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POR-2053(EX)
(WT-2053)(EX)
EXTRACTED VERSION

OPERATION DOMINIC

FISH BOWL AND CHRISTMAS SERIES

Organizational, Operational, Funding, Logistic, and Scientific Summary

Deputy Chief of Staff
Weapons Effects and Tests
Field Command
Defense Atomic Support Agency
Sandia Base, New Mexico

30 December 1963

NOTICE:

This is an extracted version of POR-2053 (WT-2053), OPERATION DOMINIC, Fish Bowl and Christmas Series.

Extracted version prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, DC 20305-1000

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The main weapons effects test effort was in the Fish Bowl Series, which consisted of five high-altitude nuclear detonations. The objectives included studies of weapons effects on radar and communications, changes in the ionosphere and the earth's magnetic field, and distribution of debris from the nuclear devices.

The principal objective of this report is to discuss the organizational, operational, funding, and logistic aspects of Task Unit 8.1.3 in Operation Dominic. The various scientific experiments are described under the general types of effects and phenomena studied. In general, the data obtained was excellant.

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FOREWORD

Classified material has been removed in order to make the information available on an unclassified, open publication basis, to any interested parties. The effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NTPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

The material which has been deleted is either currently classified as Restricted Data or Formerly Restricted Data under the provisions of the Atomic Energy Act of 1954 (as amended), or is National Security Information, or has been determined to be critical military information which could reveal system or equipment vulnerabilities and is, therefore, not appropriate for open publication.

The Defense Nuclear Agency (DNA) believes that though all classified material has been deleted, the report accurately portrays the contents of the original. DNA also believes that the deleted material is of little or no significance to studies into the amounts, or types, of radiation received by any individuals during the atmospheric nuclear test program.

OPERATION DOMINIC

FISH BOWL AND CHRISTMAS SERIES

ORGANIZATIONAL, OPERATIONAL, FUNDING, LOGISTIC, AND SCIENTIFIC SUMMARY

Deputy Chief of Staff
Weapons Effects and Tests
Field Command
Defense Atomic Support Agency
Sandia Base, New Mexico

ABSTRACT

During 1962, the Weapons Effects and Tests Group (WET), Field Command, Defense Atomic Support Agency, executed the Department of Defense (DOD) scientific programs of Operation Dominic, except those for Shot Sword Fish and the operational suitability tests of the Polaris system conducted by the US Navy.

The main WET effort was in the Fish Bowl Series, which consisted of five high-altitude nuclear detonations. The objectives included studies of weapons effects on radar and communications, changes in the ionosphere and the earth's magnetic field, and distribution of debris from the nuclear devices.

A further portion of the DOD effort was directed toward the Atomic Energy Commission tests on Christmas Island.

During the operational period of Operation Dominic, 4 April through 3 November, Task Unit 8.1.3 (the WET portion of Joint Task Force EIGHT) operated scientific stations throughout the Pacific area. Task Unit 8.1.3 was under the operational control of Joint Task Force EIGHT and received technical guidance from the Defense Atomic Support Agency.

The main objective of this report is to discuss the organizational, operational, funding, and logistic aspects of Task Unit 8.1.3 in Operation Dominic. The various scientific experiments are described under the general types of effects and phenomena studied. The results are discussed briefly; detailed discussions are available in the appropriate Project Officers Reports. In general, the data obtained was excellent.

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INTRODUCTION

1.1 SCOPE OF REPORT

This report is a summary of the participation by Field Command, Defense Atomic Support Agency (FCDASA) in Operation Dominic, a joint Department of Defense-Atomic Energy Commission (DOD-AEC) operation held in the Pacific Ocean area during the period 1 May through 3 November 1962.

The operation was conducted by Joint Task Force EIGHT (JTF-8), initially under the command of Major General Alfred D. Starbird, USA, and later by Rear Admiral Lloyd M. Mustin, USN. During the operational period, the DOD scientific element, Task Unit 8.1.3, under the Weapons Effects and Tests Group, FCDASA, was commanded by Colonel Leo A. Kiley, USAF.

Although major portions of Dominic took place in both the Christmas and Johnston Island areas, the events at Johnston Island were the ones of primary interest to the DOD and were called the Fish Bowl Series. The events at Christmas Island were basically AEC events. The AEC also had a series of airdrops in the Johnston Island Danger Area. Two weapons tests by the Navy were included in Dominic; they were conducted in the ocean area between the United States and Christmas Island by JTF-8.

No attempt is made to include in this report detailed results of the DOD scientific effort; complete reports of the various scientific experiments may be found in the Project Officers Reports (POR's) listed in Appendix A.

This summary is written primarily to report the operational, support, and fiscal aspects of the operation, together with summaries of the scientific experiments and their results.

1.2 BACKGROUND

The culmination of the DOD-AEC efforts for the resumption of an atmospheric test program occurred on 10 October 1961 when the President approved the recommendations contained in a letter from the Secretary of Defense concerning nuclear testing. The primary recommendation was that approval be given the DOD and the AEC to prepare for atmospheric and high-altitude nuclear tests at suitable locations. Prior to this approval, neither the DOD nor AEC were authorized to plan or to prepare for atmospheric tests during the test moratorium. The Secretary of Defense on 12 October 1961 forwarded a memorandum to the Chairman of the Joint Chiefs of Staff (JCS) authorizing and directing certain actions pertaining to the planning and preparation for nuclear weapons testing in the atmosphere.

On 21 October 1961, the JCS implemented the program for the proposed weapons test plans and preparations and assigned the specific responsibilities to the respective service organizations.

The specific responsibilities assigned to Chief, Defense Atomic Support Agency (DASA) were: (1) to plan and prepare experimental programs to include delivery means, for high-altitude effects tests, at an overseas location; (2) to plan experimental programs for nuclear weapons effects based on the possibility of continuing test programs; (3) to prepare to provide the necessary support to the AEC; and (4) to activate JTF-8 with the Commander to be designated by JCS.

At the National Security Council (NSC) meeting of 2 November 1961, appropriate decisions were made with regard to an atmospheric nuclear test program, and the implementation action was ordered. The JCS was directed to prepare to execute nuclear weapons tests operations in accordance with the recommended AEC-DOD program at an overseas site to commence in about 6 months (approximately 1 April 1962) and to be completed about 3 months thereafter (1 July). At this time, there was still no authority to conduct or execute an atmospheric test program. This specific authority had to be obtained from the President. On 29 November 1961, the NSC recommended to the President that a series of atmospheric nuclear tests be approved beginning in the spring of 1962. The President approved the NSC proposed list of atmospheric nuclear tests for the purpose of proceeding with preparations, but reserved judgment on the final decision for or against the resumption of atmospheric testing.

1.3 OBJECTIVES

As initially approved, the Fish Bowl Series was to be a high-altitude test program to be conducted at Johnston Island in the spring of 1962 (21 April through 1 July). It provided for: (1) Thor system proof test (nonnuclear), 1 May;

and (3) 1.45-Mt test at 400 km (Shot Star Fish), 15 June. The Thor missile was chosen as the carrier (Figure 1.1).

The purpose of the Fish Bowl Series was to satisfy JCS requirements for weapons effects data of the following general categories. The data sought from Shot Blue Gill included: (1) fireball transparency, growth, and rise; (2) intensity of beta and D-region ionization; (3) structural response to thermal radiation; and (4) radiation flux measurements. The data sought from Shot Star Fish included: (1) intensity and duration of ionization layers (fission debris and radiations), (2) radio and radar blackout areas (phenomenology of magnetic conjugate points), and (3) motion of debris pancake.

More specifically, the data sought concerned the following: (1) ICBM kill mechanisms and vulnerability, (2) penetration aids, (3) retaliatory force capabilities, (4) AICBM effectiveness, (5) early warning systems, (6) communications and control, (7) satellites, and (8) biomedical thermal responses.

In addition, information on physical aspects was needed to supplement the above data. This included: (1) debris location; (2) debris charge; (3) production and loss of electrons in the fireball; (4) production and loss of electrons in the ionosphere; (5) electromagnetic (EM) noise; (6) absorption and refraction of EM waves; (7) nuclear, thermal, and X-radiation outputs and damage mechanisms; (8) EM pulse output and damage mechanisms; and (9) ultraviolet through infrared radiation output, damage, and attenuation.

As explained in Section 1.4, the original shot schedule was changed.

1.4 SHOT SCHEDULE

The first event of Dominic, the detonation of an airdropped device (Shot Adobe), took place at Christmas Island on 25 April 1962. Airdropped devices continued to be fired until 11 July 1962, after which the effort at Christmas Island was terminated.

At Johnston Island, Phase I of Fish Bowl lasted from 2 May through 25 July, when a Thor missile burned on the launch pad. Only the 400-km (Star Fish Prime) test was successfully completed. The two attempts to conduct the test (Blue Gill and Blue Gill Prime) were unsuccessful

During the conduct of and subsequent to completion of Phase I, additional consideration was given to expanding the Fish Bowl Series to include several supplemental low-yield high-altitude effects tests. In compliance with an oral request from the Assistant to the Secretary of Defense (Atomic Energy), the Defense Atomic Support Agency prepared and submitted on 17 August 1962 a technical program for three low-yield high-altitude effects tests—Shots Check Mate, Tight Rope, and Side Show.

Other missiles and rockets for carrying warheads to detonation altitudes were first considered after the failure of the Blue Gill missile. As more Thor failures occurred, work was started on the XM-33 Strypi rocket by Sandia Corporation. During the interval between Phases I and II, the Army Nike-Hercules missile was brought into the family of available carriers. Both these carriers were used because of their respective advantages for specific events. Neither system was capable of carrying instruments similar to the pod-carrying capability of the Thor.

Refinement of the supplemental weapons effects program continued after submission, resulting in the following changes: (1) Check Mate, (2) Tight Rope, and (3) King Fish, The King Fish shot was desired The basic concern was the danger of eyeburn from the detonation if seen by the inhabitants of the Hawaiian chain.

The operational portion of Phase II began with the unsuccessful firing of Blue Gill Double Prime, 15 September, and terminated with the detonation of Tight Rope, 3 November. Side Show was eventually canceled in lieu of the other planned detonations.

A total of five high-altitude nuclear detonations occurred during the operational phase of the Fish Bowl Series. All five events were fired at night in order to improve the optical diagnostic and effects coverage. Tables 1.1 and 1.2 list the events, yields, altitudes, and burst locations; more detailed data and descriptions are contained throughout the report.

The numbers of events, types of delivery systems, and firing schedules changed continuously during the operational phases of Dominic. Nevertheless, the basic experimental plan remained unchanged, as did the primary military objective, which was to obtain data regarding interference to radar and communication systems produced by high-altitude nuclear detonations.

The general objectives of the supplemental weapons effects program of Fish Bowl were very similar to the Phase I objectives. The Phase I events each established one point in the n-dimensional measurement space comprising shot altitudes, yields, geomagnetic location, etc. The reliability of making predictions drops off rapidly as the experimenter moves away from the test conditions. One particularly difficult problem is predicting scaling laws for various yields at various altitudes. With the inclusion of the supplemental test program, it was then reasonable to extrapolate results and make predictions for other sets of conditions not too different from the actual shot conditions.

1.5 STATIONS

Maps in Appendix B show the magnitude of the array of experimental stations in the Pacific. These were supported by numerous ship and aircraft stations. This dispersion of scientific effort was necessitated by the influence of the earth's magnetic field on high-altitude nuclear detonations, resulting in perturbations in the opposite magnetic hemisphere (conjugate point) and even worldwide effects.

One unique and distinctive feature of the Fish Bowl Series over previous effects tests was the inclusion of a large number of rocketborne instruments used to obtain scientific data that could not be obtained in any other manner. It is anticipated that an extensive small rockets program will be an inherent part of any future high-altitude effects test program.

1.6 SHOT NAMES IN REPORT

Except where necessary to explain failures, the nuclear detonations will be designated in this report by the use of the event name without reference to previous unsuccessful attempts. Hence, Blue Gill will be used to refer to the Blue Gill event on 26 October 1962.

TABLE 1.1 LIST OF SCHEDULED EVENTS

Event	Carrier	Date/Time (Zulu)	Nominal Height of Burst	Launcher Coordinates	Remarks
		1962	km		
Phase I:					
Tiger Fish	Thor	2 May	No detonation	Note 1	System certification
Blue Gill	Thor	2 Jun	No detonation	Note 1	Destroyed in flight
Star Fish	Thor	20 Jun	No detonation	Note 1	Destroyed in flight
Star Fish Prime	Thor	9 Jul, 0900	400	Note 1	Lift-off to burst 821.02 seconds
Blue Gill Prime	Thor	26 Jul	No detonation	Note 1	Destroyed on launch pad
Phase II:					
Blue Gill Double Prime	Thor	16 Oct	No detonation	Note 2	Destroyed in flight
Check Mate	Strypi	20 Oct, 0830		Note 3	
Blue Gill Triple Prime	Thor	26 Oct, 1000		Note 2	
King Fish	Thor	1 Nov, 1210		Note 1	
Tight Rope	Nike-Hercules	4 Nov, 0730		Note 4	

Note 1: Pad No 1: Lat. 16° 43' 49.52'' N; Long. 169° 32' 19.50'' W.
H&N coordinates N198, 610.056; E196, 305.074

Note 2: Pad No 2: Lat. 16° 43' 58.54'' N; Long. 169° 32' 07.00'' W.
H&N coordinates N199, 520.013; E197, 519.963

Note 3: Strypi Launcher: Lat 16° 43' 40.00'' N; Long. 169° 32' 14.41'' W.
H&N coordinates N197, 650.02; E196, 800.01

[illegible]

Note 4: Nike-Hercules Launcher (Midpoint): Lat 16° 43' 39.56'' N; Long. 169° 32' ~~16.88''~~ W.
~~H&N coordinates~~ N197, ~~615.43~~; E196, [illegible]
Plane Coordinates 600.35 [illegible]

TABLE 1.2 RECORDED STATISTICS FOR FISH BOWL EVENTS

Characteristics	Star Fish	Check Mate	King Fish	Blue Gill	Tight Rope
Altitude, km	400.09				
Yield, fission/fusion, kt					
Shot Date, GMT	9 July 1962 0900:09.0290Z	20 October 1962 0830:00.0031Z	1 November 1962 1210:06.1263Z	26 October 1962 0959:48.4753Z	4 November 1962 0730:00.0678Z
Geographic Coordinates *	16° 28′ 06.32″ N 169° 37′ 48.27″ W	16° 04′ 20.57″ N 169° 36′ 35.95″ W	16° 06′ 48.61″ N 169° 40′ 56.02″ W	16° 24′ 57.03″ N 169° 36′ 11.18″ W	16° 42′ 26.71″ N 169° 32′ 32.66″ W

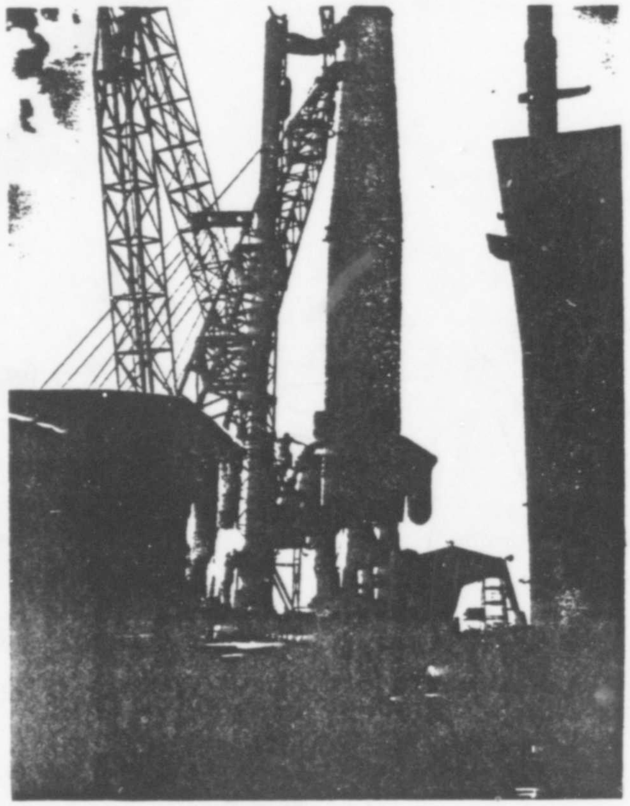


Figure 1.1 Thor missile, Shot Tiger Fish.
(DASA 26-5627-62)

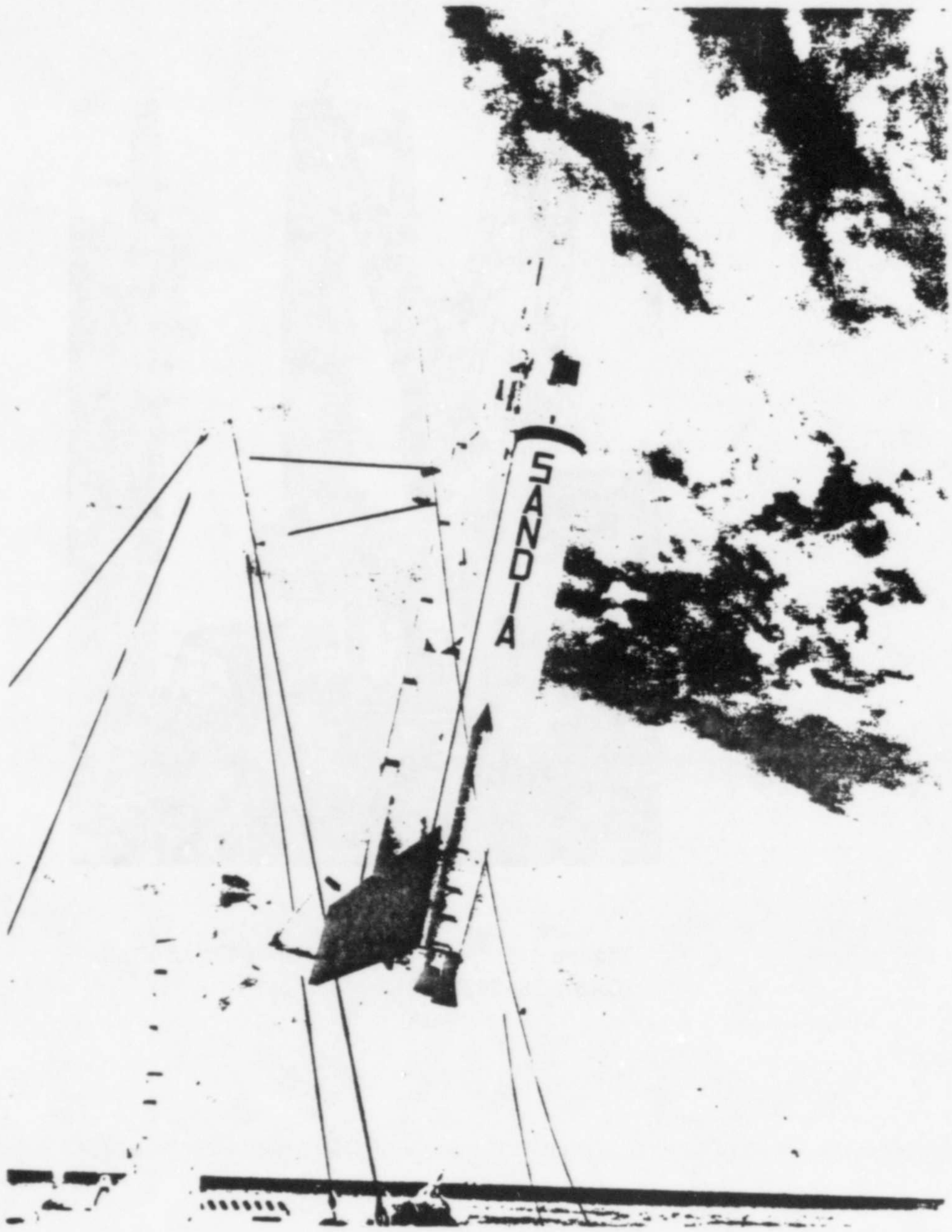


Figure 1.2 Strypi rocket, XM-33.
(Sandia D63 458)

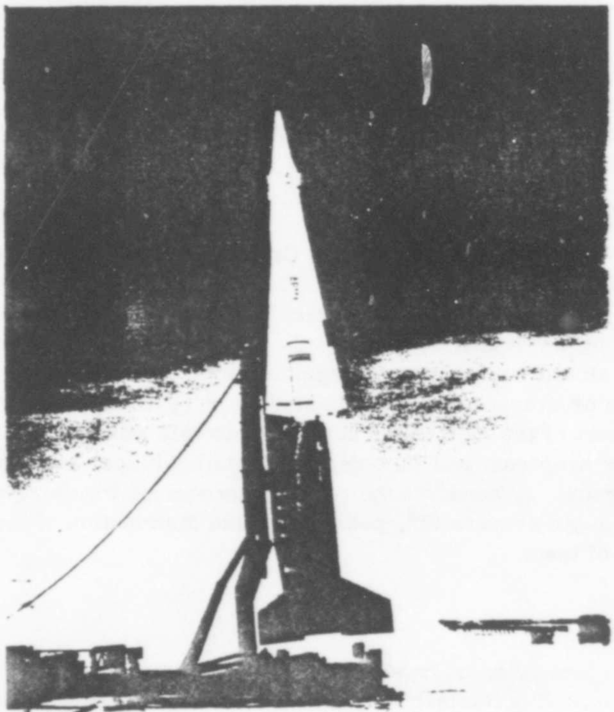


Figure 1.3 Nike-Hercules missile.
(DASA 26669962)

Chapter 2

ADMINISTRATION, SECURITY, AND PUBLIC INFORMATION

2.1 WET MISSION

The Weapons Effects and Tests Group (WET) was organized in 1956 in its present form, although some of the functions date back to 1947. Missions assigned to WET include the following: (1) exercises the technical direction of atomic weapons effects tests of primary concern to the Armed Forces and the weapons effects phases of developmental or other tests of atomic weapons involving nuclear detonations within the continental United States (CONUS) or overseas; (2) coordinates the support of military participation and assists in the support of the AEC in the conduct of atomic weapons tests within the continental United States or overseas; and (3) completes detailed plans, arranges for construction and logistical support, or conducts the technical programs involving weapons effects tests, and assists in the preparation, publishing, and distribution of the technical and operational reports of tests.

2.2 ORGANIZATION

Under authority of letter, SWPWT/960, Chief, DASA (CHDASA), 2 June 1953, Subject: "Tests Involving Nuclear Detonations Participated In or Conducted by Agencies of the Government of the United States Outside the Continental United States," CHDASA, by letter, DASATP/984, 26 December 1961, Subject: "DOD Weapons Effects Programs, Operation FISH BOWL (U)," augmented the responsibilities of Commander, Field Command, DASA (FCDASA). Augmented responsibilities for Fish Bowl included completion of detailed plans, preparation for the conduct of the technical programs, and the submission of completed reports upon the conclusion of the field operations. In execution of these functions, Commander, FCDASA, was to represent CHDASA for coordination with the AEC, its contractors, and other Government agencies in obtaining experimental data to meet service and/or other DOD requirements.

The Deputy Chief of Staff, Weapons Effects and Tests Group, FCDASA, was responsible to the Commander, FCDASA, for execution of the functions of FCDASA.

During January 1962, action was initiated for implementation of FCDASA functions, and planning for the organization and manning of Task Unit 8.1.3 (TU 8.1.3) was started. As the technical programs were developed, it was realized that the technical and scientific projects would be located over an extremely widespread area. To provide adequate supervision and control over all activities and projects, and to enable the Commander, Task Unit 8.1.3 (CTU 8.1.3) freedom of action in supervising DOD efforts for the entire operation, TU 8.1.3 was organized into five elements, each to be headed by an appointed Officer-in-Charge. The staff organization of TU 8.1.3 essentially remained unchanged (see Figure 2.1). Personnel of the TU 8.1.3 staff were located at the various task element locations as required for the accomplishment of element missions. The designations, locations, and areas of responsibilities of the task elements (TE's) were as follows:

2.2.1 TE 8.1.3.1. Location: Johnston Island. Area of responsibilities: Provide technical direction and support of all DOD projects located on Johnston Island.

2.2.2 TE 8.1.3.2. Location: Hickam AFB, Oahu Island, Hawaii. Area of responsibilities: Provide technical direction and support of all DOD projects located on the Hawaiian Islands and in the Northern Conjugate Area. Additionally, serve as the overseas base focal point for coordination and action on all transportation, supply, engineering and construction, administration, and security functions with activities in CONUS, military installations in Hawaii, and the other task elements.

2.2.3 TE 8.1.3.3. Location: Christmas Island. Area of responsibilities: Provide technical direction and support of all DOD projects located on Christmas island.

2.2.4 TE 8.1.3.4. Location: Viti Levu, Fiji Islands. (During the later phases was relocated to Tutuila, American Samoa.) Area of responsibilities: Provide technical direction and support of all DOD projects located in the Southern Conjugate Area.

2.2.5 TE 8.1.3.5. Location: Sandia Base, New Mexico. Area of responsibilities: Maintain coordination with CHDASA, Commander, FCDASA, and project agencies within CONUS on technical and support matters. Provide support to the field elements.

2.3 PERSONNEL STRENGTH

On 1 February 1962, Commander, FCDASA, by General Order Number 1, directed establishment of TU 8.1.3 (Provisional) with an authorized strength of 55 officers, 49 noncommissioned officers (NCO's), 23 enlisted men, and 3 civilians, for an aggregate strength of 130 individuals. Personnel were furnished from within the resources of FCDASA and augmented as required by CHDASA, and the services as determined by JCS.

Each of the TU 8.1.3 Support Division Liaison Offices at Travis AFB, California; Naval Supply Center, Oakland, California; and Hickam AFB was manned by one officer and one NCO during January. Advance party personnel for Johnston Island and Hickam AFB arrived on-site in mid-February. The remainder of TU 8.1.3 staff personnel and project personnel were phased-in as they were needed at the various overseas locations. The majority of staff and project personnel were in place by mid-April. On 4 April, TU 8.1.3 came under the operational control of the Commander, Joint Task Force EIGHT (CJTF-8), while remaining for technical, administrative, and support control under CHDASA and Commander, FCDASA (Figure 2.2).

Task Element 8.1.3.3 completed its phase of test participation at Christmas Island and was closed out on 13 July.

On 25 July, the Thor missile launching pad at Johnston Island was destroyed. Because of the time required to rebuild the launching pad, the decision was made to rotate personnel back to their home stations, with only minimum caretaker and operational personnel remaining on sites. Redeployment of personnel back to the test area began in the last week of August. After the final detonation in Fish Bowl on 3 November, staff and project personnel of TU 8.1.3 immediately began rollup operations and returned to their home stations.

2.4 ADMINISTRATION

The principal administrative office was located with TE 8.1.3.2. The Assistant Administrative Officer, one NCO, and three enlisted men were located with TE 8.1.3.1; one NCO was with TE 8.1.3.4; and one NCO and one to two enlisted men were with TE 8.1.3.5. TE 8.1.3.3 was administratively self-sustaining.

Each of the administrative offices had the following capabilities: (1) receipt, distribution, and dispatch of official and personal mails; (2) receipt, distribution, control, and dispatch of classified documents; and (3) preparation of vouchers for reimbursement of travel and per diem allowances. Over 22,000 classified documents were received, processed, or originated by TU 8.1.3 while in the overseas test area.

The administrative offices with TE's 8.1.3.1, 8.1.3.2, and 8.1.3.5 had additional capabilities of providing reproduction services, assistance to individuals in personal matters, and issuance of travel orders.

2.4.1 Classified Document Control. The administrative office at each TE (with exception of TE 8.1.3.5) established and operated a primary account for the control of classified documents. Secondary accounts were established, as required, with staff sections and project agencies. The primary accounts were manually operated. Because of inexperienced personnel and the volume of documents concerned, some difficulties were experienced in TE's 8.1.3.1 and 8.1.3.2. The documents handled at these two locations were in excess of 8,000 and 12,000, respectively.

For future tests of this type, it is recommended that primary classified document accounts be established and placed in operation prior to departure to the test area. This would give the clerks on-the-job training and experience in the control system. Additionally, the documents destined for a particular location would be under control prior to departure, could be shipped intact to the location involved, and be more readily available after arrival. Some consideration should be given to some type of a mechanical accounting system at TE sites having a large volume, e.g., Johnston Island and Hickam AFB.

2.4.2 Reproduction Services. Reproduction equipment was provided on a rental basis through the AEC Support Contractor (Holmes and Narver).

TE 8.1.3.1 had a Multilith machine (Model 80) and a Thermofax machine (Secretary). Considerable maintenance and repair problems were experienced on both machines, due largely to inexperienced operators and the remote location from factory maintenance representatives.

TE 8.1.3.2 was provided with a Multilith machine (Model 80) and a Xerox copier 914. No operating or maintenance problems were encountered.

In event of a future operation, it is recommended that the TE at Johnston Island be provided with a Multilith machine (Model 1250W), a Ditto (spirit process machine, electrically operated), and two office-type copying machines that have the capabilities of reproducing from other than black and white.

The TE at Hickam should be provided with a Multilith machine (Model 1250W) and a Xerox copier 914.

Personnel should be instructed in operation and maintenance procedures of all equipment prior to departure from home station.

2.4.3 Postal Services. TE 8.1.3.1 was serviced by APO 105; TE 8.1.3.2, by APO 953; and TE 8.1.3.3, by APO 86, all of which were operated by the 6005th Air Postal Group, Pacific Air Forces (PACAF). Projects located on other than Oahu Island, within the Hawaiian Islands, and islands located in the Northern Conjugate Area were served through the nearest US post office, or military post office of the Army, Air Force, or Navy.

TE 8.1.3.4 and projects located on islands in the Southern Conjugate Area utilized APO 953 for a mailing address. This mail was turned over to the MATS Intransit Mail Room at Hickam AFB for movement to destination via the Southern Conjugate Area shuttle planes. The JTF-8 Liaison Officer provided JTF-8 supervision over movement of this mail. Movement of mail, particularly registered mail, to destinations in the Southern Conjugate Area was uncertain. Registered mail on several occasions was found to be still on hand in APO 953 or the MATS Intransit Mail Room, even after two or more Southern Conjugate Area shuttle flights had departed. Initially, some of the difficulties in movement of this mail were due to: (1) reluctance of flight crews to accept mail for delivery to island sites, and (2) failure of designated individuals to meet the flights and accept the mail for delivery to addressees. These problems were later solved, when Island Commanders and Unit Mail Clerks were appointed by CJTF-8 at each island site. The solution of these problems was accomplished largely through the voluntary efforts of the Commander, 6005th Air Postal Group, who had not been assigned any responsibilities in this area. The lack of responsible qualified JTF-8 personnel to supervise mail service, and to coordinate movement by all available military aircraft, continued to exist during the entire operation.

For future operations, it is recommended that the Joint Task Force Commander provide a military postal unit stationed at Hickam AFB. This postal unit should be headed by a qualified and experienced military postal officer and manned by sufficient officer and enlisted personnel to accomplish the following functions: (1) maintain a mail-regulating section in the MATS Terminal Area to control movement of all joint task force mail, and to effect coordination with the Air Force, Navy, and Coast Guard for movement of mail by all scheduled and opportune aircraft and vessels; (2) provide a mail delivery section at Hickam AFB for delivery of mail to joint task force elements and units stationed locally; (3) provide a mobile subunit to accompany each scheduled shuttle flight to remote areas. This subunit should courier all mails (including registered items) for each destination and should be prepared to offer stamp sales; registry; certified, insured, first class, and fourth class mailings; and money order service at each destination; and (4) provide a postal directory service at Hickam AFB for the joint task force and all subordinate units.

2.4.4 Manning. After determination of the organization and manning required, the officer, enlisted, and civilian personnel currently assigned to WET were designated for attachment to the TU 8.1.3 for specific staff assignments.

The requirement for an additional 42 officers and 83 enlisted men, needed to complete the staffing of TU 8.1.3, was submitted to CHDASA for necessary action, during the first week of January 1962. The request was subsequently disapproved by JCS. Immediately, the Commander, FCDASA, took action to satisfy these personnel requirements from within his own resources. With the exception of approximately 14 officers and 10 enlisted men, personnel were provided and present for duty with TU 8.1.3 by mid-February. The 24 unfilled personnel requirements that could not be furnished from within the resources of FCDASA were requested from CHDASA. Most of these requirements were filled by CHDASA or through JCS action from the services by early April.

During the operation, it was necessary to replace some personnel for various reasons, i.e., unsuitability, hardship, discharge, permanent change of station, illness, etc. Replacement personnel were furnished by Commander, FCDASA or by JCS action from the services.

Based on the Dominic experience, it is recommended that: (1) In future operations of this nature, those administrative, logistical, communications, engineering and construction, etc., requirements that can be filled by attachment of officer and enlisted personnel from local overseas commands be designated and requested from the JCS. Personnel so furnished would join TU 8.1.3 as specified at the overseas locations. This would provide for less separation from the individual's family, decreasing the personal hardship cases. (2) Greater emphasis be placed on screening of personnel to insure that each individual selected for duty with the task unit (a) is fully qualified in the military specialty for which he is being furnished; (b) is in excellent physical condition, with no physical handicaps, illness, or disease requiring constant medical treatment or special diets; (c) does not have indebtedness or financial obligations which, by virtue of a prolonged period of temporary duty, will create a financial hardship upon himself or his dependents; (d) if married, there is no sickness or illness in his family; and (e) his moral conduct both on and off duty is above reproach.

2.4.5 Orders. CTU 8.1.3 was delegated authority by CJTF-8 and Commander, FCDASA, to authorize, approve, and issue orders for temporary duty and travel of military personnel and civilian employees (to include civilian contractor employees) participating in Operation Dominic. The widespread locations of project agencies and civilian contractors throughout CONUS required that issuance of travel orders be decentralized. Additionally, personnel travel cost and funds had been made available to the project agencies on a reimbursable authorization through the projects' funding. Consequently, the commanders of the 11 military organizations sponsoring participating projects were delegated authority to issue TU 8.1.3 travel orders for the military personnel and civilian employees (to include their civilian contractor employees) participating in Fish Bowl projects. Travel orders for employees of other civilian contractors were issued by Headquarters, TU 8.1.3.

During the period, 4 April through 10 August, CTU 8.1.3 was delegated the authority to cite JTF-8 funds to cover cost of per diem and commercial travel in the overseas area. This was most advantageous in that orders could be expeditiously issued. However, after 10 August, all such costs were funded by Commander, FCDASA. Inasmuch as authority to cite FCDASA funds was not delegated to CTU 8.1.3, orders could no longer be expedited.

It is recommended on future tests that: (1) decentralization of authority to the commanders of military-sponsored projects for issuance of TU 8.1.3 travel orders be continued, and (2) Commander, FCDASA, issue an Obligation Authority to CTU 8.1.3, so funds can be cited and travel orders can be expeditiously issued when in the field.

2.4.6 Pay, Per Diem, and Travel Allowances. Facilities for maintenance of individual pay records and payment of regular pay were not available in the test area. Pay records were retained at the home stations. Each individual prior to departure from his home station made arrangements for the disposition of his regular pay, i.e., deposit to a bank account, or for check to be mailed to the individual at his overseas location.

TU 8.1.3 provided assistance to all military personnel and federal employees in preparation and processing of their claims for payment of accrued per diem and travel allowances. Claims were processed through the appropriate service disbursing officer on Oahu Island, Hawaii, except for personnel on Christmas Island, who were serviced by a Navy Disbursing Office at that location. During the latter phase of the operation, the Disbursing Officer at Hickam AFB stationed an Agent Finance Officer on Johnston Island for the purpose of cashing US Treasury checks and making emergency payments of accrued per diem and travel allowances.

The method of utilizing the three service disbursing facilities was cumbersome, time consuming, and detrimental to the morale of personnel for the following reasons: (1) Interpretation of the provisions of the Joint Travel Regulations varied among the three services. To insure that members of each service were treated alike in payment of their claims, considerable time was spent by the TU 8.1.3 Administrative Officer in coordination between the Disbursing Officers. (2) The clerks of TU 8.1.3, providing assistance in preparation of claims, had to be completely familiar with the rules, regulations, and methods of preparation of vouchers for both military personnel and federal employees for each of the three services. (3) Per diem for members of the Navy and Air Force was paid twice monthly, whereas, that of the Army was paid once monthly. (4) Processing time for claims varied from 3 to 5 days among the various Disbursing Offices. (5) Claims from personnel on site at Johnston Island and in the Northern and Southern Conjugate Areas had to be forwarded through the mails or by courier to the TU 8.1.3 location at Hickam AFB for processing and payment by the appropriate Disbursing Officer. Individuals at Johnston Island would normally receive their payments in approximately 10 days, but individuals at other sites had to wait from a minimum of 2 weeks to a maximum of 4 weeks.

From the lessons learned, the following recommendations are offered: (1) CJTF-8 should provide disbursing facilities for maintenance of individual pay records and payment to those members desiring to receive their regular pay in the test area. (2) In future widespread operations similar to Operation Dominic, CJTF-8 should provide adequate disbursing facilities in the test area. These facilities should be capable of making payment of per diem and travel allowances to the military members and federal civilian employees of the three services. A disbursing unit should be stationed at each major location, e.g., Christmas Island, Johnston Island, and Oahu Island. Additionally, the disbursing unit on Oahu should have the capability of furnishing mobile team(s). The mobile teams would travel periodically through the remote island sites, e.g., Canton, Tutuila, Palmyra, French Frigate Shoals, and Midway, providing assistance in preparation of individual claims and making on-the-spot payments of accrued per diem and travel allowances. The Army has mobile finance units which might be made available to CJTF-8 for furnishing this vital support. (3) Accrued per diem should be paid to each military and civilian on not less than a 15-day basis. However, regardless of the period established, it should be the same for all services. (4) All commands should be instructed, through the headquarters of their appropriate services, that advance payment of per diem and travel allowances to military personnel and federal civilian employees will not exceed that which would be accrued to the individual for travel from his home station to the first overseas destination (Hickam AFB) plus approximately 10 days. (5) Prior to departure from overseas test sites for return to home station, those individuals desiring it should be paid all accrued per diem and travel allowances and advance allowances for travel from overseas test site to home station.

2.5 SECURITY AND CLASSIFICATION

The Security Section of TU 8.1.3 was organized as shown in Figure 2.3. It is recommended that, except for possible minor changes in grade structure, this organization be maintained in future overseas test operations.

Some difficulties were encountered in four major areas: classification, industrial security, personnel security, and security indoctrination. These are discussed below.

2.5.1 Classification. The major problems in this area were: (1) overclassification of messages, and (2) overclassification of photographs. Specifically, the overclassification of messages, both outgoing and incoming, tended to create unnecessary delays and administrative burdens.

To preclude these difficulties in future operations, it is recommended that: (1) Two joint task force classification officers be permanently assigned to the Pacific area with one based at Hickam AFB, and the other based at Johnston Island. These persons should have experience with both the DOD and AEC classification procedures. They should have classification authority and should be readily available to all using agencies. These officers should have derivative classification authority up to and including SECRET, Restricted Data, for all task force users. They should not be rotated into and out of the Pacific area every few weeks as was the policy during Operation Dominic. (2) Each task unit, especially the DOD scientific task unit, should be granted authority to classify and regrade photographs originated by the unit. All such classification and regrading would be subject to final joint task force classification review. (3) A system should be established whereby timely supplemental guidance is added to the joint task force classification guide. The procedure used in Dominic was inadequate in that TWX's, letters, PIO releases, and word of mouth were all used to disseminate classification guidance. For example, frequent release of information as unclassified was made while task units in the field were required to consider it classified. To preclude this, a definite system for providing timely supplemental guidance should be established and utilized by all elements of the joint task force.

2.5.2 Industrial Security. The major problems encountered in this area were (1) need-to-know of contractor personnel, and (2) security cognizance. Specifically, in most cases, neither the Task Unit Security Officer nor the various program directors were notified when a particular contract was awarded to support Operation Dominic. Also, difficulty was encountered with regard to security cognizance over a particular contractor.

To preclude these difficulties in future operations, it is recommended that the appropriate scientific task unit security officer be provided a copy of DD Form 254, Security Requirements Checklist, as soon as a contract has been let. An early determination should be made by the joint task force commander and other concerned agencies regarding the security cognizance relationship between contractors, subcontractors, etc., and the scientific task unit.

2.5.3 Personnel Security. The major problems encountered in this area were: (1) alien access to Restricted Data, (2) changes in personnel between Phases I and II, (3) clearance verification, (4) badging violations, and (5) the JTF-8 badge.

Specifically, the problem concerning immigrant aliens centered around requests for several immigrant alien civilian contractor personnel to have access to Restricted Data. These requests were submitted to JTF-8 in March 1962. The DOD Industrial Security Manual (ISM) prescribes that alien access to classified material be governed by the same rules as US citizen access, provided a security clearance has been granted and the investigation requirements have been satisfied. Sixteen immigrant aliens participated in Operation Dominic.

The changes in personnel that occurred between Phases I and II constituted a major problem. Although adequate clearance data had been obtained by means of the project experiment and requirements (E&R) plans prior to the operation, updating changes to these plans were not submitted in all cases immediately prior to Phase II. This was a particular problem in the case of civilian contract agencies in which a near-complete turnover of personnel occurred between Phases I and II.

Frequently, contractor personnel would arrive at TU 8.1.3 at Hickam AFB without orders or verified clearance data. As many as 50 percent of the new contractor personnel reporting to Hickam arrived without properly verified clearance data. Except in those most urgent cases, individuals were unnecessarily delayed at Hickam until their clearance status was verified. In many cases, both the Sandia Base office and the office at Hickam received unverified clearance data, thus causing unnecessary delays.

The specific problem area concerning badging involved badging of civilian contractor personnel. Several instances occurred in which civilian contractors sent employees direct to a site, e.g., Samoa, Rarotonga, etc., via commercial aircraft without proper clearance processing at the TE 8.1.3.2 Security Office at Hickam. As a result, personnel showed up on site without their JTF-8 badges. The JTF-8 badge failed to meet the normal requirement of a security badge in that it did not contain personal information such as date of birth, height, weight, etc., nor was it signed by the bearer. Further shortcomings of the system were noted in that badges were used as identification badges, and insufficient security area numbers were allotted for the system.

In summation of the aforementioned areas, the following recommendations are offered for possible improvement of future operations: (1) One personnel security office, including visitor control, should be established under the joint task force to support all subordinate agencies. (2) Alien access should be determined prior to the beginning of the series. (3) One overseas control point should be established through which all personnel must process. All agencies must insure that clearance data precede their personnel to the field. (4) The issued badge should be utilized for security purposes only, and the badge should be redesigned to include signatures, proper identification data, and sufficient security area numbers. (This may require producing pictures for badges in the field by means of a polaroid-type camera.)

2.5.4 Security Indoctrination. Most of the security violations occurring during Dominic could be traced to the lack of an adequate personnel security indoctrination program.

All contractors should be familiar with paragraph 5 of the DOD Industrial Security Manual which states: "The contractor shall be responsible for safeguarding all classified information under his control. In furtherance of this requirement, the contractor * * * shall bring to the attention of his personnel * * * engaged in the performance of work on contracts which involve access to classified information, their continuing individual responsibilities for safeguarding classified information * * *."

It is further recommended that a security indoctrination program be established prior to movement into the Pacific area. It is also recommended that a special booklet and possibly a short film be produced as a guide for the protection of classified information.

It is noteworthy, however, that despite the vast volume of classified documents, equipment, etc., handled by TU 8.1.3 personnel, both military and civilian, there were only a few security violations.

2.5.5 Destruction of Classified Waste. Another minor deficiency, which was more of an administrative inconvenience than a security discrepancy, was the lack of an adequate high-capacity incinerator at Johnston Island for destruction of classified waste. The lack of this facility necessitated page-by-page burning in a makeshift incinerator (perforated drum), with constant stirring to insure complete destruction.

Despite precautions, the combination of a gust of wind and the updraft from the burning materials frequently caused burning pages to be blown out of the incinerator, thereby making it necessary to chase and recover these burning papers.

This type of destruction was not only a long and tedious chore for the personnel concerned, but also affected normal operations because of the loss of these personnel from their regular duties over extended periods of time.

2.6 PUBLIC INFORMATION

On 1 February 1962, the WET Public Information Officer (PIO) was designated as the TU 8.1.3 PIO. Efforts were immediately initiated to send out approximately 300 hometown releases on the personnel assigned to TU 8.1.3. These releases were written and dispatched during March and April, prior to deployment to the Pacific area. In addition to giving recognition to the individuals involved, these releases publicized the President's decision to resume nuclear testing and included the reasons for resumption.

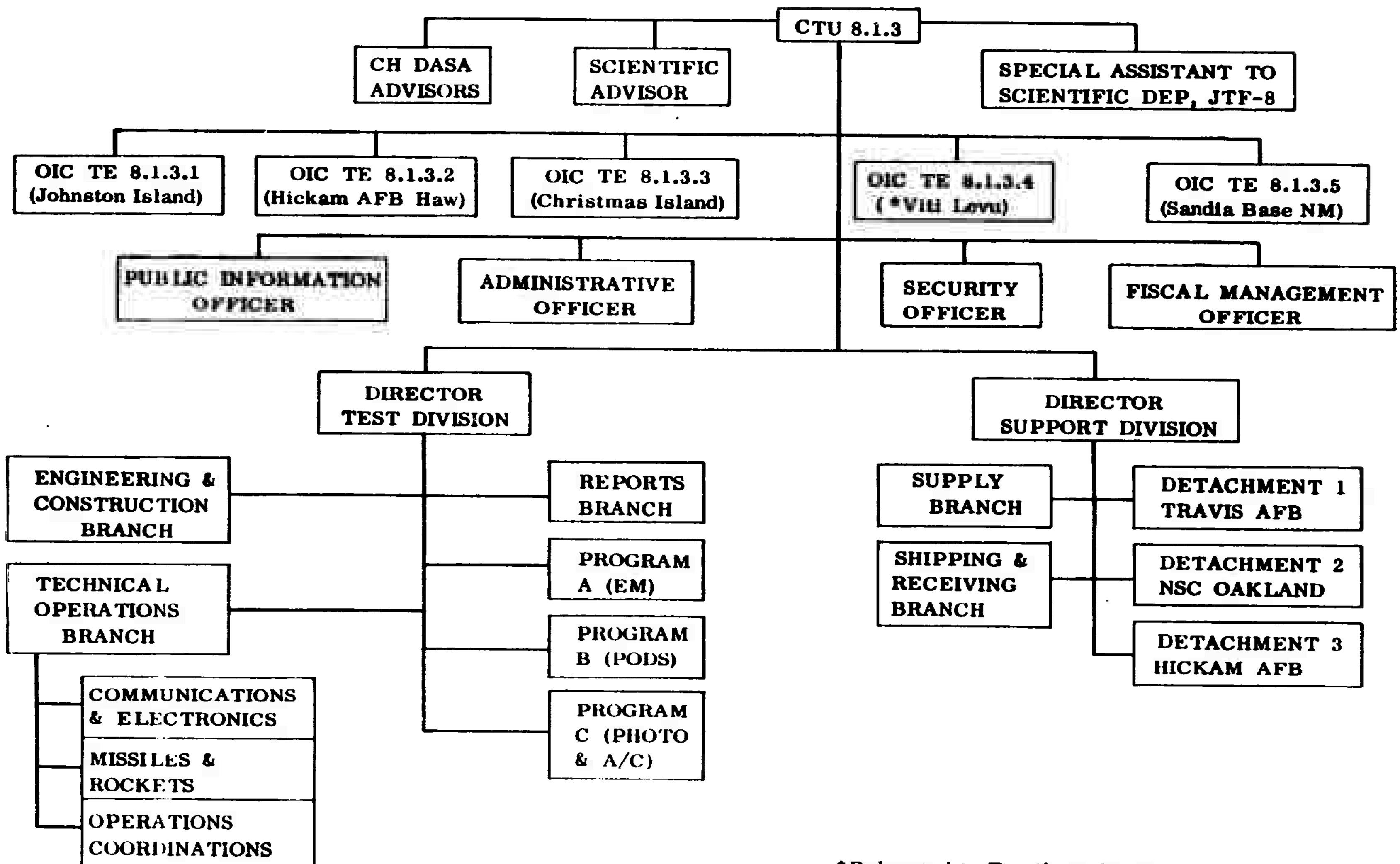
After deployment, the TU 8.1.3 PIO, assisted by a staff of two enlisted men for public information and a maximum staff of five enlisted men for visitor control, was given certain responsibilities by CJTF-8 through the JTF-8 PIO. These included the following: (1) Provide on-site PIO coverage at Johnston Island during actual events there. During these periods, the TU 8.1.3 PIO assisted JTF-8, TU 8.1.3, and Task Group (TG) 8.6 in PIO matters. Contact was maintained with the JTF-8 PIO at Pearl Harbor, Hawaii, and recommendations and information were passed to him. Only those announcements that had been cleared previously at the DOD level were authorized for release during the Fish Bowl Series. (2) Provide PIO coverage in the Southern Conjugate Area. This assignment was logical, because almost all personnel in this area were TU 8.1.3 personnel. The problems were formidable. All the governments involved were interested in informing the native populations of possible effects that could be observed in their respective areas and in announcing shot times in advance, using the official island radio nets. The announcements were needed to prevent possible panic or alarm by the native populations. Estimates of observable effects were obtained from JTF-8 and passed to the governments through the TU 8.1.3 personnel on the various islands. The timing of these reports, and more specifically the authorized shot time releases, was a continuous problem, because prior to release time the reports were classified and required encryption during transmission. The timing was such that the reports often failed to reach the island governments before the normal news releases made through commercial news media systems. The Star Fish Prime detonation did cause concern among many of the natives in the Southern Conjugate Area, even though warnings had been disseminated. No serious problems occurred, however, although some news correspondents in the area filed stories indicating extensive panic.

Much effort was expended to enhance the public relations program in the Southern Conjugate Area by providing special services as requested by the various governments. Support was arranged for two major events that took place during the operational period. These were the Pan-Pacific Conference in Samoa, attended by representatives of all the governments in the South Pacific, and the 100th anniversary celebration of the liberation of Tonga. Special supplies were provided and airlift arranged for both of these events of international stature. In addition, special support was arranged for the heads of the various governments, greatly assisting in the maintenance of good community relations.

2.7 VISITOR CONTROL

TU 8.1.3 military and civilian personnel with their equipment had to be transported to more than 20 island locations in the North and South Pacific in order to perform their missions. To insure that special airlift was available for personnel who had to establish facilities and take part in the first event, a TU 8.1.3 Visitors Bureau was established at the MATS Terminal, Hickam AFB. During the period of the operation, more than 1,800 personnel were met, provided local transportation and quarters, and furnished bookings through the JTF-8 Liaison Office to transport them and their equipment to outlying locations.

Assistance was rendered in the Honolulu area to the JTF-8 Protocol Officer in making arrangements for distinguished visitors from DOD organizations.



*Relocated to Tutuila in Sep 62

Figure 2.1 Staff organization, TU 8.1.3.

