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Development Report

MASTER

UNDERWATER SEARCH OPERATION:
NIMBUS B/SNAP 19 GENERATORS

7200 Field Testing Organization
Sandia Laboratories, Albuquerque

SANDIA LABORATORIES

OPERATED FOR THE U. S. ATOMIC ENERGY COMMISSION BY SANDIA CORPORATION

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ABSTRACT

This report describes the Sandia underwater search operation which located two SNAP 19 generators in approximately 300 feet of water off the coast of southern California.

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UNDERWATER SEARCH OPERATION: NIMBUS B/SNAP 19 GENERATORS

INTRODUCTION

This report describes the underwater search operation which located and photographed two SNAP 19 space isotope generators in approximately 300 feet of water off the coast of southern California. The SNAP 19 generators were part of National Aeronautics and Space Administration's (NASA) Nimbus B weather satellite. They were lost on May 18, 1968, when the Thorad/Agena vehicle was destroyed, because of an off course trajectory, 119 seconds after launch from Vandenberg Air Force Base (VAFB).

Included in the report are a brief discussion of Sandia's responsibilities and involvement in SNAP programs and underwater operations, the detailed planning required for this search operation and the day-by-day record of the actual operation.

The experience gained in successfully completing this search and evaluation operation is summarized in the conclusions of this report.

SANDIA LABORATORIES' ROLE IN SNAP PROGRAMS AND UNDERWATER TEST RANGES

SNAP Programs

In February 1962, Sandia undertook a program at the request of the AEC to provide a continuing effort in the area of nuclear safety for radioactive aerospace power supplies. As originally defined, this included responsibility for conducting any reentry flight tests necessary to demonstrate safety.

In February 1966, Sandia's Space Isotope Power Department was established primarily to provide technical direction of the AEC SNAP program contracts. The Advanced Development Division provides technical direction for a number of technology contracts which will affect future SNAP programs. The Space Power Research Division provides an in-house technology capability to complement the contract work.

Underwater Range Operations

During the past 18 years, Sandia Laboratories have conducted numerous nuclear weapon development test programs at various underwater ranges; and, because nuclear ordnance is invariably classified, a recovery capability is assured before a test program at a water range is authorized. As part of these underwater range operations, Sandia's Field Testing Organization also has been conducting a development and evaluation program to provide improved systems for obtaining underwater trajectories and for locating and recovering AEC hardware on the ocean floor. A partial list of related projects follows:

1. Development of an improved fixed hydrophone system to obtain underwater trajectories resulting from test shapes entering the water at high, medium, and low velocities.
2. Development of a portable hydrophone system to obtain trajectory information from tests at various locations.
3. Design of an air-drop hydrophone system for use in the location phase of Project Train.
4. Design and utilization of portable electronic, optical, and metro stations for use at various underwater test locations.
5. Exploration and utilization of various search and recovery techniques, including sonar search, television search, shallow water recovery, and deep diving submersibles.

In connection with the search and recovery evaluation of deep submersibles and the problem of surface and subsurface positioning and navigation, a joint Sandia/General Motors' operation, utilizing the General Motors' Deep Ocean Work Boat (DOWB) and the GM Automatic Ship Positioning System (ASPS), was planned during 1968. The DOWB is a three-man deep submersible, rated at 6500 feet (Figure 1), and the ASPS is a portable array consisting of three ship-mounted hydrophones and associated electronic gear. This system is capable of continuously monitoring the position of the DOWB relative to the support ship and of directing it accordingly. A polar coordinate plot of the submersible's track, similar to that in Figure 2, serves as a permanent record.

Plans had been made to use the DOWB, the support ship Swan (Figure 3), and the ASPS to conduct evaluation tests of two techniques for locating underwater objects: one would involve a search with high-resolution (200 kHz) side-looking sonar; the other would use the free submersible with optics.

A suitable target in the general area of the Santa Cruz Acoustic Range Facility (SCARF) at Santa Cruz Island was required to conduct these evaluation tests. It had been planned to plant an appropriate target near Santa Cruz Island; however, the abort of the Nimbus B launch provided Sandia with a target.

THE NIMBUS B/SNAP 19 LAUNCH

On May 13, 1968, two SNAP 19 generators, each capable of producing a nominal 30 watts of electrical power, were installed on NASA's Nimbus B weather satellite to supplement the 200 watts of power generated by the Nimbus solar panels (Figures 4 and 5). This satellite was placed aboard a Thorad/Agema booster configuration which is shown in Figure 6.

