buoy could not be made ready and fully tested without further delaying the LYNCH which had been standing by since 26 January. Accordingly, the LYNCH was released for other duty and the first implant was cancelled. Preparations for returning the buoy to Washington were made, and the field party departed from Bermuda on 5 February.

The buoy system had been checked in the NAVOCEANO laboratory where the environmental problems experienced in Bermuda did not exist. Owing to late delivery of the Transit subsystem by the contractor, the total system could not be extensively field tested. Time spent in debugging the DCP and related logic covered 14 days, primarily because of inadequacy of the DCP field test package in that it did not provide real-time testing. The result of each test could be analyzed only by observing the data received through the DCS link which required as much as 24 hours.

On 27 February, Mr. A. Fiehelly, the NASA ERTS technical monitor, was briefed on the first implant effort and understood the problems, particularly with respect to DCP difficulties. He gave encouragement for the scheduled May experiment.

The buoy arrived at Washington on 28 February, and refurbishing began for a May 1973 implant. The LYNCH was again assigned for the second implant and was scheduled to leave the Washington Navy Yard on 5 May. NAVOCEANO decided that the buoy system must be ready one week prior to ship departure. This would also provide sufficient time for the LYNCH to prepare for an alternate mission.

The DCP tester, modified to provide real-time testing, eliminated a wait for data from the DCS printout. This modification had been discussed with and approved by Mr. Earl Painter, the NASA ERTS DCP engineer.

A new timer was installed in the buoy system, which then performed satisfactorily. The DCP transmitted data was of high confidence and the positioning accuracy was within 2 kilometers.

All subsystems were sealed into the buoy for final testing on 24 April. Problems developed again and the buoy was disassembled on 26 April. The DCP tester could not be used while the buoy was sealed. Analysis showed that the DCP again had failed. This raised some concern relative to the reliability of DCP units. The problem was traced to degeneration of the data-gate signal from the DCP. This signal was used to control interface logic and shifting of stored data to the DCP. The logic was again modified and the buoy resealed on 29 April.

When the ERTS link failed to receive data from the buoy on the morning of 30 April, the implantment was cancelled and Mr. Fiehelly was notified. Subsequent examination revealed that failure of the new timer to reset properly resulted in transmission of data when the ERTS was not in view.

V. CONCLUSIONS

Unforeseen problems precluded the two implants, however, these problems have been identified and the experiences from these efforts will be valuable in future satellite/buoy operations.

VI. EXPERIMENTAL DATA

Analysis of the test location data transmitted through the DCS link is described in chapter 3 of enclosure (1). Location accuracy can be significantly improved by including daily vernier adjustments in computation of locations. Since the vernier adjustment data must be obtained daily from the Transit control center in Point Mugu, California, the adjustments were planned for at-sea experiments only and not for testing purposes.