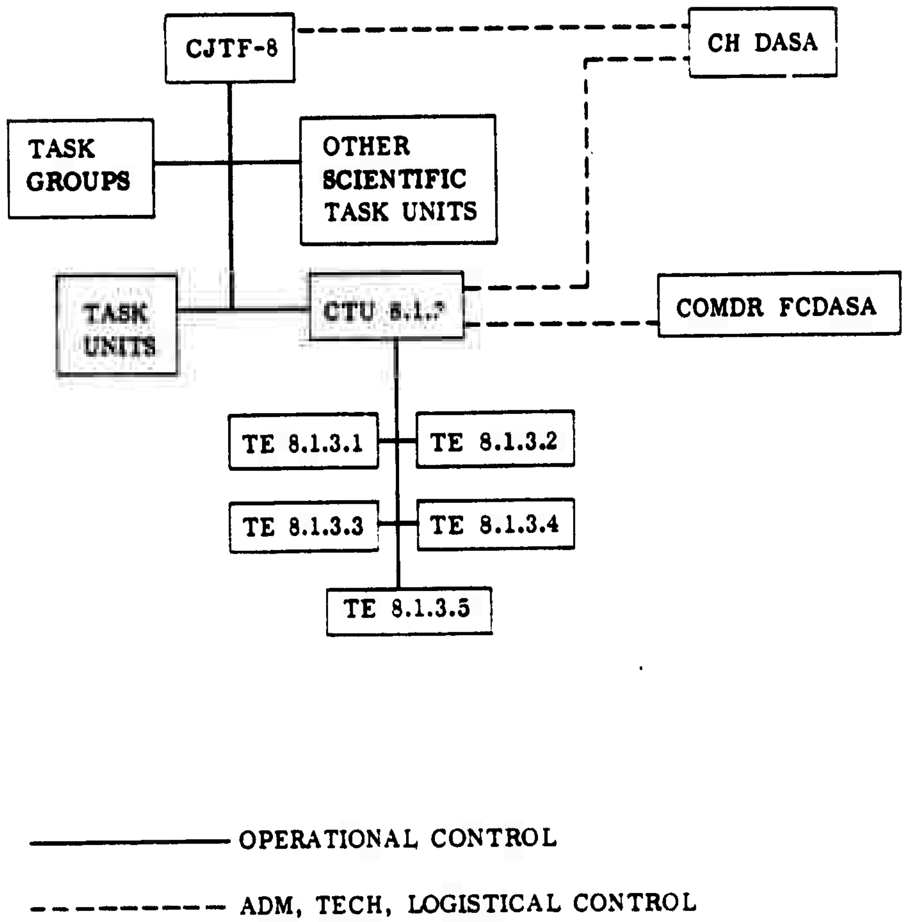


Figure 2.2 Control diagram, TU 8.1.3.

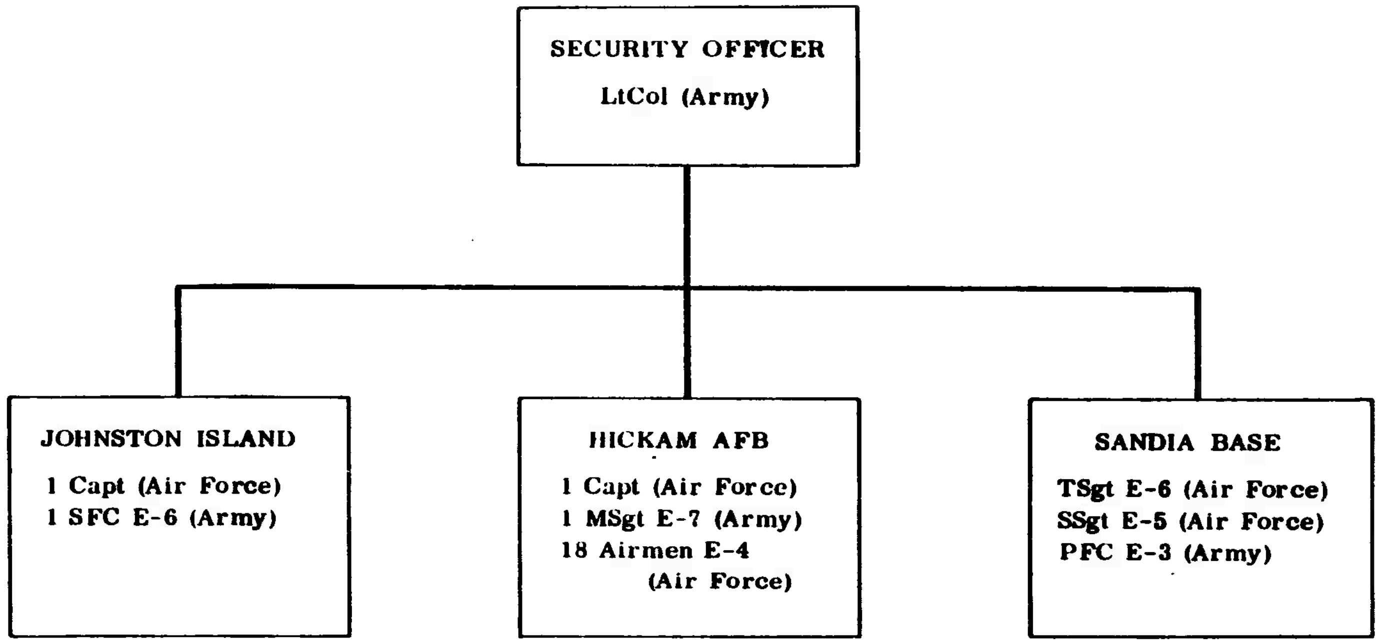


Figure 2.3 Organization of Security Section, TU 8.1.3.

Chapter 3

OPERATIONS

On 26 December 1961, when the Operation Dominic program was received at FCDASA, the Weapons Effects and Tests Group (WET) was expending a considerable amount of effort on programs and program planning for the Nevada Test Site. It was readily apparent that the same group of WET personnel could not handle both the overseas and continental programs. As a result, WET was divided into two sections, the Overseas Test Organization (OTO) and the Continental Test Organization (CTO). On 1 January 1962, the Technical Operations Branch of OTO consisted of three officers and one enlisted man.

The following major responsibilities were expected to be within the purview of technical operations during Fish Bowl: (1) Thor operations, (2) radiological safety, (3) operation of technical operations centers, (4) weather, (5) ship and aircraft operations, (6) small rockets, (7) readiness procedures, (8) rocket tracking, (9) communications, (10) timing and firing signals, and (11) evacuation. Almost immediately, the Thor missile responsibility was assigned to JTF-8, because the Thor activity was considered to be a support-type responsibility and control of the Thor project could, therefore, better be handled by the Joint Task Force.

It was also determined early in 1962 that Shot Sword Fish of Dominic, a systems test of the antisubmarine rocket weapon (ASROC), would be conducted by the Navy under JTF-8 control, and that FCDASA would have no responsibilities, other than reports, for this test. Two WET officers were assigned to Sword Fish as liaison officers and functioned as staff officers on the Navy staff during the event; however, neither operational nor logistical support was provided to this particular test by WET.

In the Frigate Bird event of Dominic, the Polaris systems test, TU 8.1.3 had neither responsibility nor participation.

The major DOD effort during Fish Bowl was concentrated on Johnston Island, although large numbers of TU 8.1.3 personnel were on Christmas Island and in the Southern Conjugate Area and Hawaii. The magnitude of the effort at each of these locations required the use of operational personnel for coordination and control. One operations officer, acting also as Deputy Officer-in-Charge (OIC), TE 8.1.3.4, was stationed on Christmas Island during the operational phase there, moving to Hickam AFB during Phase II. The OIC, TE 8.1.3.3, stationed initially at Suva in the Fiji Islands (Viti Levu), and later on American Samoa, coordinated the operational details of the activity in the Southern Conjugate Area. He was assisted by a communications officer (Capt, Army), a Deputy OIC (LT, USN), and from three to four enlisted personnel. Details of operations on Christmas Island and in the Southern Conjugate Area are discussed later.

Radiation safety problems encountered by TU 8.1.3 centered around pod recovery. Actual Rad-Safe operations were the responsibility of JTF-8. Detailed descriptions of the hazards during pod recovery are discussed in Chapter 5.

3.1 TECHNICAL OPERATIONS CENTERS

During the initial planning phases of Dominic, it was apparent that central operations centers would be necessary because of the complexity of the operation and the necessity for coordinating many activities close to the times of the various events.

Two Technical Operations Centers (TOC's) were established, one at Hickam AFB and the other on Johnston Island. The Operations Branch at Hickam AFB was responsible for operational activities in the Hawaiian and western Pacific areas (Midway, Wake, French Frigate Shoals, and Okinawa). The Johnston Island Operations Branch handled the operational activities on Johnston Island and received reports from the Southern Conjugate Area.

3.1.1 Johnston Island. The plan for the Johnston Island TOC was based on experiences during Operation Hardtack and other preceding operations, and was designed to include representatives from the various scientific programs as well as operational personnel. The communications were set up according to the best estimates available, but as the operation progressed, it became apparent that the complex as established was inadequate.

Initially, the technical representatives of the other scientific task units—Los Alamos Scientific Laboratory (LASL), Lawrence Radiation Laboratory (LRL), and Sandia Corporation (SC)—planned to be located at the main JTF-8 Command Post, but lack of space there precluded the presence of more than essential JTF-8 personnel. As a result, the LASL, LRL, and Sandia Corporation Task Units were invited to use space in the DOD Technical Operations Center. Their presence was a decided asset to the DOD, because immediate coordination was possible near shot time, and task unit communications could be shared when necessary.

The Johnston Island TOC was physically located in Building 405, an underground building previously used as a hospital. When first obtained, the building was in a poor state of preservation, requiring extensive repair before being usable. The air-cooling system initially provided was found to be inadequate; an air-conditioning system was later installed.

The TOC occupied administrative office space normally used by the Technical Operations Branch between events, space that was barely adequate during event times. A large table was built and wired in, providing space for all key personnel around a single table, with the necessary communications instruments placed under the edge of the table. Around the table (Figure 3.1) were seats for two SC representatives, two LASL representatives, one LRL representative, and TU 8.1.3 representatives. The communications plans for this installation are discussed in Section 3.9. A closed-circuit television system was installed with cameras remotely controlled from the TOC so that the scientific rocket firing line could be monitored visually. Secondarily, the TV cameras could view the Thor pods, runway, and other key operations areas of Johnston Island. Three cameras and three consoles were adequate for the purpose (Figure 3.2).

All reports of readiness were sent to the TOC prior to shot time. Readiness information was posted in the TOC and pertinent data passed to the Commander, TU 8.1.3 (CTU 8.1.3) who was located in the main JTF-8 Command Post, where he had immediate access to the Task Force Commander and the Scientific Deputy. A hot (direct) line was provided between the CTU 8.1.3 and the DOD Test Director and Deputy Commander, TU 8.1.3, the latter two in the TOC. In this manner, the CTU 8.1.3, was in a position to discuss urgent matters personally with the Commander, JTF-8, and yet have access to readiness data without being involved with the mechanical collection effort. The DOD Test Director in the TOC was able to furnish recommendations immediately, because it was possible for him to see all posted information and talk personally with the key TU 8.1.3 personnel in the TOC. To permit free exchange of data in the TOC, it was necessary to use personnel access lists to reduce the shot-time population of the TOC to the necessary minimum. Noise levels tended to become high.

Weather briefings were presented in the TOC with the same regularity as in the JTF-8 Command Post. Printouts of rawind and radiosonde soundings were available to projects at the TOC. A typical schedule of event time weather soundings is shown in Appendix C.

JTF-8 located the Johnston Island Disaster Control Team Chief in the TOC as the TOC represented one of the best sources of information regarding any disaster. The TV coverage of Johnston Island was of considerable assistance in the evaluation of accidents, although it was found that the high intensity lights at the rocket launcher pads were normally knocked out at the time rocket motors were ignited.

The JTF-8 Small-Rocket Safety Officer was also located at the TOC, where he had hot-line communications with the Small-Rocket Launch Center in Building 200. He was located in the TOC because of the communications, the ready availability of the program personnel, and the fact that he was a member of TU 8.1.3, although used by JTF-8 for the safety function because of the lack of any other qualified personnel. This arrangement worked well, although TU 8.1.3 lost the services of this officer at times. He was, however, near at hand and available to the DOD Test Director during event periods.

3.1.2 Hickam AFB. The TOC at Hickam was patterned, on a smaller scale, on the Johnston Island TOC, and had direct communications, both voice and teletype, with the TOC at Johnston Island. Both TOC's were manned continuously from approximately 24 hours prior to scheduled shot time to 6 hours after shot time. The Hickam TOC had a hot line to the LASL, LRL, and SC Filter Center in Honolulu to permit instant coordination and mutual use of communications to Johnston Island.

3.2 SHIP AND AIRCRAFT

In addition to island instrumentation sites, ships and aircraft were used during Fish Bowl as instrument platforms. The widespread effects anticipated from high-altitude nuclear detonations required instrument platforms in the vicinity of Johnston Island and in both magnetic conjugate areas. The number of ships and aircraft required for experimental purposes was determined by CHDASA. After approval by the JCS, the services made the necessary ships and aircraft available to JTF-8. The ships and aircraft operated under the operational control of CTG 8.3 and CTG 8.4, respectively. The scientific instrumentation installed was operated exclusively by project technical personnel. CTU 8.1.3 provided the operational commanders with the desired positions for ships and aircraft for each event.

3.2.1 Instrumented Ships. During January 1962, a technical program requirement was stated for four landing ships, dock (LSD's) and one destroyer (DD). LSD's were requested because they could be used as platforms for launching instrumented rockets (this capability was not used) and because they provided a large stable platform for radar tracking antennas. The DD was requested for installation of photometers and riometers planned for use in the Northern Conjugate Area.

Early in February, the US Navy made three LSD's (including one Military Sea Transport Service (MSTS) type), one landing ship, tank (LST), and two DD's available for use during Fish Bowl. The two DD's were provided to insure coverage of the Northern Conjugate Area during each of the two Fish Bowl events then planned; instrumentation was to be transferred from one DD to the other between events. These service ships were suitably modified for the installation and operation of scientific equipment. An experience report of the modification program appears in Appendix K. Figure 3.3 is a photograph of an instrumented LST.

DAMP = Downrange Antimissile Measurement Program

Two other ships, the M/V Acania and the USAS American Mariner, completed the initial scientific ship array. The DASA-owned Acania operated in the Southern Conjugate Area. The USAS American Mariner (DAMP ship) operated in the Johnston Island area under the operational control of CTG 8.3.

During June, after gaining experience under actual test conditions, it became necessary to provide a shipborne balloon-launching capability in the Southern Conjugate Area. A suitable privately owned vessel was located at American Samoa, the SS Mauna Tele. The vessel was leased for a period of 1 month by the H&N representative in the area and made available to CTU 8.1.3.

Experience indicates that any such contract negotiations for equipment and/or services at remote sites for any future operation should be completed by H&N rather than TU 8.1.3 or project agencies.

Upon the completion of Phase I of the series, the composition of the scientific ship array was reviewed in the light of experience gained during Star Fish. The one LST demonstrated that this type of ship was well adapted for use as an instrument platform and that the LSD's could be replaced by LST's. The MSTS T-AKD (LSD) was retained as a matter of convenience, being both modified and available. The two Navy LSD's were replaced with two Navy LST's, and the Navy LST was replaced by an MSTS LST.

The extended time frame for the high-altitude series (Phases I and II, approximately 3 months each with a 1-month delay between phases) and previous ship commitments precluded the participation of the same ships on both phases of the operation. See Appendix D for ship participation by phase.

It was also found that the one DD in the Northern Conjugate Area did not provide adequate geographic coverage. Three additional ships were therefore requested as instrument platforms. These were obtained by CJTF-8.

In the Southern Conjugate Area, a second privately owned vessel, the SS Hifofua, was rented as a replacement for the SS Mauna Tele, which was no longer available.

The scientific ship array (except the two ships in the Southern Conjugate Area) were under the operational control of CTG 8.3. However, CTU 8.1.3 determined the planned ship positions for each event, the time required on station, and any planned maneuvers after burst time. This required continuous liaison with CTG 8.3. Reliable voice communication circuits with CTG 8.3 were mandatory. CTG 8.3 was responsible for logistical support of the instrumented ships and, thus, required continuous long-range (4 to 6 weeks) plans from CTU 8.1.3.

During operations, there was one communications channel outside of the normal chain of command—the scientific CW and voice communications nets. These circuits were used to receive readiness reports from the projects embarked in the ships (not ship readiness or the on-station reports) and to provide instructions to those project representatives. It required a fine sense of assigned responsibility to avoid usurping the prerogatives of the operational commander in using these circuits, and this again emphasizes the need for close liaison with CTG 8.3.

Instrumented ships assigned to Johnston Island and the Northern Conjugate Area were normally required at Johnston Island about D−7 days for final checkout, calibration, and/or repair of the scientific instrumentation. All these ships were required to participate on the full-power, full-frequency rehearsals. The anchorage facilities at Johnston Island left much to be desired, when effecting emergency repairs to instruments and the delivery of spare parts. Small-boat activities were difficult because of heavy seas in the outer harbor. Only a minimal boat pool was available, and this frequently meant long delays in reaching the ships.

The positioning of the instrumented ships proved to be an operational problem of great importance. The problem was twofold. The first part concerned the positioning of the ship prior to event time, i.e., taking station and maintaining it during an undetermined number of holds. The second part involved accurately measuring and recording the ship's position. The problem was most acute for the four ships (S-1 through S-4) that were tracking rockets. These four ships operated in formation under the tactical command of a Task Element Commander embarked in one of them. Experience dictates that this Task Element Commander should be a US Navy officer embarked in a US Navy ship. The precise maneuvers required can only be carried out after considerable practice with the ships assigned. The skill and facilities required are not normally found on MSTS ships; thus, one of the ships in this group should be a US Navy ship.

Experience further suggests that planners should be pessimistic about the position accuracy achievable using normal aids to navigation. Ship position information for all Fish Bowl events is provided in Appendix D.

The following recommendations are offered for future operations.

(1) Ship requirements by type should be determined 6 to 8 months in advance of the first event.

(2) The concept of how each ship is to be employed (approximate position, estimated time on station before and after each event, and time required at Johnston Island) should be prepared 4 to 6 minths in advance of the first event, to facilitate logistical planning.

(3) Ship modification specifications should be submitted by user project officers 8 months prior to the operation. Additional recommendations on ship modification appear in Appendix K.

(4) For scheduling purposes, ships should be selected on the basis of availability during the entire operational phase.

(5) Representatives from TU 8.1.3 should brief the commanding officers of the ships assigned regarding test plans and keep ship commanders informed on changes in plans.

(6) Provision should be made to moor instrumented ships in the inner harbor each time they put in to Johnston Island.

(7) Additional aids to navigation should be provided those instrumented ships that track rockets, and this group of ships should include at least one US Navy type.

3.2.2 Pod Recovery Ship The original concept of pod recovery envisioned only pick-up and return by helicopter. However, in the early planning stages, it became apparent that a backup recovery ship capability was required. The requirement was submitted to JTF-8 in January 1962, and initial concepts were developed with members of the JTF-8 staff during a conference at Sandia Base. A dummy practice pod was provided to the Navy Task Group, and preliminary recovery practice was conducted in the San Diego area in early March. A representative of the pod project attended this practice recovery to advise on procedures. At this time, motion pictures of the operation were made by the Navy for use in later briefings and training.

A second pod was provided to TG 8.3 at Pearl Harbor for use in further practice there. Details of operational methods are reported in the final report of TG 8.3 participation in Operation Dominic.

The initial recovery ship team consisted of one destroyer, frigate (DL) (USS McCain), command ship, one salvage ship (ARS) (USS Grapple), and two ocean tugs, fleet (ATF's) (USS Mataco and USS Arikara), with ComDesDiv 253 as the officer responsible for the recovery ship operation. Prior to the Thor certification flight (Tiger Fish), the ARS and ATF's conducted recovery practice in the vicinity of Johnston Island.

The Tiger Fish pods, landing in daylight, were spotted by P2V aircraft. However, only one of the pods could be picked up by helicopter (Chapter 5); the other two were picked up by ships. The pod picked up by the helicopter was returned to the water and subsequently picked up by ship; therefore, delivery to the island was by ship for all three pods.

A postshot meeting with the captains of the recovery ships brought to light the problem of shore delivery; the tugs were unable to navigate the narrow ship channel during the hours of darkness. To alleviate this problem, an LCM was borrowed from the island boat pool and was specially rigged with nets and a concrete radiation shield, to receive the pods from the ships and transport them to shore.

Prior to Blue Gill, a night practice was staged in the anchorage off Johnston Island, with each ship making two or more transfers to the M-boat. TU 8.1.3 personnel were present to advise on techniques. At this time, each tug was supplied, by TU 8.1.3, with two foam-filled drums, two 40-foot nylon ropes, and four clevises. These drums were to be used if the pod flotation balloon failed to function properly. The 40-foot line attached the pod to the drum, and the drum provided the pickup loop necessary for helicopter recovery. Subsequently, several more drums and nylon ropes were provided to the recovery group.

On the first Blue Gill, the flotation balloons did malfunction, and the drums and lines were attached by the ships. Pod delivery to the island was by helicopter.

Prior to Star Fish, the USS Sioux (ATF) replaced the USS Mataco in the recovery group. TU 8.1.3 representatives visited the tug prior to the event and arranged for a practice transfer with the M-boat. No recovery was necessary on this event, although divers from the USS Grapple did search, for several days, for the missing R/V.

On Star Fish Prime, two pods were recovered by ships, one transferred to the M-boat for shore delivery and the other returned to the water for helicopter delivery. The third pod was located at daylight, and a drum and line attached for helicopter delivery. The only instance of damage to a pod by the recovery group occurred on this event, Pod S1 had a deep gouge in the rear bulkhead, a crack in the flare section, and one neutron detector container missing. It was believed that the pod impacted against the ship during the recovery operation, although this could not be verified.

For Blue Gill Prime, the USS Chickasaw (ATF) replaced the USS Sioux, and the USS Conserver (ARS) replaced the USS Grapple in the recovery group. Again, practice transfers to the LCM were made with TU 8.1.3 representatives in attendance to advise on techniques. No recovery was necessary.

For Blue Gill Double Prime, Blue Gill Triple Prime, and King Fish, the recovery group was reduced to the USS McCain (DL), the USS Safeguard (ARS), and the USS Engage, a minesweeper, ocean (nonmagnetic) (MSO). On these shots, the McCain participated as a recovery ship. Practices were held before each shot.

On Blue Gill Double Prime, two pods were retrieved by the ships, and the pickup drums and lines were attached for helicopter delivery. On the third pod, the recovery system had not actuated, and the pod was considered too dangerous for helicopter delivery. The pod was netted by a ship and transferred to the M-boat for delivery.

On Blue Gill Triple Prime, one pod was transferred to the M-boat for shore delivery, and the other two were delivered by helicopter.

On King Fish, two pods were returned by helicopter, one by the normal method, and the other, because of extensive damage, in a net. An exhaustive search by all recovery ships failed to locate the third pod. Many pieces of styrofoam, the ruptured flotation balloon, and the nose of the pod were found and delivered to the island.

On each shot, a project representative was permitted to accompany each of the recovery ships and the command ship. These project representatives supplied each captain with a listing of the pod identification means and acted as an adviser during recovery operations. These observers were also able to note exact pod conditions, handling during retrieval, and conditions that might have an effect on the data.

The main problem encountered during the recovery operations was communications. Late in the operation, direct coordination between the pod program and the commander of the recovery group was authorized. However, prior to this, all communications went through TU 8.3.6 and TG 8.3 resulting in a communications lag, often several days in length. This problem was partially alleviated during the shots by having a TU 8.1.3 representative present in the TU 8.3.6 Command Center. However, it still required an excessive amount of time to pass or receive information on recovery operations.

A second problem concerned briefings given to the ships' crews. The motion pictures made during practice off San Diego did provide the crews with a reasonable understanding of the problems involved. However, the briefings of new crews, as ships were replaced, was not complete in that the crews did not know, in most cases, the locations of instruments and the areas of the pod that required protection to prevent loss of data.

The problem of ship-to-shore transfer, solved by the use of the specially rigged M-boat, was a workable solution. It is not considered to be the best solution, inasmuch as it subjects the pods to additional handling, and under even normal sea conditions, increases the possibility of damage with consequent loss of valuable data.

For future operations, it is recommended that: (1) direct communications be authorized between the scientific task unit and the recovery task group; (2) those crewmen involved in the actual handling operations be brought ashore for a briefing, by scientific personnel, on the pods and instruments and on damage that may cause loss of data; (3) the placing of scientific project observers aboard each recovery ship be continued; (4) ships be equipped with receivers to home on the radio beacons used as recovery aids; and (5) the ships deliver the pods directly to shore eliminating any sea transfer or, if this cannot be done, transfer to the M-boat be accomplished inside the reef where calm water simplifies the handling problem.

3.2.3 Aircraft. Technical Aircraft. The aircraft array in support of the TU 8.1.3 technical effort for the Fish Bowl Series consisted primarily of 17 aircraft (Table 3.1).

In addition, Project 8C had two aircraft (one KC-135 and one C-54) that were instrumented for tracking the reentry phase of R/V's on Star Fish. However, following failure of this event on 20 June 1962, the R/V's for Star Fish Prime were replaced with standard General Dynamics/Astronautics (GD/A) pods. These two aircraft were, therefore, no longer required.

Support Aircraft. Navy P2V aircraft and HUS (H-31) helicopters were utilized in support of the pod recovery program. Normally, two P2V aircraft would fly to the pod impact area as soon after burst as safety permitted (to include safety from rockets launched from Johnston Island). This was normally during hours of darkness, and the P2V's would search for the pods by means of strobe lights, or Sarah beacons in the pods, and/or dye markers and smoke pots if daylight occurred. As soon as visibility conditions permitted, 9 to 12 helicopters took off from the USS Iwo Jima, amphibious assault ship (LPH), and flew to the pod impact area. When located, pods were then lifted from the ocean by means of shepherds' hooks and lifting cables, for return to Johnston Island while suspended below the helicopters.

Aircraft Requirements. The requirements for the technical and support aircraft were established and justified by TU 8.1.3, which was also responsible for outfitting and modifying the technical aircraft to support the technical mission. The technical aircraft were under the operational and technical control of CTU 8.1.3 until the aircraft reported to the overseas area (Hickam AFB), at which time TG 8.4 assumed operational control. Throughout the planning and execution of Fish Bowl, TU 8.1.3 was responsible for establishing positioning and flight requirements to TG 8.4 for the technical aircraft. Requirements for support by the naval aircraft were directed to TG 8.3.

Aircraft Control and Positioning. The airborne array was controlled by the Airborne Air Operation Center (AOCP) in an RC-121 aircraft. The Airborne Controller was normally the Commander, TG 8.4, whose call sign was ABUSIVE 1. Radio contact with ABUSIVE 1 was maintained at the Joint Command Post (JCP) on Johnston Island by a representative of TG 8.4 who kept the CJTF-8 as well as CTU 8.1.3 advised on the status of the array by means of the Sunshine reporting system, described elsewhere in this report. An alternate AOCP was established on the USS Iwo Jima. With regard to positioning of the aircraft, CTG 8.4 considered it the responsibility of the aircraft commander to correctly position the aircraft in accordance with the technical requirements. ABUSIVE 1 monitored the position of the aircraft, particularly the close-in aircraft, for gross positioning and safety purposes. Navigational aids on Johnston Island were used by the aircraft for close-in positioning. These consisted of a low-frequency beacon, TACAN, and APN-69 radar beacon. Stellar navigation was also used for gross positioning, but was not accurate enough for some of the aircraft, particularly for the KC-135's supporting Projects 8A.1 and 8A.2.

Positions of the TU 8.1.3 technical aircraft for the various events are given in Appendix E.

Recommendations. (1) The aircraft positioning and flight requirements should be defined early in the planning phases, and the capabilities necessary to attain these requirements (i.e., navigational aids, airborne beacons, etc.) should be planned and implemented. In the Fish Bowl Series, there was some doubt as to the accuracy and reliability of the navigational aids on Johnston Island.

(2) CTU 8.1.3 should have the capability to talk by radio direct to the technical crew in each aircraft in order to maintain an accurate, up-to-the-minute status of the technical effort. This will require a separate and distinct radio network between the TOC and each aircraft, particularly the high-priority aircraft.

(3) The commander of the air array (CTG 8.4) should submit the actual position of the aircraft as soon after each event as possible. This should be a formal report from the CTG 8.4 to CTU 8.1.3 within 36 hours. Considerable delay was encountered in receiving the actual position reports for the Fish Bowl events.

(4) The aircraft and technical crews should be debriefed by the local CTU 8.1.3 representative immediately following the mission, to determine problem areas and general success of the mission.

(5) If pods are used in future events, the helicopters used for recovery should have a better lift capability to return the waterlogged pods to Johnston Island.

(6) The compatibility between the homing device in the helicopters and aircraft and the pod emitter (Sarah beacon) should be established more fully prior to the series. Receiver/transmitter tests should be made early in the planning phase.

3.3 MISSILES AND ROCKETS

The experimental concept of the Fish Bowl Series required the development of a missile and rocket capability beyond that previously utilized in any previous test series. After a study by DASA, the Thor missile was selected to be the carrier for the nuclear warheads in Fish Bowl. Other carriers considered but rejected were the Redstone, Jupiter, Nike-Hercules, and Polaris. After selection, it was decided that, although DASA would fund the Thor effort through existing funding arrangements with Field Command, it would be advantageous for the Air Force Space Systems Division of USAF Systems Command to exercise project supervision under direct JTF-8 control. Hence, WET was relieved of the responsibility for Thor operations during Dominic.

The small rockets necessary to carry instrument packages to proper altitude and space remained a WET responsibility and required WET to obtain specialists in the small rocket and tracking areas. These personnel were obtained through augmentation, to insure adequate supervision in these specialized fields. The short preparation time available necessitated the decentralization of the rocket operations; consequently, a variety of rockets were used in the field. Procurement of rocket motors in the available time period required that WET assist projects in obtaining industrial priorities and in negotiating agreements with other user agencies to borrow motors until replacements could be manufactured. Although all small-rocket launch controls were in the same bunker on Johnston Island, operational methods varied between the various rocket projects. It was clearly evident at the time that the systems used left much to be desired, but time limits precluded improvement.

The TU 8.1.3 Small-Rocket Officer was subsequently appointed as the JTF-8 Small-Rocket Safety Officer and was charged by JTF-8 to provide impact predictions and trajectory information for all small rockets, including those fired by Sandia Corporation. This data was required to insure safety of ships and aircraft operating in the Johnston Island test area. Calculated risks were taken on occasion in allowing ships and aircraft into the outer reaches of the rocket impact areas. Ballisticians were furnished by the various projects for necessary computations, because no electronic computers were available for this purpose. Wind data was not available for a 1-hour period prior to launch of those rockets scheduled for shot time, precluding last-minute corrections and making accuracies less than desired. Small-rocket safety criteria were determined by the JTF-8 Small-Rocket Safety Officer.

All the rocket launchers were along the only runway on Johnston Island, and there was no adequate existing rocket assembly area on the island. It was necessary, therefore, for JTF-8 to request waivers from the Air Force regarding use of the runway.

Two grounded screen rooms (Figure 3.4) were constructed along the launcher line to provide shielded assembly and checkout areas for rockets. In spite of attempts to keep only the minimum number of rockets on Johnston Island during Fish Bowl, considerable numbers of rocket motors were in the screen rooms during nuclear launch operations, creating a somewhat unsafe condition. These situations were well known to CJTF-8 and CTU 8.1.3, but little could be done to improve safety because of time and space limitations.

The large number of separate agencies involved with rocket operations created operational and safety problems throughout the operation. The magnitude of an effort like Fish Bowl suggests the desirability for a single manager for rocket operations, from procurement through launch. This would insure proper programing of motors, payloads, telemetry, safety, etc.

Appendix F lists the rockets fired in conjunction with the Fish Bowl nuclear events. Other firings were conducted to obtain background data, to check out tracking systems, and to certify systems.

Based on the missile and rocket experience gained on Fish Bowl, it is recommended that: (1) a single contractor be selected in any future operation of the magnitude of Fish

Bowl to operate the small-rocket program; (2) more adequate facilities be developed for rocket assembly, storage, and checkout; (3) a single family of rockets be used in the operation, to preclude the problems accompanying the use of a variety of systems; and (4) rocket launch and computational systems be improved to include provisions for last-minute corrections for weather. This becomes especially important in the event of extended holds, a rather normal situation.

3.4 READINESS REPORTING

All scientific project status reports were received and evaluated at the Johnston Island TOC. Because of the many remote locations involved (Figure 3.5), a uniform reporting procedure was established to provide the necessary data to the TU 8.1.3 Headquarters, with the required clarity, speed, and economy of effort to permit rapid evaluation of the readiness status of scientific projects. The reporting procedures provided means whereby each project at each location could provide quick, direct, and unclassified readiness reports to the Task Element Commanders, who then relayed the information to the TOC.

The scientific reporting network consisted of three separate and distinct loops. One loop comprised the northern and western Pacific stations, the second loop encompassed the southern Pacific stations, and the third loop served the immediate Johnston Island area.

Each project of TU 8.1.3 was required to provide periodic reports concerning readiness of its particular scientific effort. To facilitate the transmission of these reports from the many projects and locations, an unclassified Sunshine reporting system was established. The code used in conjunction with the Sunshine reporting system and the reporting nets is described in Appendixes G and H.

3.5 GO-NO-GO CRITERIA

The CTU 8.1.3 and the Test Director established criteria for the minimum conditions acceptable for Task Unit approval for the execution of a Fish Bowl event. These criteria were in writing and represented a compromise between ideal and practicable considerations. The criteria were flexible, not binding, and were used as a guide for decisions by CTU 8.1.3.

In the early phase of the operation, conditions in the Southern Conjugate Area were not fully considered because of time lags in the readiness reporting systems. As this situation was corrected, other problems arose that required the established criteria to be continuously modified.

CTU 8.1.3 and his scientific adviser were physically located in the JTF-8 Command Post at event time, where they could discuss event criteria directly with the Commander and the Scientific Deputy. At no time during the operation was CTU 8.1.3 overruled by JTF-8 on an event shot time. Although it was theoretically possible for an event to take place against the desires of CTU 8.1.3, event time was concurred in by CTU 8.1.3.

An example of go-no-go criteria used on Johnston Island is included as Appendix I.

3.6 TRACKING

During Fish Bowl, pods and rockets were needed for collection of blast, radiation, and thermal effects data. Since essentially all of the data to be gathered was affected by the inverse-distance-squared law, it was necessary that the positions of all rockets and all pods be known to a high degree of accuracy.

A contract was awarded to Cubic Corporation of San Diego, California, to provide and operate the necessary tracking, recording, and printout equipment. This effort, designated Project 9.6, provided the capability of tracking three pods and six rockets simultaneously for each event. Because of time limitations, each rocket user had the responsibility for the installation of a tracking transponder in his rocket and for providing the transponder antenna. Cubic Corporation provided the transponders, using nine assigned frequencies. The rocket users provided to Project 9.6 the nominal trajectories, firing times, and provisions for checking the airborne transponders.

The tracking requirements of the task unit were extensive. Project 9.6 was to provide extremely accurate tracking data for the pods and tracking data of lesser accuracy for rockets. It was known that Project 9.6 could not provide for the tracking of all rockets for any one event; however, it was felt that the project agency (Cubic Corporation) would become the prime tracking agency and obtain assistance from other agencies. Additional tracking capability was available on Johnston Island from other participating agencies, and generally this was made available to TU 8.1.3 on a noninterference basis.

3.6.1 Systems. The system operated by Project 9.6 was of a phase-measurement type. This system provided the extreme accuracy required and had the advantage of simplicity in the ground equipment. The three major components of the automatic distance and angle measurement (ADAM) system are discussed in detail below.

Angle Measurement Equipment (AME). This system depended on accurate placement of the antenna field and the accurate placement of dipole antennas within the field. From the surveyed center-of-field, dipole antennas are placed at precise intervals (multiples of signal wavelengths) in two directions. The two resultant antenna legs are normal to each other and are symmetrical about the center. Base lines of $\frac{1}{2}$, 4, 16, and 64 wavelengths were used on Johnston Island (Figure 3.6).

By measuring the phase difference from the airborne target to any one pair of antennas, an angle is established that circumscribes a right half-cone along the one antenna leg. A simultaneous angle is also determined from the other leg. The intersection of these two orthogonal cones from the same origin is a straight line to the target. The data from this intersection is presented as directional cosines from the two antenna legs to the target.

The measurement is done electronically, with no moving mechanical parts in the system, and is essentially automatic. The same field can be used simultaneously for multiple targets; however, a complete receiver system is necessary for each channel (target) employed. Angles can be given to an accuracy of less than 300 parts per million absolute error in direction cosine. There is no distance-measuring capability with this system.

Distance-Measuring Equipment (DME). The DME system used a common transmitter in conjunction with nine transponders (one per object being tracked) and nine receiving antennas so that it could give distance data for nine targets in flight simultaneously (Figure 3.7). A theoretical accuracy of less than 1 meter could be achieved. The common transmitted modulated carrier signal was received by the transponder on the airborne vehicle, demodulated, phase-corrected within the transponder, retransmitted by the transponder via a separate and distinct carrier, received by the ground receiver, and demodulated by the ground receiver. The ground station then compared the phase of the modulated return signal with the phase of the modulated transmitted signal to obtain a distant measurement. These various operations upon the carrier signal introduced substantial reliability problems. The airborne transponder used was large, heavy, and expensive. Because of subjection to high accelerations and extreme vibrations in the airborne vehicles, the environmental testing standards were exceedingly stringent. Further, since the majority of transponders were not recovered after a flight, it was impossible to evaluate any faulty transponder or identify any faulty component within a transponder.

Automatic Gimballed Antenna Vectoring Equipment (AGAVE). This equipment was different from the two previous systems described in that the antenna depended upon physical positioning to determine the horizontal and vertical angles to a particular target (Figure 3.8). The pedestal angle data was transmitted to a tape recorder for future read-out. As a phase-measuring device, this equipment used the difference in the phase of the return carrier signal used in the DME system between two pairs of antennas (one pair for the elevation measurement and one pair for the azimuth measurement) to activate servos in the pedestal of each antenna assembly. The pedestal was turned in elevation and azimuth until there was a zero-phase difference among all four antennas on any one particular mount. This system was used because of its simplicity, ready availability, relatively low cost, and rapid presentation of data. The accuracy of this system was approximately $\pm 0.5°$ in both azimuth and elevation.

A combined AME-DME or a combined AGAVE-DME was required to give the spatial location of any one target at any one time. A given range described a hemisphere in space from the DME station, and the corresponding AME or AGAVE measurement gave the location on this hemisphere of the target. A succession of such points, with a corresponding time reference, produced tracking data for any one flight.

Associated Systems. During Fish Bowl, some other tracking equipment was available in the Johnston Island area. One such equipment was an AN/FPS-16 radar on board the ship USNS Range Tracker, with the primary function of tracking the warhead-carrying missile for range safety purposes. When scientific rockets were to be fired during the dead time of this radar, the USNS Range Tracker personnel helpfully tracked these rockets. Further, the USNS Range Tracker provided a printout of data for detailed analysis. In addition to this radar, a C-band radar on board the DAMP ship tracked the Project 6.13 rockets. One additional piece of tracking gear used on Johnston was the GMD-1 meteorological rawinsonde tracking equipment. This equipment provided angle data by physically following the telemetry data signal from the rocket. Although not a sophisticated piece of equipment, it was extremely reliable and was used. Project 6.7 (Star Fish and Check Mate) utilized off-island tracking stations to better analyze the flights of their long-range rockets. These included the Pacific Missile Range (PMR) TLM-18 at South Point, Hawaii, and the telemetry-tracking station on Canton Island.

The systems employed in the tracking of rockets and pods during Fish Bowl were far from perfect; however, the system was the best that could be devised in the short time permitted. There were numerous problems with the airborne transponders, antenna patterns, impedance matching with antennas, and speed of data reduction. The transponder problem could only have been solved with extensive flight testing, to include recovery and analysis of the transponders flown. The transponder antenna problem could have been overcome had there been sufficient time to place this responsibility on one contractor. In practice, each project had the responsibility of providing the transponder antenna for each of the rockets used by the project. There was inadequate time to test these various antennas. There were indications that antennas may have been responsible for lack of valid tracking data on some rocket flights. There was some difficulty with the acquisition of rockets by the AGAVE equipment. In view of the factors involved, tracking was considered satisfactory.

3.6.2 Data. To analyze and display tracking data, a Control Data Corporation (CDC) Model 160 computer was installed and placed into operation on Johnston. Two magnetic tape units, a flexwriter, a line printer, and a plotter were coupled with the computer for data analysis. There was no method whereby the raw tracking data from the ground system vans could be sent direct (electronically) to the computer van. The magnetic tracking tapes from each van were physically removed and carried to the magnetic tape units of the computer system. There, the tapes were copied, edited for gross anomalies, appropriately combined, and printed out. Only raw data was available on site. Smooth data was available from Cubic's San Diego office some months after the last event. Quick-look requirements necessitated continuous operation of the computer system for days after each event. Some of the data was too rough for any valid analysis. However, most raw data was of interest to the scientific groups and permitted a valid review of trajectories. During Phase II, this raw data was presented to each project and to the appropriate program director within hours after each event, with few exceptions.

To insure proper delegation of effort, a conference was held with each project officer prior to each event to determine the particular needs of the project, and priorities for data printout among all of the using projects. Project 9.6 had the ability to present data in many different formats, e.g., the pod projects received data in terms of X (east), Y (north), and Z (altitude) versus time in reference to Point John (H&N coordinate system, N 200,000, E 200,000) on Johnston. Some of the rocket projects received data in terms of A (altitude), H (horizontal range), and D (slant range) versus time, in reference to the particular rocket pad from which the rocket was fired. Other rocket projects received tracking data in terms of azimuth, elevation, and slant range versus time from other reference points. The distances were presented in meters, feet, or yards, as the project requested. The angular data was presented in degrees and angle cosines. When possible, and when desired, plots of trajectories were also supplied.

Some delays were encountered because data reduction programs for the computer were not ready in time. The original contract with Cubic did not require data reduction. This contract was later modified to provide for production of smooth data. Electrical connections from the various vans direct to the computer room for raw-data-transmission purposes would have been beneficial. All computer programs should be written prior to deployment and debugged.

3.6.3 Recommendations. Experience gained from Fish Bowl indicates that the following efforts would alleviate many of the difficulties encountered:

(1) Establish the requirements for the program early. Consultations with all of the using rocket and pod scientific agencies, with the program directors, with the Test Director, and with all other participating and interested agencies, are required to allow planning at the earliest date possible. Planning should provide for possibilities rather than probabilities.

(2) The tracking contract should cover all details from initial design of equipment to finished smoothed tracking data. The prime contractor must be given responsibility for the entire system. As an example, during Fish Bowl, the prime contractor did not have the responsibility for antenna design, installation, and testing. As a result, a great deal of difficulty was encountered at a very late time attempting to make field modifications to the transponder antennas to improve propagation characteristics sufficiently to insure some sort of tracking reliability. There should be redundancy in every part of

the tracking system, to include both the airborne and ground components. As many systems as possible must be used on every flight to insure adequate data.

(3) Transponder systems should be subjected to further environmental testing. This is time consuming, laborious, and lengthy, but the effort is worthwhile. Packages should be flown in test vehicles and recovered for analysis. The most frustrating aspect of the tracking system during Fish Bowl was that, after the failure of an airborne package, there was no way to examine the faulty transponder to assist in determining which component was at fault.

3.7 SOUTHERN CONJUGATE AREA

3.7.1 Establishment. An objective of the Fish Bowl Series was to observe and record resultant changes in the earth's environment in the vicinity of the magnetic conjugate points. The magnetic conjugate point is defined as that point where the earth's magnetic field lines, passing through the point of detonation, intersect the surface of the earth.

Two site surveys to the Southern Conjugate Area were made during February and March 1962. On these trips, technical sites were selected, and agreements were consummated with the local governments and land owners. A contract negotiator from the AEC was included on these trips.

The areas selected in the vicinity of the south conjugate point were American Samoa (Tutuila), Viti Levu in the Fiji Islands, and Tongatabu in the Tonga Islands (Figure 3.9). These three locations roughly surrounded the southern conjugate point for the anticipated events. Rarotonga, Canton, and Palmyra were also instrumented to observe and record the phenomena from locations either looking at the magnetic field lines from beneath, as from Canton, or looking across the field lines, as from Rarotonga (Appendix B). Wallis Island, located nearer the actual conjugate point, was a desired location from a technical point of view; however, this territory, under French control, was not available because of political considerations.

Two ships were located near the southern conjugate point for each event. During Phase I, these were the M/V Acania, operated by Stanford Research Institute (SRI), and the SS Mauna Tele. During Phase II, the M/V Acania and the SS Hifofua were used. In addition, one KC-135 and two RC-121 aircraft were operated in the conjugate area from a base at Nandi, Fiji Islands.

3.7.2 Operations. These generally involved the coordination and technical support of the scientific projects. A communications network providing 60-word/min radioteletype capability utilizing AN/GRC-26 radios was established between the Southern Conjugate Area and the worldwide military communications network. Rarotonga, with only one small project group, was not included in this network; hence, it did not have the facilities to process classified traffic. Unclassified communications were available with Rarotonga through a voice network linking all SRI projects.

Military communications facilities were supplied and operated by the 25th Infantry Division and consisted of corps-division radioteletype equipment designed to operate over distances to 250 miles. No serious problems resulted from modifying this system to operate over the long distances involved. The control station for this network was initially at Suva, Fiji, with entry into the worldwide network through Christmas Island. After closing of Christmas Island, the net control station was moved to the more centrally located American Samoa, where direct communications to Johnston Island were established. This change reduced the traffic delay between Johnston Island and the Southern Conjugate Area by eliminating two relay points, Christmas Island and Hawaii.

During the initial setup period of Fish Bowl and throughout Phase II, a program representative was in the conjugate area, greatly facilitating control of the various projects. For future operations, it is recommended that a program representative for each program involved be located in the area at all times.

The task unit representative in the Southern Conjugate Area had no real control or authority over the technical projects. Any future operation should insure that participating projects sponsored by DASA are under technical control of the task unit, wherever the project may be located.

3.7.3 Administration and Support. The operation in the Southern Conjugate Area was unique in that a small task element was dealing with several friendly governments over a large geographical area. To effect control of DOD activities, an officer from the Technical Operations Branch, TU 8.1.3, was designated to establish a headquarters in the Southern Conjugate Area. This officer was also assigned responsibilities as Officer-in-Charge of TE 8.1.3.4 and served as the JTF-8 representative for the area. Control was exercised through infrequent personal contacts and by the exchange of messages via radioteletype networks.

Headquarters for the area, designated as TE 8.1.3.4, was located with the communications net control station, initially at Suva, Fiji, and later at Leone Airstrip, Samoa. During the first phase, one officer and one enlisted administrative specialist were assigned to Headquarters, TE 8.1.3.4, with an additional officer assigned to American Samoa and an enlisted operations coordinator assigned to Nandi, Fiji Islands, the site of the main commercial airfield in the Southern Conjugate Area. The senior enlisted military representatives on Palmyra, Canton, and Tongatabu were designated as the TE 8.1.3.4 representatives at their respective sites. The senior project engineer on Rarotonga was designated as the Task element representative for that location.

For a future operation, an officer should be assigned to each island involved.

Relations with the local governments and the native populace (Figure 3.10) were good in spite of some problems caused by the delayed release of public information concerning test activities. In general, news releases from official sources were not received far enough in advance to be disseminated to the appropriate officials and news media in the conjugate area prior to unofficial receipt of the same information through monitoring of Honolulu radio stations. This caused a certain amount of official displeasure on the part of the governments concerned.

Holmes and Narver Inc. (H&N) provided fiscal support for the operation. H&N personnel were available on Palmyra, Canton, Samoa, and Tongatabu to certify expenditures at these sites. The senior project officer on Rarotonga certified expenditures for that location, and the Officer-in-Charge, TE 8.1.3.4, acted as the H&N representative for Viti Levu. Delays in payment for services and materials on Viti Levu and Rarotonga caused some poor relationships with local agencies and contractors.

For any future operation, it is recommended that a financial manager from the organization providing fiscal support be maintained at each location where project personnel are stationed and that this individual arrive in the area with the initial group of personnel.

Personal financial matters were a continual problem for military personnel. In general, basic monthly pay and allowances were no problem and were paid directly from the home station. In some areas, such as Fiji, where the cost of living on the local economy was relatively high, prompt per diem payments for extended periods of temporary duty became important. Delays of 30 days in payment after a voucher was submitted were not uncommon. Briefing of personnel involved, so that they would have known what to expect, would have been helpful. Some military personnel were paid per diem for extended periods in advance, resulting in hardships when TDY conditions were changed, and per diem rates altered.

Interisland transportation was poor at best. Commercial air transportation, except in the Fiji Islands, was limited to not more than one flight a week, and for Palmyra and Rarotonga was nonexistent. Military Air Transport Service (MATS) shuttle flights using C-124's or C-118's were set up on 6-day intervals to support all six islands. Palmyra was supported by a separate shuttle from the other five locations, using aircraft on the Hawaii-Christmas Island shuttle run. These arrangements were barely satisfactory. Any future operation should provide for a C-54 type of aircraft based in the area under control of the Officer-in-Charge. This would allow more flexibility of control and provide more economical and better service for all sites.

Maintenance and cargo-handling support for the MATS flights were inadequate for all locations except, perhaps, Fiji. At Nandi, Fiji, limited contract support from Pan American Airways was utilized. Such support was not available at other locations. In the future, at least an engine stand, a power unit, and adequate cargo-handling equipment should be provided at each site. In addition, MATS crews should be briefed in advance of the nature of the operation and the complete lack of terminal support at some sites.

Intraisland transportation and communications were generally poor. Some roads (Figure 3.11) were nearly impassable at times. Future selection of project locations should take this into consideration. Furthermore, all projects on a particular island should have a telephone link. Fiji, where commercial facilities were already available, was the only site with adequate intraisland communications. With regard to transportation facilities, leased local transportation was, in general, the most satisfactory arrangement. A future operation should make maximum use of this arrangement where available.

Satisfactory housing conditions were available at Samoa, Canton, and Palmyra, where H&N camps were established. The local economy was utilized on Fiji, Tongatabu, and Rarotonga. Fiji offered adequate hotel accommodations whenever advance notice of buildup was furnished and the necessary advance arrangements were made. During Phase I of Fish Bowl, personnel of the Fiji communications team and the task element headquarters lived on a New Zealand Air Force Base at Lauthala Bay, Fiji. This base provided excellent working and living conditions, but it was about 150 miles from most project activities. Rarotonga and Tonga had adequate commercial or private facilities to support the project personnel, but facilities were inadequate to support any additional buildup. For example, when 40 personnel unexpectedly stayed overnight on Tonga, a large number of them had to sleep in the aircraft.