Launch was at 0123 PDT on May 18, 1968, from Vandenberg Air Force Base (VAFB). A faulty guidance component in the Thorad vehicle caused the missile to veer off course, and destruction was accomplished by the Range

Safety Officer 119 seconds after launch (Figure 7). Trajectory data were obtained from a transponder in the vehicle and from an FPS-16 radar which skin tracked the spacecraft. From this data, the impact point of the debris was calculated to be in the Santa Barbara Channel, approximately 4 nautical miles north of Harris Point on San Miguel Island (Figures 8 and 9).

Because of the unsuccessful launch of the Nimbus B, a realistic target was available to Sandia at no cost, and one, which if located and recovered, would save the AEC approximately \$700,000 in reusable plutonium fuel. After discussions with representatives of ALO, SAO, and SNS of the AEC, Sandia decided to use the Nimbus B debris as a target for the DOWB evaluation tests.

INITIAL NAVY SEARCH

The Agena carried two water-actuated "pingers" designed to operate for 10 days. The U.S. Navy organized search operations immediately, but the search was hampered somewhat by weather conditions and no sound contact was made.

The first search was called off on May 29, 1968, and Ocean Systems, Inc. (OSI), under contract to the Navy, was requested to plan a second search operation. Their search plan called for the use of a Westinghouse side-looking sonar to survey the impact area. The oil supply boat Sea Tender, which was used as a support ship, carried in addition to the sonar, an underwater television system and OSI diving equipment. The mission began on July 19, 1968, but did not arrive on station until July 24, 1968. The search was conducted in a 1600 by 4500 foot "prime" area, roughly centered around the VAFB theoretical "WECO" impact point (Figure 10). This point is located as $34^{\circ}07'34.0''$ North latitude and $120^{\circ}20'45.0''$ West longitude. This rectangle was divided into 14 east-west tracking lanes spaced 165 feet apart. In addition, an extensive

northwest/southeast pattern was searched, as shown in Figure 10. To quote selected portions of an OSI report^{*} on the operation:

"..... all portions of the prime area were scanned a minimum of 5 times, with some areas being scanned as many as 15 times."

"..... However, with positive clarity it can be stated, based on the TV coverage made, that the objects being searched are not within 400 feet of datum."

"The datum point was positively established from the best known data, yet underwater TV search of the area did not disclose even one piece of debris from the Nimbus satellite, nor was a possible sonar contact developed in the flat uncluttered bottom area about datum."

The second search was terminated on July 27, 1968.

SANDIA OPERATION PLAN

While the Navy search was being conducted, the problem had been the subject of discussions in Sandia Laboratories between the Space Power and Field Testing Organizations. In accordance with the plan to perform evaluation tests of the DOWB, Automatic Ship Positioning System, and EG&G sonar, permission to conduct these tests in the general area of Nimbus impact was requested and subsequently granted.

The major steps in the operations plan are listed below:

1. Detailed maps (aeronautical, topographical, and hydrological) were obtained in order to:
 - a. Obtain geographical coordinates of the area
 - b. Select prominent terrain features for line-of-sight observations and communications, radar ranging from San Miguel Island, and sextant readings

^{*}Search OPS Nimbus, Navy Contract No. N0024-68-C-0341.

- c. Determine water depth in operating area for planning buoy and diving operations
2. Weather history and available surface and subsurface current data were obtained.
3. Cutaway views of the missile stage and detailed SNAP photographs were obtained, both for prior study and to be placed aboard the Swan and DOWB for debris identification.
4. Raw impact trajectory information was obtained from VAFB and reanalyzed by the Sandia Data Reduction Organization. This raw data combined with wind and current information for the launch date resulted in the determination of the "Sandia" point for probable location of debris. This point was approximately 400 feet south and 100 feet west of the VAFB "WECO" point, as shown on Figure 10.
5. Once the primary and secondary search areas had been determined, meetings were held with AC-DRL to coordinate all plans and to integrate the following items into the overall operations plan.
 - a. A safety evaluation of the DOWB was made before Sandians were committed as observers.
 - b. Specific plans were made for a general area search and a more detailed search in the event that debris was located.
 - c. Personnel and equipment requirements were agreed upon.
 - d. The installation of the Automatic Ship Positioning System was expedited.