In all areas, power was supplied for technical projects by gasoline or diesel generators; local power was not available. These generators were not interchangeable nor of the same make or design. No capability existed on-site for more than minor maintenance or repair. A breakdown required a replacement generator to be shipped from Honolulu. With the operation extending over 8 months, during which almost continuous operation of generators was required, the replacement rate became excessive. In addition, the replacement generators frequently arrived at sites in unserviceable condition.

In any future operation, a great effort should be made to standardize all power equipment in remote areas. Furthermore, a generator maintenance and repair mechanic should be assigned to each site, with the sole responsibility of servicing and maintaining the equipment. Many power problems could have been eliminated by proper preventive maintenance.

Data return aircraft were operated from the Southern Conjugate Area for each event. These aircraft, initially two and in the final stages only one, were required to be on the ground at Nandi, Fiji, prior to H-hour for each scheduled event. With many postponements announced after the data return flight was already enroute to Fiji, this resulted in considerable ground dead time for aircraft and crews. Inasmuch as the earliest return schedule left Fiji at H+56 hours, no apparent valid requirement existed for arrival at Fiji before H-hour. The trip from Honolulu to Fiji involved only 14 hours of flying time; therefore, a departure from Hawaii after the event would have been sufficient.

The initial concept for the organization and operation of the Southern Conjugate Area was based on estimates of low project density, minor resupply and support effort, and a minimum of communications traffic. This was not the case. Population grew to 33 technical projects on the six islands, and the personnel associated with project and support activities peaked at about 350. Many of the problems encountered throughout the operation in the Southern Conjugate Area can be directly related to the initial low estimate of the magnitude of the operation.

3.7.4 Recommendations. (1) Personnel on site survey trips should have authority to make decisions in their respective areas of interest.

(2) Each program should have a representative in the conjugate area.

(3) Positive authority should be granted the Officer-in-Charge to exercise control of project and military personnel.

(4) An officer should be assigned to each occupied area to facilitate control and coordination with local governments.

(5) Official news should be released promptly in all areas.

(6) Personnel with authority to certify expenditures should be located at each site and remain there during the entire occupancy period.

(7) Per diem payments should be made promptly and not for long periods in advance.

(8) An aircraft should be available to the Officer-in-Charge in the southern area, to be used in conjunction with the MATS shuttle service employed in Dominic.

(9) Local transportation should be used on a lease basis wherever possible.

(10) The use of contractor-operated camps should be encouraged.

(11) Means to insure more adequate power sources must be provided.

(12) Data return aircraft requirements should be reduced.

3.8 CHRISTMAS ISLAND

The Christmas Island Series of Operation Dominic was concerned only with AEC proof-testing of nuclear devices; no DOD military effects participation was originally planned.

3.8.1 Task Element Operations. As the result of correspondence between the Weapons Effects and Test Group (WET, FCDASA), Advanced Research Projects Agency (ARPA), and Aeronautical Systems Division (ASD) of the Air Force Systems Command (AFSC), two projects (7.3, Microwave Attenuation Due to Nuclear Burst, and 7.5, Thermal Radiation from Airburst Nuclear Weapons Incident on Low-Altitude Aircraft) were admitted to the Christmas Island tests on a noninterference and non-DASA funding basis, in March 1962. To accommodate these projects, TE 8.1.3.3 was activated at Christmas Island on 4 April, with the arrival of WET personnel and personnel and equipment of Projects 7.3 and 7.5. Project 4.2 (Photoelectric and Psychophysical Measures of Nuclear Weapons Flashes), and subprojects of Project 4.1 (Navy goggles) and Project 6.5a (ELF measurements) were later approved for participation, and the personnel arrived in June 1962.

TE 8.1.3.3 headquarters consisted of an Officer-in-Charge, a Deputy, and two enlisted men. This task element of TU 8.1.3 had the largest scientific group on Christmas Island, even though the DOD scientific effort was on a noninterference basis. Peak strength was 85 personnel.

The inclusion of DOD experiments in the Christmas Island Series at a late date created many problems for TE 8.1.3.3 personnel. Headquarters personnel arrived on the island just prior to the arrival of project personnel. At the time, support from H&N was extremely difficult to obtain, because many higher priority AEC projects were present. The areas selected for the DOD projects were isolated from the main camp areas, as were many scientific sites, necessitating transportation that was in extremely short supply. Aircraft parts ordered for the B-57 aircraft of Project 7.3 were placed in a common parts pool by TG 8.4 maintenance personnel, requiring personal action by the Task Element Officer-in-Charge to obtain the parts so that the experiment could be conducted.

An example of the willingness of the AEC laboratories to accommodate the DOD is evidenced by the fact that the entire countdown system at Christmas Island was changed the night before the first live event, so that Project 7.5 could safely position its aircraft. Rehearsals had been held daily for 10 days, and this change was a drastic one at this late time. Great credit must be given to the Scientific Deputy, JTF-8, for the successful completion of the DOD experiments.

3.8.2 Project Participation. Table 3.2 lists the project participation in the airdropped events at Christmas Island.

It was evident that several of the DOD projects arriving on Christmas were unprepared for a field operation. Systems had not been adequately tested prior to deployment to the test area, and project personnel were not aware of the facts of life in an overseas operation. In one instance, equipment went out of commission for lack of corrosion protection, a well-known requirement on Pacific atolls. Project 7.3 experienced extreme difficulties with the corner reflector ejection system in the aircraft; the system had not been fully tested prior to overseas deployment of the project.

3.8.3 Recommendations. (1) Sufficient time must be allowed for headquarters personnel to arrive on site prior to arrival of project personnel and equipment, if proper support is to be provided.

(2) Projects should be screened so as to field only those projects that are reasonably well prepared.

(3) The term "noninterference" should not be used in describing a project. No project operates on a truly noninterference basis. If, in fact, a low priority is placed on the activities of a particular project, the Task Unit Commander should be so notified.

3.9 COMMUNICATIONS AND ELECTRONICS

TU 8.1.3 submitted scientific communications requirements to CJTF-8 in February 1962. To assist in planning and operations, the entire system of scientific stations in the Pacific was divided into three distinct loops for communication purposes: northern and western loop, southern loop, and Johnston Island loop.

The northern and western loop was comprised of Hawaii and all island stations north and west of Hawaii, with the exception of Tern Island in French Frigate Shoals. Control of this loop was exercised by CTE 8.1.3.2 at Hickam AFB.

The southern loop consisted of all sites south of Johnston Island. There were no existing US military communication facilities at any of these sites prior to Fish Bowl. Communications for this loop were provided by CGUSARPAC (125th Signal Battalion, 25th Infantry Division). The primary communications equipment used was the mobile radio set, AN/GRC-26. The Net Control Station (NCS) for this network was at Viti Levu, Fiji (Figure 3.12) during Phase I and at Tutuila, American Samoa, during Phase II (Figure 3.13).

The Johnston Island loop was used to control all aircraft and ships in the immediate Johnston Island area, plus the scientific station at French Frigate Shoals (AN/GRC-26). This was a CW network, with the NCS on Johnston Island.

In addition to these scientific networks, an additional link was afforded by a single sideband (SSB) long-range voice circuit, operated by Projects 6.9 and 6.11 (SRI).

Teletype and voice circuits were maintained between Hickam AFB and Johnston Island; and for Phase II, a teletype circuit was operated between Johnston Island and Tutuila.

CTG 8.6 was responsible for communications on Johnston Island—both the island wire service and the off-island radio service.

CTG 8.5 maintained a limited classified radio capability from Johnston Island in conjunction with its own operations.

The scientific network of TU 8.1.3 is described more fully in Appendix C.

3.9.1 On-Island Communications. Existing telephone services were used wherever possible at all sites. In certain locations, commercial service was either not available or insufficient to meet the needs of the operation; therefore, when necessary, intercommunications systems, field telephones, and short-range radios were used.

At Hickam AFB, base dial telephone service was provided the task unit and projects by PACAFBSCOM. The Communications Center at Hickam was utilized for classified and unclassified TWX traffic.

Offices within the State of Hawaii, but not at Hickam AFB, used interisland commercial telephone service, and staff members made regular visits to TE 8.1.3.2 at Hickam AFB for the submission and collection of classified TWX traffic.

At Johnston Island, because of the nature of this particular operation and because of the extremely high density of both personnel and equipment, the on-island communications systems were quite extensive. The local 300-line switchboard system was utilized to capacity. Dial service was provided every office and every set of living quarters. This dial system was overloaded, and maintenance difficulties arose toward the end of the operation. To augment the dial system, hot lines, utilizing field telephones (TA-42, TA-312, and EE-8) and either field wire or available wire pairs in existing cables, connected every scientific station on the island to the proper location in TU 8.1.3 Headquarters in Building 405. Hot loops consisted of a varying number of stations, from 2 to 10.

An intercommunications system was used on Johnston as a convenience to projects and the task unit headquarters. It was an administrative circuit, as differentiated from the hot-loop operations circuits. It also provided redundancy within the island's communications system.

For JTF-8 operational purposes, a field telephone switchboard was installed and operated in the Command Bunker on Johnston, with stations at various strategic locations over the island.

As a final protective measure in the event of an emergency on Johnston, a small radio network was established using radio sets AN/PRC-10 and AN/PRC-6. In addition to providing operational communications in the event of telephone failures, this radio system provided mobile communications for members of the island's disaster teams. The NCS for this network was located in the JTF-8 Command Bunker.

3.9.2 Off-Island Communications. The mere size of the area over which the TU 8.1.3 scientific stations were located presented a problem in communications. The basic requirement was that of providing scientific status information rapidly to Johnston Island. A second requirement was that of providing a classified message capability to and from each site. Finally, administrative traffic had to be routed expeditiously.

The task element at Hickam AFB required rapid communications with northern loop scientific stations. Also required was a classified TWX capability with Johnston Island and with CONUS. The Hickam AFB Communications Center fulfilled these requirements. No great difficulty was experienced in using this facility for scientific, administrative, and operational traffic. A special addition to the communications capability of TE 8.1.3.2 at Hickam was a full-duplex unclassified teletype circuit connected directly with the TU 8.1.3 Headquarters on Johnston Island. This circuit was used for approximately 4 hours each day on a routine basis throughout the series. On D−1 and D-day for each event, the circuit was kept in continuous 24-hour operation. Finally, a full-duplex voice circuit between the same two locations (Hickam and Johnston Island) was also placed into continuous service from approximately H−6 hours until H+1 hour for each event.

The CW Johnston Island scientific network and the Johnston Island Communications Center, operated by TG 8.6, were very efficient. The direct TWX circuit to Tutuila for Phase II was vastly superior to the Viti Levu-Christmas-Hickam-Johnston Island circuit that was used for Phase I.

The overall off-island system detail can be found in JTF-8 Communications Operating Instructions.

The remote islands on which task unit personnel operated normally had only a single-radio off-island capability. The type of service afforded the various islands is shown in JTF-8 Communications Operating Instructions.

A valuable addition to the overall long-range radio system was the scientific voice SSB network established by Projects 6.9 and 6.11 of SRI. This network was not a common-user type and served the two projects exclusively. The NCS was in Honolulu. No facilities for classified traffic were available in this network. Verbal descriptions of the off-island communications facilities from each location would necessarily be redundant because of the many stations and the many networks involved. Line drawings may be found in JTF-8 Communications Operating Instructions.

3.9.3 TOC Communications. The TOC in Building 405 on Johnston was the hub about which all task unit activities revolved during each event. Extensive communications were required by the personnel in the TOC. Some of these communications were terminated there, and the remainder were terminated at the Johnston Island Communications Center operated by TG 8.6.

Communications requirements of the TOC to the Johnston Island stations included at least two separate and distinct lines to every manned station. Available for this purpose were: (1) dial telephone (base telephone system), (2) hot loops (field telephones with direct wire connections), (3) intercommunications systems (task unit and certain projects), (4) concurrent use of an SB-86 field switchboard), and (5) short-range field radios (AN/PRC-6 and AN/PRC-10).

The requirements of the TOC were extensive with regard to off-island sites because of the number of stations and the distances involved (Appendix B). The TOC had to be aware of last-minute changes in the status of all off-island stations and had the responsibility of informing these various stations of any operational changes at Johnston. The communications had to be rapid and reliable. For these purposes, the following circuits were available to the TOC: (1) direct unsecure teletype circuit to TE 8.1.3.2 TOC at Hickam AFB (Building 3232), (2) direct unsecure teletype circuit to AEC office in Honolulu (H&N Communications Center, 544 Ohohia Street) primarily for use of TU 8.1.1, (3) direct unsecure voice circuits paralleling the circuits of the two preceding teletype systems, (4) CW circuit (off-line encrypting capability) from the TOC to French Frigate Shoals and all scientific ships off Johnston Island, (5) unsecure voice circuit from the TOC to the shipborne alternate command post to relay scientific aircraft status, (6) unsecure teletype circuit to TE 8.1.3.4 (American Samoa) for Phase II only, (7) normal secure TWX service through the Johnston Island Communications Center, and (8) voice net between the TOC (Program A), Project 6.13 in Building 200, and the DAMP ship.

3.9.4 Timing System. The entire timing system was under the control of TU 8.1.6, Edgerton, Germeshausen and Grier, Inc. (EG&G). The responsibility of TU 8.1.3 was that of gathering all such requirements, from its many projects, arbitrating any conflicts in these requirements, presenting the needs to TU 8.1.6, and monitoring the response of TU 8.1.6 to these presented requirements.

The timing system consisted of two parts, hard-wire timing and radio timing. All signals for both systems originated within the EG&G master timer in the JTF-8 Command Bunker. The timer was synchronized with worldwide time (WWVH) from Hawaii. Prior to missile lift-off, signals were sent in reference to WWVH; however, signals sent to users after lift-off were sent in reference to predicted detonation time.

Hard-Wire Relays. Timing signals were provided in the form of relay closures at sites designated by experimenters. These relays were furnished, installed, wired, and maintained by EG&G personnel. The external connections from the relay to the particular piece of equipment were the responsibility of the using project. The principal relay employed at Johnston Island was of the DN-22 type, which had contacts capable of carrying 4 amperes of continuous current. These relays found a myriad of uses, from the starting and stopping of cameras to the firing of missiles and rockets. The relays were extremely reliable and accurate.

Hard-Wire Timing Codes. For purposes of synchronization, it was imperative that a real time reference be available and that it be disseminated in usable form to stations on Johnston Island. While WWVH on Maui provided a real time reference, this transmitted intelligence was not suitable, in most instances, to provide accurate magnetic tape marking and to allow for precise equipment synchronization. The solution by EG&G was to provide, via hard wire, the AMR D-5 code (very similar to IRIG Format B time code). This D-5 timing code was based on a 17-bit straight binary time word including hours, minutes, and seconds. This time word had a 5-bit subword for hours, a 6-bit subword for minutes, and a 6-bit subword for seconds. The system producing this time code recycled each 24 hours. In this code, the "ones" and the "zeros" were sent as 6-msec bits and as 2-msec bits, of a 10-part time interval. The synchronization pulse was 8-msec long, and the decade index pulse was 2 msec. The time code was provided via 2.75-volt RMS maximum amplitude 1-kc sine wave, with a 600-ohm unbalanced output impedance. Other time codes were available at Johnston Island, e.g., the B-2 time code. However, the D-5 code was primary.

Radio Relays. Many stations near Johnston Island were unable to utilize the hard-wire timing relays, e.g., ships, aircraft, barges, etc. To provide these stations with accurate timing signals and relay closures required the use of radio relays. Each radio relay consisted of a radio receiver, an antenna, the relays, and battery pack with all components (except the antenna) contained in a single unit. Each unit contained three relays of the single-pole double-throw type, with each relay capable of conducting 2 amperes of continuous current. Therefore, each unit was capable of providing three accurate relay closures for each operation. All radios were tuned to an identical carrier frequency for any one operation. A common modulating frequency for all relays, plus a unique modulating frequency for a desired time, permitted accurate, interference-free, relay closures for these remote stations.

3.9.5 Voice Countdown. To coordinate scientific activities on a near-worldwide basis, an accurate voice countdown was an essential part of Fish Bowl. In addition to the projects located on Johnston Island, there were stations in far-flung locations that depended upon this countdown for the success of experiments. Aircraft and ships as close as 25 miles and scientific stations as far away as Israel depended equally upon the reception of this transmitted information.

On Johnston Island, the countdown presented no difficulty; countdown speakers were placed throughout the area. There were few locations where the voice countdown could not be heard.

The voice countdown was originated in the JTF-8 Command Bunker by EG&G timing personnel who sat directly in front of the Master Timing Console. The output was fed into a line amplifier with approximately 12 outputs. Of these, one output was sent to the long-range radio transmitter, one was fed directly into a VHF transmitter in the Command Bunker, and the remaining outputs were scattered over the island.

The main method of transmitting the voice countdown from the island was by means of three Collins KW-2 SSB transmitters of 10 kw each. Antennas for these transmitters were located on the southwestern end of the island during Phase I, and on the northeastern end of the island during Phase II. Although these transmitters were installed and maintained by TG 8.5, their only input came via the hard-wire voice transmissions from the Command Bunker. For the periods between events, the output from the transmitters came from an endless magnetic tape with a short message identifying the transmitter. This was done for equipment calibration and tuning purposes. Each long-range transmitter operated simultaneously on three different HF frequencies, determined by the propagation forecasts of the particular time period involved. Although the transmission was SSB, the signal had a full carrier (carrier and sideband of equal amplitude) so that the stations with only AM receivers could demodulate the countdown signal without serious distortion or loss of intelligibility.

The voice countdown over VHF and HF circuits was identical. (The voice countdown was sent to the Johnston Island stations via wire.) The VHF countdown was used because of the lack of HF receivers in some of the participating aircraft. The voice countdown scripts (one for each event) used by the personnel of TU 8.1.6 were prepared by the J-3 section of JTF-8, based on requirements submitted by the various task units. DOD scientific projects presented their script requirements to TU 8.1.3, which then presented a consolidated request to JTF-8.

3.9.6 Closed-Circuit Television System. For purposes of rocket safety, a closed-circuit television system was installed on Johnston. Since no personnel were allowed outside their designated manned stations at event time, this system provided positive information concerning conditions on the small-rocket launching pads. The Rocket Safety Officer, in the TOC, by use of this system, continuously monitored the small rockets during each event for possible safety hazards.

There were three cameras, all situated on the north side of the runway, one at the east end of the island atop a 20-foot steel tower, one at the approximate center of the island atop the aircraft control tower, and one farther west atop Building 200.

One monitor was located in Building 200, for the use of project rocket personnel. Three monitors were located in the TOC.

The entire system was dismantled after Phase II, and shipped back to the contractor for rehabilitation and subsequent storage by FCDASA.

3.9.7 Frequency Coordination. One problem not covered in the discussion above involves radio frequency authorization, allocation, and interference.

On any land mass as small and thickly populated by emitters as Johnston Island was during Fish Bowl, interference problems must be expected and anticipated at the earliest possible date. The importance of full-power full-frequency dry runs cannot be overemphasized. Interference from any electric motor or appliance must be detected early and corrected.

Authorization for use of frequencies must be requested early, to avoid last-minute problems. Authorizations for use of emitters on foreign islands is slow and must be started in the early stages of an operation.

3.9.8 Recommendations. In any future operation, plans should provide for transportable SSB units for voice channels, on-line secure teletype circuits, and off-line CW backup capability at remote locations.

Single-source (military or contractor) operation of all on-site communications facilities should be provided to simplify and clarify responsibilities.

Early action must be taken to insure proper frequency allocations, to prevent RF interferences insofar as possible.

3.10 MANNED STATIONS AND EVACUATION, JOHNSTON ISLAND

For each of the high-altitude events, only those individuals essential to the conduct of the scientific program were permitted on Johnston Island at event time. The personnel who were authorized to remain were assigned to manned stations; all other individuals were evacuated by helicopter to the USS Iwo Jima, which was then positioned at a safe location.

The primary hazards that existed during the nuclear event resulted from the brightness of the burst itself (possible eye damage), the firing of many small solid-propellent rockets, and the early flight of the Thor missiles over the island.

Each of the project agencies was required to establish manned station requirements and prepared a manned station roster listing specific individuals by location and covering time periods of concern. Generally, individuals not assigned manned stations were evacuated starting about H−12 hours, with completion and physical accountability by H−6 hours. During the course of the countdown, a physical muster of all manned stations personnel was completed and reported at about H−1 hour. One individual was placed in charge of each manned station to insure the overall safety of the station and to insure compliance with the published regulations and procedures. The muster system of TU 8.1.3 on Johnston Island was the responsibility of the Operations Branch.

There was one minor problem involved in the area of manned stations. This involved the requirement to have as few people as possible on the island during a nuclear event to maximize personnel safety. This was not always consistent with the requirement for conduct of a large scientific program. Because the DOD had the largest scientific effort on

Johnston Island, TU 8.1.3 always had the largest number of personnel assigned to manned stations. This generally required an individual justification for each man and for each event, which consumed a considerable amount of time and effort with little or no change in the TU 8.1.3 scientific requirements for manned station personnel.

The Support Division was responsible for the actual evacuation and return of TU 8.1.3 personnel.

Those personnel not scheduled for manned stations were tentatively listed as evacuees and their names placed on rosters of helicopter teams. Each team consisted of a team captain and seven others to conform to the normal helicopter passenger load, excluding the helicopter crew. These teams were scheduled as to their priority of departure and return to the island.

Completed rosters (emergency data roster, team rosters, manned station rosters, and roster of personnel evacuated to other ships) were taken to Headquarters, Task Group 8.6, where persons designated as team captains were notified and an evacuation briefing scheduled. At this briefing, captains were given the time and date of evacuation and provided with team rosters. Many changes had to be made to the manned station and evacuation rosters, due to personnel arriving and leaving the island and changing scientific requirements. These changes would be relayed to Task Group 8.6, which, in turn, corrected their rosters. In many instances, changes were made five times or more prior to the actual evacuation.

On shot days, all personnel to be evacuated assembled at the Support Division Office 20 minutes prior to scheduled departure time for last-minute changes and for final briefing by team captains. After movement to assembly areas, team numbers were called by the Mustering Officer, TG 8.6, for movement of teams from the assembly area to helicopters for airlift to the USS Iwo Jima. Loading cards were given to the Marine Control Group by team captains for manifest purposes.

On board the evacuation ship, personnel were quartered according to their rank or grade. GS-10's and below were quartered in the enlisted area and GS-11's and above were quartered in the officers area.

For return to Johnston Island, reverse procedures were followed. On Johnston Island, all TU 8.1.3 team captains accounted for team personnel and supplied the Muster Officer, TU 8.1.3, with reports. The information was relayed to the Muster Officer of TG 8.6.

In those instances where M-boats and LCU's were used for evacuation and return, the procedures were similar to those for helicopter evacuation.

TABLE 3.1 TECHNICAL AIRCRAFT

Project	Call Sign	Type of Aircraft
8A.1/8A.2	Kettle 1	KC-135
8A.1/8A.2	Kettle 2	KC-135
6.10	Kettle 3	KC-135
4.1	Caboodle 11	C-118
4.1	Caboodle 12	C-118
4.1	Caboodle 13	C-118
4.1	Caboodle 14	C-118
4.1	Caboodle 15	C-118
7.4	Bryon	B-47
7.4	Baxter	B-47
7.4	Cognac 01	KC-135
7.4	Cognac 02	KC-135
7.4	Cordova	KC-135
6.9	Lambkin 1	RC-121
6.9	Lambkin 2	RC-121
6.9	Lambkin 3	RC-121
6.9	Lambkin 4	RC-121

TABLE 3.2 DOD PROJECTS, CHRISTMAS ISLAND

Shot Number	Shot Name	Date	Project Participation				
			4.1	4.2	6.5a	7.3	7.5
		1962					
1	Adobe	25 Apr	NP*	NP	NP	NP	POS†
2	Aztec	27 Apr	NP	NP	NP	NP	POS
3	Arkansas	2 May	NP	NP	NP	NP	NP
4	Questa	4 May	NP	NP	NP	NP	POS
5	Yukon	8 May	NP	NP	NP	POS	NP
6	Mesilla	9 May	NP	NP	NP	NP	POS
7	Muskegon	11 May	NP	NP	NP	POS	NP
8	Encino	12 May	NP	NP	NP	NP	POS
9	Swanee	14 May	NP	NP	NP	POS	NP
10	Chetco	19 May	NP	NP	NP	POS	NP
11	Tanana	25 May	NP	NP	NP	NEG‡	NP
12	Nambe	27 May	NP	NP	NP	POS	POS
13	Alma	8 Jun	NP	NP	NP	NEG	POS
14	Truckee	9 Jun	NP	NP	NP	NEG	NP
15	Yeso	10 Jun	NP	NP	NP	NP	POS
16	Harlem	12 Jun	NP	NEG	NP	POS	NP
17	Rinconada	15 Jun	NP	POS	NP	POS	POS
18	Dulce	17 Jun	NP	POS	POS	POS	NP
19	Petit	19 Jun	NP	POS	POS	NEG	NP
20	Otowi	22 Jun	POS	POS	POS	POS	NP
21	Bighorn	27 Jun	NEG	POS	POS	NEG	POS
22	Bluestone	30 Jun	NEG	POS	POS	NEG	NP
23	Sunset	10 Jul	POS	POS	POS	POS	NP
24	Pamlico	11 Jul	NEG	NP	POS	NP	NP

* No participation. † Useful data obtained. ‡ Negligible data or no data obtained.

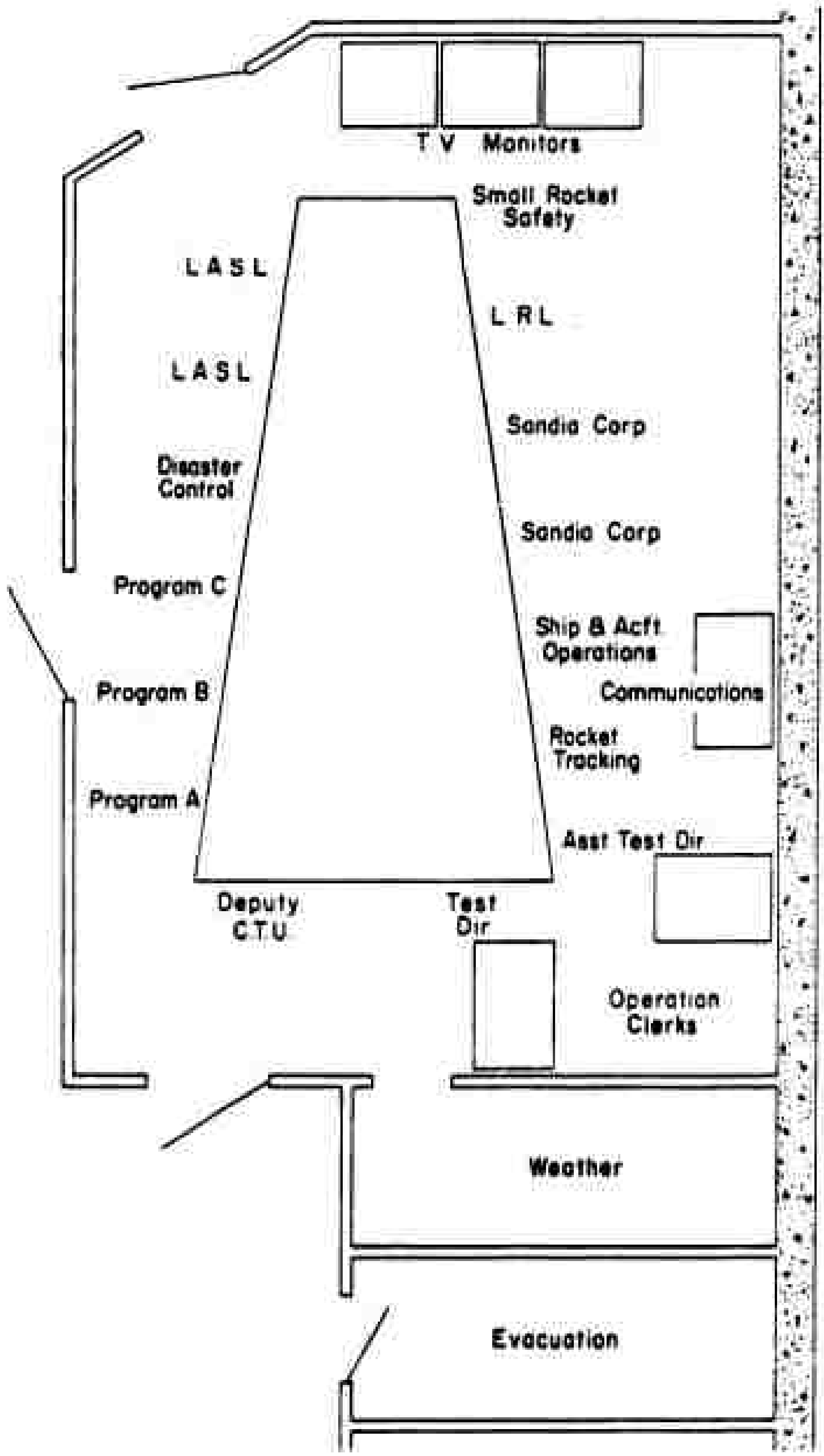


Figure 3.1 Plan of Technical Operations Center, Johnston Island.

Figure 3.2 Technical Operations Center at Johnston Island.
(DASA-26-9053-62 photo)

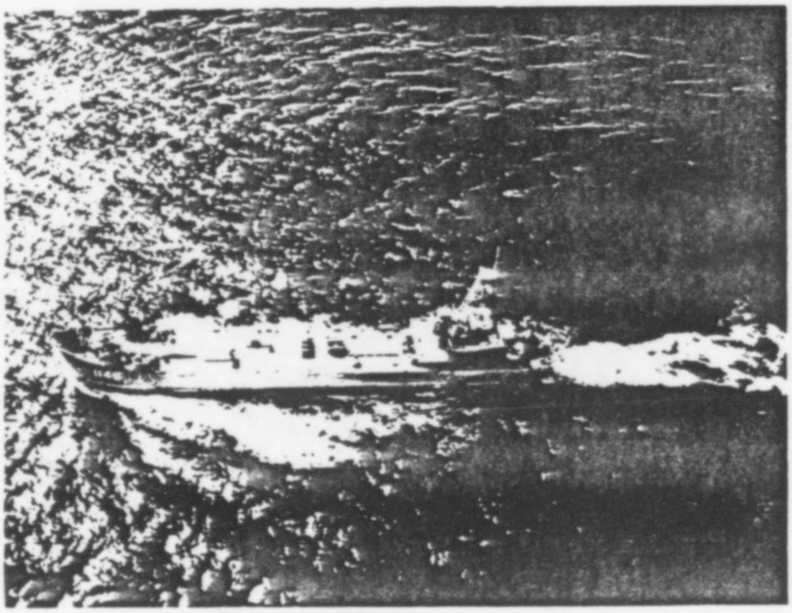


Figure 3.3 Instrumented LST.
(DASA-26-6743-62 photo)

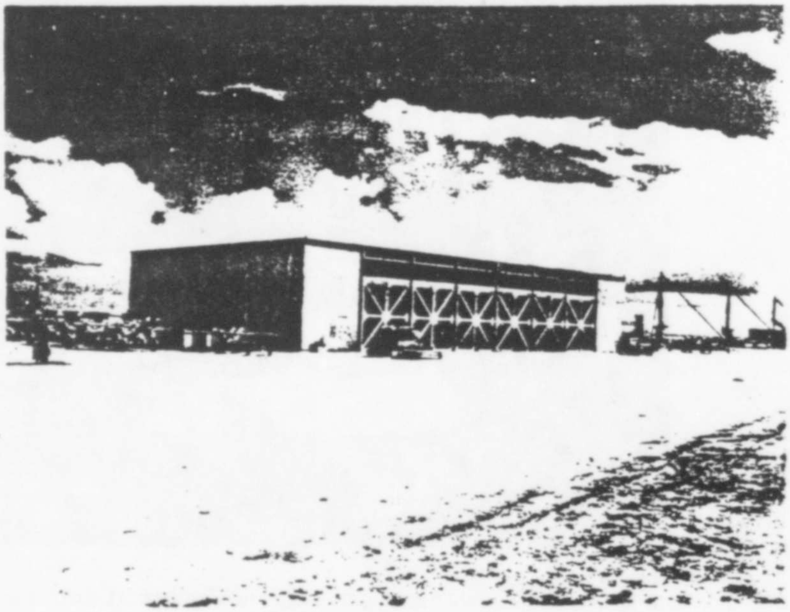


Figure 3.4 Screen room on Johnston Island. (DASA-26-5953-62 photo)

Figure 3.5 Tern Island, French Frigate Shoals; one of several isolated sites used by Fish Bowl projects. (DASA-26-14152-62 photo)

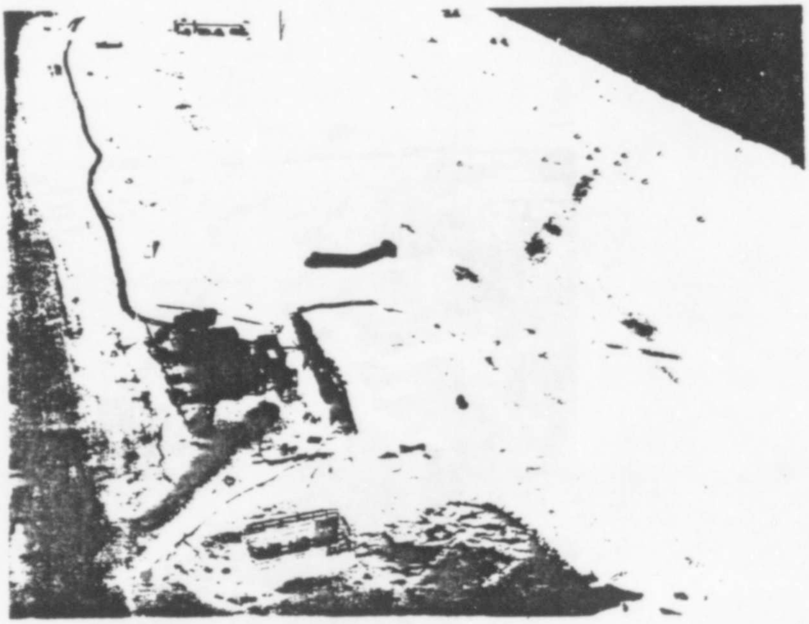


Figure 3.6 AME antenna field. The plastic domes covering the dipole antennas can be seen in upper right. The Cubic AME instrument trailer was in the shelter in the foreground. (DASA-26-6236-62 photo)

Figure 3.7 DME installation. The three DME trailers are in the foreground with the associated helix antennas alongside. The AGAVE trailers and antennas are beyond the DME trailers. The revetments in front of the trailers were designed to lessen danger to personnel in trailers during small rocket firings. (DASA-26-5809-62 photo)

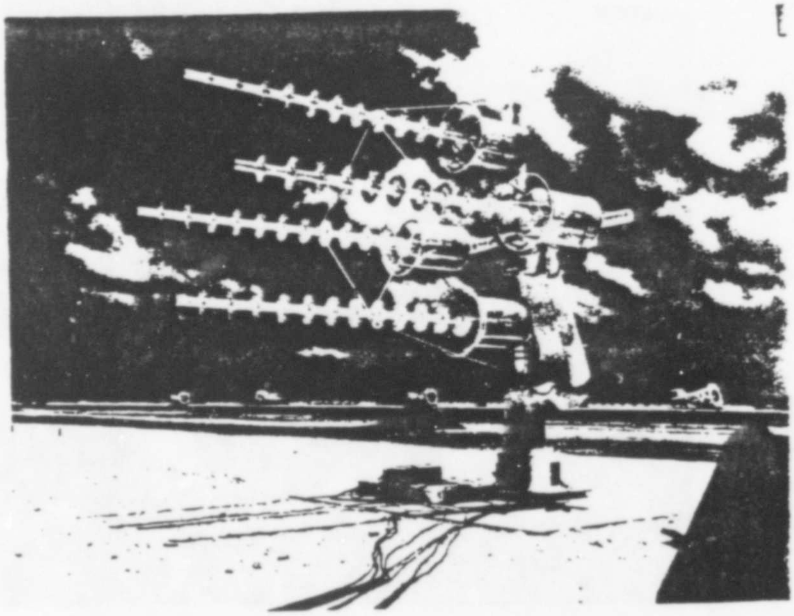


Figure 3.8 AGAVE antenna. (DASA-26-5546-62 photo)

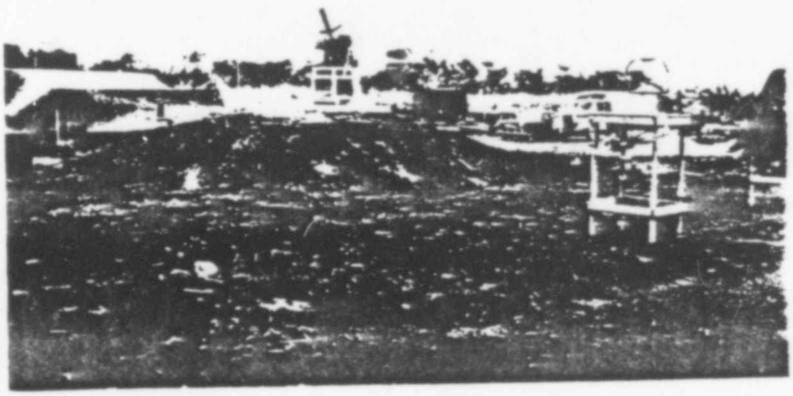


Figure 3.9 Typical scientific station in Southern Conjugate Area, Tonga. (DASA-26-13695-62 photo)

Figure 3.10 Inflation of weather balloon on Samoa. (DASA-26-14038-62 photo)

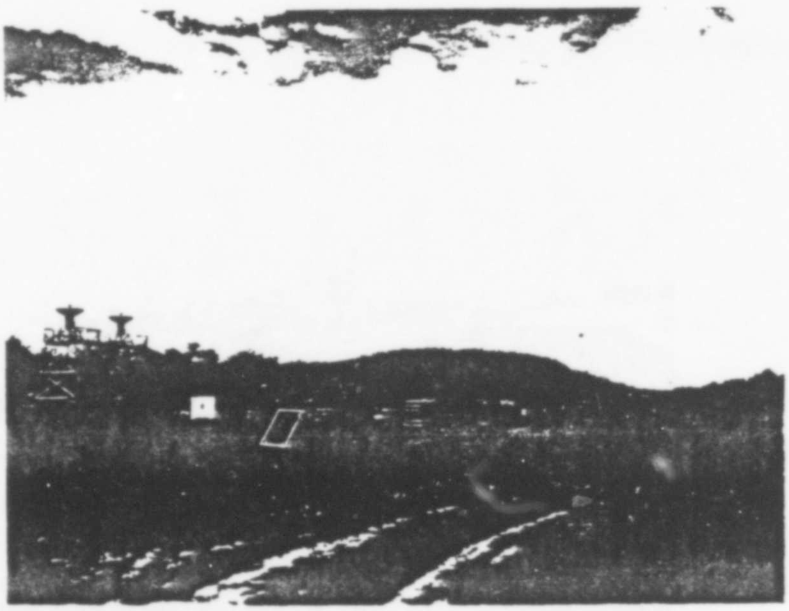


Figure 3.11 Road across Leone Airstrip, Samoa. (DASA-26-13439-62 photo)

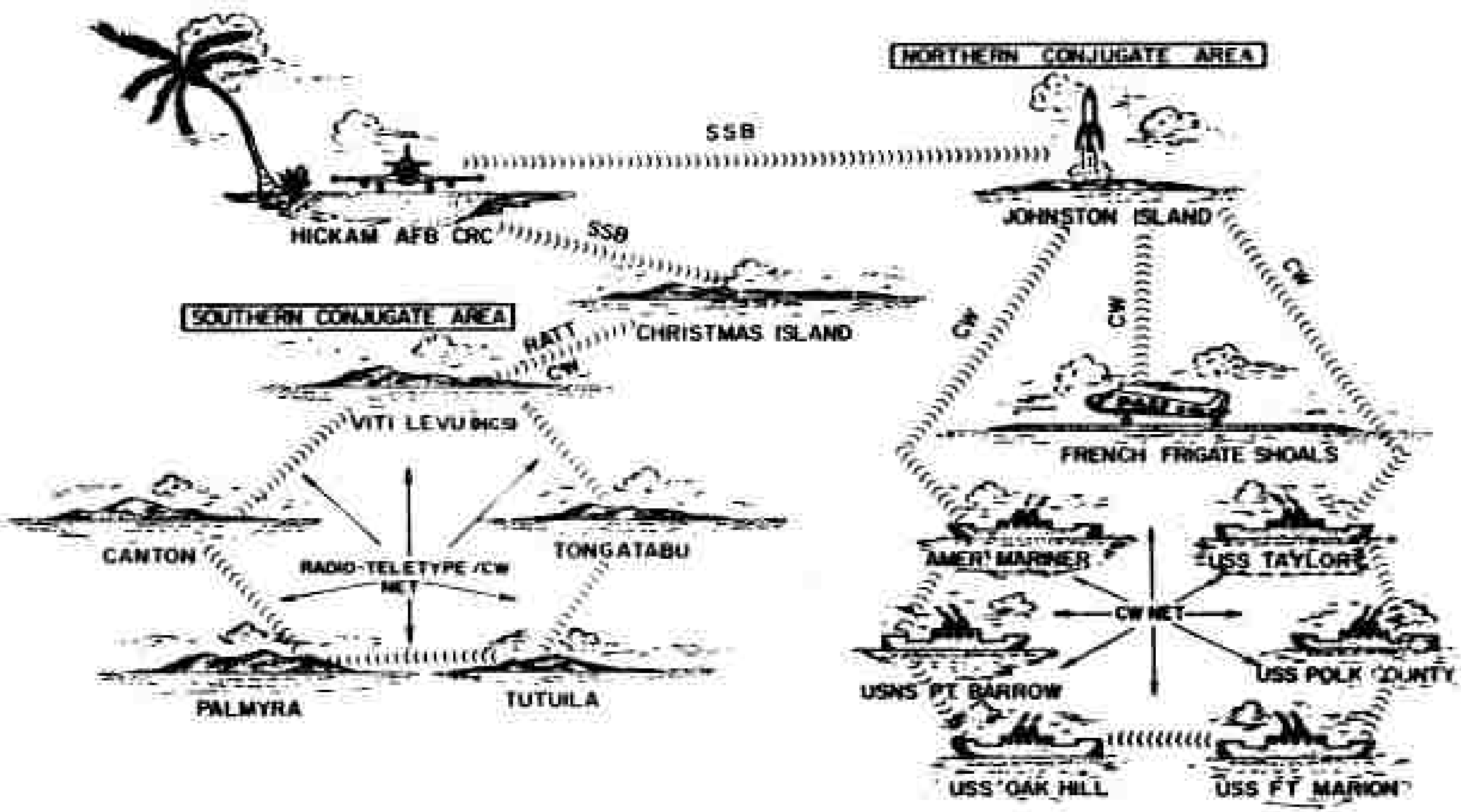


Figure 3.12 Communications systems, Phase I.

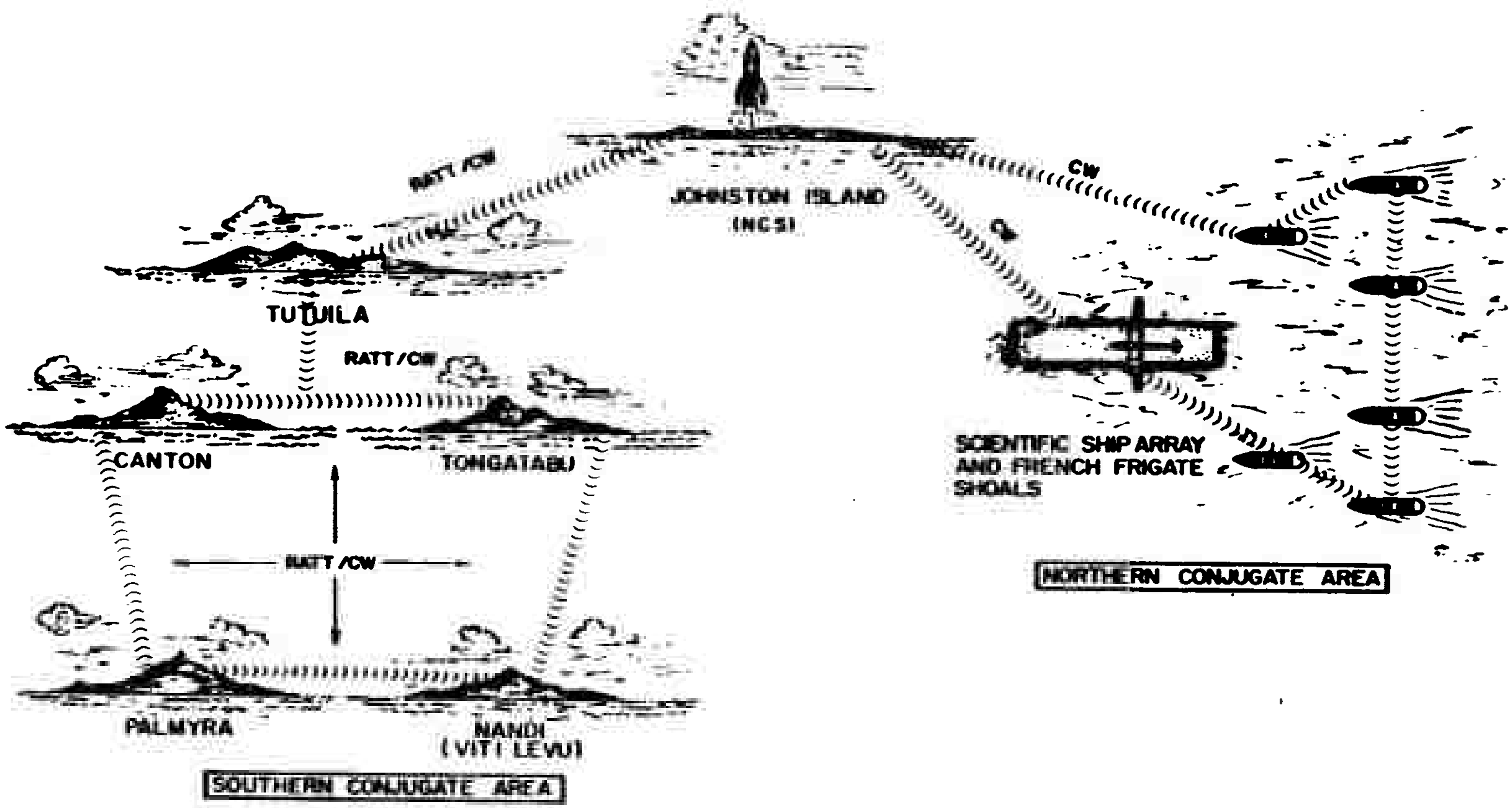


Figure 3.13 Communications system, Phase II.

Chapter 4

LOGISTICS AND TECHNICAL SUPPORT

4.1 LOGISTICS

4.1.1 Supply and Equipment. With the receipt of the Fish Bowl program on 26 December 1961, action was immediately taken to provide all designated project agencies with the overseas testing standing operating procedures (SOP's) and an accompanying request for submission of the initial experiment and requirements (E&R) plan by 15 January 1962.

The E&R plans submitted by the project agencies were carefully screened. All requests for supplies and equipment to be furnished these agencies were consolidated into a Logistics Requirements Manual. Considerable effort went into the preparation of this manual, and the short time allowed to consolidate project agency demands forced Support Division personnel to work numerous overtime hours. In spite of the magnitude of data received and the short span of time in which to compile it, this booklet was completed and forwarded to JTF-8, the Atomic Energy Commission (AEC), and Holmes and Narver, Inc. (H&N), 13 March 1962. It was arranged into four categories: (1) office furniture and equipment: desks, chairs, tables, blackboards, wastebaskets, adding machines, square-root calculators, typewriters, typing tables, file cabinets, storage cabinets, lab stools, refrigerators, and safes; (2) vehicles: sedans, station wagons, carryalls, trucks (all sizes), buses, and bicycles; (3) special equipment: forklifts, cranes, truck-tractors, air conditioners, air compressors, bomb dollies, walky-talky radios, and flying suits; and (4) personnel at sites: anticipated arrival date and number of personnel scheduled to occupy given sites.

All project agencies were requested to ship office machines they intended to use at forward areas. Some agencies could not do this and advised the Procurement Office what was required.

The refrigerators mentioned above were required for film storage in several areas.

To provide in the manual a means of determining those items required at a given site, project agencies were indicated, the code number for the site affixed, and the date the item(s) had to be on location was annotated. All items that could not be furnished by the using agency or TU 8.1.3 were indicated in appropriate sections of the manual. Austerity was the byword. Every possible means of obtaining supplies and equipment from Sandia Base and the Nevada Test Site were taken to prevent costly purchase for short-time usage. The Procurement Officer was able to obtain 290 items of equipment in this manner.

Noting that office equipment needed to be obtained for TU 8.1.3 offices at Johnston Island and in the Honolulu area, the Procurement Officer, Support Division, placed a purchase request on the General Services Administration (GSA) at San Francisco, California. Three hundred sixty-three items were purchased at a total cost of $10,985.95. Office furniture in the quantity required was not available in the overseas test areas.

Expendable supplies were purchased as required from the Base Procurement Service Store (BPSS) at Hickam AFB or in downtown Honolulu, Hawaii, depending upon the type item and availability. The Procurement Officer was charged with all purchasing responsibility, using funds set aside for this purpose. Three enlisted supply personnel were authorized to make purchases from the BPSS at Hickam. The Base Equipment Management Office (BEMO) assigned account code NVJWT to TU 8.1.3. The codes were entered on AF Form 93 "Supply Representative Authorization." This procedure insured swift local purchase action.

By mutual agreement, those logistical support items required in the forward area were provided by the AEC. If the AEC could not secure needed items from military or governmental agencies, action was taken by the AEC to procure items through H&N, a contractor to the AEC. The completed Logistics Requirements Manual was provided the AEC at Las Vegas, Nevada, and to H&N at Los Angeles, California, simultaneously to expedite procurement. Amendments were furnished as they became known.

JTF-8 was provided a consolidated fuel requirement to support all sites for the duration of the nuclear series.

Office machines and equipment of special-purpose nature that were available in the Honolulu area from military sources were secured on loan basis by the Property Book Officer and returned upon termination of need.

In those instances where time allowed and a savings to the government could be effected, purchases of nonexpendable property were made through the facilities of the Hickam AFB Purchasing and Contracting Office. Such items were issued to the Property Book Officer for inclusion in the property book of the Weapons Effects and Tests Group, FCDASA, Property Book 008.

One thousand four hundred eighty separate items of special service equipment accumulated at Sandia Base were shipped to forward areas for recreational purposes. The Procurement Officer was able to obtain over five hundred additional items such as books, playing cards, baseball equipment, etc., from US Army Hawaii Special Services Unit at Schofield Barracks, Tripler Army General Hospital, and Hickam AFB Special Services. These items contributed immeasurably to the morale of TU 8.1.3 personnel during off-duty hours and aboard ship prior to and after scheduled test shots. Special Service items of nonexpendable nature were again recorded in Property Book 008 and hand-receipted to users.

A contract was arranged through H&N for supply of nitrogen, liquid and dry, and for dry ice. Supplies were picked up by Support Division personnel direct from the supplier to effect speedy procurement.

The Procurement Officer soon realized that the normal procurement procedures established by H&N in the Honolulu area, which took 3 to 7 days, could not supply off-shelf items of equipment needed for testing in the short time required. Through coordination with AEC and H&N representatives, a 1-day purchase system was arranged. This new procedure enabled TU 8.1.3 purchasing agents to secure approval of the H&N Purchasing Control Representative on buck slip requests up to $100 valuation, procure funds from the H&N cashier, purchase the off-shelf item(s), provide the cashier with paid invoice and balance of funds, and deliver the item(s) to the TU 8.1.3 Procurement Officer within a few hours of receipt of requirement from project agencies. This system proved to be a tremendous time-saver to all agencies and should be used during any future overseas operation.

In many instances, requirements of Johnston Island projects placed on the Procurement Officer at 0730 hours, were purchased under this system and placed into the hands of project agencies on Johnston Island by noon of the same day. Over one thousand buck slip requisitions were issued to H&N by the Procurement Officer. Of these, about 60 percent required fast-action purchase in support of impending tests.

All property records and procedures used by TU 8.1.3 were in accordance with Army Regulation 735-35. Property Book inspections were made during the operational period.

A rating of excellent was maintained in spite of the numerous transactions and expedited procedures required to support the operation. The hand receipt system of accounting for issues was maintained even though property was in widely scattered locations.

4.1.2 Support. Project agencies provided the Support Division with requests for suitable and desirable site areas for installation of test equipment as part of the E&R plans submitted. These requirements were provided to the AEC so that land lease and agreement teams could arrange the necessary site negotiations. In coordination with the Engineering and Construction (E&C) Branch, selected facilities to accommodate project agencies and TU 8.1.3 personnel were secured, modified as required, and subsequently maintained in serviceable condition.

Contracts for office machine repair, both manual and electric, were arranged with Hickam AFB if the machines were of military origin, and through H&N in those instances where short-term machine rental arrangements had been made. Buck slip requests on H&N showing items requiring repair, serial number, brand name, and fund citation were prepared by the Procurement Officer. Items were delivered to the Office Services Branch of H&N and a receipt obtained. When repair(s) had been accomplished, the Support Division Procurement Officer was notified, and arrangements made to pick up the repaired item and deliver it to the user. Thermofax and Xerox machines were serviced by contract, and supplies for these machines were purchased from the contractor.

Modification to special test equipment was arranged through Naval Public Works Center (NPWC) at Pearl Harbor. Fabrication of special test items was accomplished by NPWC from design drawings submitted by project agencies after their arrival in the test area.

Storage facilities were made available to project agencies. The areas provided were large enough to allow working space for assembly of test equipment as well as storage space. Frequently, Support Division personnel assisted in assembly operations under project direction, since several Support Division personnel were skilled forklift operators.

Locker space for clothing and personal effects of all personnel was provided at TE 8.1.3.2 (Hickam) on a short-term storage basis. A double-locking system was used with keys maintained in the Support Division office.

Sign painting, road oiling, minor construction, telephone, and TWX services were provided as required in the Hickam area.

Billeting of all TU 8.1.3 personnel, civilian and military, was a responsibility of Support Division. Facilities were secured and billets assigned/terminated by representatives of Support Division. Prior to arrival of TU 8.1.3 personnel at Johnston and Christmas Islands, names of project agency personnel and their anticipated on-site arrivals were requested from subordinate agencies and provided to island commanders for planning purposes. Billeting in the Honolulu area was provided military personnel only; all civilians resided off base. Billeting was arranged through H&N for those areas in which H&N camps were established. When H&N facilities did not exist, billeting arrangements on the local economy were made by project personnel.

The Procurement Officer arranged through the Barbers Point Naval Supply Quarters Furniture Section for dressers, beds, chairs, and lamps to furnish TU 8.1.3 enlisted quarters at Hickam AFB.

Automatic clothes washing machines and automatic dryers were secured on a rental basis and installed in TU 8.1.3 enlisted quarters at Hickam. Approval for installation was achieved through the Base Exchange Services Officer.

Television sets for recreational rooms of TU 8.1.3 enlisted barracks at Hickam were arranged for on a rental basis.

Special purpose equipment and special purpose vehicles were obtained at Hickam through NPWC or Base Motor Pool as required.

4.1.3 Transportation. In early January 1962, when the JTF-8 liaison offices (LNO's) were being manned at Travis AFB and Oakland Naval Supply Center in California and at Hickam AFB in Hawaii, the Director of the Support Division foresaw a pressing need to establish TU 8.1.3 LNO's at the same locations to insure the rapid and orderly movement of TU 8.1.3 passengers and cargo to forward areas. A requirement was placed on FCDASA to provide three experienced transportation officers on TDY to set up these offices under supervision of the Support Division Director. It was necessary for task unit personnel to work in close coordination and cooperation with JTF-8 LNO personnel. The large number of passengers and the vast quantities of test equipment moved in so short a time attests to the close working relationship between the liaison offices.

The E&R plans submitted by project agencies indicated quantity and type of transportation required. Transportation requests fell into five separate categories: (1) passenger (air), (2) cargo (air), (3) passenger (surface), (4) cargo (surface), and (5) passenger and cargo (vehicle).

Air Transportation. The TU 8.1.3 LNO at Travis AFB was established in January 1962, to insure that TU 8.1.3 passengers and cargo moved through the Aerial Port of Embarkation (APOE) in a smooth orderly flow and to furnish any assistance and advice needed by shippers. It was anticipated that the two personnel assigned would be concerned only with TU 8.1.3 cargo and passengers, but it soon became apparent that around-the-clock operation would be required and that more than two representatives would be required. The TU 8.1.3 representatives, therefore, combined forces with the JTF-8 LNO to provide a working group of three officers and six enlisted men for the overall JTF-8 aerial port mission. This arrangement was in effect for the remainder of the operation.

Project agencies requested passenger movement from the Travis LNO, through Support Division, furnishing names and anticipated dates their personnel would desire to depart from Travis. Spaces were secured from the Air Force LNO; the projects were then advised of flight number, date, and time of departure. A question arose concerning the requirement for government civilian employees and contractor civilian employees to utilize military air transportation beyond the continental limits. The basic problem involved whether civilians in these categories forfeited their insurance rights while traveling aboard a military aircraft and whether they could in fact be required to perform such travel. The cost savings resulting from such a requirement are considerable. Research proved that both categories of personnel could be required, by regulation and contractual stipulation, to perform such travel on regularly scheduled MATS flights, but not on flights considered tactical in nature. Steps were taken by JTF-8 and DASA to enforce this requirement.

Project agencies requested cargo space direct from the Travis JTF-8 LNO and furnished information on the weight, cubage, type of cargo, estimated time of arrival at port, etc. LNO personnel coordinated the estimated cargo arrival time with the Air Force LNO and MATS personnel to insure that airlift would be available for timely shipment. All JTF-8 cargo was given Priority 1, which did not permit easy identification of those items needed ahead of other cargo. Considerable time was spent by LNO personnel in hand-carrying critical items through shipping procedures.

The MATS system was used in handling all shipments. Every effort was made to prevent deviations from the established procedures and policies. In return, MATS personnel made a determined effort to assist in every way possible.

During the operational period, the Travis LNO arranged for 1,512 passenger spaces and 1,578,641 pounds of cargo for TU 8.1.3.

The movement of cargo through the Travis APOE was effected smoothly and, with few exceptions, expeditiously. Most of the shipments were correctly prepared and documented and required a minimum of effort on the part of LNO personnel. A few delays were encountered when the shipper had to be contacted for additional information and/or instructions. Excellent cooperation was received from shippers, and only a telephone call was required to insure correct procedures on future shipments.

Project equipment and personnel that could not meet delivery schedules via MATS due to short lead time were moved from origin to destination via special air mission aircraft, i.e., Lowry AFB to Johnston Island. When not fully loaded, these aircraft were routed through Travis AFB and topped off with cargo prior to CONUS departure.

From the beginning, it was planned that Hickam AFB would be a breakpoint where all MATS cargo (not special air mission) would be unloaded and rerouted to destination. Confusion arising from the use of island designators (numbers representing specific islands) early in the program caused some misrouting with subsequent delay in delivery. Also, the MATS Air Freight Section at Hickam was not geared to handle the enormous amount of cargo that was off-loaded, reprocessed, and manifested, then on-loaded again. Often, the reprocessed cargo was assigned a different air movement designator (AMD) number when departing Hickam, thus precluding rapid and accurate tracing. Later in the program, the JTF-8 LNO at Travis was allowed to schedule complete aircraft loads, when available, from Travis to destination, i.e., Travis to Johnston or Christmas Islands. This reduced the workload at Hickam with subsequent reduction in backlog.

The movement of passengers and cargo from Hickam AFB to destination was accomplished by use of MATS channel aircraft when MATS had regular flights (Hickam to Wake, Guam, Midway, etc.) and MATS special mission aircraft where no regular flights existed (Southern Conjugate Area, Nandi, Christmas, etc.). Orderly schedules were difficult to maintain in the Southern Conjugate Area because of the size of loads, size of individual pieces, lack of range of aircraft when heavily loaded, lack of maintenance and gassing facilities, etc. In some cases, the aircraft landed first at the last scheduled stop, or other itinerary changes were made after departure from Hickam.

Rockets, rocket motors, and other dangerous material are easily shipped in the MATS system; however, they do not reach destination as quickly as other cargo. MATS has a large portion of its airlift capability in contracts with commercial carriers that are more restricted than MATS in what they can carry. Also, special storage areas are required, and dangerous cargo must be loaded into the aircraft so that it can be jettisoned in flight. This type of item was shipped to the Travis APOE by numerous shippers who were apparently not well briefed on shipping procedures, documentation and notification requirements. It would have been advantageous to have one control point (or office) for these items to insure orderly movement from the time of procurement to destination.

Surface Transportation. When the LNO was opened at Travis AFB, one officer and one enlisted man from TU 8.1.3 reported to the Oakland Naval Supply Center (NSC) at Oakland, California, to coordinate surface movement to the forward areas. These two personnel set up an operation similar to that of the Travis LNO. They worked direct with the JTF-8 LNO at Oakland, which resulted in better coverage for the movement of all JTF-8 cargo. Shipments were made on Military Sea Transport Service (MSTS) and commercial ships from the Oakland NSC and Concord Naval Ammunition Depot (NAD) (explosives and other dangerous material). Some of the duties performed were:

(1) Maintained contact with all shippers to ascertain what immediate and future shipments they would have coming into Oakland and Concord.

(2) Maintained close liaison with the freight terminal offices at Oakland and Concord to assist them in preplanning the movement of cargo.

(3) Maintained liaison with the JTF-8 LNO at Pearl Harbor, informing him of all JTF-8 cargo shipped.

(4) Maintained liaison with the JTF-8 LNO Travis to coordinate on the diversion of cargo from Oakland and Concord to Travis if it became apparent that such cargo would not meet its date material required (DMR) if shipped by surface. Also performed coordination for diversion of cargo from Travis to Oakland when conditions indicated that this was acceptable.

(5) Maintained a continuous check on outgoing cargo and backlogged cargo to insure that all cargo was being shipped in an expeditious manner and that no cargo was being mislaid.

(6) Insured that all poorly crated JTF-8 cargo was recrated and properly marked prior to reshipment from the terminal.

(7) Maintained a record of all cargo shipped. Such records were broken down by task unit or task group. This record was also broken down by vessel in which cargo was shipped. Records of JTF-8 costs were also kept and forwarded to Headquarters, JTF-8.

During the period of this operation, JTF-8 agencies shipped 20,974 measured tons through Oakland and Concord. Of this total, TU 8.1.3 shipped 3,555 measured tons at a cost of $76,725.00. In a breakdown by short tons, JTF-8 shipped 6,220, of which 748 were TU 8.1.3 cargo.

Surface shipments from the Honolulu area were initially made by means of LSD and LST ships. The cargo required for the establishment of the southern conjugate stations was shipped by LSD and subsequently supported by air cargo shipments as previously described. Surface shipments to Johnston Island were by LST and tug-towed barges. A regular schedule was maintained from Honolulu to Johnston with two trips a month; however, schedules were varied according to existing requirements. Schedules were made and load planning accomplished while the cargo was enroute from Oakland to Pearl Harbor. Following the completion of the operation, an MSTS LSD made a trip to the Southern Conjugate Area to pick up all returning cargo for rollup.

Vehicle Transportation. Personnel requiring vehicles in forward areas made their requirements known to include earliest date vehicle would be required, location, accessories needed, and anticipated release date. Operational control, dispatching, and servicing was a Support Division responsibility.

Dispatch and other motor pool functions were accomplished in the normally prescribed manner except that long-term dispatches of vehicles were made whenever justified. Motor maintenance was secured through H&N. Personnel assigned vehicles were charged with first echelon maintenance responsibilities, and periodic inspections were conducted by Support Division to insure proper vehicle servicing.

Fifty-five rental vehicles (4-door sedans and station wagons) and five military trucks on temporary loan from US Army and US Navy organizations were pooled in the Hickam area. Thirty-one military trucks and 69 bicycles were used at Johnston Island. Vehicles were also provided projects at all other test sites as required.

Hickam bus service (daily except Sundays) from the TU 8.1.3 enlisted barracks to the work area was arranged through the Base Motor Pool. Buses were made available for recreational purposes. On workdays, the bus drivers were provided by the Support Division.

4.1.4 Rollup. Preparations for rollup began with submission of E&R plans by project agencies. Mode of transportation for return of scientific test equipment from the test area was indicated by projects. Justification for air shipment was required.

Standing Operating Procedure 90-1, Rollup Activities, was published and distributed by the Overseas Test Organization, WET, FCDASA, 29 June 1962. This SOP provided project agencies with pertinent information as to the method of preparing test equipment for rollup. Data Sheets were distributed to all agencies and each project was directed to appoint a rollup representative.

When data sheets were received and compiled by the Support Division, arrangements for packing, when needed, were made through H&N. Arrangements were also made for air and surface shipments from sites as indicated on these data sheets.

For the northern conjugate islands, the greatest percentage of material was moved to CONUS or the Honolulu storage area by surface transportation booked through the Naval Supply Center, Pearl Harbor. Special airlift was provided when fully justified. Approximately 50 tons of cargo was moved by special airlift arranged through JTF-8 or MATS from the various northern islands.

Rollup from the southern conjugate islands was accomplished by surface and by air. A converted LSD departed Johnston Island about the middle of November 1962, for the various islands in the Southern Conjugate Area. This ship, with a TU 8.1.3 officer and enlisted man temporarily attached, was scheduled to stop at designated islands in accordance with a JTF-8 schedule based on the measurement tons of material to be loaded. This ship arrived at the Naval Supply Center, Pearl Harbor during the second week of December 1962.

Material designated for CONUS points was transshipped on available transportation to west coast ports of entry; material to be stored in the Honolulu area was delivered to the H&N warehouses in the Damon Tract area at Honolulu.

Project rollup representatives in the Southern Conjugate Area were not released from site areas until all cargo was properly packed, marked, and readied for shipment. Project rollup representatives in the Northern Conjugate Area were released when the material and equipment was turned over to the proper representative of the island site for shipment.

Certain sites in the Southern Conjugate Area had to be maintained beyond the time of the ship departure from the islands. Material and equipment on Canton, Fiji, and Rarotonga were flown out by C-124's scheduled through the JTF-8 LNO at Hickam AFB. Contacts were also established with MATS representatives, and about 15 tons of cargo moved out on a space-available basis from the southern islands.

TU 8.1.3 Support Division representatives remained at the sites and cleared all projects in the Southern Conjugate Area and some in the Northern Conjugate Area.

One warehouse (Building T-303) in the vicinity of the MATS Terminal at Johnston Island was obtained for storage of rollup equipment. About 650 items of equipment were stored at this site. Steps were taken to insure proper ventilation, military police instructed to provide security checks of the area, and signs were erected to clearly designate the warehouse as a DASA storage area. All office machines and sensitive items were shipped to Honolulu for storage, as described below.

Data obtained from all projects indicated a requirement for a covered storage area of at least 15,000 square feet. This was obtained in the Damon Tract area of Honolulu under the supervision of H&N. Most of the FCDASA materials and equipment are located in this area. The east end of Warehouse 23 was assigned to FCDASA for materials requiring covered storage. A fence was later constructed for security purposes. As equipment began to arrive aboard aircraft and ships, action was taken to tag, transport, inspect, pack, preserve, and inventory items prior to storage. Warehouses 12 and 27, with open sides, were obtained for the storage of the 20 rocket launchers following preservation and painting. A section of Warehouse 25 was obtained for the storage of the two TU 8.1.3 boats.

To provide periodic inspections of stored items and maintain liaison with other governmental agencies and services in the Pacific area, WET organized an LNO in Honolulu. This is manned by Support Division personnel. The office maintains surveillance over the assigned buildings at Hickam, materials and equipment stored at Damon Tract, and materials stored at Johnston Island. The LNO is located in the AEC building, Honolulu. Following the establishment of this office on 6 January 1963, all materials in Damon Tract were inventoried item by item and preserved as necessary for long-term storage. Additional warehouses were obtained as needed. Equipment items received on loan from other governmental activities were returned and the books cleared.

4.1.5 Recommendations. In future operations: (1) Send one officer and one enlisted man to each port (Oakland, Travis, and Hickam). Retain one officer and one enlisted man at the headquarters (whether at Sandia Base or Hickam). All of these should have prior experience in the types of shipments to be made. Send them to the posts before shipments start, so they can get to know the people they will be dealing with and set up a system for handling personnel, cargo, and tracing procedures.

(2) At the initial project officers meeting, hold a special briefing of TU 8.1.3 liaison personnel and project shipping representatives to insure that shipping requirements (packaging, marking, documentation, tracing, etc.) are clearly understood by all.

(3) Air movement designator numbers assigned at origin should be used until cargo has reached final destination. Tracer action is nearly impossible when new numbers are assigned during movement as occurred in the early months of Dominic.

(4) Limit the size of instrument (and other) trailers to 30 feet long, 8 feet wide, and 10 feet high. Also, do not have equipment mounted below frame level; otherwise, loading problems will occur because of the aircraft ramp angle. Trailers with these dimensions would fit in several types of cargo aircraft. (During Operation Dominic, the C-133 was the only aircraft large enough to transport some of the trailers, and these aircraft were grounded during part of the operation.)

(5) Utilize at least two shipment priorities. This would allow for easy identification of those items most important to the mission.

(6) When possible, load aircraft from Travis to destination, eliminating any break point beyond Travis.

(7) All cargo should be signed for by recipient. This allows for tracer action in event cargo is erroneously delivered to wrong receiver.

(8) Personnel sign-in and quarters assignment should be made immediately upon arrival in site area.

(9) Quarters should be allocated to programs, based on their size. Project personnel of the same agency should be quartered together. Project officers should determine the type of billets to be assigned personnel of their projects.

(10) Quarters assigned permanent task unit officer personnel should not be used to accommodate civilian contract employees. When vacant, these quarters can be used for billeting DOD civilian and visiting military officers.

(11) Transient quarters should be available to all visitors at the site.

(12) Close liaison should be maintained between the Honolulu (forward) joint task force transportation representatives and Honolulu (forward) task unit transportation rep-

resentatives in the establishment of facilities for the return of rollup material after operations. Furthermore, changes in schedules and policy concerning use of surface and air for transportation of rollup should be coordinated in advance with task unit personnel by the joint task force prior to dissemination of the change.

(13) One week following removal of rollup from all island sites, a representative of the Support Division should visit each site to check on the condition of the FCDASA cargo in the hands of shipping activities. Further, this representative should view the condition of the sites with the island command or civilian representative to determine that the site location has been restored to an acceptable condition. These checks should be accomplished for each site location unless a representative of Support Division is present at the off-loading of the material and equipment.

(14) Authority should be delegated to the joint task force liaison officer in the forward area to approve and arrange for fully justified special airlift movements of special items back to CONUS as required by the task unit representative. This would preclude the necessity of contacting the Washington headquarters of the joint task force and the continental headquarters of the task unit and improve the efficiency of movement of critical required equipment when lead time has been drastically reduced due to change of shot schedule, etc.

(15) Funds available at the POE and APOE for retrograde movements. Returning cargo with no fund citation on shipping documents could then be moved with no delay.

4.2 FISCAL

The initial budget provided for Fish Bowl by HQDASA, 4 January 1962, was broken down as listed in Table 4.1.

On 1 June 1962, after adjustments and additions to the program and just before the first shot, the budget was as given in Table 4.2.

After the failure of the first two events in June 1962, it appeared that the entire operation would be extended 6 weeks, and the budget was reaccomplished on 1 July 1962 (Table 4.3).

After additional shot failures in July 1962 and a cost identification meeting on construction items with JTF-8 and the Nevada Operations Office (NVOO) of the AEC, the budget was again reaccomplished. Table 4.4 presents a breakdown. It appears that final costs will be consistent with the listed amounts.

One of the most persistent and complex problems in funding this program was determining responsibility for funding off-island camp support and construction costs. After numerous meetings with JTF-8 and NVOO representatives, the following splits in costs were agreed upon: (1) FCDASA would pay for all scientific costs and direct support and construction related thereto for the DOD scientific program, regardless of location; (2) AEC would pay for all AEC scientific costs and direct support and construction related thereto, regardless of location. AEC would also pay for all camp support and construction costs at Christmas Island, Johnston Island, and in the Hawaiian Islands; and (3) JTF-8 would pay for all camp support and construction costs for all off-islands other than Christmas, Johnston, and Hawaii.

AEC's responsibility in the camp support and construction area included cost of refurbishing all existing facilities of an administrative, warehousing, or laboratory nature and the provision of such new facilities as required. The only exception to this situation was in Projects 9.4a, 9.4c, and 9.4d; such costs were charged to the projects themselves, because it was determined that they were of both a scientific and support nature.

4.3 ENGINEERING AND CONSTRUCTION

In accomplishing the tasks of construction and related items, the following organizations furnished support:

(1) United States Army Pacific Engineer, Ft Shafter, Hawaii. The offices of primary assistance were the Supply and Maintenance Division, and Intelligence and Mapping Division.

(2) United States Navy Pacific (Midway). Commanding Officer, Naval Station, Midway, Navy 3080, San Francisco, California.

(3) Pacific Missile Range (Kwajalein). Commanding Officer, Pacific Missile Range, ATTN: Code 130, Point Mugu, California.

(4) United States Army (Okinawa). Commanding General, US Army, Ryukyu Islands, APO 49, San Francisco, California.

(5) Federal Aviation Agency (Wake). Regional Administrator, Region 6, FAA, ATTN: Engineering Section, Hawaiian Life Building, Post Office Box 4009, Honolulu, Hawaii.

(6) Commanding Officer, Military Sea Transportation Service and Bureau of Ships, Washington, D. C.

The initial arrangements for the support and written agreements with the various supporting military commands were accomplished by the Support Division.

The organization of the Engineering and Construction (E&C) Branch for this operation is shown in Figure 4.1. The mission included the review and formulation of all construction requirements submitted by the project agencies. The construction included the project layout, general (scientific) construction field support for the scientific construction, and office and laboratory requirements. The requirements were transformed into criteria letters and forwarded to the AEC Architect-Engineer and Contractor Manager (A-E), H&N, for implementation as outlined in Appendix J, which is a summary of the experience of a construction officer at Hickam AFB whose areas of interest included all sites.

The branch also had the responsibility for the review of modification requirements for ships receiving the scientific instrumentation. After review, the requirements were forwarded by criteria letters to the Bureau of Ships (BUSHIPS) and to the Commanding Officer, Military Sea Transportation Service (COMSTS) for implementation by their respective shipyards. Two criteria letters were submitted, one to BUSHIPS for their five ships and one to COMSTS for its one ship. The shipyards completed the design and modification based on this criteria letter. Approval of the design drawings was received from the project and E&C Branch representatives prior to modification. Appendix K contains an experience report on ship modification.

Staff engineering and field supervision to insure proper and timely construction was performed by the personnel of the E&C Branch. The mission of the E&C Branch was limited to scientific construction and did not include construction required for housing, or procurement of generators for power and heavy equipment for hauling and transportation.

The total DOD construction cost for the Fish Bowl Series was $3,829,213.

The operations of the E&C Branch were divided between Johnston Island and Hickam AFB. The Johnston Branch was responsible for all construction at that site, and the Hickam Branch supervised construction at all other locations.

The construction at Johnston represented the major effort and included such items as rocket pads, screen rooms, photo stations, laboratory, and modification of buildings. Figure 4.2 is an aerial view of Johnston Island taken during the construction phase of Fish Bowl.

Appendix S is a plot plan of the Johnston Island station locations.

A summary of the experience of a construction officer on Johnston Island is outlined in Appendix L. The comments pertain to other sites where indicated.

The construction at the other sites, exclusive of Hickam AFB, included such items as concrete pads for instrument stations, small-equipment shelters, road construction, provisions for electric power, housing and messing camps, and antenna erection. These were supervised by the Hickam office of the E&C Branch.

Figure 4.3 is an aerial view of the project site on Olotele Hill, American Samoa. Figure 4.4 is an aerial view of a project site at Midway showing isolated scientific sites along the beach. Figure 4.5 is a view of a project site at Tongatabu showing a riometer antenna field in the foreground and a rhombic antenna in the background.

Construction at Hickam consisted of building modification for laboratory, office, and storage use.

A compilation of scientific stations (instrument chart) was accomplished by the Hickam office for all sites. After this compilation was coordinated, the AEC and A-E published the finished instrument chart at the completion of the test series.

The construction requirements were submitted by the project agencies as part of their E&R plans in compliance with the applicable SOP's published by WET, FCDASA. Annex E, Construction Requirements, of the E&R plan was reviewed as received at FCDASA. Appropriate comments were written on this review and were returned to the WET Program Manager for action. This action included such things as obtaining additional construction data or clarification of what was presented so that a complete construction criteria letter could be sent to the AEC and A-E. The criteria letters were then prepared, based on the Annex E, and forwarded to the AEC.

The criteria were used in preparation of the construction drawings by the A-E. The drawings were then submitted to the E&C Branch and projects for approval prior to construction. Figure 4.6 shows the routing of the design (construction) drawings, which expedited the final approval. H&N airmailed one set of the final design drawing prints to FCDASA and, concurrently, one set to the project agency. The project agency submitted (by telephone followed by electrical message) its corrections and comments, which FC DASA coordinated with its own comments. All corrections were then indicated on the FCDASA set of prints. FCDASA filed this set and telephoned approval or corrections to H&N; the original tracings were then corrected as necessary. At the same time, FCDASA sent a message to H&N, with an information copy to the AEC, in which it was stated that the drawings were approved or approved subject to correction. This teletype message number and date were entered in the approval block and constituted the indorsement of the approving officer. The drawings were then signed by H&N and the AEC, and at this stage were passed on to the jobsite for construction and to all others on the normal distribution list for information. All transmittals of drawings were by airmail, or if urgency required, by courier.

Although effective, the actual construction was not done in an efficient manner because of the excessive amount of contractor premium time expended as a result of the compressed time schedule. During Fish Bowl, no scheduled event was delayed because of construction activities.

An experience report of the E&C effort at Johnston Island is given in Appendix L. Although this construction effort was concentrated at Johnston Island, it extended as far south as Tutuila and north to Tern Island in French Frigate Shoals.

The construction effort by H&N is indicated in Figure 4.7. The construction effort by the E&C Branch, by projects making their own arrangements, and by military installations at Wake, Midway, Kwajalein, and Okinawa is indicated in Figure 4.8. This construction effort extended as far south as Tongatabu, west to Okinawa, north to Fairbanks, Alaska, and east to Palo Alto, California.

The Fish Bowl experience indicates that: (1) Annex E to the E&R plan should be submitted as reproducibles. This would give FCDASA (WET) a reproducible document to make the required multiple distribution without retyping and also provide a document upon which to make changes as they materialize. These annexes should also be sent immediately to the field to reflect changes that will subsequently arrive as construction drawings, thereby minimizing construction changes.

(2) Individually prefabricated units (trailer mounted) containing water points, carpenter shops, and generators would be cheaper and more effective than similar items that were used and constructed from individual components. The present Fish Bowl units will, in most cases, be abandoned or dismantled. The same unit, if trailer mounted, could be used for future operations, thereby costing less over a period of time or even costing less on a one-time basis.

The following recommendations are based on the experience gained during Fish Bowl:

(1) The project office and laboratory facilities at Johnston Island should be reconstructed. This reconstruction should include one facility to house all the laboratories, offices, operations, and control bunkers previously scattered around the island. The facilities requiring bunker-type (manned) stations should be below surface (basement) of a 2-story building that would house the other facilities mentioned above.

(2) Facilities for storage should be constructed for such items as rocket launchers and similar bulky items, as well as smaller items capable of long-term storage.

(3) The planning and engineering for future tests of this type should begin at least 18 months in advance to preclude the problems inherent in a compressed schedule.

(4) Four-wheel trailers should be prefabricated for use at sites other than the primary site, i.e., Johnston Island, for water distillation, powerplants, maintenance, laundry, scientific instruments, etc.

(5) Ship modification should be accomplished by one shipyard, not several, as was the case in this operation.

(6) Trailers and plywood shelters or compartments should be used for laboratory and instrument shelters on ships versus modification of the ships' steel compartments. The former are more suitable for use, and easier and cheaper to construct than modification of the steel compartment.

(7) Shipyards should assign one individual to supervise the ship modification program.

(8) For instrumentation, power motor generators should be used operating from ship's dc power instead of separate diesel generators.

(9) Local resources should be used for construction in remote areas.

(10) Whenever feasible, military construction units should be used in remote areas where local capability does not exist.

(11) A Navy officer, LCDR or above, should be assigned on ship modification projects. This officer should have shipyard, waterfront, or deck experience.

(12) On all major construction items, a user representative should be at the jobsite when construction begins.

(13) A pool of portable power units ranging from 10 to 100 kw should be provided at the primary site. Recommended numbers and types (primary site only, other sites 100-percent backup for power) are as follows: six 10-kw, four 15-kw, ten 30-kw, six 60-kw, and two 100-kw units.

4.4 REPORTS

Subsequent to previous test operations, there was a steady increase in the time delay between collection of data in the field and publication of the data in a report. To accelerate the flow of DOD weapons effects information from the 1962 tests, CHDASA published a letter dated 20 April 1962, subject: Weapons Test Report Procedures. The letter modified the procedures set forth in the manual, Preparation of Weapon-Test Reports, March 1958.

The modifications pertain to report content, submission dates, review procedures, printing, and report nomenclature. The Interim Test Report (ITR) became the Project Officers Interim Report (POIR), and the Weapons Test Report (WT) became the Project Officers Report (POR). The POIR and POR are the experimenter's reports to Chief, DASA, rather than DASA reports. A listing of POR's is contained in Appendix A.

The POIR is primarily a description of the experiment, a listing of the data records obtained, and a presentation of such preliminary results and conclusions as may be immediately derived. Draft copies of the POIR are to be forwarded to CHDASA, within 30 days of the last event to which the POIR applies.

The POR is the final report; its primary purpose is to present the data in reduced form with all corrections, calibrations, etc., explained and applied. Copies of the draft POR are to be forwarded to CHDASA, within 6 months after the last event.

All necessary editorial functions and technical review are retained by FCDASA. The POIR is published for limited distribution by Field Command. The POR is published by the Division of Technical Information Extension, USAEC, at Oak Ridge National Laboratory.

Security review and classification of the POIR is performed by Field Command. The POR is reviewed by Headquarters, DASA, for security classification and distribution. HQDASA does not review the POR for technical content.

The high-altitude events of the Fish Bowl Series involved projects scattered throughout the Pacific. To serve the maximum number of project authors, Reports Branch offices were established both at Johnston Island and Hickam AFB. Each office was manned by a clerk and two or more draftsmen. Both offices provided drafting support and had a limited reference library of reports from previous tests. The editor and analysis officer commuted between the two offices, as necessary.

Task Unit 8.1.3 provided two liaison officers to TG 8.3 during the planning, execution, and reporting phases of Shot Sword Fish, a weapons test conducted by the Navy TG 8.3. In addition, during the reporting phase, a reports office was established at the Naval Repair Facility, San Diego. The staff consisted of an editor, analysis officer (one of the liaison officers), two draftsmen, and a clerk. This office was maintained until all Sword Fish POIR's that could be completed in a reasonable amount of time (5 out of 8) were approved and processed.

Because Fish Bowl was divided into two phases, some projects submitted two POIR's. The series included 24 Phase I, 22 Phase II, and 10 combined Phases I and II POIR's.

4.5 DOCUMENTARY PHOTOGRAPHY

Documentary still and motion-picture photography was performed under Project 9.5a by the 1352d Photographic Group, USAF. Although this organization was planned and deployed to support TU 8.1.3 in the field, the organization was assigned to the Air Task

Group (TG 8.4). In spite of some difficulties resulting from this arrangement, the requirements of the task unit were satisfied and a notable amount of coverage was accomplished. The documentary photo element supporting TU 8.1.3 exposed approximately 75,000 feet of 35-mm Eastman negative color film and over 4,000 still black-and-white negatives. The small film-processing facility located on Johnston Island provided laboratory support to TU 8.1.3 and produced nearly 25,000 photographic prints. Primarily, this coverage was devoted to documenting construction, project activities, missile launches, nuclear detonations, and PIO activities.

During the operation, sequence photographs taken by this project provided valuable evidence in determining the causes of the destruction of one of the Thor missiles in flight.

After the first successful detonation, a quick-look motion-picture film report with sound track was produced and delivered to Washington within 68 hours.

Live-action footage to be incorporated into a 40-minute weapons effects film report covering various aspects of the DOD scientific experiments was also taken.

All still photographs taken during the operation have been assembled in albums which constitute a major source of illustrations for POR's and for briefing materials.

The minimum laboratory facilities, deployed under the original austere guidance, were inadequate to meet the needs of the expanded test program accomplished in the field. It was frequently necessary to mail large amounts of film to CONUS for processing. This procedure could have been most inconvenient had not the overall test program suffered delays due to missile failures.

The following recommendations are based on experience during Fish Bowl:

(1) Any future documentary photographic unit required to accomplish photography for the DOD task unit should be assigned directly to, and placed under the administrative and technical control of, the task unit concerned.

(2) Sufficient laboratory facilities to meet the estimated photo support requirements should be procured, tested, and held ready for deployment. The readiness of photo facilities and the readiness of scientific projects are dissimilar. The photo labs must be deployed during early construction, far in advance of the scientific projects, and remain in operation to produce illustrations for reports, often long after some projects are no longer active in the field.

TABLE 4.1 DASA BUDGET, FISH BOWL, 4 JANUARY 1962

Project	Agency		Amount
Program 1			
1.1	Ballistic Research Laboratories		$ 190,000
1.2	US Naval Ordnance Laboratory		10,000
		Total	$ 200,000
Program 2			
2.1	US Army Nuclear Defense Laboratory		$ 175,000
2.2	US Army Nuclear Defense Laboratory		75,000
		Total	$ 250,000
Program 6			
6.1a	US Army Electronics Research and Development Activity		$ 1,350,000
6.2	Electro-Optical Systems		1,400,000
6.3a	Geophysics Corporation of America		525,900
6.3b	Electro-Optical Systems		430,000
6.3c	Air Force Cambridge Research Laboratories		748,000
6.3d	US Army Radio Propagation Agency		806,100
6.4	Air Force Cambridge Research Laboratories		1,500,000
6.5a	Air Force Cambridge Research Laboratories		1,000,000
6.6	Geophysics Corporation of America		350,000
6.7	Air Force Special Weapons Center		700,000
6.8	Air Force Cambridge Research Laboratories		500,000
6.9	Stanford Research Institute		1,000,000
6.10	Air Force Cambridge Research Laboratories		200,000
6.11	US Army Signal Research and Development Laboratory		2,100,000
6.12	Air Force Cambridge Research Laboratories		750,000
		Total	$ 13,360,000
Program 8			
8.A1	Air Force Cambridge Research Laboratories		$ 695,000
8.A2	Edgerton, Germeshausen & Grier, Incorporated		1,500,000
8.A3	Aeronautical Systems Division		800,000
8B	Air Force Special Weapons Center		500,000
		Total	$ 3,495,000
Program 9			
9.1	Air Force Cambridge Research Laboratories		$ 450,000
9.2	Bureau of Ships		1,000,000
9.3	Air Force Cambridge Research Laboratories		800,000
9.4a	Air Force Systems Command		18,305,000
9.5a	Lookout Mountain Air Force Station		550,000
9.6	Cubic Corporation		2,580,000
		Total	$ 23,685,000
		Grand Total Funded	$ 40,990,000

TABLE 4.2 DASA BUDGET, FISH BOWL, 1 JUNE 1962

Project	Agency		Amount
Program 1			
1.1	Ballistic Research Laboratories		$ 202,000
1.2	US Naval Ordnance Laboratory		10,000
		Total	$ 212,000
Program 2			
2.1	US Army Nuclear Defense Laboratory		$ 173,000
2.2	US Army Nuclear Defense Laboratory		73,000
		Total	$ 246,000
Program 4			
4.1	Aerospace Medical Center		$ 635,000
		Total	$ 635,000
Program 6			
6.1a	US Army Electronics Research and Development Activity		$ 3,209,000
6.1b	Ballistic Research Laboratories		40,000
6.2	Electro-Optical Systems		1,272,000
6.3a	Geophysics Corporation of America		535,000
6.3b	Electro-Optical Systems		430,000
6.3c	Air Force Cambridge Research Laboratories		750,000
6.3d	US Army Radio Propagation Agency		733,000
6.4	Air Force Cambridge Research Laboratories		1,197,000
6.5a	Air Force Cambridge Research Laboratories		301,000
6.5b	Armour Research Foundation		427,000
6.5c	National Bureau of Standards, Central Radio Propagation Laboratory		170,000
6.5d	US Army Radio Propagation Agency		103,000
6.5e	US Army Signal Research and Development Laboratory		175,000
6.6	Geophysics Corporation of America		350,000
6.7	Air Force Special Weapons Center		2,596,000
6.8	Air Force Cambridge Research Laboratories		498,000
6.9	Stanford Research Institute		1,211,000
6.10	Air Force Cambridge Research Laboratories		192,000
6.11	US Army Research and Development Laboratory		2,100,000
6.12	Air Force Cambridge Research Laboratories		750,000
6.13	Army Ordnance Missile Command		135,000
		Total	$ 17,174,000

TABLE 4.2 (CONTINUED)

Project	Agency	Amount
Program 7		
7.3	US Army Electronics Research and Development Activity	$ 400,000
7.5	Aeronautical Systems Division	20,000
	Total	$ 420,000
Program 8		
8A.1	Air Force Cambridge Research Laboratories	$ 675,000
8A.2	Edgerton, Germeshausen & Grier, Incorporated	1,474,000
8A.3	Aeronautical Systems Division	798,000
8B	Air Force Special Weapons Center	300,000
8C	Air Force Special Weapons Center	2,000,000
	Total	$ 5,247,000
Program 9		
9.1	Air Force Cambridge Research Laboratories	$ 432,000
9.2	Bureau of Ships	150,000
9.3	Air Force Cambridge Research Laboratories	865,000
9.4a	Air Force Systems Command	13,000,000
9.4b	Air Force Special Weapons Center	1,814,000
9.4c	Pacific Missile Range	1,800,000
9.5a	Lookout Mountain Air Force Station	204,000
9.5b	Kin-Tel Division, Cohu Electric	7,000
9.5c	Field Command, Defense Atomic Support Agency	17,000
9.5d	Postshot "A"	1,606,000
9.5e	Kaman Nuclear	51,000
9.5f	Technical support	25,000
9.5g	Miscellaneous general support	120,000
9.5h	Field support	200,000
9.5j	Administration facilities	130,000
9.6	Cubic Corporation	3,209,000
9.7	Ship rental	400,000
9.9	Uracca (Atomic Energy Commission)	1,716,000
	Total	$ 25,746,000
	Grand Total Funded	$ 49,680,000

TABLE 4.3 DASA BUDGET, FISH BOWL, 1 JULY 1962

Project	Agency		Amount
Program 1			
1.1	Ballistic Research Laboratories		$ 271,000
1.2	US Naval Ordnance Laboratory		60,000
		Total	$ 331,000
Program 2			
2.1	US Army Nuclear Defense Laboratory		$ 201,000
2.2	US Army Nuclear Defense Laboratory		91,000
		Total	$ 292,000
Program 4			
4.1	Aerospace Medical Center		$ 961,000
4.2	Naval Air Development Center		5,000
		Total	$ 966,000
Program 6			
6.1a	US Army Electronics Research and Development Activity		$ 4,370,000
6.1b	Ballistic Research Laboratories		40,000
6.2	Electro-Optical Systems		1,375,000
6.3a	Geophysics Corporation of America		634,000
6.3b	Electro-Optical Systems		493,000
6.3c	Air Force Cambridge Research Laboratories		980,000
6.3d	US Army Radio Propagation Agency		998,000
6.4	Air Force Cambridge Research Laboratories		1,200,000
6.5a	Air Force Cambridge Research Laboratories		554,000
6.5b	Armour Research Foundation		660,000
6.5c	National Bureau of Standards, Central Radio Propagation Laboratory		230,000
6.5d	US Army Radio Propagation Agency		141,000
6.5e	US Army Signal Research and Development Laboratory		236,000
6.6	Geophysics Corporation of America		533,000
6.7	Air Force Special Weapons Center		2,695,000
6.8	Air Force Cambridge Research Laboratories		754,000
6.9	Stanford Research Institute		1,563,000
6.10	Air Force Cambridge Research Laboratories		440,000
6.11	US Army Research and Development Laboratory		3,460,000
6.12	Air Force Cambridge Research Laboratories		925,000
6.13	Army Ordnance Missile Command		135,000
		Total	$ 22,436,000

TABLE 4.3 (CONTINUED)

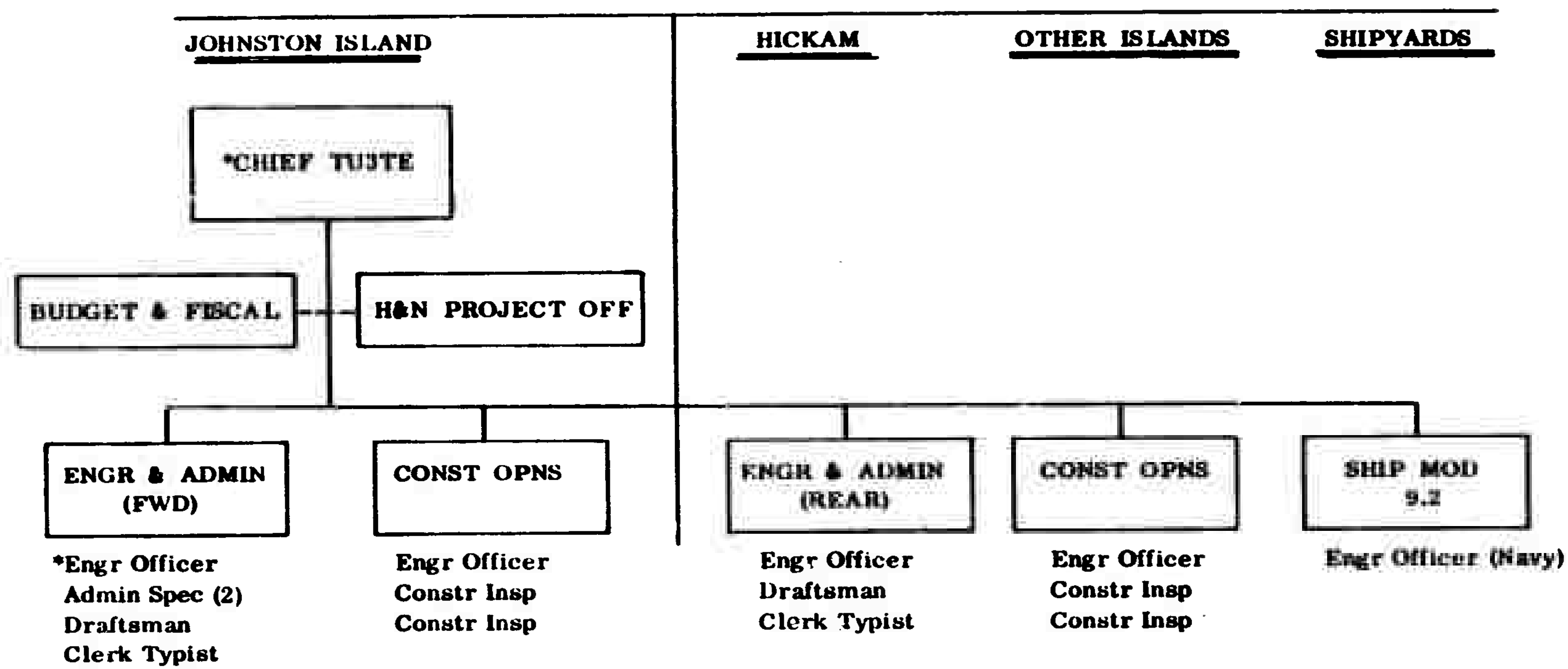
Project	Agency	Amount
Program 7		
7.2	Massachusetts Institute of Technology, Lincoln Laboratory	$ 11,000
7.3	US Army Electronics Research and Development Activity	525,000
	Aeronautical Systems Division	33,000
	Total	$ 569,000
Program 8		
8A.1	Air Force Cambridge Research Laboratories	$ 1,320,000
8A.2	Edgerton, Germeshausen & Grier, Incorporated	1,718,000
8A.3	Aeronautical Systems Division	1,280,000
8B	Air Force Special Weapons Center	397,000
8C	Air Force Special Weapons Center	2,340,000
	Total	$ 7,055,000
Program 9		
9.1	Air Force Cambridge Research Laboratories	$ 665,000
9.2	Bureau of Ships	205,000
9.3	Air Force Cambridge Research Laboratories	902,000
9.4a	Air Force Systems Command	8,640,000
9.4b	Air Force Special Weapons Center	2,244,000
9.4c	Pacific Missile Range	2,400,000
9.5a	Lookout Mountain Air Force Station	280,000
9.5b	Kin-Tel Division, Cohu Electric	15,000
9.5c	Field Command, Defense Atomic Support Agency	20,000
9.5e	Kaman Nuclear	51,000
9.5f	Technical support	75,000
9.5g	Miscellaneous general support	200,000
9.5h	Field support	200,000
9.5j	Administration facilities	130,000
9.6	Cubic Corporation	3,356,000
9.7	Ship rental	544,525
9.9	Uracca (Atomic Energy Commission)	1,716,000
	Construction funded	3,629,656
	Total	$ 25,273,181
	Grand Total Funded	$ 56,922,181

TABLE 4.4 DASA BUDGET, FISH BOWL, 1 OCTOBER 1962

Project	Agency		Amount
Program 1			
1.1	Ballistic Research Laboratories		$ 361,000
1.2	US Naval Ordnance Laboratory		60,000
		Total	$ 421,000
Program 2			
2.1	US Army Nuclear Defense Laboratory		$ 276,000
2.2	US Army Nuclear Defense Laboratory		114,000
2.3	US Army Nuclear Defense Laboratory		66,000
		Total	$ 456,000
Program 4			
4.1	Aerospace Medical Center		$ 1,461,000
4.2	Naval Air Development Center		5,000
		Total	$ 1,466,000
Program 6			
6.1a	US Army Electronics Research and Development Activity		$ 5,916,000
6.1b	Ballistic Research Laboratories		37,000
6.2	Electro-Optical Systems		2,335,000
6.3a	Geophysics Corporation of America		1,135,000
6.3b	Electro-Optical Systems		526,000
6.3c	Air Force Cambridge Research Laboratories		1,584,000
6.3d	US Army Radio Propagation Agency		1,511,000
6.4	Air Force Cambridge Research Laboratories		1,564,000
6.5a	Air Force Cambridge Research Laboratories		1,028,000
6.5b	Armour Research Foundation		1,229,000
6.5c	National Bureau of Standards, Central Radio Propagation Laboratory		338,000
6.5d	US Army Radio Propagation Agency		128,000
6.5e	US Army Signal Research and Development Laboratory		422,000
6.6	Geophysics Corporation of America		765,000
6.7	Air Force Special Weapons Center		2,773,000
6.8	Air Force Cambridge Research Laboratories		1,075,000
6.9	Stanford Research Institute		2,024,000
6.10	Air Force Cambridge Research Laboratories		817,000
6.11	US Army Research and Development Laboratory		3,763,000
6.12	Air Force Cambridge Research Laboratories		902,000
6.13	Army Ordnance Missile Command		585,000
		Total	$ 30,696,000

TABLE 4.4 (CONTINUED)

Project	Agency		Amount
Program 7			
7.1	Kaman Nuclear		$ -0-
7.2	Lincoln Laboratory, Massachusetts Institute of Technology		11,000
7.3	US Army Electronics Research and Development Activity		525,000
7.4	Aeronautical Systems Division		4,000
7.5	Aeronautical Systems Division		33,000
		Total	$ 573,000
Program 8			
8A.1	Air Force Cambridge Research Laboratories		$ 2,112,000
8A.2	Edgerton, Germeshausen & Grier, Incorporated		2,461,000
8A.3	Aeronautical Systems Division		1,398,000
8B	Air Force Special Weapons Center		687,000
8C	Air Force Cambridge Research Laboratories		2,340,000
		Total	$ 8,998,000
Program 9			
9.1	Air Force Cambridge Research Laboratories		$ 1,215,000
9.2	Bureau of Ships		311,000
9.3	Air Force Cambridge Research Laboratories		1,443,000
9.4a	Air Force Systems Command		13,735,000
9.4b	Air Force Special Weapons Center		2,885,000
9.4c	Pacific Missile Range		2,626,000
9.4d	Redstone Army Missile Center		2,337,000
9.5a	Lookout Mountain Air Force Station		245,000
9.5b	Kin-Tel Division, Cohu Electric		81,000
9.5c	Field Command, Defense Atomic Support Agency		17,000
9.5d	Postshot "A"		2,157,000
9.5e	Kaman Nuclear		51,000
9.5f	Technical support		50,000
9.5g	Miscellaneous general support		271,000
9.5h	Field support		300,000
9.5i	Administration facilities		130,000
9.6	Cubic Corporation		3,973,000
9.7	Ship rental		759,000
9.9	Uracca (Atomic Energy Commission)		1,716,000
		Total	$ 34,302,000
	Grand Total Funded		$ 76,912,000



* DUAL ASSIGNMENT

NOTE: Offices for other islands and shipyards were located at Hickam AFB.

Figure [illegible] Organization of Engineering and Construction Branch.