- e. Redundant communications networks were established between the Swan and the mainland to insure communication. In addition, voice codes were devised so that information regarding the progress of the search could be transmitted by radio or telephone without divulging the nature of the mission (see Figures 11-13).
 - f. Arrangements for Health Physics and Radiation Safety personnel and equipment were made.
 - g. Scheduling of EG&G sonar operations was accomplished.
 - h. Three methods of positioning the ship in the desired area were planned: VAFB radar, ship's radar using a range/range technique, and sextant readings from prominent points on or surrounding San Miguel Island.
 - i. The following items were obtained: surface and subsurface buoys and mooring lines, 1500-foot lane-identifying cables, and 14- and 27-kHz pingers with 75-day life spans.
 - j. Provisions were made for processing color film on board the Swan so that immediate and positive debris identification could be made.
6. Preoperational test activities were conducted in the primary search area to:
- a. Check out the various ship positioning systems
 - b. Install a current meter in the primary area for a period of 2-1/2 days so that more realistic information regarding actual current velocity and direction could be obtained.

- c. Perform five drops of a SNAP mock-up to obtain accurate drift information.
7. Overall plans were refined on the basis of the preoperational test.
8. Daily weather reports (forecasts) were scheduled from Sandia and Point Mugu. Sandia personnel aboard the Swan were to keep Sandia and Mugu informed of actual weather conditions in order to continuously improve the accuracy of the forecasts.

SANDIA SEARCH OPERATIONS

Monday, September 23

The Swan departed Santa Barbara Harbor at 0200 PDT and arrived on station at dawn. As a safety precaution, the DOWB was launched for a shake-down dive without a Sandia observer aboard since extensive modifications of the optical viewing system and internal configuration had been completed just prior to the mission.

As the shakedown dive was in progress, VAFB radar proceeded to position the Swan at the WECO and FFT (Free Flight Trajectory) points, and marker buoys were placed at each point for future reference. The Swan's radar was then used to confirm the VAFB position by using multiple range readings for greater accuracy. A plotting of this point placed it 600 feet from the VAFB point, and a third check, utilizing a sextant, resulted in a "triangular" WECO area, as shown in Figure 14.

Tuesday, September 24

The relative accuracy of the three WECO positions was considered, and it was decided that the sextant position provided the most reliable starting point. The DOWB was launched at this location with a Sandia observer on board. For

the major portion of the dive, the search was uneventful; however, as the battery power began to decrease and signal the end of the dive, debris was sighted. This debris was a large section of the missile shroud, and it was immediately marked with a buoy which was thereafter referred to as "Delta I."

Wednesday, September 25

Diving continued and, as battery power again became marginal, debris was again sighted in the general area. A variety of debris was found (Figures 16-20)—shroud sections, spherical tanks, clamps, assorted electronics, etc.—but the most prominent assembly of debris resembled a child's "jungle gym." This was identified as the actual Nimbus portion of the Agena which was marked with an additional buoy, referred to as "Delta II" (Figures 14 and 18). VAFB radar was requested to mark the Swan's position at Delta II, which, relative to the VAFB "WECO" point, proved to be 200 feet on a true bearing of 155 degrees. Considering the actual triangle of WECO points, this agreed closely with the Sandia predicted point.

After the DOWB had been recovered, the EG&G side-scanning sonar was used to search on either side of a line through Delta I and Delta II. It was known from optical observation of the bottom that the flat, soft, sandy bottom was bordered by rock ridges and that Nimbus debris was in the area, but the sonar records indicated only "probable" targets. The quality of the sonar records was excellent (Figure 15).

Thursday, September 26

Prior to the dive, the Swan placed two 1500-foot marker cables on the bottom in the form of a cross at the Delta II position (Figure 14). Each cable had numbered wooden blocks at 100-foot intervals; each block floated on a 3-foot line and served as a bottom reference marker for the DOWB. In the process of re-positioning the Swan prior to the dive, the anchor probably picked up one of the bottom marker cables and possibly moved the position of both cables; in any case, the DOWB was unable to relocate Delta II. Various pieces of debris were sighted, however, including additional portions of the shroud.

Friday, September 27

New areas of major debris were sighted and extensively photographed during the dive. When possible, debris was turned over or moved by DOWB on the chance that the SNAP 19 might be hidden from view. Examination of the film from this dive indicated that the sensory ring (Figure 16), and the SNAP 19 (Figure 20) had been found; these parts were positively identified by representatives of NASA, AEC, and Sandia.