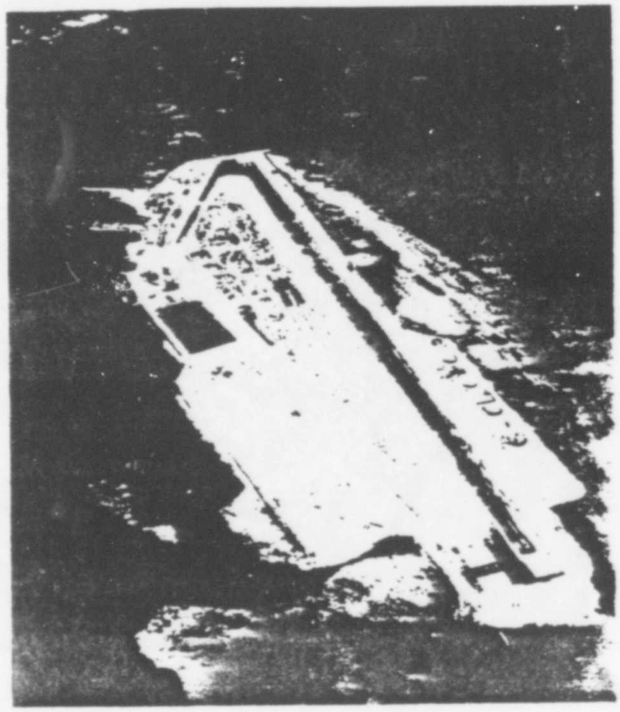


Figure 4.2 Aerial view of Johnston Island.
(DASA 26-6582-62)

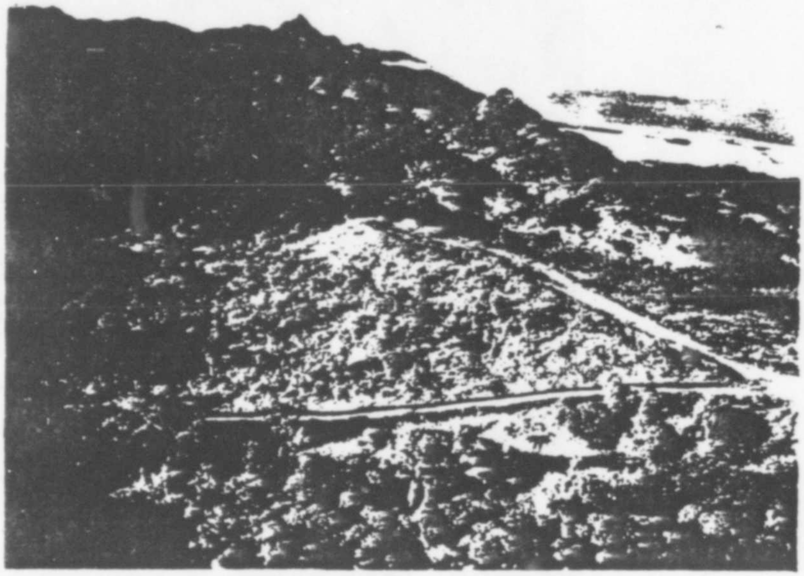


Figure 4.3 Project site, American Samoa.
(DASA 26-13512-62)

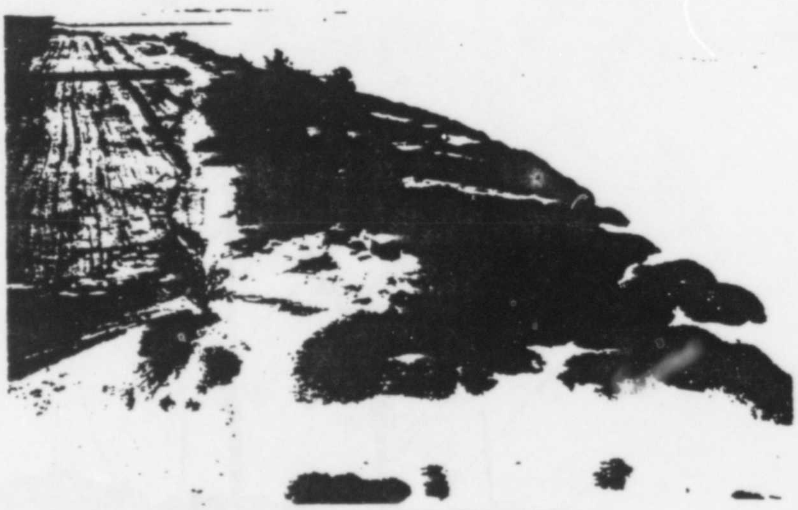


Figure 4.4 Project site, Midway.
(DASA 26-13221-62)

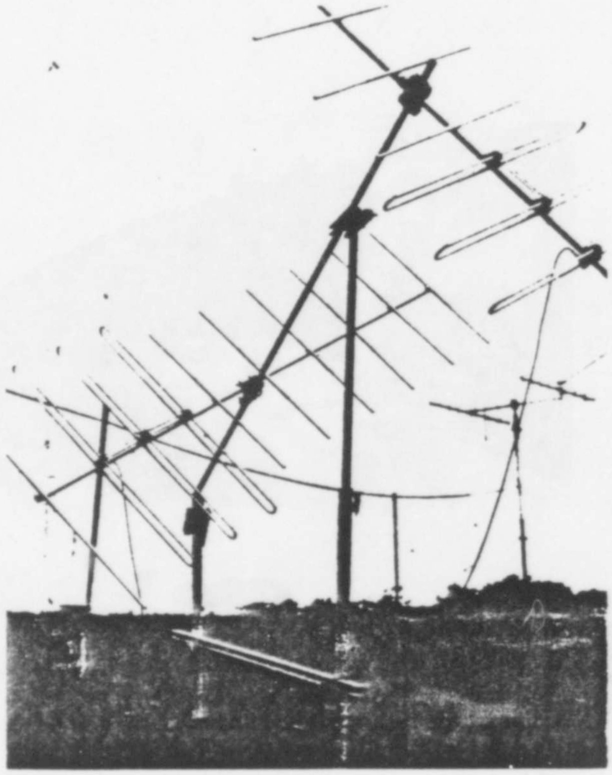


Figure 4.5 Project antenna field, Tongatabu. (DASA 26-13809-62)

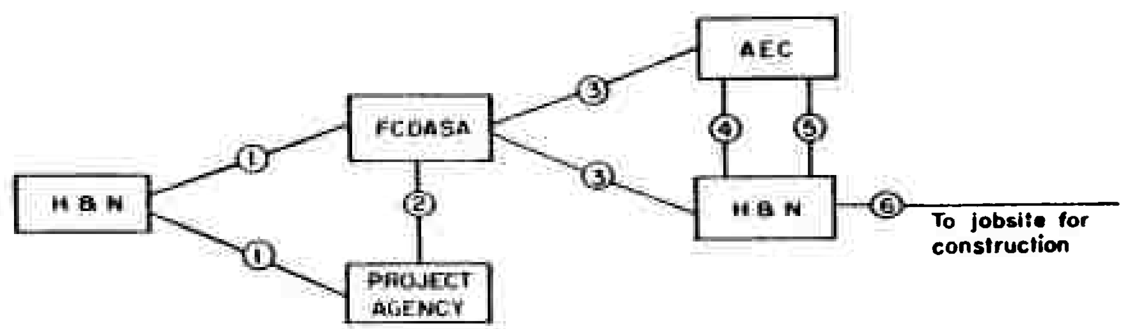


Figure 4.6 Routing of design drawings. Circled numbers indicate chronological order of transmittals.

Project	Ships S-1 through S-8	DAMP ship	M/V Acania	Aircraft	Adak	Fairbanks	Palo Alto	Oahu	Maui	Kauai	Tern Island	Midway	Wake	Johnston Island	Kwajalein	Palmyra	Christmas Island	Canton	Tutuila	Rongatabu	Rarotonga	Hickam AFB	Mauna Loa	Viti Levu, Fiji	Okinawa	NOL (MD)	Trinidad
1.1														■													
1.2								■						■													
2.1														■													
2.2														■													
2.3														■													
4.1								■	■					■													
6.1a														■													
6.1c																											
6.2														■													
6.3														■													
6.4														■													
6.5a												X	X	■		■	■	X	■	■							
6.5b																			■	■							
6.5c											■	P	P						■	■							
6.5d										■				■													
6.5e																											
6.6											■			■					■								
6.7														■													
6.8														■			■										
6.9														■													
6.10								■																			
6.11																											
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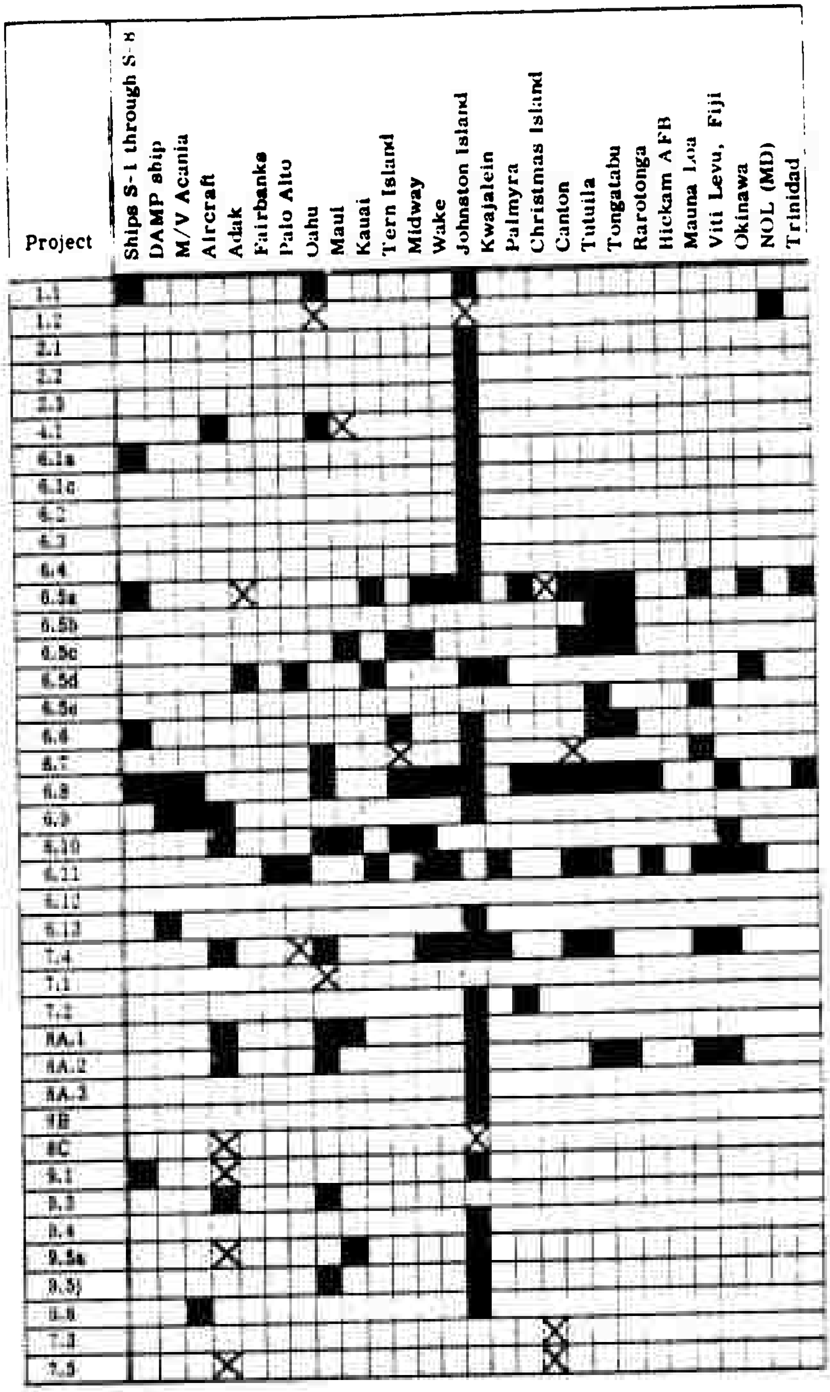
6.13														■													
7.4								■						■													
7.1																											
7.2														■		■											
8A.1								■	■					■													
8A.2								■						■					■	■			X	■			
8A.3														■													
8B														■													
8C														■													
9.1														■													
9.3								■																			
9.4														■													
9.5a									■					■													
9.5b								■						■													
9.6														■													
7.3																	■										
7.5																	■										

NOTE: ■ Construction and field support furnished by Holmes and Narver.
P Generators furnished to project for power.
X Additional sites requiring construction subsequent to Shot Blue Gill Prime.

Figure 4.7 Construction and field support, H&N.



NOTE: ■ Construction and field support regardless of the source of this effort.
✕ Projects did not participate in events at these sites subsequent to Shot Blue Gill Prime.

Figure 4.8 Construction and field support, all agencies.

Chapter 5

SPECIAL INTEREST AREAS

5.1 INSTRUMENT CARRIER PODS AND REENTRY VEHICLES

5.1.1 Background. Several of the scientific experiments proposed for the Fish Bowl Series required the placement of passive instruments close to the detonations with subsequent recovery of instruments for extraction of data. Several systems, such as the use of sounding rockets, were considered, but the required placement accuracy of ±20 percent in burst-to-instrument separation distance could not be satisfied. Based on a feasibility study by Douglas Aircraft Company (DACO), which concluded that the Thor system could place instrument-carrying pods designed by General Dynamics/Astronautics (GD/A) within this accuracy, the Thor pod system was selected to carry these instruments. The pod selected was a modification of one previously flown on the Atlas missile. A subcontract for the basic pod was awarded by DACO to GD/A, DACO being the prime contractor to Space Systems Division, USAF, with responsibility for providing the Thor which was to carry the warheads. In January 1962, responsibility for providing pods to meet all design criteria for the Blue Gill and Star Fish events was transferred to Air Force Special Weapons Center (AFSWC), acting as a project agency of FCDASA.

5.1.2 Modification and Testing. Several modifications to the basic pod structure were considered to be necessary. These consisted mainly of strengthening (hardening) the pod to withstand the predicted stresses, providing a parachute recovery system, and provision for spaces and mountings for the scientific instruments. The first strengthened pod structure was tested by explosive loading tests at Stanford Research Institute (SRI). This pod withstood the anticipated Star Fish loading, but failed in the flare and nose sections under the predicted Blue Gill stresses. A second pod was built with a further strengthened flare section and an increased number of nose attachment bolts. This modified pod sustained only slight damage under the predicted Blue Gill loadings.

Eighteen pods were built, using three patterns. Three pods, of the Star Fish pattern (first hardened design), were further modified to permit installation of telemetry antennas. These three pods, designated C1, C2, and C3, were used in the certification event, Tiger Fish. Four pods including a test pod, E1, were built using the Star Fish pattern, and 11 pods, including Test Pod E2, were built to the second hardened design, the Blue Gill pattern.

Scientific instruments, carried on the backplate of the pod, required a near-vertical pod orientation, backplate up. Since the Thor missile had a near-vertical trajectory, the initial orientation was accomplished by mounting the pods with the backplate forward on the missile and releasing them in this attitude. To maintain this attitude, a flywheel 15 inches in diameter and weighing 65 pounds was mounted in the forward portion of the pod body. Designed to rotate at approximately 4,000 rpm at pod release, this flywheel was believed capable of limiting the coning angle of the pod to within $\pm 7\frac{1}{2}°$ under the perturbations expected during release. The first pods flown on the Tiger Fish certification event used a $\frac{1}{7}$-hp, 28-volt dc motor to power the flywheel. This motor proved to be inadequate, and all subsequent flights used a 200-volt, 400-cycle, 3-phase motor of 1.85 hp. This second motor gave a flywheel speed of approximately 5,700 rpm at lift-off.

The stabilization system was powered through an umbilical cord prior to lift-off and was unpowered after lift-off. The motor was coupled to the flywheel by a clutch designed to disengage after power was removed from the motor. After Star Fish, tests run by GD/A indicated that the clutch imposed more drag on the wheel than did the motor and, consequently, the clutch did not disengage. Because the clutch also had a history of shearing under the high starting loads, the clutch was eliminated and a direct drive substituted. At the same time, the thickness of the flywheel cover was increased to eliminate warping and thus decrease the drag on the flywheel.

Instrument mounting locations were agreed upon among the scientific projects and furnished to GD/A, which designed the necessary mountings into the pod. For Project 8B, Nuclear Weapon X-Ray Effects as Measured by Passive Instruments, GD/A also performed the necessary drilling on the backplates for instruments that were to be mounted directly to the backplate. For Project 8A.3, Structural Response to Thermal Radiation from High-Altitude Fireball, GD/A furnished the backplates to American Science and Engineering (ASE), which performed the drilling of mounting holes.

The final pod configuration was a vehicle 80 inches long with a 30¾-inch diameter, flaring to 48-inch diameter at the backplate. The heat shield was refrasil phenolic, bonded to the aluminum substructure by silicone rubber. A removable nose contained a transponder antenna and provided access to equipment and instruments located in the forward portion of the pod.

The recovery system was housed in a 15-inch-diameter tube extending down the longitudinal axis of the pod. To provide the recovery systems, GD/A subcontracted to Northrop-Ventura. The predicted radiation environment made the use of nylon material undesirable for parachute systems. Northrop-Ventura selected DuPont HT-1 material for all recovery unit fabric applications because of its high resistance to radiation damage. However, because of the difficulty of procuring this material, it was necessary, during the later stages of the operation, to use nylon fabrics in some recovery units.

The recovery system incorporated a pilot parachute, employed to provide pod stabilization at subsonic velocities, a 4.5-foot drogue parachute, and a 20-foot-diameter main parachute. At impact, the parachute system was released, and a balloon on the end of a 40-foot line was ejected from the pod. This balloon inflated automatically and contained a flashing light mechanism and a Sarah beacon transmitter. Dye marker and shark repellent packages were attached to the 40-foot line. On the 40-foot line of the balloon were two wire-supported loops. These loops provided a means of grappling, either by ship or helicopter, for recovery of the pod. This 40-foot standoff line was considered necessary because the pods would be radioactive after exposure to the burst. Estimates of the degree of radioactivity ranged from 350 r/hr for Star Fish to 100 r/hr for Blue Gill pods at 1 hour after burst.

Actuation of the recovery system was accomplished by use of high-pressure nitrogen rather than by standard pyrotechnics because of the radiation environment anticipated. System arming, accomplished by accelerometers, was designed to resist the short-duration loadings imposed by the nuclear detonation, yet activate under the longer duration loadings experienced during reentry. The system was tested, first in a modified T-1 test vehicle and later in the repaired E1 test pod, in drop tests over the Salton Sea.

In flight configuration, each pod weighed 1,200 pounds including approximately 150 pounds of scientific instruments.

Pod backplates were covered with a layer of refrasil for Project 8A.3 and by a layer of graphitic carbon for Project 8B. The instrumentation for Project 1.1, Blast Measurements at Various Distances from High-Altitude Nuclear Detonations, was mounted in the forward portion of the pod body. The gamma detectors for Project 2.2, Gamma Radiation Measurements, were mounted in the body of the pod, 18 inches below the backplate. All other projects mounted instruments on or protruding through the backplate. To provide additional buoyancy, all empty space within the pod was filled with styrofoam. The pods floated without additional support (Figure 5.1).

5.1.3 Operations. The pods and warhead were carried aloft by the Thor missile. Three pods were located at 120° intervals around the boattail of the missile. An external fairing, attached to the missile structure, supported each pod. Two explosive bolts, through fittings on the pod backplate, attached the pod to the fairing. Additional support was provided by a metal band around the cylindrical portion of the pod, cinching the pod into a saddle attached to the Thor. Two explosive bolts secured the band to the saddle. The pods were released by firing the four explosive bolts. Release signals were originated in the missile guidance system.

For the Star Fish and King Fish events, pods were released during vernier engine solo (after main engine cutoff), the vernier power providing the differential velocity to place the pods at the proper position with respect to the warhead. Each pod was released at a different time. Because of the relative short pod-to-warhead distances desired for Blue Gill, it was necessary to release the Blue Gill pods after vernier engine cutoff. All pods were released simultaneously, and differential velocity was supplied by pushoff springs with different spring constants for each pod.

For analysis of the data obtained, it was necessary to know, after the event, the exact position of each pod relative to the warhead at burst time. Cubic Corporation, Project 9.6, was requested to provide transponder tracking to accomplish this objective. The original concept called for Cubic to track each pod in addition to the warhead. Due to space and power limitations, Cubic transponders could not be installed in the warhead. The problem was resolved by placing a Sandia Corporation transponder in one pod. Sandia Corporation then tracked one pod and the warhead, and Cubic Corporation tracked all three pods. Transponder power in pods was provided by a GD/A-furnished 28-volt thermal-activated battery.

GD/A provided the field crew necessary for final assembly and checkout of the pods at the test site. Northrop-Ventura furnished personnel to check out and install the recovery systems. Each project was responsible for installing its scientific instrumentation in each pod.

Recovery operations were the responsibility of the Naval Task Group, TG 8.3. Search operations were initiated at approximately H+1 hour by P2V aircraft and recovery ships. At daylight, Marine HUS helicopters joined the ships and aircraft. The pods could be recovered by either ships or helicopters for return to Johnston Island. If the pods were located near or after daylight, the helicopters picked up the pods and flew them directly to the island, landing the pods on a special pad made of unserviceable mattresses (Figure 5.2). If located during darkness, the pods were picked up by the ships, which proceeded toward the island. If the island was not reached prior to daylight, the pods were returned to the water at daylight and picked up by helicopter for fly-in. If the ships reached the island during darkness, the pods were transferred to a specially rigged LCM at some point outside the reef (Figure 5.3).

The M-boat brought the pods to the shore, where a mobile crane was used to complete movement to the pod recovery area. This area, designated as a radiation-exclusion area, was delineated by unused fuel storage tanks on two sides and by an 18-foot-high earth embankment on the inland side. The fourth side was open to the sea. The area contained three concrete wells, sunk into the earth embankment, for storage of radioactive pods; an open-top hot cell with lead-shielded cavefront providing manual manipulator operations; and a mattress-padded area for helicopter delivery of the pods (Figure 5.4).

Work on the recovered pods was confined to this area until decay had reduced the radioactivity to a level considered safe for movement to the pod assembly building. Scientific project personnel, assisted as necessary by GD/A, accomplished the removal of the instruments from the pods.

5.1.4 Results, Shot Tiger Fish. The primary objective of Tiger Fish was to proof-test the Thor pod system; however, the opportunity was used to obtain information on pod performance.

Two pods, C1 and C3, were instrumented and carried telemetry systems to provide desired information on temperature, accelerations, attitudes, etc. Scientific projects flew some instrumentation for proof-testing and to obtain background data. The third pod, C2, was not instrumented and, because of nonavailability, carried no recovery system. All three pods carried both Cubic and Sandia transponders. Pod releases were programed to test placement for both Star Fish and Blue Gill.

During the prelaunch countdown, the dc flywheel motors on Pods C1 and C2 burned out. The motor on Pod C1 was replaced, and, as an added precaution, the motor on Pod C3 was also replaced. The motor in Pod C2 was not replaced because of lack of time. During terminal count, the motor on Pod C1 again burned out, so, at launch, only one flywheel was running and this one at less than desired rpm.

All three pods were recovered. C2, as expected, and C1, because of failure of the recovery system, sustained impact damage. Pod C3 was undamaged except for minor reentry heating effects.

Postflight analysis of telemetry data, photographs, and pod appearance indicated that Pod C1 tumbled 4 seconds after release, probably because of impingement of retrorocket blast on the aft portion of the pod. Pod C2 was probably tumbled at the same time. The data also indicated higher disturbing moments during release than were originally estimated by DACO. Tracking data indicated that pod placement (C3 testing Star Fish placement, and C1 and C2 testing Blue Gill placement) was good. The coning angle on C3 was ±20°, with the excess angle attributed to slow wheel speed and larger-than-expected release forces. The failure of the C1 recovery system was attributed to inverted reentry.

As a result of the data obtained, DACO delayed the firing of the Thor retrorockets by 2 seconds on all subsequent missiles for Blue Gill.

5.1.5 Results, Shot Blue Gill. For this event, the 400-cycle flywheel motors were installed in all pods. No particular difficulties were encountered during prelaunch countdown.

Because of a random failure in the missile, Pod B1, the close-in pod, and Pod B3, the middle-distance pod, were not released. Pod B2, the far-distance pod, was released normally.

The warhead was destroyed 180 seconds prior to scheduled burst time because of a range safety problem. Extrapolation of tracking data from B2 indicated that, at burst time, the pod would have been at 3,800 feet instead of the desired 6,000 feet from burst.

Tracking signal strength records showed that the B1 signal became stable toward the end of the flight, indicating the pod had broken free from the missile. The B3 signal continued to fluctuate until signal strength dropped below readable level.

All three pods were recovered, and apparently, all three had reasonably normal reentry attitudes. All three recovery parachute systems functioned, and no impact damage was sustained. The B1 main parachute failed to release on impact, and as a result, the balloon recovery aid did not deploy. The balloon systems on B2 and B3 actuated, but because of weak ejection springs, were ruptured in the pod upon inflation. Strobe lights and Sarah beacons were inoperative because of this rupture.

All pods were returned to the island by helicopter. The rear bulkheads on Pods B1 and B3 showed abnormal heating of the refrasil covers. At the time, this was attributed to effects encountered on reentry while still attached to the Thor.

5.1.6 Results, Shot Star Fish. Only one GD/A pod was flown on this event; the other two positions were occupied by Mark 5 reentry vehicles (R/V). Pod checkout, prelaunch countdown, and lift-off were normal, but because of Thor malfunction, the missile and warhead were destroyed at 30,000 feet.

One of the R/V's and the pod impacted on the island. The pod was severely damaged, and only the recovery system parachutes and a few scientific instruments could be salvaged for future use.

A DACO analysis of the flight attributed the failure to extensive heating of the boattail of the missile structure, caused by hot gases from the main engine turbine exhaust being drawn into the low pressure area created by airflow around the pods and R/V's. It was concluded that similar heating probably occurred on both previous Thor flights and that the change in configuration from pods to R/V's increased this heating and caused the failure. Further examination of Blue Gill pod backplates indicated that such heating might have occurred (Figure 5.5).

To prevent subsequent recurrence, the entire boattail of the missile was insulated, and a ring was attached to the pod fairing, which, extending aft, sealed the gap between the fairing and the rear bulkhead. These measures did not prevent the recirculation of hot gases, but did protect the missile boattail and the scientific instruments from damage by such flow.

At this time, it was decided to refurbish four of the previously flown pods, then on hand. Pods C3, B1, B2, and B3 were returned to the GD/A plant for the work necessary to permit them to be reused on a second flight.

5.1.7 Results, Shot Star Fish Prime. This event used three GD/A pods. During the full-power full-frequency dry run, the S2 flywheel failed to operate properly, and the motor burned out. The malfunction was corrected by installing a spare flywheel assembly.

After the pods were mounted on the Thor, the launch was delayed 4 days because of weather. During these holds, the recovery system in S2 began to lose nitrogen pressure, and the leak grew progressively worse. The unit was removed and recharged after the first 24-hour hold, and after the third hold, was removed and replaced with a spare unit. During the terminal count, the flywheel motor in S1 malfunctioned, and the wheel attained only 3,600 rpm, instead of the expected 5,700 rpm, at lift-off.

The Thor flight was nominal, and all three pods were released. Analysis of tracking data indicated that S1 tumbled and S2 wobbled. S3 tracking appeared to be good to detonation.

All three pods were recovered, one returned by ship and two by helicopter. All parachute systems operated successfully. The balloons and location aids on S1 and S3 operated normally, but the balloon in S2 had burst on inflation, probably within the pod.

Only normal reentry heating and X-ray shadowing were observed on S2 and S3 (Figure 5.6). S1 suffered a circumferential crack in the flare section about 3 inches from the backplate. This crack extended around the flare for about 120°. A deep gouge in the edge of the rear bulkhead was noted near the center of the crack. Contact with some heavy object was postulated as the cause of the gouge and crack. Char depth in the crack indicated that the damage occurred after reentry, probably during recovery. Analysis of the X-ray shadows on the pods indicated that S1 was almost nose-on to the burst. S2 and S3 were oriented off vertical at angles of 43° and 41°, respectively.

Tracking data snowed that S1, the close-in pod, was within ±20 percent of the desired separation distances, S2, the middle-distance pod, just exceeded the desired ±20 percent, but S3, the far-distance pod, was almost twice as far from burst as desired. Calculations by DACO indicated this pod was released earlier than programed and while the missile was under full thrust. All pods gave evidence of contamination by bomb debris as well as neutron activation of pod materials. After the pods were returned to the island, the highest radiation reading was approximately 5 r/hr. Radioactive decay appeared to follow, fairly closely, the Na^{24} half-life.

5.1.8 Results, Shot Blue Gill Prime. Two new pods and one refurbished pod were mounted for this event. All pod checkouts prior to launch were normal except for a slipping clutch on the B1 flywheel. This was not replaced, and at lift-off time the wheel was at normal speed.

Because of a missile malfunction, the Thor and warhead were destroyed on the pad. Burning missile fuel badly charred the pods. The fall from the missile activated two of the recovery systems, but not the third. The refrasil heat shields on all pods were cracked because of impact, and all pods were alpha contaminated. It was possible to salvage one complete recovery system plus chutes and other parts from the others. Impact switches and g-switches were salvaged from the contaminated recovery system containers. Neutron detector packages and flywheels were salvaged from all three pods; antennas and transponders were salvaged from two pods. All other parts were disposed of as radioactive waste.

After this failure, two additional pods, Star Fish Pods S2 and S3, were returned to GD/A for refurbishing, and GD/A was instructed to build four new pods. This made a total of 18 pods manufactured and 6 refurbished for use on subsequent flights.

5.1.9 Results, Blue Gill Double Prime. Three refurbished pods, two from Blue Gill and one from Tiger Fish, were mounted for this event. During the D−6 day tests, the Cubic ground station had considerable trouble in receiving signals from Pods B1 and B3. Later tests indicated that the problem was limited to RF multipaths around the pad area. This problem was solved on subsequent events by pointing the Cubic antenna toward the pad area until after launch. All pod checkouts were normal, and all transponders and flywheels were operating at lift-off. The Thor missile was destroyed 94 seconds after lift-off, prior to scheduled pod release.

All pods were recovered and returned to the island, two by helicopter and one by ship. All pods showed evidence of having moved sideways. Many instruments were sheared off the backplate, and many bent or damaged by forces parallel to the backplate. On both B1 and B3, mounting brackets were sheared off about 1 inch from the backplate. On B2, both mounting brackets were intact, and one had still attached to it a part of the mounting structure from the Thor. All intact mounting brackets contained parts of the explosive bolts that held the pod to the missile, indicating that pod release was not effected but that the pods were blown off the missile when the missile was destroyed.

Pod B1 showed only a very slight darkening of the heat shield; B3 had some very light charring of the nose section of the pod, whereas B2 was rather severely charred over the entire body of the pod except where the saddle and saddle band fitted about the center of the pod cylinder. B1 received impact damage even though the recovery system had activated and the main chute had deployed. On B3, the recovery system operated with full parachute deployment. The balloon was deployed, but broken wiring prevented inflation. B2 showed no impact damage despite the fact that the recovery system did not activate. The system doors were intact and the system retained nitrogen pressure.

5.1.10 Results, Shot Blue Gill Triple Prime. One new pod and two refurbished pods, from the Star Fish Prime event, were used on this flight. Contrary to normal practice, the Sandia Corporation transponder was mounted in the pod designated to be in the middle position for this flight. This was necessary because one pod was of the Star Fish design; to insure its survival, this pod, which was not wired for dual transponders, had to be placed farthest from the burst.

All pod checkouts were normal until the D−1 day full-power, full-frequency dry run. During this check, the flywheel in B1 would not run up to speed. The trouble was traced to a short between one phase of the 400-cycle flywheel motor and ground and was corrected by disconnecting the ground wire from the 400-cycle power unit. The Cubic transponder in B3 showed a modulation amplitude lower than the other two transponders and was replaced. The flight was nominal, and all pods were released.

The flashing light on B1 was sighted shortly after H-hour, and the pod was picked up and returned by ship to the island before daylight. The pod suffered only reentry heating damage plus charring of the refrasil backplate cover by the burst. Orientation had been excellent, and all instruments were in good condition. The only item that did not function as designed was the Sarah beacon antenna on the recovery aid balloon.

Pods B2 and B3 were returned by helicopter after daylight. Pod B2 had sustained impact damage, with the backplate bent and the entire flare section missing. Most of the backplate instruments were present and appeared to be in good condition. Shadowing indicated that burst-time orientation was excellent. Pod B3 was in good condition, showing only reentry heating and burst effects. All instruments were in excellent condition, and the orientation was excellent. The only malfunctions on the pod were the failure of the main parachute to release on impact and the subsequent failure of the recovery aid balloon to deploy.

Because of the shortage of HT-1 material, some of the recovery unit elements in these pods were of nylon; however, no adverse effects could be attributed to this substitute material.

During the flight, the Cubic tracking system experienced a malfunction, resulting in the loss of time correlation of track positions.

All pods were radioactive; the highest level was 14 r/hr, 8 hours after the event. Decay followed the typical Na^{24} decay scheme.

5.1.11 Results, Shot King Fish. Three new pods were used in this event. Pretest flywheel and transponder checks were normal, with the flywheels showing the best rundown characteristics of any tested. A small amount of material was ground off each pod rear bulkhead circumference to obtain proper clearance within the DACO pod fairing.

Of the recovery units remaining, only one checked out in all respects. This system was selected to go into K2. Of the other systems, one designated for the K1 pod had a 100-psi leak in 24 hours, one designated for K3 had a 300-psi leak in 24 hours, and the reserve unit exhibited a totally unacceptable leak rate. On D−2 days, a valve exploded in the unit designated for K3, damaging the unit beyond field repair. The undamaged systems from Pods B1 and B3 were removed from the recovered Blue Gill Triple Prime pods and tested. Neither system would pass all tests, and the unit selected, while showing no pressure leaks, had a mulfunction in the delay switch designed to prevent early release of the main parachute. This switch was supposed to delay activation of the main parachute release mechanism for at least 9 seconds after main parachute deployment, but in this unit the delay never exceeded 2 seconds. All of these systems used nylon fabric, and only K1 and K2 units had flashing lights. None had Sarah beacons, but all had sea dye and shark repellent.

At lift-off, all transponders and flywheels were operating properly. Pods were successfully released and tracked to burst time.

Pod K1, the pod closest to the burst, was returned to the island by helicopter with only normal reentry heating damage and charring of the backplate cover. Shadowing on the backplate indicated that orientation had been excellent. All instruments were intact.

Pod K2 was also returned by helicopter but had suffered extensive impact damage, even more severe than the Tiger Fish pod that had no recovery system. The entire rear bulkhead and most of the flare section was missing, and the nose was broken off just behind the antenna (Figures 5.7 and 5.8). Only one instrument, of those originally mounted on the backplate, was present, and it was lying loose in the rear of the pod. The flywheel mounting and several instruments in the nose of the pod were broken from their mounts. The recovery system appeared to have worked only partially. The drogue parachute had deployed and pulled out the main parachute; however, the main parachute riser was broken just below the swivel. The broken end was badly frayed, and it appeared that the riser had twisted until each strand had broken. From X-ray shadows on the pod and the surviving instrument, orientation appeared to have been excellent.

Pod K3 was never recovered; only a part of the nose and the recovery aid balloon were found and identified.

After the shot, it was determined that Pods K2 and K3 had been interchanged in position on the missile. Since the two pods contained identical instrumentation, the only difference was that the Sandia Corporation transponder was placed in the middle position instead of in the outside position. Such a change would not reduce tracking accuracy. Both recovered pods were radioactive with a high reading of approximately 2 r/hr, 8 hours after the event. Evidence of bomb debris impaction was found on Pod K1.

5.1.12 Mark 5 Reentry Vehicles. For Star Fish, it was decided that full-scale R/V's should be tested under the stresses imposed by a nuclear burst. This was set up as Project 8C, Reentry Vehicle Tests.

The R/V selected was the Mark 5, designed for the Minuteman missile. Three of these vehicles were available for test. After analysis, DACO reported that, with proper ballasting, the Thor missile could carry two of the Mark 5 vehicles and one GD/A pod, or three of the Mark 5 vehicles. A last-minute decision was to use Mark 5 R/V's in the close-in and far-out positions and a GD/A pod for the center position (Figure 5.9). The GD/A pod was to carry Project 8B instruments.

Each Mark 5 vehicle was modified to provide attitude control and stabilization, a recovery system, hardening of the rear plate, and instrumentation. The time available for development limited the project to the use of existing items with only necessary modification to fit them to the proposed use. A side-on orientation with respect to the burst was desired. To achieve this, a Mark 11 pitch-and-spin system was adapted to the Mark 5 vehicle.

The modified recovery system limited the total flight weight of the vehicle to 450 pounds. The system was basically a parachute retarding system activated by pyrotechnics. Since the vehicle would not float, it was necessary to provide a flotation bag. This bag, suspended between the main chute and the vehicle, filled with air during descent and provided sufficient buoyancy to support the vehicle after landing. Pickup loops, Sarah beacons, flashing lights, sea dye, and shark repellent were incorporated as recovery aids.

To cut down on undesired effects, the rear plate of each R/V was covered with a graphite-base compound to lower the X-ray impulse on this portion of the vehicle and thus improve chances of survival. Instrumentation included altitude sensors, spall gages, accelerometers, displacement gages, strain gages, and gamma detectors. Impact detectors and arming and firing components from the standard R/V were tested (Figure 5.10).

No active tracking system was incorporated in the R/V's. Optical tracking equipment was located on Johnston Island and aboard two aircraft to track the R/V's during reentry. As an aid to this, optical signature pellets, using different materials in each R/V, were used. Should the R/V break up on reentry, these optical signatures would be visible. If the R/V survived reentry, no signature would be visible. The R/V's were mounted on the same DACO fairing on the Thor missile as for the pods except that no restraining band was used on the body of the R/V. Separation was achieved by explosive cutting of a spacer between the body of the R/V and the fairing. Separation times were transmitted through the Thor telemetry system and through a separate telemetry system mounted in the spacer between the R/V and the fairing. The modifications necessary for this test changed the R/V's from the operational configuration by changing weight, internal components, etc. However, the external configuration and structural integrity were maintained. The Star Fish missile was destroyed at approximately 30,000 feet. One R/V impacted on the island and was almost totally destroyed, and the second R/V was never located. No data was obtained by the project.

5.1.13 Discussion, Thor Pod System. Only one of the Thor failures was attributed to the presence of pods. This was the Star Fish missile carrying one GD/A pod and two Mark 5 R/V's. The failure was caused by recirculation of hot exhaust gases, as explained earlier. It was felt that the failure to release two pods on Blue Gill was a random failure of a missile component. The failure of Blue Gill Prime was attributed to a faulty lox valve, and Blue Gill Double Prime failure was caused by a malfunction in a missile power supply.

5.1.14 Discussion, Pod Positioning. Placement of pods with respect to the burst was marginal. Five of the nine instrument-carrying pods exposed to nuclear bursts exceeded the ±20-percent placement accuracy desired. Table 5.1 presents the desired and measured distances and pod orientation angles at time of burst for the flights of interest.

Blue Gill Prime, Blue Gill Double Prime, and Star Fish flights provided no separation distances for pods. On the Blue Gill flight, only one pod released from the missile. The flight was not considered to be a valid test of pod separation distances. On Star Fish, Pod S3 exceeded the ±20-percent separation accuracy because of early release, prior to main engine cutoff. The cause of the early release has not been determined. On King Fish, Pods K1 and K3 (near the middle position) exceeded the desired separation accuracy although the release sequence appeared to be normal. The cause of these excessive errors has not been determined.

5.1.15 Discussion, Pod Stability. For Tiger Fish, only one pod, C3, had an operating flywheel at lift-off. This pod, simulating the 14-km Star Fish position, showed a ±20° wobble at simulated burst time. Both of the other pods tumbled almost immediately after release from the missile. Analysis of the rate gyro data from C1 and C3 indicated that both these pods, and probably C2 as well, experienced significantly higher disturbing moments during release than were originally estimated by DACO. It is believed that both C1 and C2 were hit by the second Thor retrorocket blast. For this reason, the retro firing on all subsequent Blue Gill flights was delayed by 2 seconds.

The Blue Gill flight produced no definitive data on pod attitude.

Despite the use of higher speeds on the flywheels for Star Fish Prime, the S1 pod tumbled, and S2 and S3 were off axis by 43° and 41°, respectively. The S1 flywheel had achieved a speed of only 3,600 rpm instead of the designed 5,700 rpm, at lift-off. This malfunction was later checked by attempting to duplicate the failure. The exact cause could not be pinpointed; however, it is believed that the malfunction was a loss of one phase of the 3-phase power to the motor, either through grounding or opening of a line.

The failure of the flywheels to stabilize the pod was first attributed to release disturbances higher than those for which the system was designed. However, additional tests were run on the flywheels, during which it was found that the flywheel cover tended to warp under flight loading, and the clutch did not disengage from the flywheel as designed. Warping of the cover increased the friction on the wheel, and before Blue Gill Double Prime all remaining flywheels were modified to strengthen the cover. Since the clutch was no longer required and had a history of failure under starting loads, all flywheels were further modified to provide direct coupling of the motor to the wheel. This did not increase lift-off wheel speed but did improve the run-down characteristics so that wheel speeds at release and burst time would be somewhat higher than before.

Blue Gill Triple Prime and King Fish both had longer flight times than did Star Fish, but, for both these last events, it appears that pod orientation was very good, close to the $\pm 7\frac{1}{2}°$ from vertical used as design criteria.

A postseries test run by GD/A indicates that the pod and wheel system respond like an inertia wheel spinning in space after separation from the missile. The wheel gradually slows, imparting the lost angular momentum to the pod through bearing friction. After a long time, nearly all the angular momentum will be in the pod structure, and the system response will approximate that of a vehicle spinning about a minimum axis of inertia. Both of these systems possess a high degree of rotational stability. However, in progressing from an inertia wheel configuration to a spinning vehicle, the pod will, at some time, respond like a sphere spinning in space. For the GD/A pod, this period was reached when the ratio of wheel speed to pod speed was approximately 350. During this transition period, the spin vector momentum vector is not restricted to any position in the body. Although the pod and wheel are not unstable in themselves, any large initial disturbance or pod dynamic unbalance will cause the spin vector to become highly disoriented during this period, and very large wobble angles or even complete tumbling of the pod could result before rotational stability is again achieved.

It is felt that, on Star Fish Prime, the no-spin stability point was reached, because of high motor drag and wheel cover friction, before burst time. The higher-than-initially calculated disturbances at release were probably sufficient to cause the S1 pod, with low wheel rpm at lift-off, to tumble as it passed through this no-stability point, and to cause the large wobble angles of the S2 and S3 pods on passing through this no-stability point.

For Blue Gill Triple Prime and King Fish, the improved wheel run-down characteristics probably allowed the system to remain in the inertia wheel configuration through burst time. Despite the fact that time from lift-off to burst was almost 2 minutes longer than on Star Fish, the pods had only the small wobble angles imported at release and thus performed as designed.

5.1.16 Discussion, Pod Recovery System. The pod recovery system had a mixed success. Because of the difficulty of obtaining HT-1 material (desirable because of its radiation resistant properties), it was necessary to substitute nylon fabric in some units. However, none of the failures experienced were attributed to the substitution of materials.

Because of the use of other long-lead-time items, it was necessary to refurbish some of the recovery units used in the earlier flights and reuse them in later events. Refurbishment of these units was accomplished at the Northrop-Ventura plant. In some cases, it was necessary to construct new units, using parts recovered from used units.

The failure of the recovery unit in Pod C1 was attributed to an inverted reentry, preventing the arming switch from experiencing the required deceleration forces.

On the Blue Gill flight, all parachute units operated successfully, despite the fact that two of the pods did not release from the missile and must have broken away on reentry. On B1, the parachute failed to release from the pod on impact, presumably due to an impact switch malfunction, preventing deployment of the recovery aid balloon. On B2 and B3, the balloons were activated but weak springs failed to eject the balloons from the pods, and the balloons burst on inflation, causing failure of the flashing lights on Sarah beacons.

On Star Fish Prime, all portions of all units functioned as designed, except for a burst recovery aid balloon on S2, again attributed to a weak ejection spring.

On Blue Gill Triple Prime, two parachute systems operated, but the main parachute did not release from B3, preventing recovery aid balloon deployment. This malfunction was believed to be caused either by a faulty g-switch or an impact of less than the 5 g required for operation. On the B2 pod, the main parachute was cut off just below the swivel. It is believed that the recovery aid balloon ejected prematurely and the ejection spring cut through the parachute risers.

On King Fish, the recovery system in K1 functioned as designed. On K2, the main parachute riser was broken, appearing to have been twisted until each individual strand gave way. Why the swivel did not prevent twisting, or why the twisting did not collapse the parachute prior to riser failure, has not been explained. Pod K3 was not recovered, and no analysis of the failure was possible. One possibility is that the parachute release delay switch did not function properly and the parachute was released from the pod immediately after opening. This pod contained the recovery unit salvaged from a Blue Gill Triple Prime pod. The delay switch was designed to prevent arming of the parachute release system for 9 seconds after parachute deployment, but, during checkout, had never provided more than a 2-second delay. If opening shock occurred later than 2 seconds after the deployment signal, the parachute may have been released from the pod.

Star Fish and Blue Gill Prime provided no opportunity for recovery units to function, although on Blue Gill Prime two of the units had activated, blowing off the rear doors, and all three units retained nitrogen pressure through the missile fire.

On Blue Gill Double Prime, two of the parachute systems had deployed, one pod being undamaged. The other pod received impact damage, and it is believed that parachute deployment was too late to slow the descent. The main parachute had two splits in the fabric when recovered. The third pod showed only slight impact damage, but the recovery unit had not activated. It is believed that the pod probably impacted while still attached to some large portion of the missile and broke loose on impact.

5.1.17 Conclusions. The overall capability of the Thor pod system for placement, and subsequent recovery, of passive scientific instrumentation in the vicinity of a nuclear high-altitude detonation was found to be marginal. However, it is felt that postflight analyses of the Fish Bowl events point the way to solutions of the problems encountered.

The pod was designed to withstand, structurally, the impulsive loads expected from the Fish Bowl events. Since the majority of pods flown (including those pods closest to

Blue Gill Triple Prime and King Fish events) reentered and were recovered, even when the recovery system failed, it is concluded that the pod met and exceeded design objectives.

Tracking data indicated that placement generally was marginal, and in five cases did exceed the ± 20-percent accuracy desired. Since these discrepancies have not been explained, the method of attaining separation distance must be considered marginal.

It is concluded that pod stabilization obtained in the Fish Bowl events is marginal at best. The extreme angle of wobble experienced on Star Fish is believed attributable to release and flame impingement perturbations in excess of those estimated by DACO for stabilization design, and to the lack of stability imposed by progression from a spinning wheel to a spinning vehicle configuration.

The Blue Gill Triple Prime pod orientation, and pod stabilization, possibly did not meet design criteria, but did permit achievement of objectives.

On King Fish, pod orientation and stabilization appear to have been good.

The recovery system, in the overall program, was less than satisfactory. Field maintenance experience indicated that the highly complex system used could not be adequately serviced under field conditions. For example, the recovery unit pressure system could not be pressurized when the unit was installed in the pod. The complexity of the recovery system is concluded to have seriously degraded reliability.

The pod tracking system used must be considered inadequate from the standpoint of accuracy of preliminary data and in the time required to produce final data. An additional objection stems from the use of two systems, one tracking pods and the other tracking the warhead and one pod. This introduces bias errors between the systems, which must be resolved to obtain final separation distances.

5.1.18 Recommendations. It is believed that a highly reliable stabilization system can be obtained from a design embodying the following: (1) A flywheel possessing greater moment of inertia, and providing several times as much momentum. (2) An electric motor on the flywheel shaft, with continuous access to battery power. This motor would bring the flywheel up to planned speed before launch, and this speed would be maintained during powered flight. After ejection, the motor would be powered on command from an autopilot system. (3) A high-pressure gas tank and valve system feeding pitch and yaw nozzles on command from the autopilot system. (4) A compact, lightweight autopilot system controlling both the pitch and yaw nozzles, and also the flywheel motor switch. This autopilot system would actuate the nozzles to pitch and yaw the pod (overpowering gyroscopic effect of the wheel) to the desired orientation. The wheel then would hold the pod in the position reached at nozzle cutoff. The autopilot system would control the motor switch, supplying power in the proper direction to stop rolling.

It is believed that a satisfactory recovery system can be provided through a design modification. The primary objective of the design would be reliability through simplicity of the system, and through easy field servicing. The parachute system used is considered very successful. (Failures occurred only when parachutes were reused, and telemetry data from Tiger Fish flights indicated that parachutes performed as planned.)

5.2 AIRCRAFT MODIFICATION

The program herein defined and performed on Contract AF 19(628)-348 was assigned as Project 9.3 for direct support of the objectives of Projects 8A.1 and 8A.2. These project assignments were made by CHDASA as part of JTF-8 participation in Fish Bowl.

The modification program was performed by the Cook Technological Center Division, of Cook Electric Company, contracted by the Air Force Cambridge Research Laboratories (AFCRL), and funded by DASA.

The objectives of Project 9.3 were to provide airborne platforms appropriately modified for the incorporation of scientific research instruments, to support the data acquisition objectives of Projects 8A.1 and 8A.2.

Two KC-135 aircraft were modified for this purpose. Between Phases I and II of Fish Bowl, one of these aircraft was destroyed in a landing accident at L. G. Hanscom Field, Bedford, Massachusetts (August 1962). The contract was accordingly amended to include the modification and subsequent demodification, after test completion, of a C-135 aircraft to replace the loss of the KC-135.

Fifty-two viewing apertures were provided on each KC-135 aircraft, and 43 such apertures were provided on the replacement C-135 aircraft. These apertures were enclosed with specific materials possessing finite spectral transmission characteristics consistent with the requirements of the mounted research instruments. All such instruments were mounted to provide a variety of preselected pointing angles and tracking capabilities. The installation of these instruments and their associated electronics and supporting systems were integrated to produce a highly specialized airborne research capability.

Primary power systems were augmented. Aircraft attitude parameters and navigational systems were complemented to supply definition of aircraft position and attitude. Crew accommodations were supplied to provide intercommunication and oxygen distribution to the in-flight scientific crew. Defrosting provisions were incorporated to provide frost-free unobstructed instrument viewing. Timing and time integration for manual and automated instrument operation were incorporated. All these provisions were integrated into the instrumentation systems.

As aircraft were completed at the modification center, they were dispatched to Hickam AFB for project participation. Cook Electric supplied a field crew to maintain the modification, support the project's data acquisition and recording equipment, and modify and adapt systems to the specific mission profile. This technical assistance proved invaluable, with a mission record of all systems 100-percent operational.

The two KC-135 aircraft were completely modified, instrumented, and delivered within 95 days of contract initiation; the C-135 modification was accomplished in 40 days. The 40-day modification is not a recommended procedure. This rapid delivery date was accomplished only by having a very high priority and working on a 7-day-week, around-the-clock schedule. These accomplishments were a direct result of the direction, support, and coordination of all activities involved, which were carried through during the field test phase to the same degree of completion, resulting in a state of readiness for all scheduled test participations.

During the course of the modification program, engineering and logistic problems were many and varied. Details concerning these areas of irterest are contained in the following reports published by AFCRL: (1) Final Report, AFCRL-63-284; "Modification of Two KC-135 and One C-135 Aircraft for the Acquisition of Thermal and Optical High-Altitude Data"; DASA Project 9.3, Project No. 7674, February 1963. (2) Final Report, AFCRL-63-283; "Design Study for the Modification of KC-135 Aircraft for the Acquisition of Thermal and Optical Data"; Project 7674, February 1963.

TABLE 5.1 POD POSITIONING

In all cases, the desired orientation was $\pm 7\frac{1}{2}°$ off vertical.

Shot	Pod	Desired Separation	Measured Separation	Percent Error	Measured Orientation
Tiger Fish	C1	2,500 ft	2,300 ft	8	Tumbled
	C2	6,000 ft	5,700 ft	5	Tumbled
	C3	14 km	15.5 km	11	± 20°
Star Fish Prime	S1	7.5 km	8.7 km	16	Greater than 100° (tumbled)
	S2	10 km	12.3 km	23	43°
	S3	14 km	23.4 km	67	41°
Blue Gill Triple Prime	B1	2,500 ft	3,280 ft	31	11° ± 2°
	B2	4,000 ft	4,603 ft	15	7° ± 2°
	B3	6,000 ft	6,760 ft	13	Less than 15°
King Fish	K1	1.9 km	2.5 km	30	5° ± 1°
	K3	2.4 km	2.9 km	22	9° ± 1°
	K2	3.3 km	3.8 km	16	—

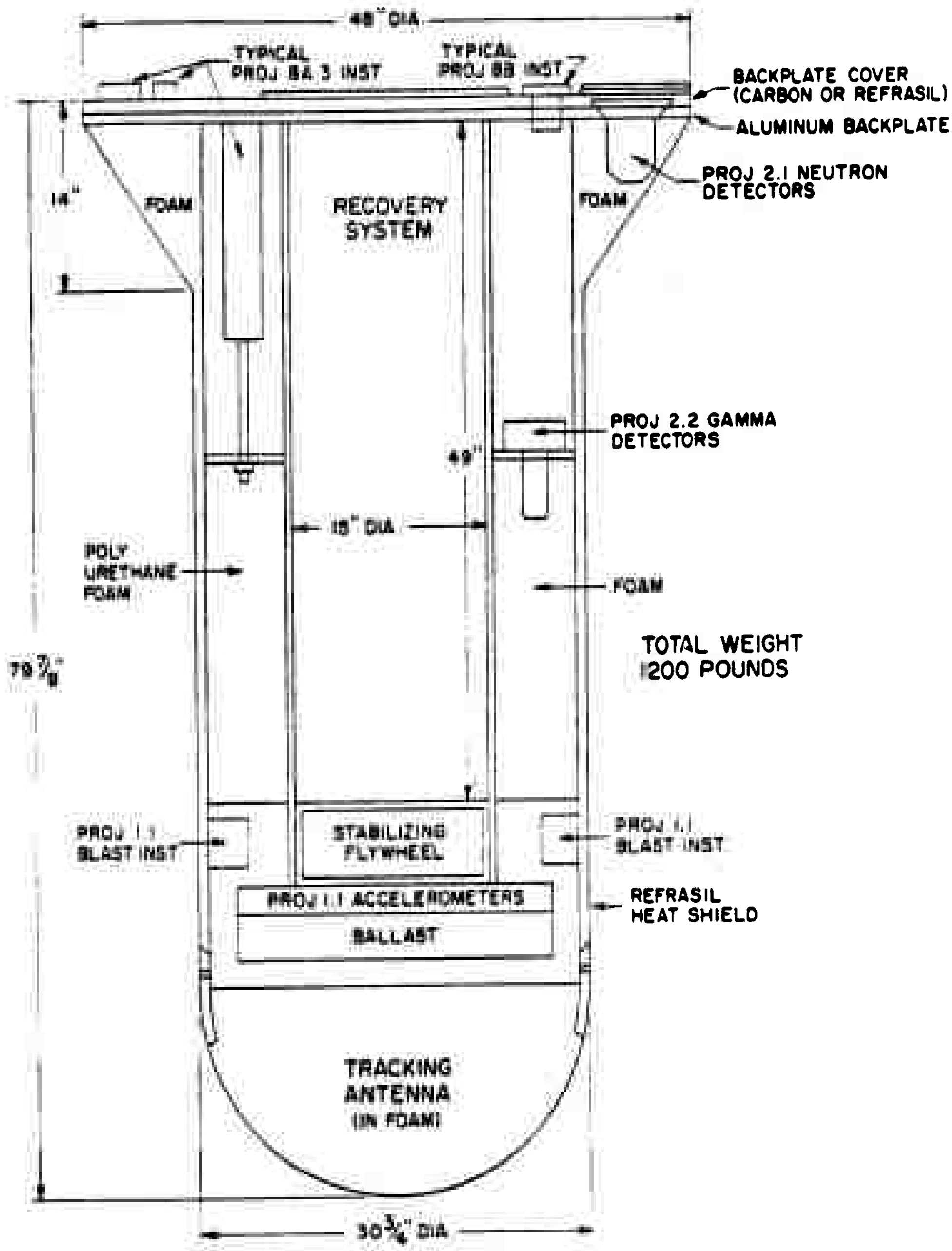


Figure 5.1 Typical pod structure.

VMRL-364

Figure 5.2 Helicopter landing a pod on Johnston Island. (Worldwide countdown antennas in the background.) (DASA 26-6279-62)

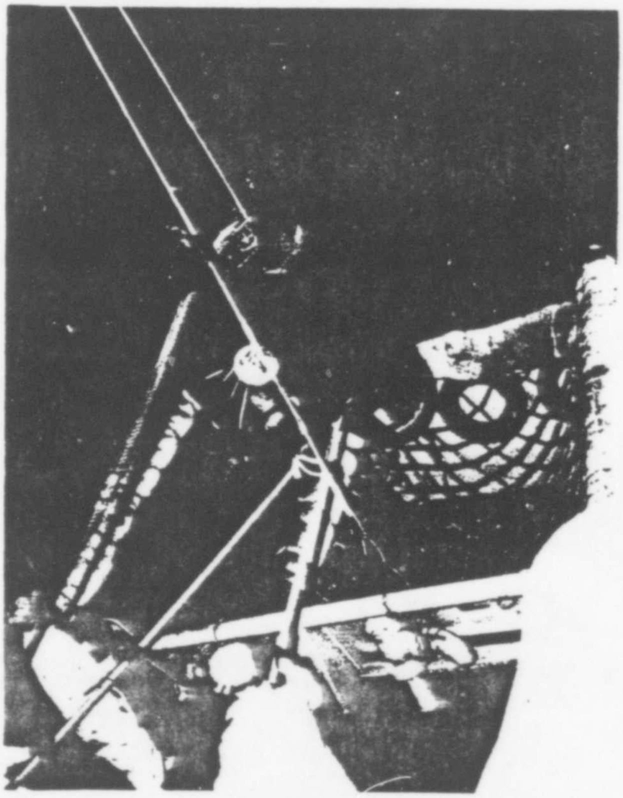


Figure 5.3 Ship transferring a pod to M-boat.
(DASA 26-6303-62)

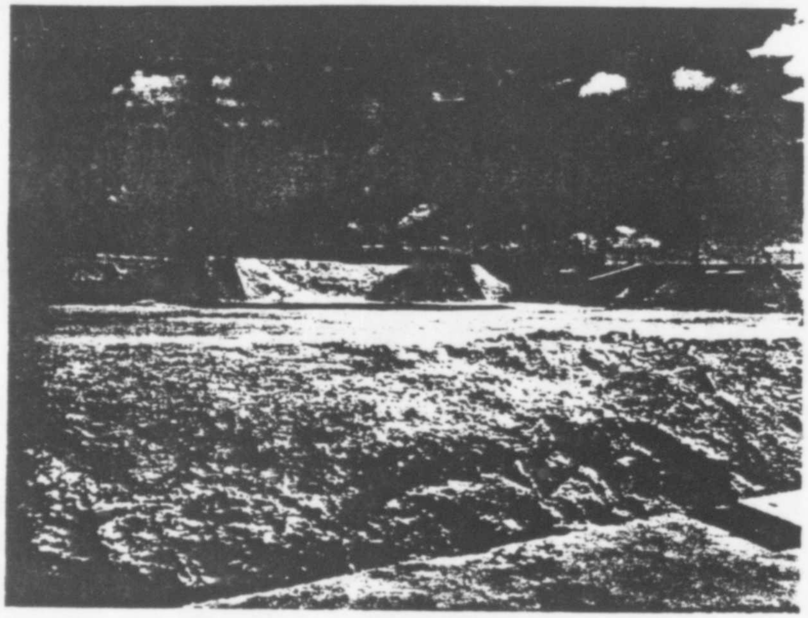


Figure 5.4 Pod recovery area.
(DASA 26-6185-62)

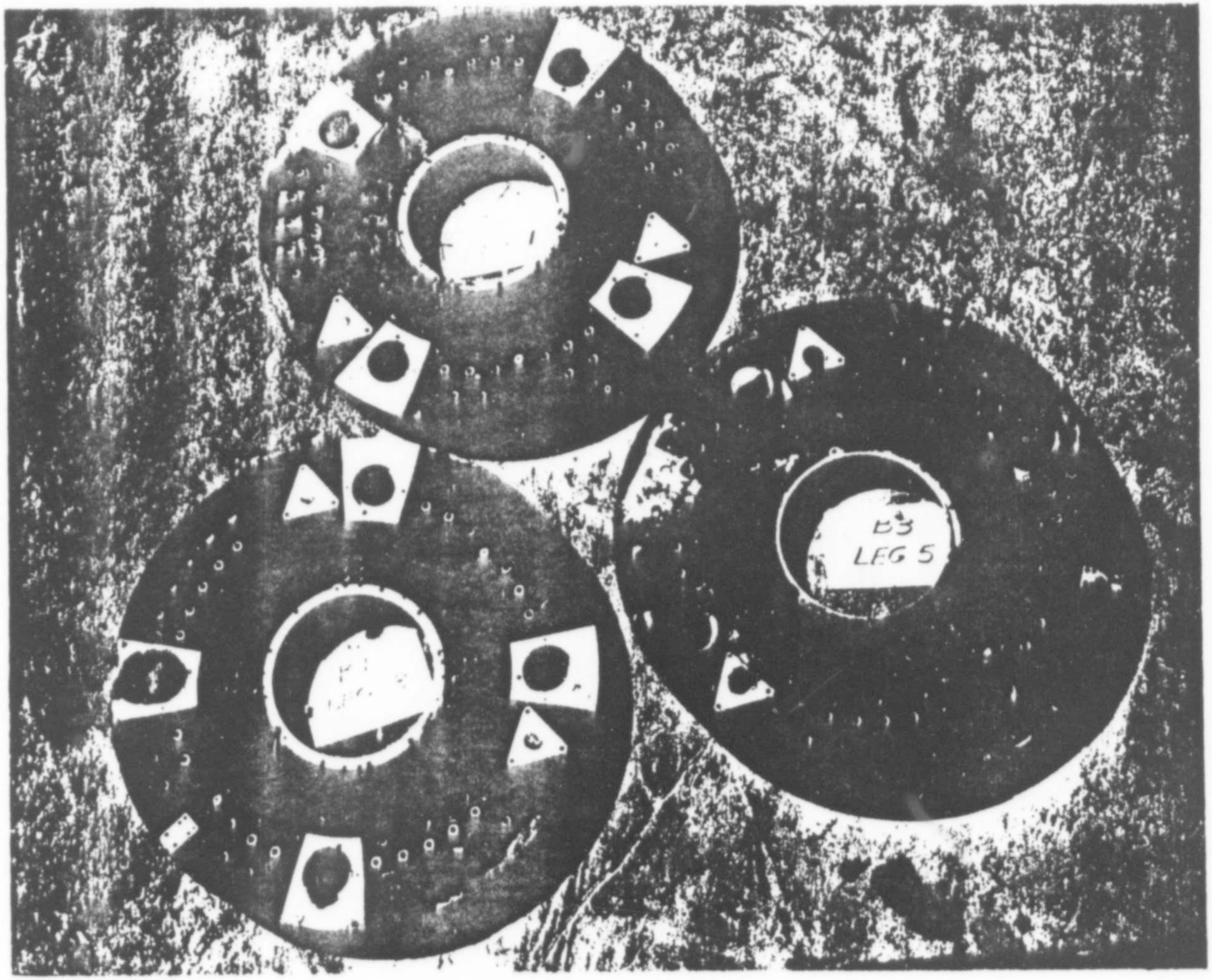


Figure 5.5 Pod backplate, Shot Blue Gill.
(DASA 26-6169-62)

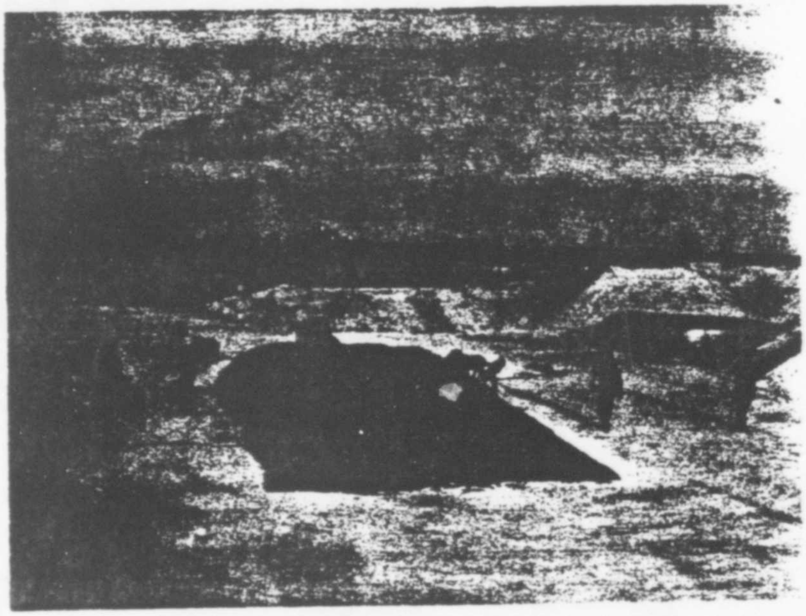


Figure 5.6 Pods after recovery, Shot Star Fish Prime. (DASA 26-6282-62)

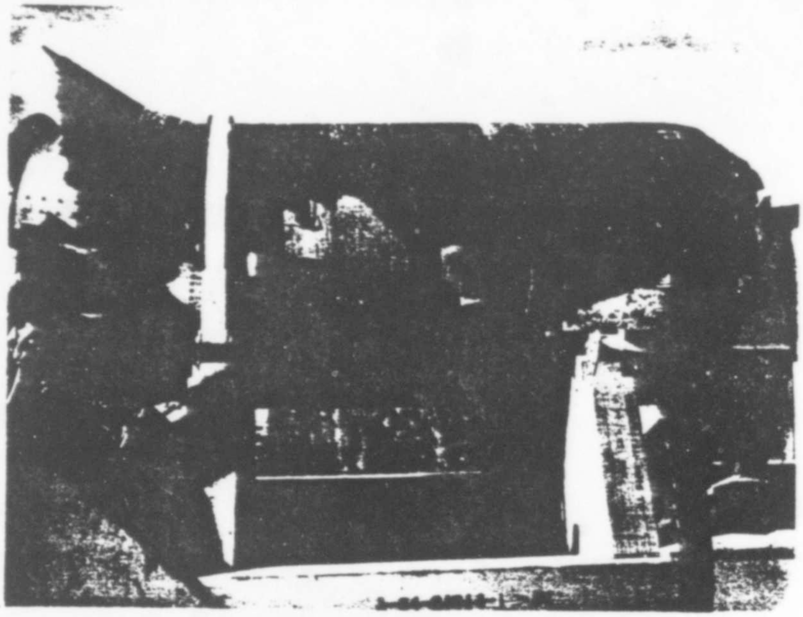


Figure 5.7 Impact damage on Pod K2, Shot King Fish. (DASA 26-6869-62)

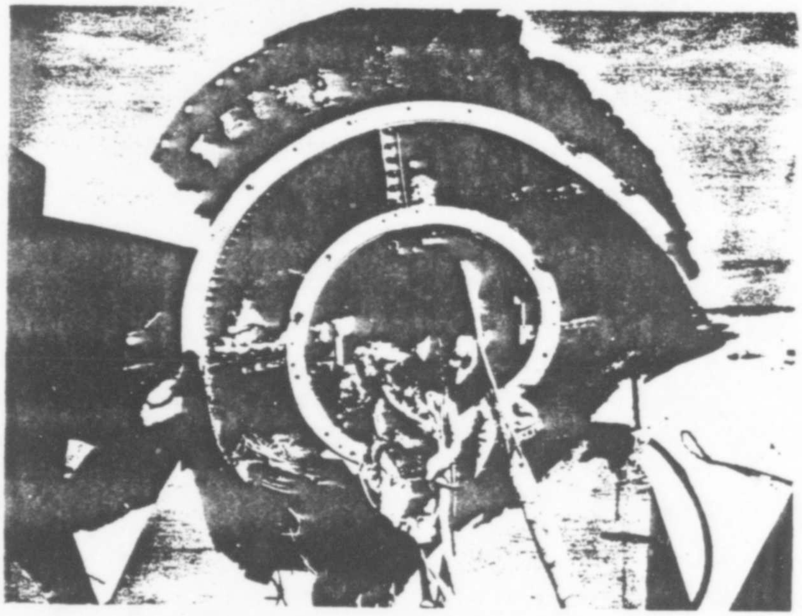


Figure 5.8 Additional view of impact damage on Pod K2, Shot King Fish. (DASA 26-6870-62)

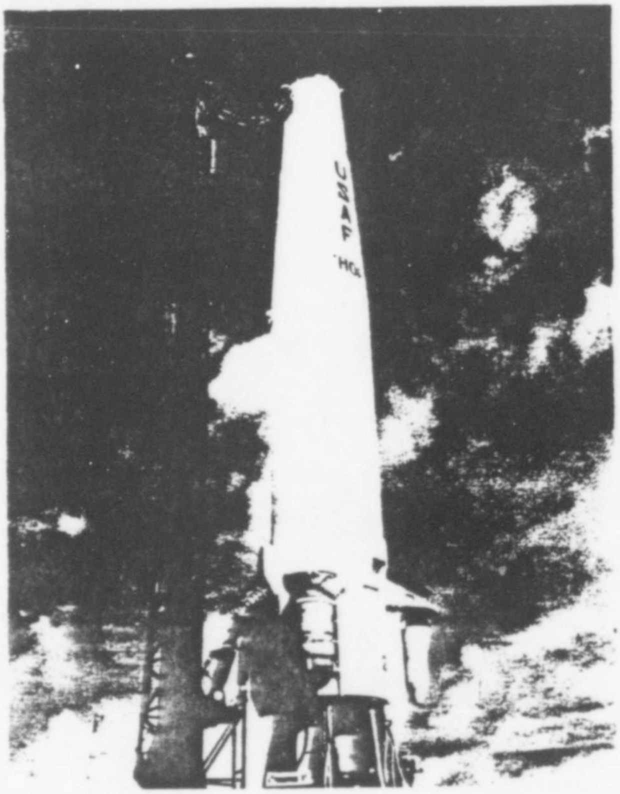


Figure 5.9 Reentry vehicles and pod on Thor, Shot Star Fish. (DASA 26-6045-62)

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Chapter 6

SCIENTIFIC ACTIVITY

6.1 COMMUNICATIONS EFFECTS

6.1.1 Background. Shots Teak and Orange during Operation Hardtack, and the Argus shots of 1958, demonstrated that high-altitude nuclear explosions can significantly alter the electrical properties of large volumes of the atmosphere. High-energy radiation, subatomic particles, and high-speed debris particles may partially or completely ionize the air they penetrate. The ionization, in turn, may cause absorption and refraction of electromagnetic (EM) waves. Consequently, high-altitude nuclear detonations may have profound effects on the performance of radio communications systems.

Military communications systems use frequencies from VLF to UHF in a variety of propagation modes. Long-distance communications between surface stations and satellites or space vehicles must traverse the ionosphere and may be affected by ionization produced by high-altitude nuclear bursts. Even in the absence of nuclear burst induced disturbances, the changing nature of the normal ionosphere requires consideration of a number of factors such as modulation, power, antennas, noise, and operating frequencies to maintain communications efficiency. Artificially created anomalies in the ionosphere need not necessarily be large to have significant effects.

Electron densities in the ionosphere can be altered either because the total number of electrons present is changed, or because electrons already present are redistributed. Both types of changes are produced by nuclear detonations. Electrons are produced by ionizing emanations from the burst. In some cases, molecular species not normally present may be produced by the detonation, which subsequently leads to anomalous electron loss rates. Various types of traveling disturbances redistribute electrons at great distances from the burst point. Alterations in the ionospheric electron density were studied during Operation Dominic by riometers, ionosondes, and Granger sounders at stations throughout the Pacific during each of the events in the Fish Bowl series.

The Fish Bowl instrumentation to determine nuclear effects on communications covered all frequencies of military interest, but the effort was concentrated on the HF band. During Operation Hardtack, limited measurement indicated that severe communications blackouts existed for long periods after the detonation of Teak and Orange, both in the burst and magnetic conjugate areas. The data available consisted primarily of vertical-incidence soundings at a few points, backscatter soundings, riometer measurements, and magnetometer records. The only data of a real communications nature consisted of logs of various operational circuits. Analysis of these logs indicate that the communication circuits failed shortly after the detonations and remained unusable for many hours. Unfortunately, these records were made at only a few frequencies and without any special test instrumentation.

In the period after Hardtack, requirements for more rapid and precise evaluation of the propagation conditions existing on communications circuits led to the full development by Granger Associates of improved sounder equipment. The Granger oblique incidence, step-frequency sounder system employs a transmitter at one end of the communications path to be studied and a receiver at the other end. The synchronized transmitter and receiver pair are electronically stepped through 160 channels (frequencies) in the band from 4 to 64 Mc in a time as short as 3.2 seconds. Pulses are transmitted on each channel, and the equipment is designed to permit a number of modes of operation by varying the pulses per channel, pulse repetition rate, and pulse width. A program control unit permits a network-type of operation in which a transmitter can serve more than one path, and a receiver can be associated with more than one transmitter.

The use of short pulses allows a determination of such characteristics as mode structure, signal strength, pulse distortion, and multipath propagation. The extremely short scan time permitted a nearly simultaneous study of all the frequencies in the band of interest.

Ionospheric vertical sounding techniques provided a vast amount of information on the structure of the ionosphere. Ionosondes measure the lowest frequency reflected from the ionosphere (f-min) and the critical, or maximum, frequency reflected at vertical incidence. The value of f-min is related to the amount of absorption in the ionosphere; as the absorption increases the minimum observable reflected frequency also increases. The critical, or maximum, frequency reflected at vertical incidence is a function of the electron density, increasing as the square root of the electron density.

The ionosonde is a radar-type instrument which transmits short pulses of RF energy directly overhead and receives echo returns from reflections in the ionosphere. Echoes occur from regions where electron densities are great enough to reflect the RF energy. Typically, the frequency is swept through the range of 1 to 25 Mc in about 15 seconds. Data is obtained by photographing the oscilloscope display of echo returns. This yields virtual height of the reflecting layer as a function of frequency.

6.1.2 Objectives. The primary objective of the communications-effects measurement program was to determine the effects of high-altitude nuclear explosions on communications performance at frequencies of military interest. Measurements to determine communications performance included: attenuation of signals, phase shift of signals, noise, propagation mode structure, multipath propagation, distortion, and ionospheric composition.

The secondary objective of the communications-effects measurement program was to obtain data of a scientific nature bearing on problems not yet clearly defined or of unknown military application. Data obtained will help assess the usefulness of various EM phenomena as detection tools and will help assess the high-altitude detonation as an aid in the study of upper atmospheric processes. Measurements made at ELF and sub-ELF (dc to 3 kc) are considered magnetic in nature for the purposes of this report and are covered in a later section. Table 6.1 lists the frequency bands of interest in military communications.

6.1.3 Instrumentation. VLF noise produced at about 5 kc is attributed to motion of particles released by a nuclear detonation. This noise peaks at 4 to 5 kc and is known to be enhanced during periods of magnetic disturbances. AFCRL (Project 6.5a) operated 5-kc receivers on Samoa, Johnston Island, Ship S-5, Palmyra, Kauai, Canton, and Tongatabu (Tonga).

The EM pulse generated by the detonation was measured by broadband receivers on Johnston Island, Hawaii, Palmyra, and Ship S-3. This pulse peaks at a few kilocycles. Instrumentation included two underwater trailing antenna installations on Navy ships operated near Oahu (Shot Star Fish only). The underwater measurements were obtained to provide information on indirect bomb damage assessment (IBDA) useful to submarine commanders. This project (7.1) was primarily interested in the atmospheric shots at Christmas Island but did obtain data during Star Fish.

VLF propagation instrumentation is shown in Table M.1. Much research has been performed to establish VLF for worldwide communications and as a navigational aid. Fish Bowl instrumentation consisted primarily of receivers and on-site frequency standards (stability of a few parts in 10^{10} per day) to monitor existing VLF transmitters. Measurements of noise, signal strength, and phase changes yield information on the amount and arrival time of D-layer ionization induced by the high-altitude nuclear bursts. Information on service-sponsored measurements using existing operational circuits is not included in this report.

LF propagation instrumentation is shown in Table M.2.

No special instrumentation was fielded for MF measurements. Military operational circuits in this band include the worldwide Loran navigation system (1800 to 2000 kc).

HF propagation instrumentation is shown in Table M.3.

VHF/UHF propagation measurements were made by Project 7.4 using a KC-135 and a B-47 to form a line-of-sight communications link between Johnston Island and Hickam AFB.

HF sounders used during Fish Bowl are listed in Table M.4. These sounders were operated for several weeks before Star Fish and before the events in October and November 1962, to obtain background data.

6.1.4 VLF Results. The high-altitude events of Fish Bowl were not effective in producing significant degradation of VLF communications. However, all events produced a pronounced change in phase of the received signal and some change in amplitude over certain paths. Both absorption and signal enhancement were noted. The change in phase is associated with the decrease in D-layer height, the decrease generally being limited to a reduction in height from 90 km to about 70 km. Typically, the phase of the received signal advanced several hundred degrees shortly after burst. The effects at VLF from the Fish Bowl type of events are most significant if phase information is being used, such as in certain navigational systems.

6.1.5 LF/MF Results. Significant localized effects on both phase and amplitude were noted on LF and MF bands. MF sky modes were generally lost on propagation paths crossing the burst or conjugate area; ground waves were not affected.

On Star Fish, LF and MF circuits crossing the burst auroral regions were unusable for one to several hours. By H+2 hours about half of the circuits were usable, but none of the circuits were completely back to normal until the following night. The 76-kc circuit from Johnston to Hickam was out from H+0 to H+2 minutes. The 46-kc circuit from an aircraft south of Johnston Island was usable after burst at a somewhat reduced signal strength (antenna arced over at burst time for 1 to 2 seconds, cutting off transmission).

Check Mate produced effects at LF and MF, which were very similar to those produced by Star Fish. Loran-C signals (100 kc) through the burst region and passing as far north as French Frigate Shoals showed immediate loss of signal, which lasted for several minutes. Some phase shift problems existed for about 1 hour.

King Fish and Blue Gill produced outages of the Loran-C signal on north-south paths for several hours with King Fish somewhat more effective than Blue Gill. The effects produced on other LF and MF circuits were less pronounced than for Star Fish.

Tight Rope produced no significant effects in the LF and MF bands.

6.1.6 HF Results. At HF, the ionospheric absorption, traveling disturbances in the F-region, synchrotron noise, and spurious reflections affect communication circuits.

However, actual circuit outages due to the events were less extensive and of shorter duration than had been anticipated. The use of oblique sounder technique, which can rapidly identify usable frequencies and optimum routing, can to a large extent overcome the effects noted after the Fish Bowl types of bursts. Data obtained during Fish Bowl will permit a refinement of ionospheric reaction rates, which may permit better scaling of communications effects from nuclear detonations.

The HF blackout problem, however, has not been resolved by the Fish Bowl tests; changes in weapon orientation, use of multiple bursts, detonations under daytime conditions or at extreme altitudes (above 1,000 km) may well induce alterations to the ionosphere sufficient to blackout HF communications for thousands of miles for many tens of minutes after burst.

Star Fish blacked out HF communications circuits for 1 to 4 minutes through the burst and conjugate regions. Attenuation was noted in both magnetic conjugate areas for 12 hours. One path, Kauai to Midway, was affected for 2 days. Star Fish caused frequency selection problems, but did not seriously degrade communications effectiveness.

Check Mate effects resembled those of Star Fish, but were greatly scaled down in spatial extent. Only paths within 700 km of Johnston Island were significantly affected.

The effects from King Fish were delayed up to 1 hour on some paths. Immediate attenuation was noted on signal paths within 2,500 km of Johnston Island, but severe attenuation was limited to paths within 500 km of the burst point. F-layer depletion in the northern area started at H + 25 minutes and resulted in poor communications for the rest of the night.

Blue Gill and Tight Rope produced significant effects at HF only, on paths through the burst region. Unlike Star Fish, Check Mate, and King Fish, no bomb-created modes of propagation were observed. In summary, from an HF communications standpoint, the effects of Blue Gill and Tight Rope were minor.

6.1.7 VHF/UHF Results. Line-of-sight propagation paths that did not cross the D-layer (or the fireball) were not affected by the Fish Bowl events. The aircraft UHF communications link between Johnston and Hickam AFB suffered no degradation from any of the shots. The DCA Midway to Kauai ionospheric scatter circuit (53 Mc) was adversely affected for 21 minutes by King Fish, 30 seconds by Star Fish, and 20 minutes by Check Mate.

6.1.8 Ionosonde Results. Prompt absorption effects were observed at all ionosonde stations following Star Fish, Check Mate, King Fish, and Blue Gill. These events also caused traveling disturbances in the F-region over a large portion of the Pacific Ocean. Tight Rope produced no noticeable effects except at the ionosonde located at Johnston Island.

The changes in the ionosphere resulting from Star Fish were greatest at stations located near the magnetic meridian passing through the burst point. The greatest duration of total blackout, approximately 85 minutes, occurred at French Frigate Shoals. Following this total blackout, a large amount of absorption persisted for several hours, and only weak echoes from the F-region were observed.

At Tonga and at the north conjugate point near French Frigate Shoals, an extended period of blackout was also observed following Star Fish. At H + 51 minutes, weak returns from high in the F-region were observed. The value of f-min at H + 80 minutes was near 8 Mc, decreasing to 2 Mc at H + 3 hours, a value only 1 Mc above preshot conditions.

At Tutuila (Samoa), very dramatic ionospheric effects were also observed after Star Fish. Total blackout lasted only for a few seconds. The value of f-min, although exceeding 12 Mc for a short time, did not cause a blackout beyond the initial 6 seconds as critical frequencies in the F-region increased concurrently to values greater than the 20 Mc (upper limit of the ionosonde); thus, communications circuits having reflection points in this region would have suffered only temporary interruption. The value of f-min dropped very rapidly from the initial high value to within 1 Mc of its preshot value by H + 10 minutes. The critical frequency, however, remained very high. It is interesting to note that the ionization created over Tutuila following Star Fish was on the order of 4 times the maximum value that exists at noon on a normal July day. The increase of F-region critical frequency from 4 Mc to more than 20 Mc indicates a greater than 25-fold increase in electron density.

Star Fish produced perturbations in the ionosphere in the equatorial region over Canton Island which, while significant, were much less than observed at other ionosonde stations along the magnetic meridian. Blackout occurred for only a little over a minute after burst. No F2-layer effect was observed until about H + 7 minutes, when the critical frequency began to increase, rising to a value of 11.5 Mc at H + 20 minutes. This increase of critical frequency corresponds to an increase in electron density of more than 2.5 times that which existed prior to the detonation.

The effects observed at Maui, Midway, Kwajalein, and Wake were smaller in magnitude than at the stations discussed previously.

At Johnston Island, Star Fish caused complete absorption for several minutes. At H + 24 minutes, a new layer formed, which had a critical frequency range of 10 to 15 Mc at heights from 400 to 550 km. A considerable spread effect was noted. The layer density increased with time, and the highest frequency was greater than 25 Mc; f-min was observed to be 5 Mc. At sunrise the following morning, f-min remained at a higher-than-normal value. The F-layer critical frequency was considerably lower than normal.

Check Mate, King Fish, and Blue Gill caused prompt absorption effects at all ionosonde stations. These events also produced traveling disturbances in the F-region over a large portion of the Pacific Ocean. The delayed effects noted were greatest following King Fish, but these were still considerably less than the effects noted after Star Fish. The overall effect of Check Mate and Blue Gill tended to be about equal. However, the principal traveling disturbance was located higher in the ionosphere (mainly above the peak electron density of the F-region) for Check Mate than for Blue Gill. Following King Fish, daytime f-min was higher than normal at Maui, French Frigate Shoals, Tutuila, and Tonga. Blue Gill was followed by abnormally high daytime f-min at French Frigate Shoals, Canton, Tutuila, and Tonga. On Johnston Island, complete blackout was observed for 45 seconds after Check Mate, 2 hours after King Fish, and 3 hours after Blue Gill. Blackout on Johnston Island was followed by abnormally high f-min and critical frequency for the remainder of the nights following these three events.

Tight Rope produced effects detectable only in the Johnston Island area.

6.2 RADAR EFFECTS

6.2.1 Background. One of the more significant military effects of nuclear detonations at high altitudes is the degradation of radar system performance. Experimental data is urgently needed to design defense systems which will be effective (in a nuclear environment) against ballistic missiles. Information gained on the defense problem is applicable to the complementary offensive problem of ballistic missile penetration. Present and proposed defense systems require radar early warning, acquisition, discrimination, and high-precision target tracking on incoming reentry vehicles.

The detonation of nuclear devices at high altitudes produces complex phenomena dependent not only on yield, altitude, and fission-to-fusion yield ratio, but also upon weapon orientation, burst location with respect to the earth's magnetic field, and the time of day. The ionizing radiation and ionizing particles from the detonation produce wide-scale effects. In addition, the fission products are a significant continuing source of ionization that remains effective for many hours.

Typically, radar search systems operate in the UHF band (300 to 3000 Mc) and tracking and guidance radars in the lower part of the SHF band (3000 to 10,000 Mc). Even short periods of degradation of these frequency bands induced by high-altitude nuclear bursts may seriously affect system performance. Degradation of surface and air search radars whose propagation paths do not traverse the ionosphere can result from backscatter and EM noise produced by a nuclear detonation.

6.2.2 Objectives. The general objective of the radar measurements program was to obtain data on the magnitude, duration, and spatial extent of burst-induced EM noise, radar clutter, signal refraction, and attenuation at commonly used radar frequencies.

RF noise is an important parameter in any radar system in that it determines the minimum signal that can be detected, and hence, the maximum range of detection for a given target. The objective of the noise measurement program was to determine the EM energy incident upon radiometer antennas on Johnston Island and on the USAS American Mariner (DAMP ship).

The objective of the clutter measurement program was to assess the military significance of the radar reflection phenomena of high-altitude nuclear detonations. Specifically, the objective was to determine, as a function of time, the strength, position in space, and variation as a function of frequency, of the radar reflections associated with the burst region, auroral display occurring in the magnetic conjugate areas, and tube of ionization passing overhead at the magnetic equator.

Following a high-altitude nuclear explosion, the refractive index of the atmosphere is modified by the sudden increase in air temperature and by the change in the density and distribution of electrons. This may cause the paths followed by EM waves to differ from those in the normal atmosphere. Also, the apparent angle of arrival of the return signal may fluctuate, because the signal crosses regions of time-varying refractive index, so that tracking would be extremely poor or even impossible. Both of these effects were investigated on paths through and near the burst region, and on paths through other regions of high electron density, at frequencies of 1000 to 10,000 Mc.

The objectives of the attenuation measurements program were to measure: (1) one-way attenuation of CW RF signals at 1000, 5000, and 10,000 Mc through the fireball and its near vicinity as a function of time, (2) one-way attenuation of a C-band (5775 Mc) signal through the burst region and through other regions of high electron density as a function of time, (3) attenuation of RF signals passing through the D-, E-, and F-layers of the ionosphere at selected frequencies between 37 and 1800 Mc as a function of time and space, (4) electron line density as a function of time and space, and (5) electron density as a function of time and space.

6.2.3 Instrumentation. Burst-induced radar noise was measured during all five Fish Bowl events by the instrumentation listed in Table N.1. The location of the DAMP ship for each event is shown in Appendix D.

Radar clutter was observed during all five Fish Bowl events by the instruments listed in Table N.2. The ships and aircraft carrying clutter instrumentation are also listed in Table N.2. Figure 6.1 is a photograph of the 86-foot-diameter antenna at Johnston Island, used by SRI in Project 6.9.

Radar refraction and refractive jitter were measured on all five Fish Bowl events by the instrumentation listed in Table N.3. Figure 6.2 is a photograph of the DAMP ship. Rocket-firing schedules for Projects 6.1 and 6.13 are given in Appendix F.

Attenuation at radar frequencies was measured directly on all five Fish Bowl events by instrumentation listed in Table N.4. The location of ships used as receiving stations is shown in Appendix D. The general experimental plan for obtaining data on attenuation is shown in Figure 6.3.

Measurements of electron line density and electron density were accomplished by instrumentation listed in Table N.5. Figure 6.4 is a photograph showing four Project 6.13 Nike-Apache rockets equipped with C-band beacons on Johnston Island. Figure 6.5 is a photograph of the Project 6.1 shipboard antenna system.

6.2.4 Results, Noise. The data obtained on the Fish Bowl events is adequate to determine directly the amount of noise injected into radar and communications antennas by such bursts. The function of altitude and yield in determining the amount of radar interference may also be deduced from the data. A typical radar receiver with a noise figure of 3 db corresponding to internal noise of 290° K would be subjected to a 30-fold increase in the noise background level for a short time by the Check Mate burst. On the other hand, Star Fish produced only a small amount of noise jamming. Further analysis of the radiometer data will permit calculations of: added noise arising from the burst region, attenuation through the fireball, temperature of the fireball, and electron density in the disturbed region.

The highest antenna temperatures were observed for Check Mate, with a maximum of 9,000° K at S-band. Smaller antenna temperatures nearly proportional to the burst altitudes were measured for King Fish, Blue Gill, and Tight Rope. As expected, the duration of the signals was shortest at K_a-band (35,000 Mc) where the average duration was 30 seconds. The excess antenna temperatures at S- and L-bands lasted approximately 10 times as long as those at K_a-band. The peak temperatures did not appear to be a strong function of the weapon yield as had been previously expected.

Selected raw data on maximum excess temperature is tabulated in Table 6.2. This data has not been corrected for the burst size relative to the antenna beam size. The approximate duration of the excess temperature is shown in Table 6.3.

Such increases in noise can degrade radar performance. The actual reduction in signal-to-noise ratio for any particular radar system requires a detailed analysis of the individual system characteristics.

6.2.5 Results, Clutter. A very good correlation was found to exist between the spatial extent of radar clutter from the burst region and the visual effects. Table 6.4 shows the duration of this clutter as measured by SRI on Johnston Island. Star Fish produced no significant burst region clutter and is not included in the table.

The DAMP ship also obtained data on burst region clutter at C-, L-, and UHF-bands.

The SRI radar on Johnston Island observed echo signal-to-noise ratios considerably in excess of 30 db (echoes were saturated). These echoes were observed on radars with sensitivities of about 40 db less than the sensitivity of radars planned for use in ballistic missile defense applications. Thus, the echoes observed would be seen with signal-to-noise ratios in excess of 70 db on future ballistic missile defense systems radars and would make it difficult to track a reentry vehicle in the burst region. In addition, these echoes are sufficiently intense to be seen in the side lobes of such radars when tracking targets outside the burst region.

A preliminary investigation of the echo amplitude characteristics showed that the burst area echoes at all three frequencies saturated to some degree within the first 60 seconds. The onset of echoes usually occurred a few seconds after burst; absorption at very early time was sufficient to black out any echoes. For Blue Gill, the 1210-Mc echoes first appeared at H+3 seconds, the 850-Mc echoes appeared at H+5 seconds, and the 398-Mc echoes appeared at H+8 seconds.

The existence of radar clutter from the vicinity of high-altitude nuclear detonations has now been established. Previous effects tests and predictions have suggested that such burst-region clutter might be seen, but the fact that it was seen so early and for so long a time is of great importance to ballistic missile defense radar design.

Energetic beta particles and ioniz d debris, confined by the geomagnetic field, travel to the conjugate points producing radar clutter, auroras, and absorption in those areas as they reenter the atmosphere. Extensive field-alined radar clutter from Teak and Orange was observed during Hardtack. Much of this bomb-produced clutter is believed to be due to ionization that becomes alined with the earth's magnetic field into long columns, which scatter anisotropically. Field-alined ionization is by no means the entire story; absorption, localized debris cloud, shock waves, and other traveling disturbances complicate the picture so that no single radar location, or single frequency, is adequate to separate the effects observed and to resolve the uncertainties. During Fish Bowl, long-lasting, field-alined auroral clutter was observed in both the Northern and Southern Conjugate Areas after Star Fish, Check Mate, and King Fish.

The ionospheric clutter formed in the Southern Conjugate Area was found to be quite restricted in spatial extent at early times. To observe this clutter, the radar must be directed to a point approximately 75 km in altitude and down range sufficiently to look perpendicular to the field lines. The clutter area appears to expand after tens of seconds, and at late times can become quite widespread. Observations in the Southern Conjugate Area indicate that a systematic error exists between the conjugate point calculated using Finch and Leaton coefficients (Monthly Notices, R. Astron. Soc., Geophys. Sup., Vol. 7, pp 314-317, 1957) for 48-term expansion of the magnetic field and the observed conjugate point. This error is about $^3/_4$° latitude from the true conjugate point located south of the calculated point. No error in longitude was noted.

The field-alined clutter in the Northern Conjugate Area was observed for several hours after Star Fish, Check Mate, and King Fish. Echoes at 400 Mc persisted considerably longer than at the higher frequencies. The overall significance of this clutter in relation to ballistic missile radar systems must await further data analysis.

The Canton Island 27-Mc radar received echoes from the tube of ionization and/or debris connecting the burst region and the magnetic conjugate region on all tests except Tight Rope.

6.2.6 Results, Refraction. A very considerable body of data on refraction of radar signals was obtained by Projects 6.1 and 6.13. Much more data reduction and analysis is required to assess the significance of refraction and refractive jitter measured during Fish Bowl. Figure 6.6 shows the periods of time around H-hour during which rocketborne beacons and transmitters were aloft and operating. No gross refraction of radar signals was readily apparent from a preliminary analysis of the data. However, it appears that refractive jitter may be a severe problem under some conditions. On Blue Gill, Project 6.13 encountered severe angular jitter between H+318 seconds and H+348 seconds and actually lost track due to jitter at H + 546 seconds. On King Fish, track loss at H + 321 seconds has been tentatively attributed to angular jitter.

Initial radiations from high-altitude detonations caused widespread ionization for 1 to 2 seconds, which induced tracking scintillations at a frequency as high as 20 cps. This prompt effect adversely affects radar tracking capability and makes target discrimination more difficult. Effects at later times depend upon the location of debris and other regions of intense ionization.

6.2.7 Results, Attenuation. Radar signals from rocketborne transmitters also provided one-way path attenuation information during the periods of time around H-hour shown in Figure 6.6. Test results indicate that the fireball is opaque to radar frequencies for 40 to 60 seconds after burst. Figure 6.7 is an example of the type of data obtained. The figure shows the AGC (automatic gain control) record obtained on Ship S-3 during Blue Gill for X-, C-, and L-band frequencies. The rocketborne CW transmitter from which the data was obtained was launched from Johnston Island at H−112 seconds. As viewed from Ship S-3, the transmitter was behind the fireball at burst time and remained behind the fireball for at least 150 seconds.

Star Fish was not effective in degrading radar system performance. No intensive absorption of the type that would affect radar propagation persisted for more than a few seconds. No debris pancake was formed. There were no intense clutter effects at radar frequencies.

No fireball attenuation measurements were made on Check Mate. The burst-produced ionization did not prevent track of a C-band beacon by Project 6.13, but careful data analysis will be required before extrapolation can be made to other frequencies and other types of tracking systems. Radio noise and long-lasting UHF auroral clutter tentatively appear to be more effective in degrading radar than attenuation at the Check Mate yield and altitude.

The King Fish burst would have caused considerable reduction in sensitivity of any radar attempting to track a target through the fireball region. At L-band, the attenuation would have been in excess of 114 db for 16 seconds decreasing to 30 db between H + 16 and H + 39 seconds. The actual reduction in overall defensive effectiveness would depend critically upon the actual radar. The King Fish burst also produced a beta patch that may have remained stationary for as long as 30 seconds before moving northward. Severe attenuation through this beta patch at both C- and L-bands was observed for 40 seconds after burst. It is concluded that the occurrence of a King Fish burst in the locale of a ballistic missile defense radar would seriously degrade its performance for appreciable lengths of time.

The most serious effect of Blue Gill was the fireball blackout. X-band attenuation exceeded 30 db for 40 seconds with recovery at H + 80 seconds; C-band attenuation was greater than 52 db for 40 seconds with recovery at H + 90 seconds; L-band attenuation exceeded 47 db until H + 65 seconds with recovery at H + 107 seconds. In addition, gamma-, X-ray-, and beta-induced ionization produced blackout outside of the fireball, which caused very large L-band attenuation until H + 60 seconds to distances of 15 to 20 km from the fireball center. A more extensive ionized region out to at least 50 km caused severe attenuation at 37 Mc for more than 30 minutes. It is difficult to imagine a ballistic missile defense system in which such performance degradation could be tolerated. The Blue Gill burst, in addition to causing fireball blackout, also degraded radar performance by producing extensive long-lasting radar clutter (to H + 25 minutes at UHF), by causing angular tracking errors, and by producing an increase in background noise.

The Tight Rope detonation produced a well-confined fireball that was opaque to radar frequencies. Strong reflections from the fireball were observed for 4 minutes after burst.

Fireball attenuation is most difficult to determine without extensive data analysis because of the tight geometry associated with the small (0.7-km radius at 10 seconds) fireball, but it is known that X- and C-band frequencies were blacked out or highly attenuated on paths through the fireball for 7 to 17 seconds after burst. Severe L-band attenuation through the fireball is believed to exist for times up to 1 minute after burst. There is not enough information yet available to translate these times into a solid angle of the absorbing region, but the absorption is certainly sufficient in both time and space to be of some concern to ballistic missile defense radars.

6.3 DEBRIS HISTORY

6.3.1 Background. The dispersion of nuclear debris deposited in the upper atmosphere as a result of a high-altitude detonation depends markedly upon the height of burst. Debris distribution will be affected by the magnetic field, high-altitude winds, and diffusion processes. It is useful to determine the location of this debris as a function of time in order to arrive at a better understanding of the phenomena of high-altitude detonations and their effects. In addition to direct measurements, the location of debris may be inferred from effects measurements obtained by such instruments as vertical and oblique sounders, riometers, and clutter radars. Photography and spectroscopy also yielded data bearing on debris history; the data is presented in Section 6.6.

Project 6.7 rocketborne magnetometers, beta detectors, mass spectrometers, gamma detectors, faraday cups, and photometers gathered information on early debris history in the immediate burst region. Project 6.5b balloonborne gamma and neutron detectors made measurements in the Southern Conjugate Area. Gamma detectors in aircraft mapped debris in the burst and conjugate regions. Optical resonance scattering techniques were used by Project 6.6 for detection and tracking of debris at selected Pacific sites, and Project 6.12 satellite observations attempted to perform a worldwide survey for evidence of fission debris.

Following the radiative phase of a nuclear detonation, about 25 percent of the bomb yield remains in the form of hydrodynamic energy of the debris. The debris then expands until brought to rest by the surrounding medium. For lower altitude shots, the fireball and debris rise and expand. The hydrodynamic streaming of the air around the fireball causes an upwelling of air at the bottom of the fireball that eventually converts it into a toroid. This interaction imparts a lateral velocity to the fireball, and the debris is spread out horizontally. For higher altitude shots, radioactive decay of the fission debris provides relativistic electrons, which may be guided to the opposite hemisphere by the geomagnetic field. Those beta rays that mirror at altitudes above about 200 km will drift eastward. However, because of the scattering at the mirror points, betas may drift only a short distance to the east before they are removed.

The low atmospheric density at the altitude of Star Fish permitted the debris to expand to great distances. At early times, the primary interaction was with the geomagnetic field. If the debris is highly ionized, it excludes the magnetic field from its interior as it expands, forming a bubble in the magnetic field. The larger the fraction of debris that is ionized, the greater the energy available to interact with the magnetic field and the larger the bubble. As the magnetic pressure outside the bubble increases, the ionized portion of the debris is slowed and finally stopped when the magnetic pressure equals the material pressure. The neutral portion of the debris is not affected by the magnetic field and continues to expand.

The high-altitude Fish Bowl shots provided an opportunity to verify experimentally (or refute) various theoretical models of detonation phenomenology as related to the ultimate fate of the debris.

6.3.2 Objectives. The objectives of the debris measurements program were to determine: (1) interaction of the debris with the geomagnetic field, (2) state of ionization of the debris as a function of time, (3) flux of gamma and beta radiation from the debris as a function of time, (4) extent of electron trapping by the geomagnetic field, (5) location of the debris as a function of time, (6) density of selected nuclear debris constituents over a wide geographical area as a function of time, (7) processes (i.e., diffusion, magnetic guiding, wind transport, turbulence) that act to distribute the debris and the relative importance of each, (8) amount of ionized debris guided to the conjugate area by the geomagnetic field and the debris arrival time, (9) ion density by species in the burst region, and (10) intensity and spectral distribution of aurora.

6.3.3 Instrumentation. The instrumentation employed to determine debris history is listed in Table 6.5.

The Project 6.5b balloonborne gamma detectors and neutron counters were released from Samoa and from a ship in time to drift to the approximate conjugate point and be at 100,000-foot altitude at burst time. Preburst flights were made to obtain background data; postburst flights were also made to determine long-term effects.

Project 6.5b photometric and photographic instrumentation consisted of six tricolor photometers, five all-sky cameras, two time-of-arrival photometers, two camera spectrographs, and two 35-mm cameras.

Project 6.6 used both birefringent and four-barrel interference photometers. In both types of instruments, photomultipliers with high cathode efficiency and filters were used. Four-barrel photometers were used at Johnston Island and on Ships S-2 and S-4; birefringent photometers were located on Ship S-1, French Frigate Shoals, Tutuila, and Tongatabu.

The Project 6.10 gamma-ray spectrometer was installed in the project KC-135, which operated in the Southern Conjugate Area at an altitude of about 40,000 feet. At this altitude, the atmosphere above the aircraft causes 5 to 10 scatterings of gamma rays in the 0.5- to 1.0-Mev energy range. Gamma rays in the 4- to 5-Mev range undergo only two or three scatterings with much less degradation of energy. Suitable calculations are required to properly interpret the measured energy spectrum.