Debris had been located on four successive days, and the primary goal was attained, but efforts to relocate the SNAP 19 on September 28 and 29 were unsuccessful. It became evident that a strong wind and strong current, working in opposite directions, had moved the surface buoys.

The mission was terminated the evening of September 29, 1968.

CONCLUSIONS

1. In an underwater search and recovery mission, the search phase is by far the most difficult and time-consuming portion of the operation.

2. Limited range of visibility places a severe restriction on manned submersibles and underwater television. Continuing research on blue or green underwater laser illuminators may improve this range.

3. Lack of ability to navigate accurately underwater is a serious handicap to the search mission. This is a problem involving equipment, skill, and procedures.

4. Manned submersibles provide a realistic means of locating underwater targets if they can be vectored from either the surface or the bottom.

5. Towed, high resolution, side-scanning sonar did not show up identifiable wreckage, even though the scan was made in an area already known by optical observation to contain that wreckage. Perhaps the reason for this is

that mashed, mixed up missile debris more closely resembles normal under-sea environment than distinctly man-made objects.

6. Submersibles have a great potential in the search and recovery field.

7. Evaluation must continue until a composite requirement can be drawn up for a submersible tailored to AEC's recovery requirement.

Figure 1. Deep Ocean Work Boat (DOWB) and R/V Swan

Δ DELTA II SURFACE BUOY RELATIVE TO SWAN
TIME: 1425 SUNDAY SEPT 29, 1968

Figure 2. Acoustic Ship Positioning System Plot of DOWB Movements

Figure 3. AC Electronics-Defense Research Laboratories - R/V Swan

Figure 4. SNAP 19 Principal Dimensions

Figure 5. Nimbus B

Figure 6. Nimbus/Agena/Thorad Launch Configuration

LAUNCH SITE	- VANDENBERG AIR FORCE BASE
DATE AND TIME	- MAY 18, 1968, 0123 PDT
COURSE	- 180° TRUE
PLANNED ORBIT	- POLAR
DESTRUCT	- 119 SECONDS AFTER LAUNCH
REASON	- THOR VEERED TO APPROX. HEADING OF 160°
CAUSE	- GYRO MALFUNCTION IN THOR GUIDANCE SYSTEM

Figure 7. NASA'S Nimbus B Launch

Figure 8. Launch Area

Figure 9. Impact Area

Figure 10. Search Area

- ① DIVE START**
- ② ENVIRONMENT OK (1/2 HOURLY)**
- ③ PREPARE TO SURFACE**
- ④ ON BOTTOM (DEPTH)**
- ⑤ OBJECT (MISSION) IN SIGHT**
- ⑥ MISSION COMPLETED**
- ⑦ MY DEPTH IS—**
- ⑧ MY COURSE IS —**
- ⑨ WATER DEPTH IS —**

Figure 11. Alpha Code

- ① TUES. DEBRIS**
- ② WED. DEBRIS**
- ③ HAVE SAMPLE**
- ④ PLACE 27 KC PINGER**
- ⑤ PLACE 16 KC PINGER**
- ⑥ NO FURTHER DEBRIS IN SIGHT**
- ⑦ NEW DELTA 2**
- ⑧ BINGO (SNAP UNIT IN SIGHT)**

Figure 12. Delta Code

- ① SNAP UNIT IS STILL CONNECTED TO LARGE PORTION OF NIMBUS**
- ② SNAP UNIT HAS BROKEN LOOSE FROM NIMBUS**
- ③ NO RESULTS TO DATE**
- ④ SNAP UNIT LOCATED AND MARKED**
- ⑤ SIGHTED DEBRIS, PLAN TO START INTENSIVE SEARCH OF AREA**
- ⑥ DOWB SHOULD BE ABLE TO RECOVER**
- ⑦ NEED HARD HAT DIVERS TO RECOVER**
- ⑧ SNAP CASE HAS FRACTURED AND CYLINDER IS EXPOSED**

Figure 13. Zulu Code

Figure 14. Relative Positions - Nimbus Operation

Figure 15. Sonar Record of Debris Area

Figure 16. Nimbus Shroud

Figure 17. Sensory Ring Structure

Figure 18. "Jungle Gym"

Figure 19. Nimbus Structure

Figure 20. SNAP 19 Generators

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