Project 6.8 used riometers to measure ionospheric absorption and synchrotron radiation. The riometer, or relative ionospheric opacity meter, was originally developed for the International Geophysical Year (IGY) by Little and Leinbach at the Geophysical Institute, College, Alaska. Riometer stations operating at frequencies of 20, 30, 60, and 120 Mc were established at various distances and directions from ground zero. Other stations were located about the conjugate points. Twenty-two sites (Table 6.5) were chosen for riometer locations. Following installation, in May 1962, the equipment was kept in continuous operation so that typical quiet-day curves for each area could be obtained. By measuring the intensity of cosmic noise received at the earth's surface with riometers, the variations in ionospheric absorption at various frequencies with respect to time after detonation and distance from burst point could be determined.

Project 6.7 launched five rockets for Star Fish and two for Check Mate to study magnetic containment of debris. Trajectories for the Star Fish rockets are shown in Figure 6.8 and listed in Table 6.6. All project rocket payloads were identical. The complete payload weighed 433 pounds and was 26 inches in diameter and 52 inches long. Instrumentation in the payload is listed in Table 6.7. Data was telemetered to receiving stations on Johnston Island, Canton, French Frigate Shoals, Oahu, and Hawaii.

Projects 6.2 and 6.3 launched rockets from Johnston Island during Star Fish, King Fish, and Blue Gill. Project 6.4 had instrumentation in some of the rockets for Star

Fish and King Fish. The rocket-firing schedules and types of measurements are given in Appendix F.

Project 6.12 attempted to investigate the spread of fission debris around the earth with specially designed research packages on Discoverer satellites. Because of the schedule slippages encountered in attempting the nuclear detonations, the project was not able to obtain data during the time of primary interest.

6.3.4 Results, Shot Star Fish. The Star Fish debris was not confined locally, and there are indications that more than half of the debris was ultimately deposited in the Southern Conjugate Area. The initial expansion of the debris had a velocity asymmetry of about 3 to 1 with the initial velocity being about 2,000 km/sec horizontally and about 700 km/sec vertically. The initial excursion of the debris in the downward direction was less than 200 km. The Project 6.2 gamma ray scanner was not able to map the burst region debris contours, because the detectors were saturated by bremsstrahlung radiation. Project 6.6 photometers observed lithium at all stations. Stations in the Johnston Island area noted a maximum concentration of lithium during the first twilight. At Tutuila, the maximum concentration of lithium was observed during the third twilight. Barium, ionized barium, and zirconium were detected only from Johnston Island and the close-in stations. Reduced concentrations of debris were measured during the 2 weeks following the event. The data obtained will permit a calculation of specie density contours.

Gamma ray mapping by U-2 aircraft several hours after burst indicated that the debris concentration in the Northern Conjugate Area was 10 times greater than in the burst region. A gamma ray counter in the Project 6.10 aircraft in the southern area indicated that the debris was centered about 200 miles west of the true conjugate point and that about 50 percent of the Star Fish fission debris was deposited in the southern hemisphere. The debris appeared to have a very sharp northern boundary and a diffused southern boundary. The Project 6.5b balloonborne gamma ray detectors obtained data that, on preliminary analysis, indicates that substantially more than half of the Star Fish debris was deposited in the Southern Conjugate Area.

Riometer records following Star Fish are difficult to interpret because of synchrotron radiation. In general, noise exceeded the attenuation at riometer stations within 20° of the magnetic equator; varying amounts of attenuation were observed elsewhere. Some debris did remain below the burst, with a maximum density at about 300-km altitude at about H + 25 minutes. Very little debris was below 150-km altitude at this time. This shows that, at least in the downward direction, very little debris became neutral at early times. A nonuniform pattern of debris below the burst point is indicated by a second maximum in attenuation measured at several riometer stations. This debris could be toroidal in shape with a radius of about 150 km.

The geographical distribution of delayed attenuation is consistent with containment of charged debris by the geomagnetic field, yielding areas of strong attenuation at each end of those field lines passing through the burst point. These areas were about six times longer along the magnetic field than across it. The attenuation observed in Alaska indicated that an appreciable fraction of the debris must have risen to several thousand kilometers above Johnston Island. However, there is no indication that a significant quantity of debris escaped from the earth.

Synchrotron radiation showed that an artificial belt of electrons, trapped in the magnetic field, was produced by Star Fish. There was an intense burst of synchrotron noise, peaking within 5 minutes after detonation, detected at sites along the magnetic field line within 23° from the magnetic equator. About 25 percent of the electrons producing noise in this burst made at least one drift around the world. There was a second maximum in noise that followed the first maximum by 22 to 23 minutes. A third maximum was detectable on several riometers. At Huancayo, Peru, the fourth maximum was also observed. This indicates that the electrons remained partially bunched for several passes around the world.

6.3.5 Results, Shot Check Mate. The initial size of the Check Mate fireball

remained nearly constant for several minutes after the detonation. After the initial fireball formation, the fireball rose as a whole and elongated along the magnetic field. The debris rose to approximately 250-km altitude and spread into long streamers along the magnetic field, slowly forming an arc that stretched all the way between the conjugate points. The main part of the northward-moving debris stopped within a few minutes. The debris also drifted eastward as a unit with a velocity of 100 to 150 km/hr for the first few hours. An estimated 5 percent of the debris was deposited in the Southern Conjugate Area.

Photometers on Johnston Island detected ionized barium from 180-km altitude down to about 100 km. Below 100 km, the barium had probably recombined. Neutral barium, lithium, and zirconium were also detected at Johnston Island. No debris was detected by photometers in the Southern Conjugate Area. At the second twilight (H + 21 hours), ionized and neutral barium were still present at Johnston Island; however, there had been a marked decrease since morning, and at succeeding twilights all species were below threshold.

Immediate attenuation was observed by the riometer stations within 900 km of Johnston Island and by the M/V Acania at the southern conjugate point. Delayed attenuation was experienced at stations in the burst area and along the magnetic meridian north of the burst point. The delayed attenuation at Ships S-4 and S-7 and the DAMP ship is consistent with what would be expected from fission debris rising to an altitude of 200 to 300 km. The DAMP ship riometer noted the beta patch sweeping across the antenna as the debris rose. Except for the immediate attenuation noted by the Acania, no southern hemisphere riometers observed effects from Check Mate.

Trapped beta electrons from the Check Mate burst were very quickly lost by collision. Riometer stations along the magnetic meridian through the detonation point recorded excess noise for a short time. However, no synchrotron radiation was noted at Christmas Island, Palmyra, or any station to the east of the detonation.

6.3.6 Results, Shot King Fish.

By 90 seconds, the fireball was primarily growing along the magnetic field lines. Early instabilities in the expansion were not apparent, and no jetting of debris occurred.

Riometers observed immediate attenuation in the northern region between Johnston Island and French Frigate Shoals. Delayed attenuation measured at riometer stations north of the burst point is consistent with a rising debris cloud that deposited debris along geomagnetic field lines above an altitude of 350 km. The decrease of attenuation is very closely proportional to $t^{-1.2}$, indicating that the debris did not continue to expand. The bulk of the fission debris was deposited at the base of those magnetic field lines lying between 400- and 700-km altitude above ground zero. Riometer records also indicate a low-lying debris region (100- to 150-km altitude) containing perhaps 10 percent of the debris that expanded to a radius of about 200 km within 15 minutes.

The gamma ray counting rate as measured by the U-2 aircraft at H + 6 hours was greater by a factor of 40 at French Frigate Shoals than at ground zero. Measurements of gamma ray intensity in the southern hemisphere indicate that only a very small fraction of the fission debris was deposited in the Southern Conjugate Area.

No significant quantity of long-lived betas were trapped in the geomagnetic field. The artificial electron belt loss rate was exceedingly high. Peru recorded an increase in noise of 10 percent above background at H+11 minutes, but there is no indication of further eastward movement of the belt.

6.3.7 Results, Shot Blue Gill. The behavior of the Blue Gill fireball was reasonably consistent with preshot predictions. Initially, a well-defined fireball was formed, which grew to a radius of several kilometers in a few seconds.

A luminous cloud, presumably the bomb debris, was observed within the fireball. This cloud rose relative to the fireball as a whole, eventually pushing through the top of the fireball and spilling down the sides. Still later the cloud evolved into a torus which continued to rise to an altitude of about 80 km, at which time vertical motion ceased.

The debris from Blue Gill was contained by the atmosphere, with late-time motion being determined primarily by wind patterns, and with no significant influence by the magnetic field. The debris moved at a velocity of about 100 km/hr, on a heading of approximately 70°. No neutrons, delayed gamma rays, or resonant scattering from debris were detected in the southern hemisphere, indicating that all the debris remained in the burst area as was anticipated. The balloonborne gamma detectors in the Southern Conjugate Area did observe a sharp increase in background count, but the energy distribution indicates that this count is due to bremsstrahlung from betas. Birefringent photometer data from Ship S-1 (located in the Johnston Island area) shows that there was a very small trace of ionized barium and a small amount of neutral lithium from 130 km down to 90 km at the first morning twilight. At the second twilight, a reduced amount of lithium was observed. No other photometer stations detected any debris.

At Johnston Island, riometer measurements were made on 30, 60, and 120 Mc. The maximum attenuation observed was 15 db. The attenuation decreased to 7.8 db at about H+7 minutes. A further slight decrease in attenuation to about 7.6 db occurred between H+7 and H+13 minutes, after which it increased to 7.8 db by about H+20 minutes. After H+50 minutes, the attenuation decreased monotonically to 3 db at about H+85 minutes. Recovery was complete by H+4.5 hours.

Similar results were observed on 60 Mc, where the maximum attenuation observed was 18 db. The initial fast recovery rate lasted until H+3 minutes, when the attenuation had fallen to 6.5 db. A minimum of 3.2 db was observed at H+7 minutes. An increase to 4.8 db followed, and the attenuation remained at this value until H+32 minutes, when recovery began. By H+45 minutes, the attenuation had fallen to 3 db, and the return to normal was completed by H+3.5 hours. The maximum attenuation observed on 120 Mc was about 2 db. This had decreased to 1 db by H+5 minutes, and then slowly decreased to an unmeasurable value by H+65 minutes.

The initial blackout and relatively fast recovery appear to be caused by prompt gamma-ray ionization, together with a contribution from prompt neutrons and beta rays. The decrease in rate of recovery probably corresponds to the onset of a significant beta-ionization contribution. As the debris cloud spreads and covers a greater fraction of the riometer antenna pattern, the observed attenuation tends to increase. At the same time, the overall beta activity is decreasing as $t^{-1.2}$, tending to decrease the attenuation. For a while, the opposing tendencies nearly balance, and the attenuation remains essentially constant. Finally, the beta-ionization region has completely covered the antenna pattern, and the attenuation decreases with the decaying beta activity.

Riometers aboard Ships S-1 through S-4, located near ground zero, observed effects very similar to those on Johnston Island. In the Southern Conjugate Area, no attenuation was observed at any site except at Samoa, and on the ships Acania and Hifofua. The Acania reported prompt 100-percent absorption on 30 Mc with recovery to 3 db by H + 2 minutes. The prompt blackout was probably caused by Compton electrons following the field lines to the conjugate point. Ships S-6, S-7, and S-8, located 420 to 485 km north of the burst point, observed prompt attenuation of 8 to 3 db at 30 Mc but no delayed attenuation. French Frigate Shoals, at 875 km from the burst point, was the most distant station to report any prompt attenuation. The fact that no delayed attenuation was observed on the DAMP ship (135 km north of ground zero) until H + 60 minutes supports the conclusion that the debris did not go much above 100 km.

Blue Gill produced no trapped betas and so no synchrotron noise.

6.3.8 Results, Shot Tight Rope. The Tight Rope debris was contained locally. The fireball formed a torus between 10 and 20 seconds.

The fireball rose to a maximum altitude of 30 to 40 km. Soon after this, the debris location was governed by the atmospheric mass motions. By H + 3 to H + 4 hours, the debris was still over Johnston Island with a windblown tail at 270° true. By H + 18 hours, the debris had been blown 500 km at about 290°. By D + 1 day, the debris had settled well into the atmosphere, probably at an altitude lower than that of the burst point.

Photometric observation of resonant scattering was made from Ships S-1, S-2, and S-4, and at Johnston Island, Tutuila, Tonga, and French Frigate Shoals. No debris, not attributable to the previous King Fish event, was detected. A balloonborne gamma ray detector in the Southern Conjugate Area detected no effects.

Riometer stations within 10 km of ground zero observed immediate attenuation of 3 to 6 db at 30 Mc. Immediate attenuation was observed out to 100 km but not to 200 km from ground zero. The Acania riometer, in the conjugate area, noted an immediate 1-db attenuation at 30 Mc, presumably caused by neutron decay electrons and Compton electrons guided to the area by the magnetic field. No other riometer stations in the southern hemisphere detected any effects. Delayed attenuation due to debris-induced ionization was recorded by stations near the burst point. Recovery to normal background occurred within 10 minutes.

6.4 WEAPON OUTPUT AND KILL MECHANISMS

6.4.1 Prompt Neutron Measurements. Measurement of neutron fluxes from high-altitude detonations was first attempted during Operation Hardtack; however, equipment problems limited the data obtained. The Fish Bowl series presented an opportunity to measure prompt neutron flux and spectrum close to high-altitude bursts using a proven detector system.

The objective of Project 2.1 was to measure neutron flux as a function of distance from high-altitude nuclear detonations.

The instrumentation consisted exclusively of the Nuclear Defense Laboratory (NDL) threshold detector system. This system consists of a series of materials activated through capture of, or fission by, neutrons with energies above a threshold energy, as listed in Table 6.8.

It should be noted that U^{235} and Pu^{239} do not possess natural thresholds; however, by the use of a B^{10} shield, an artificial cross section can be produced. Four complete detector systems were located on the backplate of each of the three pods flown on Thor Fish Bowl events. After recovery, the neutron packages were removed from the pods as soon as possible and taken to a project mobile laboratory for analysis. Scintillation counting techniques were used to measure activities induced in the various detector materials from which the exposure fluxes were calculated.

Table 6.9 presents the data on the average neutron flux measured. The Star Fish pod at 8.4 km had an orientation nearly nose-on to the burst with the mass of the pod interposed between the detectors and the burst. On King Fish, only the detectors from the close-in pod were recovered.

Neutron flux measurements for Star Fish, Blue Gill, and King Fish must be considered successful, although shielding factors caused by pod misorientation complicated final data corrections.

6.4.2 Prompt Gamma Measurements. Early predictions of the effects of nuclear weapons detonated at high altitude led to gamma measurements during Operations Teapot and Hardtack. Since these operations, considerable interest has been generated in the effects of prompt radiation from high-altitude bursts on the guidance systems and electronic components of missile weapons systems.

The objective of Project 2.2 was to measure total gamma radiation dose as a function of distance from high-altitude nuclear detonations.

Gamma dose measurements used the following techniques: (1) darkening of photographic film, (2) photoluminescence phenomenon of silver phosphate glass, (3) production of hydrogen and carbon dioxide in an oxygen-saturated aqueous formic acid solution, (4) optical density change in cobalt-activated borosilicate glass, and (5) thermoluminescence of manganese-activated calcium fluoride.

Three different film emulsions, covering the general range from 0.1 rad to about 5×10^4 rads, were exposed in National Bureau of Standards (NBS) film holders. The use of the NBS film holder essentially eliminated energy dependence from the film measurements. Film calibrations and data readout were accomplished by the U. S. Army Signal Corps.

The range of the glass microdosimeters (glass rods) was extended, by appropriate heating and readout techniques, to approximately 1×10^6 rads.

Radiolysis of formic acid exposed in transparent quartz ampoules produced hydrogen, hydrogen peroxide, and carbon dioxide. Determination of the molecular product yield provided the information necessary to calculate the gamma dose.

The cobalt-activated borosilicate glass, on exposure to radiation, was pronouncedly darkened. The amount of change in absorption at 360 microns gave direct readings of gamma dose when compared to plates previously calibrated.

After exposure to radiation, the thermoluminescent calcium fluoride detector, upon heating, emitted light which was measured by a photomultiplier tube. A plot of the luminescence versus temperature at a constant heating rate, compared to calibration plates, provided the gamma dose.

All detectors required neutron dose corrections.

Three detector packages were placed in each pod for each event. The detector package was mounted to the pod substructure approximately 18 inches below the backplate.

Table 6.10 presents the available data. The Star Fish Prime data is difficult to interpret and correct, because pod misorientation presented many unknown shielding factors. The center-position pod on King Fish was not recovered. The formic acid dosimeters provided no reliable gamma dose data because of dose rate dependence. The calcium fluoride thermoluminescent dosimeters, exposed in Star Fish, provided measured doses generally high compared to other systems. This difference is not fully explained but is believed to be due to dose-rate dependence.

The project must be considered to have accomplished its objective. The gamma flux on Star Fish Prime was lower than predicted. This low flux cannot be explained at present. On future tests, placement of the gamma dosimeters near the exterior of the vehicle would minimize the dose correction problems imposed by pod or instrument mass shielding. It appears that further development is required to obtain dose-rate dependence information and neutron interaction information on present dosimeters and to develop new measurement systems.

6.4.3 Alpha Contamination Monitoring. Following the destruction, on the launch pad, of the Blue Gill Prime missile and warhead, a project was instituted to provide an accurate monitoring of the alpha contamination occurring downwind from any future similar incidents.

The objective of Project 2.3 was to determine the alpha hazard following the destruction of a missile-mounted warhead in the vicinity of the missile launch pad.

The instrumentation consisted of two systems, one for gross plutonium contamination and the second for plutonium particle size analysis. The gross detection system utilized four collection methods: (1) 12- by 6-inch concrete blocks, (2) staplex high-volume air samplers, (3) cyclone air samplers, and (4) cellulose acetate sticky paper. The particle size determination system used four-stage cascade impactors to separate particles into four size ranges and passive collectors consisting of silicone-resin-coated microscope slides.

Both Thor missile pads, both Nike-Hercules launchers, and the XM-33 launch pad were instrumented with both land and downwind waterborne arrays. Around the Thor pads, the land arrays consisted of three arcs, each containing 88 concrete monitoring blocks, 44 microscope slides, 8 sticky paper samples, and 4 staplex air samplers. The small rocket land arrays each had two arcs containing 39 concrete monitoring blocks and 39 microscope slides. The water arcs, for all events, consisted of an arc of six rafts anchored approximately ½ mile downwind from the launch pad. Each raft was equipped with an electric generator, one cyclone air sampler, two concrete blocks, two microscope slides, one staplex air sampler, one cascade impactor, and one sticky paper sampler. All electrically operated equipment (cascade impactors, staplex and cyclone air samplers) were activated by tone barrel relays 60 seconds prior to lift-off. The cascade impactors operated for a period of 5 minutes after lift-off and the air samplers for a period of 30 minutes after lift-off.

During the period this project was operational, only the Blue Gill Double Prime missile was destroyed. This destruction occurred approximately 90 seconds after lift-off and at an altitude of approximately 100,000 feet. As a result, no data was obtained by the project.

6.4.4 Reentry Vehicle Kill Mechanisms. There have been postulated five possible kill mechanisms for use against ICBM warheads: (1) crushing or breaking up of the reentry vehicle (R/V) because of blast, (2) neutron heating and consequent melting of the fissionable materials, (3) ablation of surface materials of the R/V by vaporization and/or melting to the point where the R/V cannot survive reentry, (4) thermomechanical loading generated by the pressure of the vapor generated when the R/V surface is exposed to short-time thermal radiation from an intermediate altitude detonation, and (5) X-ray-induced impulsive loading of the R/V structure by the pressure of the vapor generated at the R/V surface by absorption of X-rays from a weapon detonated in near-vacuum conditions.

The primary objective of the pod program in Fish Bowl was the investigation of the ablation, thermomechanical, and X-ray kill mechanisms. Previous attempts to evaluate kill mechanisms, on Shot Logan at the Nevada Test Site (NTS) and during Operation Hardtack in the Pacific, had produced little data. Shot Marshmallow, at NTS, was successful in investigating X-ray effects. No previous tests have been performed to investigate the thermal kill mechanism. Blue Gill, provided the opportunity to evaluate the thermomechanical kill estimates. King Fish and Star Fish allowed X-ray effects experiments.

Thermal Effects. The objectives of Project 8A.3 were to investigate, for an intermediate-altitude burst, (1) the existence of the postulated thermomechanical effect and its properties, (2) the characteristics of the thermal source as viewed at the test vehicle surface, (3) the nonthermomechanical effects (such as material ablation), and (4) the proportion of observed effects attributable to X-rays.

The instrumentation (Figure 6.9) used in Blue Gill generally falls into four categories based on the objectives.

The existence and magnitude of the thermomechanical effect was investigated by means of indent recorders and spall gages. An indent recorder is basically a piston and anvil arrangement with different materials of interest exposed on the head of the piston. The impulse imparted to the piston was delivered to the anvil in the form of an indent. Pistons with various ratios of mass to exposed area were used in an attempt to develop a time history of the effect through analysis of piston response times compared to measured impulse. Forty-eight indent recorders were exposed on each of the three Blue Gill pods.

The spall gage was a lucite cylinder, supported by styrofoam, with a lead disk glued to the lucite on the surface exposed to the burst. It was anticipated that the stresses set up in the gage by the thermal reactions would cause fractures in the lucite, thus proving the existence of a pressure pulse generated at the surface of the lead. To provide for a range of pressure pulses, the enclosing heat shields were pierced by different sizes of apertures for different gages. One instrument, with four aperture sizes, was used on each pod.

Ablation effects were investigated by 18 ablation condensation gages on each pod. The gages exposed various materials of interest with each sample material having a hole drilled down the center of the sample which terminated in the gage body. It was believed that, as the materials vaporized, some vapor would be forced inside the gage and there plate-out on the sidewalls. Analysis of the plated-out materials was expected to help in development of the mechanics and pressures involved in ablation and to aid in determination of amounts of materials lost. Thirteen different materials were investigated on each pod.

Source information was investigated by use of thermal pinhole cameras, cutoff filter spectral gages, reflective coating spectral gages, and long-time thermal gages. The thermal pinhole cameras had two major functions; to measure the time history of the absorbed thermal radiation, and to measure the spatial characteristics of the thermal source. Apertures were drilled in the micarta heat shields that covered the pinhole camera gage body. Each gage provided four apertures, one on top and three spaced equidistantly about the side. The thermal radiation incident through each pinhole caused irreversible structural changes in the heat-sensitive detector slab. Seven cameras were used on each pod.

The cutoff filter spectral gage utilized a variety of cutoff filters to allow only a portion of the energy spectrum to impinge on a detector material. By observing the relative intensity transmitted through different filters, it would be possible to derive information concerning the spectral distribution of radiation from the source. Filter materials used were fused quartz, titanium dioxide, magnesium fluoride, and aluminum oxide. Three aperture sizes and two detecting materials provided the dynamic range desired. Four gages, providing 16 data channels, were used on each pod. The spectral gages with reflective coatings had the same objective, the investigation of source spectral distribution, but achieved discrimination between wavelengths by use of reflective coatings of known properties, with wavelengths selectively passed or reflected. Six such gages on each pod, with six combinations of detector materials and reflective coatings, provided, with redundancy, 24 data channels per pod.

The long-time thermal gage was designed to derive the total thermal pulse experienced by the pod over a relatively long period. The gage is basically a heat sink containing strips of materials having a range of melting temperatures. Two heat sink materials, steel and copper, and five strip materials provide the great range of temperatures covered. The heat sink, exposed to the thermal radiation, increases in temperature, causing the strip materials to melt to a depth proportional to their melting points and, thus, to the thermal radiation absorbed.

At the intermediate altitude of Blue Gill, the X-ray flux from the nuclear burst is mostly absorbed by the atmosphere; however, some X-rays were expected to reach the close-in (2,500-foot nominal distance) pod. In order to determine this X-ray flux, and thus differentiate its effects from the thermal effects, an X-ray pinhole camera was mounted in the close-in pod, and X-ray photocell detectors were mounted in all three pods. The pinhole camera had a focal length of 12 inches and diameter of 3.75 inches. Three pinhole sizes were used. The detector materials, steel, lead, and magnetic mylar tape were used in the film plate. The photocell detector used as a sensitive element a Sylvania 131 long-persistence phosphor. X-ray impingement on the phosphor caused a light flash, the intensity of which was detected by the photocell and was stored by stepping a series of magnetic latching relays.

All three Blue Gill pods were recovered, but the middle-distance pod was damaged, and some instruments were lost. The indent recorders apparently functioned as intended; however, many of the samples, glued to the piston heads, were missing. Lead samples appeared to have melted off, and other metals showed various degrees of melting. In some cases, the bonding had failed. Nearly all anvils showed indents, and most appear to be valid data. Although the calibration and readout of data are not complete, preliminary data indicates impulse to refrasil on the order of 10^4 dyne-sec/cm^2. The spall gages showed loss of the lead foil but no observable fracture of the lucite. Ablation condensation gages appear to have worked as expected. The ablation data presented in Table 6.11 is preliminary. Most metal samples showed varying degrees of melting and resolidification. Pyrolytic graphite samples appeared to be unaffected except for one sample that had laminations parallel to the surface. This sample appeared to have lost material through delamination. All other instruments appear to have functioned as intended, but results must await the completion of the data readout.

The thermal experiment appears to have been a success; however, ambiguity in reduced data casts some doubt on the validity of impulse data recorded for different materials. All materials appear to give approximately the same impulse readings. This has led to speculation that the vapor cloud created by ablation of the refrasil backplate cover effectively shielded the instruments from the burst after the first few milliseconds and that the impulse recorded is essentially that of refrasil vapor pressure. Resolution of this problem must await final reduction of data. Pending receipt of final data, no recommendations can be made.

X-Ray Effects. X-ray effects were investigated on two events, Star Fish Prime and King Fish. Project 8B participated in both events. Project 8A.3 participated in King Fish only.

The objectives of Project 8B were to measure (1) the total X-ray-induced momentum on materials of interest and (2) the X-ray flux characteristics. The objectives of Project 8A.3 were to measure (1) total impulse due to interaction of the weapon energy with selected materials, (2) impulse due to X-rays alone, (3) impulse due to energy forms other than X-rays, (4) time history of the total loading, (5) ablation from materials of interest, (6) characteristics of the X-ray source, (7) characteristics of any non-X-ray source, and (8) to separate, by controlled measurement, the effects due to X-rays from those due to other energy sources.

Project 8B instrumentation was essentially the same for both events (Figure 6.10). The instruments were of two types, effects and diagnostics. Effects instruments included three variations of a basic indentor gage, a metallurgy gage, samples of reentry vehicle materials, and a fracture gage.

The indent recorders utilized a piston-anvil arrangement in which the pistons, made of various materials exposed to the burst, delivered momentum to the anvils where the momentum was recorded as an indent. Aluminum and magnesium pistons were used with lead anvils. The three variations were achieved by the manner in which the materials of interest were contacted by the pistons. The Mark I design was used to record the impulse due to metal blowoff, with the metal samples of interest glued to the top of the piston surface. The Mark II design tested primarily R/V and plastic materials samples. In this design, the center of the piston face was relieved to a predetermined depth, and the material sample was inserted into this space and glued in place. The instrument case design assured that only the material of interest was exposed to the burst. The Mark III design utilized a striker slab of material covering the entire surface of the gage body with the piston held in contact with the striker plate by a retaining spring. This design was necessary because of the relative X-ray transparency of some materials of interest. By using the material of interest as the striker plate, the thickness could be increased, over that possible with the Mark II, to provide X-ray opacity. In all designs, the anvil was free-floated by a spring, and the pistons were held in place by retaining springs. Approximately 20 materials of interest were exposed in each pod.

The metallurgy gages utilized known characteristics of selected metals as indicators of pressure and temperature histories. Stable or metastable structural alterations occurred when the samples were subjected to the X-ray-induced thermal and peak pressure gradients. The samples were mounted in the case below an aperture that exposed part of the sample, and were supported by a styrofoam shock absorber, designed to prevent damage to the sample when the X-ray impulse drove the sample toward the rear of the case. Ten different metallurgical samples were exposed in each pod.

The R/V materials gages mounted samples of selected R/V structures for exposure to burst effects. The samples included not only heat shield material but also bonding and intermediate layers, and R/V substructure. The cross-sectioned structure samples were mounted in a gage body and held in place by springs to isolate the effects on the samples from the effects on the gage body. Seven different structural samples were exposed on each pod.

The fracture gage was designed to give information as to the shape of the X-ray-induced blowoff pulse. The gage was designed to blow off on exposure to the X-ray flux, transferring a compressive pulse to the lucite cylinder. By studying the fracture pattern produced in the lucite, an estimate of the duration and peak amplitude of the pulse could be made.

Diagnostic instruments consisted of carbon calorimeters, K-edge filters, and a plated hole instrument. The calorimeter was a carbon disk utilizing temperature-sensitive paints as the element to record the peak temperature at equilibrium. Two calorimeters were flown in each of the outer pods.

The K-edge instruments were designed to provide spectral information. Filter elements pass certain wavelengths preferentially, and these were detected on a stack of alternate layers of metal foils and mylar plastic. Seven different filter elements were used and, in the detector stacks, three different metal foils provided additional ranges for the flux levels. Fourteen detector channels were provided in each pod.

The plated hole gage was basically a cone-shaped hole drilled in a block of carbon, with the inside of this hole plated with one of three metals: chromium, lead, or gold. The X-rays, impinging on the carbon block at the end near the apex of the cone, penetrated the carbon and were attenuated selectively with wavelength. The energy density recorded by the plated metal should decrease monotonically as distance from the apex of the cone increases. Analysis of vaporization, melting, heating, and in chromium, crystalline changes, provides information on spectral energy distribution within the incident flux. For King Fish, the design of this instrument was modified to provide a cone of carbon resting within a cone-shaped hole in the instrument body. A gap was provided between the carbon cone and the gage body which provided the plated surface.

Project 8A.3 instrumentation for King Fish was basically the same as that used for Blue Gill. Indent recorders were identical, but additional recorders were provided with beryllium windows, which were intended to be relatively transparent to X-rays but to prevent the piston seeing any type of nonpenetrating energy. An additional control was provided on these pistons by having one with a blowaway hatch to be blown away by the X-rays, thus proving the penetration of the beryllium window. The piston should record no indent, thus proving the opacity of the window to late-time radiations.

Spall gages and ablation condensation gages, identical to those for Blue Gill, were used, but materials of interest were, in some cases, changed. The thermal pinhole cameras were modified by the addition of an X-ray-opaque hatch, to be blown away by the X-ray impulse, and thus expose the detector element to the thermal or debris energy fluxes. In addition, reflective coatings were used on some of the detector elements. Two X-ray intensity gages were added to the instrument array on the project pod. These were stacks of plastic sheets with metal plating or with metals imbedded in the plastic. The incident flux and spectrum were derived from the depths, within the stack, at which phase changes occurred in the metals. Several aperture sizes were used, and in one gage the problem of aperture closure was tested by making the aperture a slot tapered from zero width to 3-mm width.

Long-time thermal gages, as used in Blue Gill, were used on the close-in pod on King Fish. X-ray pinhole cameras with focal lengths of 4 and 12 inches and a new type of structural gage were used. This structural gage, a disk of material supported by a hollow cylinder, was to test the effects of X-rays on bare structural materials.

Large errors in pod orientation were experienced on Star Fish. The close-in pod was almost nose-on to the burst, and none of its instruments were exposed directly to the burst. Instruments on the middle pod viewed the burst with an angle of 43°, and the outer pod viewed the burst with an angle of 41°. In addition, the outer pod was almost twice as far away from the burst as desired. Because of these excessive look angles, none of the source parameter instruments operated. Many of the indent recorders and R/V materials gages on both the middle and outer pods did operate, and it is estimated that approximately 50 percent of the desired data was obtained. Impulse and material effects data was obtained but has not yet been reported in final form. Some of the R/V structure samples did experience failures of varying degrees under the X-ray flux. It is hoped that metallurgical techniques used on some gage bodies and on the metallurgy gages will provide some source parameter data.

Of the three pods flown on King Fish, only two were recovered, and on one of these the entire backplate and all but one of the X-ray instruments were missing. The close-in pod, which carried the Project 8A.3 instruments, was recovered intact, and all instruments appear to have functioned as designed. The one instrument recovered in the other recovered pod also belonged to Project 8A.3.

Project 8B obtained no data from King Fish. On the instruments recovered, X-ray impingement areas were prominent. On the indent pistons, approximately half the exposed samples were lost, primarily through bonding failures. Almost all of the indent recorders provided indents. The impulses vary with the material exposed but generally appear to be of the order of 10^3 dynes/cm^2 for this distance of approximately 8,200 feet from the burst. Fracture gages showed no observable results other than the loss of the lead foil covering. The samples in the ablation condensation gages showed effects ranging from almost complete disintegration, for Avcoat 19 and Rad 58B, to essentially no change in pyrolytic graphite.

None of the thermal cameras showed discernible images. The X-ray intensity gages showed stippling of the beryllium windows, but X-ray source images were not visible. The long-time thermal gages were unaffected except for cracking of quartz filters. The X-ray pinhole cameras did show images of the X-ray source, and structural gages showed varying degrees of deformation depending on material and disk thickness.

All of these observations are preliminary and definitive data awaits publication of the Project Officers Report. It appears that considerable X-ray effects data was obtained, but the validity and interpretation of the data depend on many calibration and correction factors.

6.5 GEOPHYSICAL EFFECTS

6.5.1 Background. Early speculations had led to the conclusion that high-altitude nuclear explosions should produce global hydromagnetic effects in the upper atmosphere, which could be detected by highly sensitive, ground-based magnetometers and earth current instruments. Shots Teak and Orange of Operation Hardtack produced widespread magnetic effects in the Pacific area. In addition to instrumentation by US Army Electronics Research and Development Laboratory (USAERDL), AFCRL, and others in the Pacific area, magnetometers recorded data in Iceland, Sweden, the Russian Arctic, French Antarctic, Algeria, Ghana, Arizona, and New Jersey during Argus II and Argus III, in 1958. The physical mechanisms which generate these phenomena and the mode(s) of propagation continue to be puzzling.

6.5.2 Objectives. The objectives of the magnetometer and earth current measurements were: (1) to obtain data on geomagnetic field effects from high-altitude nuclear detonations and (2) to help evaluate the feasibility of using these devices for the effective detection of high-altitude nuclear detonations of unknown origin.

6.5.3 Instrumentation. Many different types of variometers (fast-response magnetometers) and magnetometers were employed in the Pacific area and worldwide. Appendix O lists the location and types of these instruments.

In a considerable number of cases various earth current systems were also emplaced. Due to the difficulty of calibrating such systems, their primary purpose was for waveform and arrival time data. In addition to the funded projects, magnetometer and earth current data were obtained from scientific sources throughout the world. A partial list of these is included for information and reference as Table 6.12.

A large amount of various geophysical data was collected by the Armour Research Foundation (now Illinois Institute of Technology, Research Institute) under Project 6.5b from all over the world. This data has been forwarded to the DASA Data Center.

6.5.4 Results. A very large amount of magnetometer and earth current data was collected during the operation, but for the most part, only onset times, magnitudes, waveforms, and durations have been reported. There is much more data analysis work to be done. One overall result of importance is that it appears feasible to detect high-altitude nuclear detonations with magnetic sensing devices, because the signature of such detonations is completely different from natural earth magnetic disturbances.

Star Fish data was obtained from all project stations except Okinawa, which was in a typhoon alert status. Unofficially, data was also received from Paris, Ghana, Pennsylvania, Australia, Tasmania, Alaska, Massachusetts, Texas, Maine, Florida, and New Jersey. Signals were generally much greater than anticipated, with many equipments being saturated at early times. Launch area signals of 150 gammas were reported. A helium magnetometer on Hawaii reported a signal of 300 gammas. There were two distinct signals in the early period. The first, at H=0, was of relatively high frequency, short duration (less than 1 second). A large-loop magnetometer on Hawaii measured a rise time of 5 μsec for this pulse. The rise time appeared somewhat slower in the conjugate areas. The second signal generally arrived 1.5 to 2.0 seconds after detonation. Maximum signal arrived in the conjugate area at H+3.5 seconds with a predominant frequency of 0.3 cps. The late-time signal was very complex. Identical equipment measured the arrival time to be 0.4 second later at Tongatabu than at Samoa.

Star Fish earth current signals lasted on the order of 40 seconds with E-W systems showing amplitudes of twice N-S systems. Arrival times and waveforms generally agreed very well with magnetometer data.

Results from Phase II of Dominic were generally more complicated than from Star Fish. At first look, the Project 6.5b magnetometers and earth current instruments appeared to show no data for this phase. The signals again arrived in two parts, the first an almost instantaneous EM pulse followed by a later magnetic pulse with generally increasing period. Table 6.13 shows the onset time for each event at the Project 6.5e locations.

Apparently, the propagating medium interacts in some manner with the primary signal. The primary signal appears to be a structureless broadband pulse containing an equal distribution of frequencies from nearly dc to the 100-kc or low-Mc region. Results of Project 6.5e initially indicate that, for burst heights above 400 km, signal propagation is apparently isotropic, whereas for lower burst heights, propagation is increasingly anisotropic.

Very few measurements were obtained on Tight Rope.

Check Mate results were negative at Okinawa, Wake, Trinidad (variometer), and Tongatabu (low-sensitivity N-S variometer). An earth current record was obtained in Trinidad. Records indicate prompt arrival (within milliseconds) of a 2-cps signal, an arrival at about H + 1 second (½ cps), and distinctive arrivals up to H + 27 seconds. The large-loop magnetometer on Hawaii received a signal in the direction of a decrease in the earth's magnetic field reaching a minimum of −0.117 gamma/sec at H + 15 msec.

Also at Hawaii, a helium magnetometer recorded a minimum of −2.5 gammas at H + 2 seconds. A N-S variometer record at Samoa showed a slow oscillation with a period of 15 to 20 seconds, which did not appear on the E-W record. A helium magnetometer on Samoa recorded a signal decrease to −0.07 gamma at H + 0.030 second. The first maximum was 0.2 gamma at H + 5.6 seconds.

At Blue Gill event time, all equipment was operational, although negative results were reported from Trinidad, Okinawa, and Wake. The recorded signals were relatively simple and of low amplitude. Variometer records lasted about 40 seconds in the Southern Conjugate Area, 20 seconds on Canton, and 7 seconds on Kauai. Magnetometers on Samoa and Canton showed sizable slow changes: 1.3 to 4.3 gammas at Samoa, 100 milligammas to 1.1 gammas at Canton. The large-loop magnetometer signal on Hawaii decreased to a minimum of −0.055 gamma/sec at H + 15 msec. Later signals were overridden by a 1-cps modulation and a very weak oscillation with a period of 10 to 12 seconds. A helium magnetometer at Samoa recorded a −0.95 gamma signal at H + 3 seconds. Small-amplitude (0.15 gamma) 40-second-period oscillations were observed for several hours postshot. Good earth current signals were observed at many stations.

All equipment was operational during King Fish, although negative results were reported from Trinidad, Okinawa, and Wake. King Fish results were the most complicated of all the events. A Samoa variometer showed a prompt arrival (30 to 40 msec) followed at H + 0.5 second by a rectangular-appearing pulse, which may represent a succession of arrivals, probably as a result of dispersion. This type of signal lasted for 1.25 seconds at Samoa, 2.5 seconds at Tongatabu, and 2 seconds at Canton. A N-S variometer on Kauai presented a complex record, whereas the E-W instrument showed only a short period prompt pulse. The Southern Conjugate Area variometer records show effects up to 4 minutes; Kauai up to 30 seconds. Variometer signals in the Southern Conjugate Area reached a strength of about 2 gammas.

The large-loop magnetometer on Hawaii had a first minimum of −0.156 gamma/sec at H + 0.015 second, crossing the zero line at H + 0.030 second, and a maximum of 0.234 gamma/sec at H + 0.060 second. For the first 2 seconds, a low-amplitude 2.0-cps signal was visible. Between 3.0 and 10 seconds, a 0.3-cps signal predominated. The only activity after 15 seconds was a 60-second-period train of oscillations that lasted for several minutes.

The helium magnetometer on Hawaii recorded a first minimum of −1.3 gammas at H + 4 seconds. The signal crossed the zero line at H + 19 seconds and oscillated about this line with an amplitude of approximately 0.3 gamma with a progressively increasing period.

The helium magnetometer on Samoa recorded a minimum of −1.0 gamma at H + 3 seconds and a maximum of 1.1 gamma at H + 11 seconds. Later signals show an oscillatory character with gradually changing periods.

The earth current recorded at Hawaii was saturated for more than 1 hour after an initial negative signal at H + 0.1 second. An earth current signal on Samoa initially went positive to 0.1 mv/1,000 feet at H + 0.1 second, crossed the zero line at H + 0.2 second, went to a minimum of −0.5 mv/1,000 feet at H + 0.7 second, followed by a sequence of six complete 0.6-cps oscillations.

Only minor effects were noted from Tight Rope. At Kauai, a high-sensitivity N-S loop showed an 8-milligamma pulse at H + 0.2 second lasting 0.1 second. The E-W record showed a small pulse at H + 0 lasting 10 msec. At Canton, the N-S earth current showed a small effect with a maximum of 20 μv lasting for a minute. The E-W earth current on Canton showed a slight effect for about 20 seconds.

A Russian high-altitude detonation took place on 22 October 0340:45Z, An earth current was recorded at Trinidad with a strength of 2,000 μv/km N-S and 3,300 μv/km E-W, peak to peak. Variometers in Trinidad recorded peak intensity of 100+ milligammas on the N-S loop, and 100 milligammas on the E-W loop. A prompt signal arrival was noted on the Kauai N-S variometer, lasting less than a minute.

Another Russian shot took place on 28 October 0441:19Z, A variometer at Kauai recorded a signal of short duration, virtually over at H+2 seconds. Several arrivals were noted, the strongest at about H+6 seconds with a period of about 5 seconds and a strength of about 100 milligammas.

6.6 OPTICAL AND BIOPHYSICAL EFFECTS

6.6.1 Background. Shots Yucca, Teak, and Orange, high-altitude shots of Operation Hardtack, In particular, Teak and Orange produced optical effects in the form of large fireballs and extensive auroral displays. Although many optical records were made of the phenomena in the burst region, instrumentation was generally inadequate to record fully the extensiveness of the display. In addition, reports indicated similar displays in a southern conjugate region near the Samoa-Fiji area. Although no instrumentation covered this region, the reports tended to verify the Christofilos theory, i.e., the trapping of electrons in the earth's magnetic field.

Accordingly, CHDASA planned and rapidly executed a series of three high-altitude detonations (Argus Series) in the South Atlantic to verify this effect. Because of the impending test moratorium, time did not permit the recording of the visible effects of these three detonations.

The resumption of atmospheric testing in 1962 presented the first opportunity to fully instrument and record these effects since their disclosure during the 1958 test series.

6.6.2 Objectives. The objectives of the optical program for Fish Bowl were alined within three main areas: visible effects, infrared effects, and biomedical effects. One project was assigned to each of these areas.

The project assigned to the visible portion had the overall goal of accomplishing optical recordings. These would provide a unifying spatial and temporal framework that would permit the recording, isolation, and identification of all the visible phenomena associated with the events. Specific objectives were to provide: (1) high-speed photographic recordings of the fireball region from both surface and airborne stations to determine the energy disposition at early times; (2) medium- and high-speed photographic recordings of the fireball region from both surface and airborne stations to determine vertical asymmetries, overall hydrodynamic motion, debris shock, and late-time debris motion; (3) high-dispersion time-resolved and static spectroscopy of the burst region to identify and follow: atomic and molecular processes, continuum emission processes, and afterglow and residual debris-cloud emissions; (4) low-speed photographic recordings from surface stations to record the spatial and temporal development of artificial auroras; (5) high-dispersion time-resolved spectroscopy in the Southern Conjugate Area to identify and follow spectral emission processes at that location; and (6) extensive qualitative (sensitometrically controlled) still- and motion-picture coverage of all events in both the burst and auroral zones.

The second main area of investigation concerned itself with the infrared effects of the high-altitude nuclear detonations on weapon systems that employ infrared techniques for detection, tracking, homing, and surveillance. Emphasis was placed on those infrared effects that may degrade defense systems relating to early warning, terminal intercept, and penetration. Specifically, the project sought to investigate the detailed spatial and temporal characteristics of the fireball thermal output and airglows in the region from 0.2 to 7.0 microns, with special emphasis at 2.7 and 4.3 microns. Secondly, the project sought to determine the processes in the perturbed upper atmosphere that lead to these radiations, in order to confirm theories and to develop scaling and prediction techniques relating to the effects.

The third or biomedical area was concerned with the chorioretinal burn hazard that may result from the detonation of nuclear weapons at high altitudes. There were two specific objectives: (1) to test and improve methods for predicting the threshold distances at which chorioretinal burns will be produced, particularly from high-altitude detonations, and (2) to test the responses of protective devices and various phototropic materials to the thermal and visible radiations produced by nuclear detonations.

6.6.3 Instrumentation. A relatively large number of both ground and airborne stations were used on all shots. Ground stations were located on Johnston, Maui, Hawaii, Fiji, Samoa, and Tongatabu (Table 6.14). Seven instrumented aircraft were used on most shots at optimum distances and positions relative to each of the bursts. Two KC-135 aircraft (Figure 6.11) were jointly used to collect optical and infrared data. Five C-118 aircraft were used exclusively for biomedical data collection. Other than for minor instrument repointing, stations remained unchanged for all events. The interior of the Johnston Island DOD photo station is shown in Figure 6.12.

The optical aircraft, however, were repositioned for each shot to allow optimum pointing of the instrumentation that was set at fixed-look angles within the aircraft. The shot time positions of the optical-infrared aircraft are given in Appendix P. Burst position data in Appendix P is early data. Corrected burst positions are given in Table 1.2.

The slant range to the biomedical aircraft for each of the high-altitude shots on which they participated is given in Table 6.15.

A consolidated list of infrared instrument characteristics is given in Appendix Q. A consolidated list of optical instrument characteristics is given in Appendix R. The instrument lists are not complete; only representative instruments are listed. A complete listing of instrumentation is contained in the Project Officers Report (POR) for each of the project areas.

6.6.4 Results. In general, it appears that the well-known characteristics of atmospheric fireball formation and growth change drastically as the altitude of detonation increases. From preliminary study, it appears that altitude of detonation has a far greater effect than yield in this respect (Figure 6.13). Although Blue Gill had 20 times the yield of Tight Rope, the fireball size, growth, and rate of rise were not greatly different. If a comparison is made between Tight Rope and Check Mate, or between Blue Gill and King Fish, where only the altitude is different, tremendous differences appear. Another interesting comparison is that of the Star Fish 1.4-Mt detonation and the Check Mate In neither case was an X-ray-heated fireball formed, rather weapon debris was thrown out and expanded in what appeared to be a hydrodynamic manner. The maximum diameter of visible debris was measured in both cases

Tight Rope. This shot, behaved in a manner very similar to a near-surface detonation (Figure 6.14). First, a spherical radiative fireball, created by X-ray-heated air, was formed and then grew. The optical opacity of the fireball was somewhat less than would be found in a near-surface detonation. It was possible to detect a debris shock formed at about $\frac{1}{10}$ second which moved out rapidly and caught up with the radiative fireball.

No visible stream of electrons, beta patch, or aurora were formed.

Relative radiance curves for three spectral bands are given in Figures 6.15 through 6.17. Time has not permitted calculation and plotting of all curves in absolute values. The data reduction phase will take into account instrument calibration, pointing corrections, window, and atmospheric corrections as well as readout of additional channels of data. The Tight Rope thermal pulse was similar in character to that from Shot Yucca of Operation Hardtack.

A well-defined maximum, minimum, and interval of constant intensity were resolved on the rise to the first maximum. Evidence of similar irregularities were encountered on the leading edge of the Yucca pulse. The reported time to minimum could be in error due to the inaccuracies inherent in the field data reduction technique. The ratio of the intensities of second to first maximum was observed to decrease with decreasing wavelengths.

Tight Rope produced chorioretinal burns in animal specimens at slant ranges from 11.5 to 56 naut mi. No significant burns were produced beyond this range. The lesions produced varied from 1.2 mm in diameter at the 11.5-naut mi station to 0.19 mm in diameter at the 56-naut mi station.

Blue Gill. This shot, proved to be one of the most interesting of the series. For the first time, a series of shock and rebounding waves were clearly recorded within the radiative fireball of X-ray-heated air (Figure 6.18). The fireball rose at a relatively constant rate throughout the first 2 minutes at which time preliminary measurement ceased (Figure 6.19).

The fireball was initially a nearly perfect sphere with blue streams of electrons extending north and south for a distance of approximately two fireball diameters at early times. These appeared to be closely alined with the earth's magnetic field lines at shot altitude. Other than this rather localized effect, no auroral phenomena were observed. After about 3 minutes, the fireball developed into a conventional vortex toroid, which grew slowly and persisted visibly nearly 30 minutes.

The visible, near-infrared, and 1.58-micron detectors all gave signals of an order of magnitude above natural sky background for about 2,000 seconds (Figures 6.20 through 6.22). As the early curves cannot be made to fit a power law function, it is doubtful that the effect is due to fission product decay. Rather the emission phenomenon appears to be due to a one-body aerochemical reaction. Later data analysis may confirm or deny this early assumption.

Chorioretinal burns were produced in all animals at all exposure stations from 32.7 naut mi out to 103 naut mi as a result of Blue Gill. In many instances, the burns were so severe that they were obscured by hemorrhages within the eye. There is some reason to believe the aircraft were positioned incorrectly due to erroneous predicted brightness values. This matter will receive considerable study.

Two humans accidentally received chorioretinal burns on Johnston Island during this event. Both were military personnel who have since been assigned to the School of Aerospace Medicine for continued observation and treatment. This unfortunate occurrence will, however, present the first opportunity to correlate chorioretinal burn comparisons in both human and animal subjects on a single well-instrumented detonation.

Some visible aurora was observed in the Southern Conjugate Area in the form of a brief white flash. No other phenomenon was recorded at that location.

King Fish. This shot, produced several interesting visual phenomena, probably associated with the beginning of a transition zone between the denser atmosphere below this altitude and the thinner atmosphere above. The detonation produced a relatively large, transparent, nonsymmetrical fireball, which grew quite rapidly in size —well out of proportion to the device yield (Figure 6.23). In addition to its rapid growth, the fireball rose at a faster rate than any of the other shots of the series,

During its growth, the upper limb was preceded by a reddish glow that moved upward ahead of the fireball and appeared to have the characteristics of a shock wave.

The time history of King Fish in the first 5 μsec as recorded by a camera located on Johnston Island is shown in Figure 6.24. The first frame recorded approximately the first 0.1 μsec after the beginning of the release of the X-ray energy. The outward expanding shells shown in subsequent frames represent X-ray pulses made visible by the air fluorescence process. The existence of three distinct rings, which implies the presence of three X-ray pulses, is a most interesting phenomenon and the following explanation has been suggested.

Late-time fireball photographs show that. the King Fish fireball had developed definite asymmetries. A strong group of beta-ray auroral streamers were seen following the geomagnetic lines down to the north. A shock wave was seen penetrating the auroral streamers. three shocks emanated from the fireball. The group of streamers developed a slight bend a short distance below the fireball, and a definite bend developed beneath the fireball. The region between the fireball and the bend was probably partially ionized air left in the wake of the fireball. This plasma temporarily froze the magnetic field lines that were stretched between the initial and present positions of the fireball.

The fireball photographs taken after detonation time of King Fish showed a filamentary structure in the upper region of the fireball. This structure appeared to be associated with the geomagnetic field lines originally excluded from the expanding fireball and their return into the excluded volume. The debris was seen to be widely dispersed throughout the fireball. From Maui, the original fireball was seen to be rising, preceded by a bright red, expanding air-shock region such as was seen during Shot Teak. The evidence that the major component of the light from the red air shock lies in the 6,240- to 6,390-Å region, and that a major portion of the red flux reaching the Haleakala station lies in that wavelength band, is borne out by comparison of the signals received through the narrow 6,300-Å (half power 6,240 to 6,390Å) channel and the wideband red (5,640 to 6,400 Å) channel filters. By 300 seconds, virtually no red light outside of this band was received. The emission within the band decayed, approaching a half-life of 125 seconds. This red glow was most probably the atomic oxygen 1D-3P doublet at 6,300 to 6,363 Å, excited by the high temperature behind the shock front. Assuming no further excitation after 300 seconds, and assuming further that collisional quenching at low (less than 200 km) altitudes is no longer important at 300 seconds, the 125-second half-life appears to be indicative of the OI forbidden red transition. It must be emphasized that this is a preliminary result, which will be subject to further readout of data from these channels and from that in the other photomultiplier systems, microdensitometry of the films, and to a more careful analysis of the response of the phototube-filter combinations.

Radiance versus time curves for the 0.4- to 0.5-micron and 4.8- to 5.5-micron bands are given in Figures 6.25 and 6.26, respectively.

Animals exposed to the fireball at distances ranging from 65 to 405 naut mi experienced no chorioretinal burns. It would appear that the large area of the fireball did not produce a sufficiently bright surface to inflict visible damage to the eye.

Check Mate. This shot, appeared to define the upper limit of the transition zone,

No fireball, or sphere of X-ray-heated air was produced. Rather, weapon debris was thrown outward at a rapid rate (Figure 6.27).

Early recordings show sharp spikes protruding from the rapidly expanding spherical debris mass. Also shown is a faint halo at great distances from the burst, probably caused by light emission from metastable excitations in the X-ray deposition region. Recordings made show clearly that the debris from Check Mate is not distributed isotropically at early times, but is confined mainly to an expanding toroidal ring. This conclusion is supported by other pictures which show that the plane of the ring is normal to the axis of the weapon at detonation time. Photographs show that the instabilities in the debris motion had developed into massive jets.

the Check Mate fireball was characterized by both the instabilities noticed earlier and by a beta-ray aurora. These features were taken by a cloud camera in an aircraft located north of the burst. At + 35 seconds, the fireball was rising fast, and the auroral streamers appear to be disconnected from it. This latter effect probably was caused by a local distortion of the magnetic field lines when they were frozen in the ionized gases of the fireball. This behavior was similar to that observed during King Fish. Photographs which portray the development of the debris aurora from the late fireball stage show the debris ring beginning to lose its circular shape.

Thereafter, the debris gradually slowed down and stabilized at an altitude of 250 km by 75 seconds.

Relative radiance curves for the 0.75- to 1.0-micron and 1.88- to 2.55-micron bands are given in Figures 6.29 and 6.30, respectively. Time has not permitted reducing these curves to absolute values. Absolute values for the 4.8- to 5.5-micron band are given in Figure 6.31.

Because of the low predicted visible output, no animal specimens were exposed on this event. Many phototropic filters and electromechanical goggles and components were exposed. Details of the materials and components exposed and the results of the exposure can be found in the appropriate POR's.

Star Fish. This shot, 1.4 Mt at 400 km, produced no conventional fireball. The weapon debris moved outward at a very rapid rate, reaching a diameter of about 65 km in 20 msec (Figure 6.32).

The early stages of the debris expansion of Star Fish were recorded by several high-speed cameras. The films distinctly show a rapidly expanding shell, which leaves behind a slower moving core. Measurements on this film showed that this shell is expanding radially with a velocity of 1.6 m/μsec. The station on Mauna Loa, Hawaii, proved to be an ideal location from which to view large-scale auroral effects; photographs taken by a camera operating at 100 frames/sec clearly show the early-time history of the debris as it expanded with the earth's atmosphere. An upward-moving component of the debris was observed to rise from the inner core; the downward-moving debris is seen to collide with the earth's atmosphere and produce a marked increase in the brightness of the sky over a considerable region beneath the burst point.

A number of time exposures using 35-mm still cameras located directly below the burst recorded the late-time phenomena when light output was weaker. Two such photographs show auroral streamers extending upward and generally following the geomagnetic lines heading toward the Southern Conjugate Area. This auroral display continued at later time. The general red glow that extended over a large volume of space surrounding the burst area is attributed to emission in the red lines of atomic oxygen.

Photographs taken from Tongatabu show the southern hemisphere aurora as a concentration of streamers almost due north of the station. The same display was observed visually almost due south from Tutuila and Samoa. This auroral display was not associated with the main auroral concentration, which was southeast of Tutuila. Further details and examples of the photography are contained in the POR's.

Strong radiation was observed at 5.3 microns from the production of nitric oxide. Upper and lower limit calculations on radiation intensities to be expected from nitric oxide indicate that levels are considerably above what might be expected from an IRBM/ICBM target. The radiation at 5.3 microns was about three orders of magnitude greater than predicted as observed by three of the four 5.3-micron photometers for approximately 70 seconds (Figure 6.33).

As predicted for this event, no signals were observed in the 2.7-micron region. Intense optical-IR background radiation in the 0.8- to 1.1-micron region was four orders of magnitude above normal, 90 seconds after detonation. At 700 seconds, the intensity was still one order of magnitude above the natural background. Many auroral/airglow lines and bands were observed to be extremely bright and persistent. Typical of the narrow band spectral data was strong radiation in the neighborhood of 3,460 Å for about 150 seconds; this persistent radiation has been tentatively attributed to either the (1-10) Vegard-Kaplan band at 3,425 Å or the (NI)31 transauroral multiplet at 3,466 Å.

Although animal specimens were exposed to the detonation at distances ranging from 297 to 834 naut mi, no retinal burns were produced. Thus, no retinal burns resulted from any of the shots of the series above 90 km for the yields and altitudes tested.

6.6.5 Participation in AEC Developmental Tests. Retinal burn and flashblindness studies were conducted on the AEC airdropped diagnostic shots. (See POR-2014.)

The flashblindness project participated on eight of these events. It was found that no loss in visual acuity occurs for a night-adapted observer exposed for intervals approaching 10 msec to the detonation of megaton weapons in the lower atmosphere at ranges greater than 10 miles. Photographic records of time-intensity characteristics of weapon flashes were obtained from oscilloscope traces of the output of photo receivers. It is hoped that final data analysis and extrapolation to lower yields and closer ranges will provide information necessary for the final design of flashblindness protective equipment responsive over a wide range of yields.

6.7 BLAST AND PRESSURE EFFECTS

6.7.1 Background. Although no successful close-in blast measurements were made on high-altitude detonations in previous operations, the surface level measurements of overpressure-time taken during Operation Hardtack indicated that, for nuclear detonations up to altitudes of 250,000 feet, the effects of blast at altitude could be substantial and that overpressures at the earth's surface could be predicted. Some theories were developed, and machine calculations were made in an attempt to find a means of determining blast effectiveness under the conditions of interest. However, as burst altitude is increased, the partition of released energy changes, and consequently, the apparent blast yield, at altitude, cannot be predicted with any accuracy. The Fish Bowl Series offered an opportunity to make measurements close to high-altitude nuclear bursts as well as the usual surface overpressure measurements.

6.7.2 Objectives. The objectives of the blast and shock measurement program were: (1) to obtain close-in measurements of peak overpressure and overpressure-time from high-altitude nuclear bursts, (2) to obtain peak acceleration and acceleration-time measurements for specific vehicles close to high-altitude nuclear detonations, (3) to obtain surface level measurements of peak overpressure and overpressure-time from high-altitude nuclear detonations, and (4) to determine the blast effectiveness, early blast-thermal interaction, and missile response to high-altitude nuclear detonations.

6.7.3 Instrumentation. To obtain the close-in measurements desired, the Ballistic Research Laboratories (BRL), Aberdeen Proving Ground, Maryland, (Project 1.1) provided pressure and acceleration gages for mounting in the instrument pods carried aloft by the Thor missile (Figures 6.34 and 6.35). Two types of pressure gages, two types of accelerometers, and one type of shock spectra sensing device were utilized.

Since all time-dependent gages had a limited recording time, it was necessary to provide a sequence timer to turn on the gages in each pod just before burst time. The programer selected was crystal-controlled with a variable R-C network for manual adjustment of total time. The missile lift-off signal activated this programer which, after the lapse of the preset time, activated the gages. Once activated, one gage controlled the recording time of the other gages in each pod.

At the Star Fish altitude, no actual overpressure was expected close-in to the burst; therefore, only two pressure gages were flown on this event. These gages were mounted in the middle-distance (S2) pod. Two accelerometers, two shock spectra gages, and one programer were mounted in each of the pods.

On Shots Blue Gill and King Fish, four pressure gages, two accelerometers, and two shock spectra gages were mounted in each pod. Programers were used in all pods except the middle and far (K2 and K3) pods for King Fish. These pods depended on activation by a gamma switch, used previously as backup in all other pods, to start the recording gages.

Further details on the above instrumentation are contained in POR—2010.

Surface level measurements were made by two project agencies, BRL and AFCRL. BRL utilized Wiancko microbarographs and Statham low-pressure strain gages, changing sensing device ranges as necessary to cover the ranges of overpressures predicted for each event. For Star Fish, stations were established at Johnston Island and on scientific ships S-1 (USS Oak Hill) and S-4 (USNS Point Barrow). For Shots Blue Gill, King Fish, Tight Rope, and Check Mate, the Johnston Island and Ship S-4 stations were continued, but the station on Ship S-1 was moved to Wheeler AFB, Oahu.

For all shots, stations were activated shortly before burst and operated postshot for sufficient time to insure reception of all pressure waves. AFCRL, for Star Fish, established stations at Midway, Samoa, Wake, and Shemya (Alaska), each station using NBS microbarographs N-3 and N-6. On subsequent shots, the Wake and Shemya stations were eliminated. All stations were operated continuously for the duration of their establishment.

Further details on this instrumentation are contained in POR's 2010 and 2020.

6.7.4 Results. Pod Data. On Star Fish, all instruments in Pods S1 (near) and S2 (middle) operated satisfactorily. In Pod S3 (far), only the gages not requiring electrical power operated. The malfunction of other gages was attributed to battery failure. Pressure and acceleration gages did not reveal any discernible data. The shock spectra gages did show fluctuations, but plots of the data presented no clear trend of accelerations for any pod.

On Blue Gill, only those gages not requiring electrical power operated in B1 (near) and B2 (middle) pods. The cause of the malfunction of the remaining gages is undetermined. All gages in B3 (far) operated, but on some of the gages the time base markings were not present. On all gages that functioned, there were discernible fluctuations in the recording throughout the recording time. However, the fluctuations were somewhat sinusoidal in appearance, and there were no apparent differences from one pod to another, therefore no shock parameters could be implied. All of the shock spectra gages showed evidence of inputs; however, the data gave no obvious pattern of vibration.

On King Fish, all gages in K1 (near) operated, but some recordings were lacking the time base. In K2 (middle), only the spring-motored gages operated. Since this pod was badly damaged by water impact, it is believed that these gages were activated at water impact. Apparently, the gamma switch failed to activate the gages at burst time. All gages in this pod were damaged to some degree. Pod K3 (far) was never recovered. On all recordings obtained, there were sinusoidal fluctuations similar to those seen in Blue Gill, and nothing that could be pinpointed as data was discernible. The shock spectra gages again showed inputs, but no obvious pattern of vibration and no shock parameters could be deduced. Investigation and examination of all these gages is continuing in an attempt to interpret the recordings obtained.

On Star Fish and King Fish, no overpressure data was expected, but shock spectra and acceleration data were anticipated. On Blue Gill, no overpressure data were expected from the two outer pods. The procurement of overpressure data on the close-in pod was considered marginal, because the pod velocity at burst time was in excess of 10,000 ft/sec. Calculations indicated that the pod had to be within 3,000 feet of the burst to be overtaken by the shock wave. Beyond 3,000-foot separation, the pod would outrun the shock wave.

Surface Measurements. On Star Fish, the recorder aboard Ship S-4 malfunctioned, and no data was obtained. On Ship S-1, the prevailing ambient conditions, wind up to 20 knots and ship roll of up to 20°, completely obscured any signal from the overpressure wave. The Johnston Island station operated successfully, reporting a maximum overpressure of 170 microbars at the surface, with a positive phase duration of 10 seconds and an arrival time of 455 seconds after burst.

On all other high-altitude events, all stations were operated except the Oahu station during King Fish and the Ship S-4 station during Tight Rope. Table 6.16 presents data obtained. No discernible data was obtained on any of the high-altitude events by the Midway, Samoa, Wake, or Shemya stations.

BRL also operated the Johnston Island and Oahu stations during all airdrops conducted in the vicinity of Johnston Island, and the Ship S-4 station for two of these events. Table 6.17 shows data available.

For these events, instruments were also placed on the target barges and on the USS Forster. However, the data from these instruments has not yet been reduced.

6.7.5 Summary. Close-in blast data from high-altitude events was not obtained. It had been predicted that any data obtained would be marginal at best. Although some records were obtained, their interpretation is not possible at present, and instrument functioning must be considered marginal. Surface level measurements, using long proven techniques, were successful. However, the loss of data on Star Fish indicates the need for stable platforms for instruments to measure the very low overpressures generated by high-altitude events.

Further development should be pursued to produce a system of instruments capable of measuring blast parameters close to high-altitude events. Means of positioning these instruments must also be further investigated. To insure success, it appears necessary to place instruments above, and moving toward, the burst.

6.8 ATMOSPHERIC PARAMETERS

6.8.1 Background. Accurate information on certain atmospheric properties was required during Fish Bowl, in order to: (1) relate test data to theories of blast and shock phenomena in the upper atmosphere, (2) relate observed radiation fluxes to ionization produced, (3) determine the mass transport of nuclear debris by high-altitude winds, and (4) measure diffusion coefficients.

Since the atmospheric physical properties are somewhat variable, the climatological data based on previous measurements was not adequate to properly interpret other data or to determine debris motion.

6.8.2 Objectives. The objectives of the atmospheric parameters measurements program were: (1) to determine profiles of air density in the 30- to 105-km altitude region, (2) to deduce atmospheric pressure and temperature from the density measurements, (3) to measure wind velocities, diffusion coefficients, regions of turbulence, and eddy spectra in the altitude region between 60 and 150 km, and (4) to determine whether the nuclear detonations had any effect, on atmospheric circulations at high altitudes, that would persist for hours.

6.8.3 Instrumentation. In the falling sphere experiment, air density was calculated from the equation for aerodynamic drag applied to a free-falling 7-inch rigid sphere that contained a transit-time accelerometer with omnidirectional characteristics. The sphere was ejected from a Nike-Cajun rocket vehicle (Figure 6.36) at an altitude of about 60 km during the upleg portion of the trajectory. The sphere velocity at ejection was sufficient for it to attain an apogee altitude of nearly 158 km.

Because of inherent design features, the transit-time accelerometer provided incremental data rather than continuous information. Thus, the value of air density obtained represents an average value for the altitude region traversed by the sphere during the measurement. Density values were averaged over a greater altitude range at the higher altitudes. This resulted from a reduction in sphere drag acceleration due to decreases in both air density and sphere velocity. On the upleg portion of a typical sphere trajectory, accelerometer transit-times increased until the instrument no longer responded to the very small accelerations. This threshold sensitivity limited measurements of drag acceleration to approximately 10^{-4} g, corresponding to an altitude of about 105 km, with the Nike-Cajun trajectory. On the downleg portion of the sphere trajectory, good data was again obtained at an altitude of about 105 km, corresponding to the accelerometer threshold sensitivity.

The drag acceleration data was telemetered from the sphere and used to calculate atmospheric density. However, to make this data meaningful, the sphere trajectory had to be accurately known. By successive integration of the acceleration data, the sphere velocity and trajectory were determined. This property made it possible to successfully use the falling sphere technique without tracking facilities, but the accuracy is limited because the acceleration is measured only during part of the flight. In the Fish Bowl Series, radar tracking was used to obtain a more accurate trajectory for the falling sphere.

The technique used to measure high-altitude winds involved the ejection of a sodium vapor trail from the second stage of a Nike-Cajun rocket at dusk or dawn twilight. The rockets were tracked by radar.

The sodium was sunlit and, as a result of emission of resonance radiation, was visible against a darkened background for about 20 minutes. The trail was photographed simultaneously from Johnston Island, and Ships S-1, S-2, and S-4, permitting subsequent triangulation to determine the altitude of various parts of the cloud.

During the period when the trail is visible, its shape undergoes continuous changes due to the wind velocity at various altitudes. If the trail expansion is radial in a coordinate system moving with the wind, the magnitude and direction of motion of the trail center gives a direct measure of the winds in that region.

6.8.4 Results. Good data was obtained by both the falling sphere and the sodium vapor trail experiments. Tables 6.18 and 6.19 show time of rocket firings and the success or failure of each flight.

Rockets 1 through 4, for the falling sphere experiment, were launched during June and July. On these flights no measurements of detonation-produced changes in the atmosphere were made or planned. The data obtained on ambient air density is in general agreement with that expected at Johnston Island.

During October and November, Rockets 5 through 9 were launched; one for background data and the other four a few minutes after Check Mate, Blue Gill, King Fish, and Tight Rope. All, except the post-Tight Rope rocket, provided excellent data. Measurable heating effects and reduction in density were observed after the detonations.

The data obtained from the sodium vapor experiment showed that the winds in the D- and E-regions before Star Fish were typical for this location and time of year. The measurements at dawn following Star Fish showed that the atmosphere was considerably disturbed. The wind directions, in particular, were completely different from those normally observed. Above 97 km, the wind was from almost due north, probably due to induced currents parallel to the magnetic field.

During October and November, data was obtained after Blue Gill, at three different times after King Fish, and at dusk before Tight Rope. King Fish caused a considerable disturbance of winds in the ionosphere, whereas only a relatively small perturbation was produced by Blue Gill. Following King Fish, the winds had returned almost to normal by dusk on D + 3 days. The perturbation caused by King Fish was not as pronounced as that produced by Star Fish.

TABLE 6.1 FREQUENCY BANDS OF MILITARY INTEREST

Band	Frequency Range	Wavelength meters
VLF	3 to 30 kc	10^5 to 10^4
LF	30 to 300 kc	10^4 to 10^3
MF	300 to 3,000 kc	10^3 to 10^2
HF	3 to 30 Mc	100 to 10
VHF	30 to 300 Mc	10 to 1
UHF	300 to 3,000 Mc	1 to 0.1

TABLE 6.2 MAXIMUM EXCESS TEMPERATURES

All temperatures in °K.

Shot	925 Mc	3000 Mc	35,000 Mc
Star Fish	250	22	Negligible
Check Mate	4000	9000	8700
King Fish	670	4700	4700
Blue Gill	350	2200	3300
Tight Rope	55	730	2000

TABLE 6.3 DURATION OF EXCESS TEMPERATURE

Duration is approximate time required for a 10-fold decrease from maximum observed.

All times in seconds.

Shot	925 Mc	3000 Mc	35,000 Mc
Star Fish	>120	>120	—
Check Mate	220	150	9
King Fish	60	30	14
Blue Gill	160	110	45
Tight Rope	60	120	18

TABLE 6.4 DURATION OF BURST REGION CLUTTER

All times in minutes.

Frequency	Check Mate	King Fish	Blue Gill	Tight Rope
Mc				
1210	3	9	10	6
850	3	12	12	6
398	7	16	25	8

TABLE 6.5 DEBRIS HISTORY INSTRUMENTATION

Instrumentation	Project	Location	Shot	Remarks
Gamma-ray detector	6.5b	Conjugate Area	All	Telemetry from balloonborne detector
Neutron detector	6.5b	Conjugate Area	All	Telemetry from balloonborne detector
Photoelectric detector	6.5b	Conjugate Area	All	Time of onset of auroral emission
Photometer	6.5b	Conjugate Area	All	Emission at 6300 Å, 5577 Å, and 4278 Å
Photometer	AFTAC*	Wake, Midway	All	Emission from LI, BA, BA^+, and ZR
Photometer	6.6	Johnston, S-1, S-2, S-4, S-5, Tongatabu, F. F. Shoals, Tutuila	All	Emission at 6708 Å, 6130 Å, 5535 Å, 4554 Å of neutral LI, BA, and ZR, and ionized BA
Riometer	6.8	Boston, Midway, Wake, Tutuila, Tongatabu, Oahu, Johnston, S-1 thru S-8, F. F. Shoals, Palmyra, Canton, DAMP Ship, Viti Levu, Acania, Christmas, Peru, Rarotonga, Trinidad	All	Measured synchrotron radiation and ionospheric absorption
Riometer	6.5b	Tongatabu, Tutuila	All	Measured synchrotron radiation and ionospheric absorption
Gamma-ray detector	AFTAC*	Hickam	All	Gamma-rays counted by a U-2 aircraft in burst and northern conjugate area
Gamma-ray spectrometer	6.10	Fiji	All	Gamma-rays counted by a KC-135 aircraft in the southern conjugate area
Rockets	6.7	Johnston Island	SF/CM	Magnetic field strength, neutron, beta, and gamma fluxes from rocketborne sensors
Gamma-ray scanner	6.2	Johnston Island	SF/KF/BG	Mapped debris region using rocketborne sensors
Rockets	6.3/6.4	Johnston Island	SF/KF/BG	Electron and ion densities, X-ray and gamma-rays (prompt and delayed), electron temperature and ion species from rocketborne sensors
Gamma-ray detectors	6 12	Satellite	SF	No data obtained

* Air Force Technical Applications Center.

TABLE 6.6 PROJECT 6.7 ROCKET TRAJECTORIES FOR STAR FISH

Rocket Number	Launch Time sec	Distance from Burst at H−0 feet	Nominal Splash Coordinates
1	H−462	800*	24.6 N 170.06 W
2	H−266	400*	24.6 N 170.06 W
3	H−160	100†	6.14 N 171.83 W
4	H−140	200†	0.29 S 172.49 W
5	H−510	1,000‡	0.29 S 172.49 W

* Measured perpendicular to field line through burst away from surface.

† Measured perpendicular to field line through burst toward surface.

‡ Measured along the field line through burst toward the south.

TABLE 6.7 PROJECT 6.7 ROCKET PAYLOAD INSTRUMENTATION

Instrument	Data
Rubidium vapor magnetometer	Total instantaneous magnetic field intensity
Hall effect magnetometer	Component of instantaneous magnetic field intensity parallel to spin axis of payload
Beta counters (6 per payload)	Instantaneous flux of fission beta particles
Gamma counters (3 per payload)	Instantaneous flux of fission gamma and of bremsstrahlung
Faraday cups (3 per payload)	Debris ion current and fission beta current

TABLE 6.8 MATERIALS USED IN NDL THRESHOLD DETECTOR SYSTEM

Detector	Threshold Energy	Reaction
Gold	Thermal energy up to 0.3 ev	Au^{197} (N, γ) Au^{198}
U^{235}	1.5 kev (x/B^{10} shield)	Fission
Pu^{239}	10 kev (x/B^{10} shield)	Fission
Np	0.63 Mev	Fission
U^{238}	1.5 Mev	Fission
Sulfur	3.0 Mev	S^{32} (N, P) P^{32}
Magnesium	6.3 Mev	Mg^{24} (N, P)Na^{24}
Aluminum	8.1 Mev	Al^{27} (N, γ) Na^{24}
Zirconium	12.1 Mev	Zr^{90}(n, 2n)Zr^{89}

Page 162 deleted.

TABLE 6.12 UNFUNDED GEOPHYSICAL EFFECTS INSTRUMENTATION

Instrument	Location	Sponsor
Earth current	Newton, Massachusetts	Space Science, Inc.
Variometer	State College, Penna.	HRB-Singer, Inc.
Earth current	Ghana, West Africa	University of Ghana
Variometers (N-S) (E-W) (vertical)	Brisbane, Australia	University of Queensland
Flux-gate magnetometer	Brisbane, Australia	University of Queensland
Variometer	Hobart, Tasmania	University of Tasmania
Magnetic and earth currents	Cold Bay, Alaska and Oamaru, New Zealand	Mather and Wescott
Metastable-helium magnetometer	Near Dallas, Texas	Texas Instruments
Large-loop magnetometer	Lebanon, New Jersey	USAERDL
Earth current	Lebanon, New Jersey	USAERDL
Rubidium vapor magnetometer	Lebanon, New Jersey	Columbia University
Earth current	Flamingo, Florida	USAERDL
Large-loop magnetometer	Baxter State Park, Maine	University of Maine
Large-loop magnetometer	Columbia, South Carolina	University of South Carolina

TABLE 6.14 GROUND STATION POSITIONING DATA

Station	Information	Actual Position (Preliminary)
Photo Station J820 Johnston Island	Latitude	16°44'6"N
	Longitude	169°31'43"W
	Absolute altitude	7 feet
Mauna Loa Site Hawaii	Latitude	19°32'21"N
	Longitude	155°34'42"W
	Absolute altitude	11,150 feet
Tutuila Site Samoa	Latitude	14°19'18"S
	Longitude	170°50'10"W
	Absolute altitude	600 feet
Ovalau Site Fiji	Latitude	17°41'36"S
	Longitude	178°49'54"E
	Absolute altitude	200 feet
Tongatabu Site Tonga	Latitude	21°03'56"S
	Longitude	175°04'33"W
	Absolute altitude	20 feet
Haleakala Site, Maui Island, Hawaii	Latitude	20°42'30"N
	Longitude	156°15'25"W
	Absolute altitude	10,000 feet
Camera Station J-811 Johnston Island	Latitude	16°44'06.4"N
	Longitude	169°31'43.4"W
	Absolute altitude	10 feet

TABLE 6.15 SLANT RANGES OF BIOMEDICAL AIRCRAFT

All distances are given in nautical miles slant range to burst.

Shot	Aircraft				
	P-1	P-2	P-3	P-4	P-5
Star Fish Prime	297	371	487	694	754
Check Mate	No participation				
King Fish	506	113	205	306	405
Blue Gill Triple Prime	44	56	79	103	Abort
Tight Rope	25.8	56	99	150	—

TABLE 6.18 FALLING SPHERE MEASUREMENTS

Rocket Number	Date	Time	Shot	Remarks
	1962			
1	1 Jun	1800W	—	Good data obtained. Shot postponed.
2	19 Jun	2230W	—	Good data obtained. Shot aborted.
3	8 Jul	H−30 min	Star Fish	Good data obtained.
4	23 Jul	1940W	—	Good data obtained. Shot postponed.
5	19 Oct	H + 10 min	Check Mate	Good data obtained.
6	26 Oct	H + 15 min	Blue Gill	Good data obtained.
7	29 Oct	2300W	—	Background data. Good data obtained.
8	1 Nov	H + 10 min	King Fish	Good data obtained.
9	3 Nov	H + 4 min	Tight Rope	Failure of second stage to ignite produced much less than normal altitude, with consequent loss of most of the data.

TABLE 6.19 SODIUM VAPOR TRAIL MEASUREMENTS

Date	Time	Shot	Remarks
1962			
1 Jun	Dusk	–	Rocket or payload failed. No data obtained.
3 Jun	Dusk	–	Rocket or payload failed. No data obtained.
19 Jun	Dusk	–	Rocket or payload failed. No data obtained.
8 Jul	Dusk	Star Fish	Good data obtained.
9 Jul	Dawn	Star Fish	Good data obtained.
23 Jul	Dusk	–	Rocket second stage failed to ignite. No data obtained.
25 Jul	Dusk	–	Good data obtained.
15 Oct	Dusk	–	Rocket failed to reach programed altitude. No data obtained.
19 Oct	Dusk	Check Mate	Flight canceled because of cloud cover.
20 Oct	Dawn	Check Mate	Rocket misfired. No data obtained.
25 Oct	Dusk	Blue Gill	Flight canceled because of cloud cover.
26 Oct	Dawn	Blue Gill	Good data obtained.
31 Oct	Dusk	King Fish	Rocket second stage failed to ignite. No data obtained.
1 Nov	Dawn	King Fish	Good data obtained.
2 Nov	Dawn	–	Good data obtained.
2 Nov	Dusk	–	Good data obtained.
3 Nov	Dusk	Tight Rope	Good data obtained.
4 Nov	Dawn	Tight Rope	Rocket failed. No data obtained.

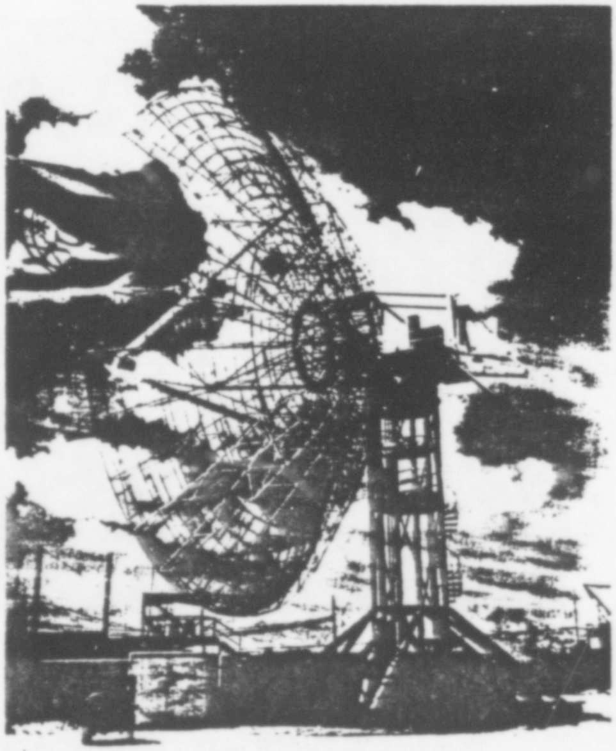

Figure 6.1 86-foot-diameter antenna, Johnston Island (DASA-26-6191-62 photo)

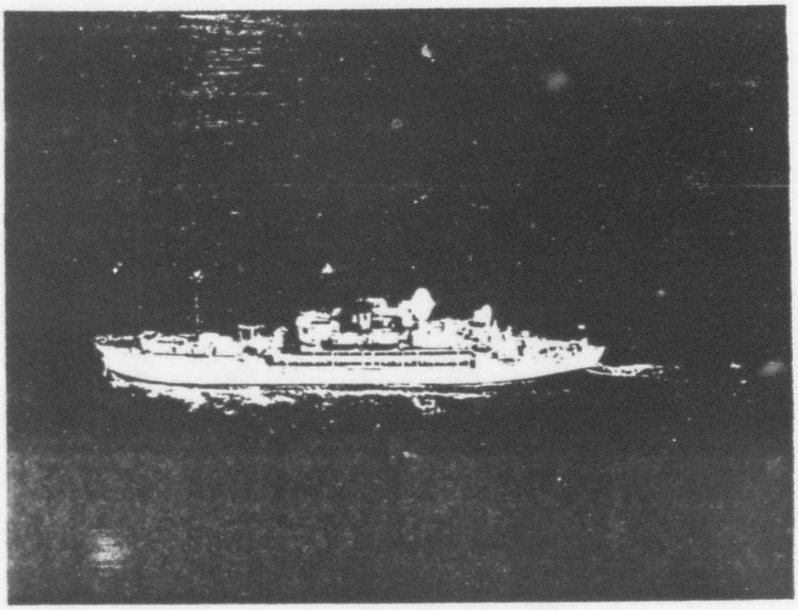

Figure 6.2 DAMP ship, USAS American Mariner. (DASA-26-6744-62 photo)

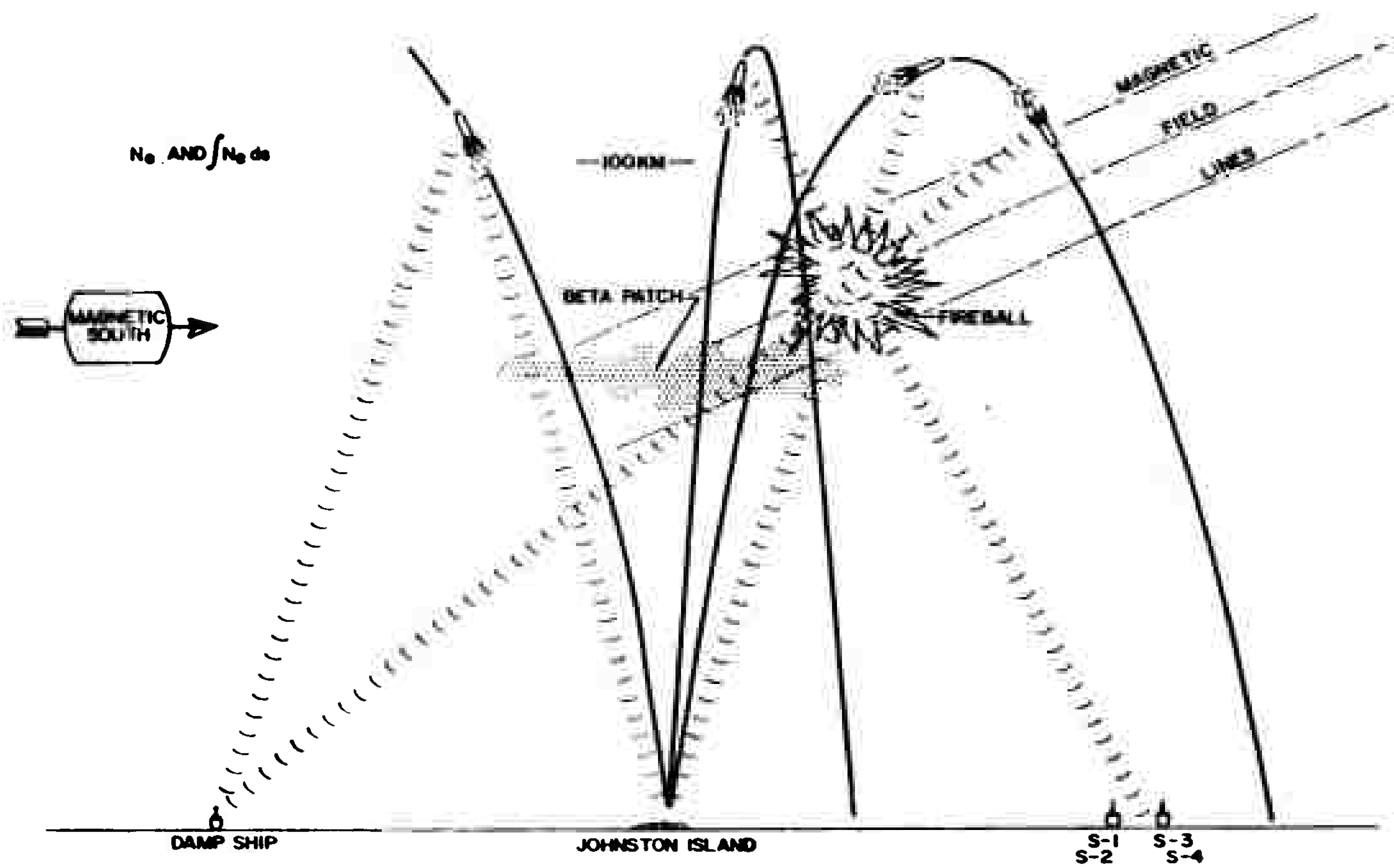

Figure 6.3 General experimental plan, radar attenuation.

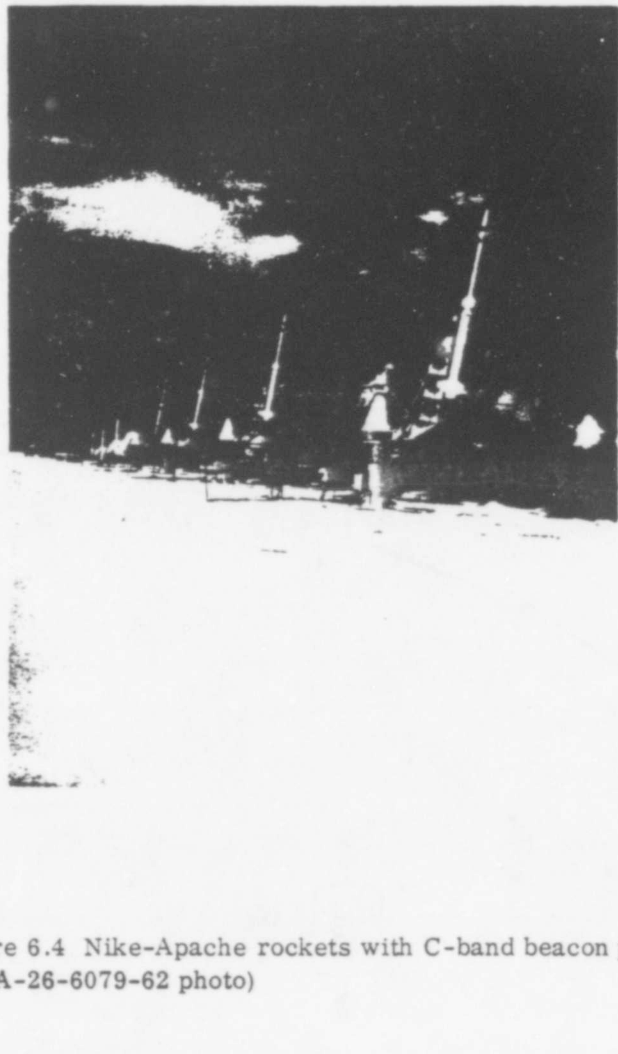

Figure 6.4 Nike-Apache rockets with C-band beacon payloads. (DASA-26-6079-62 photo)

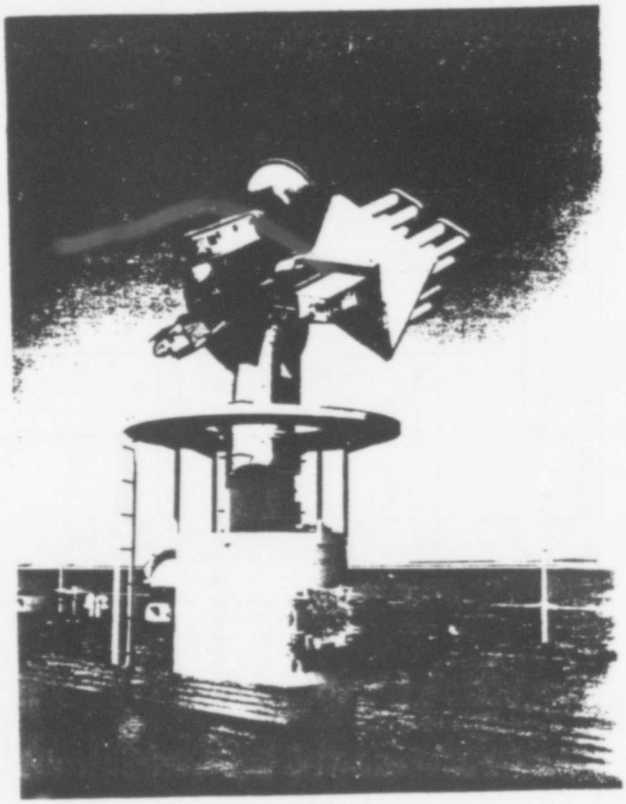

Figure 6.5 Shipboard antenna pedestal with L-, C-, and X-band antennas. (DASA-26-6835-62 photo)

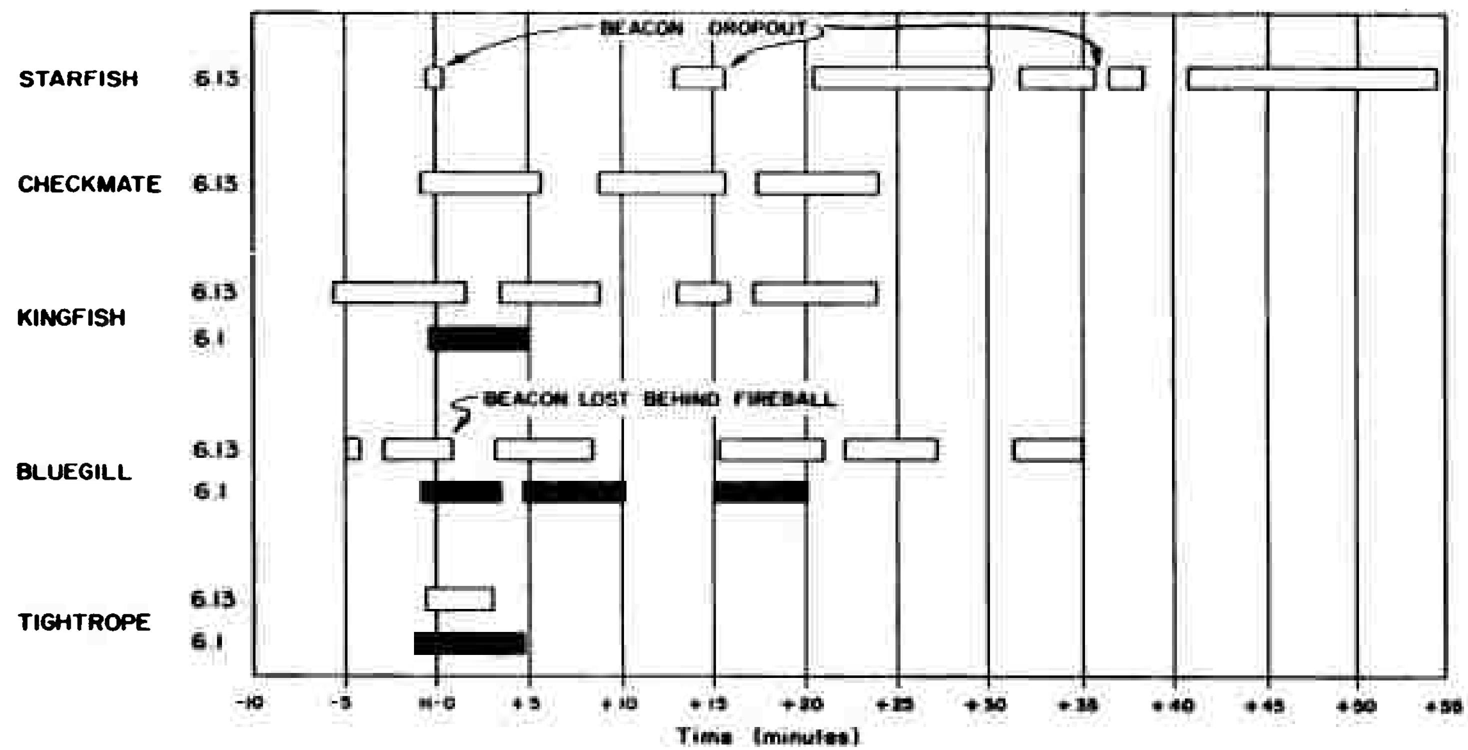

Figure 6.6 Data gathering times for Project 6.1 and 6.13.

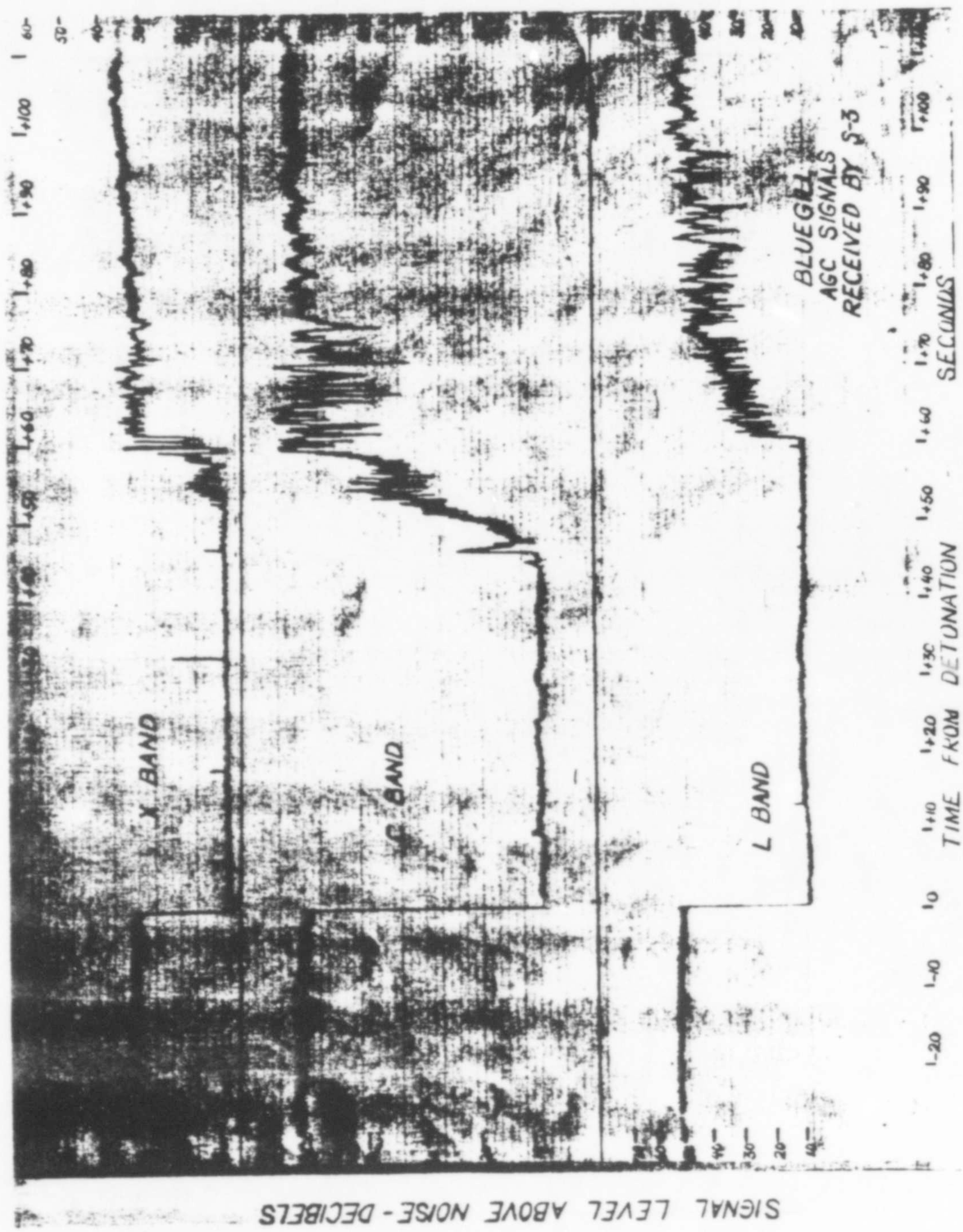

Figure 6.7 AGC record.

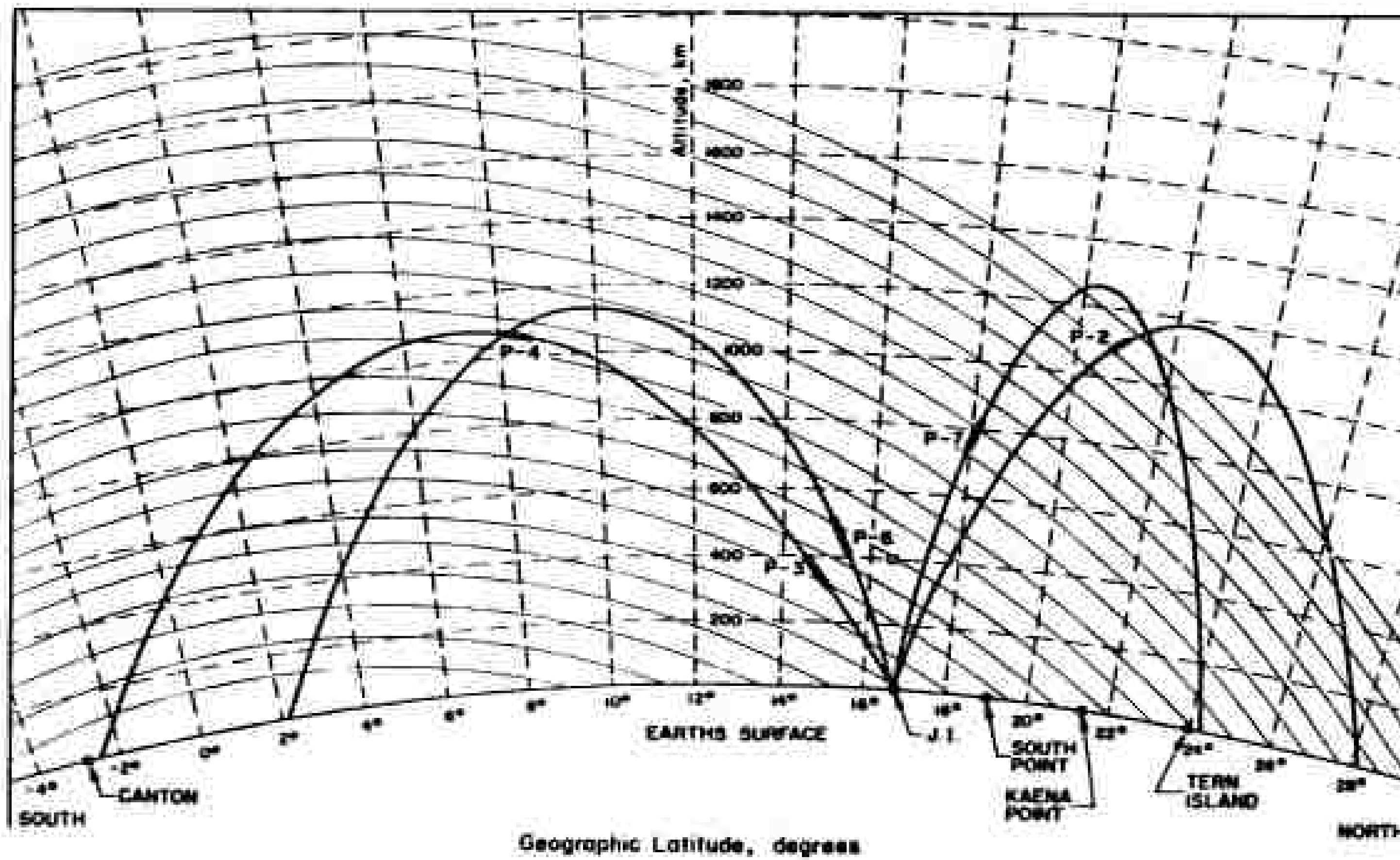

Figure 6.8 Rocket trajectories, Project 6.7, Shot Star Fish.

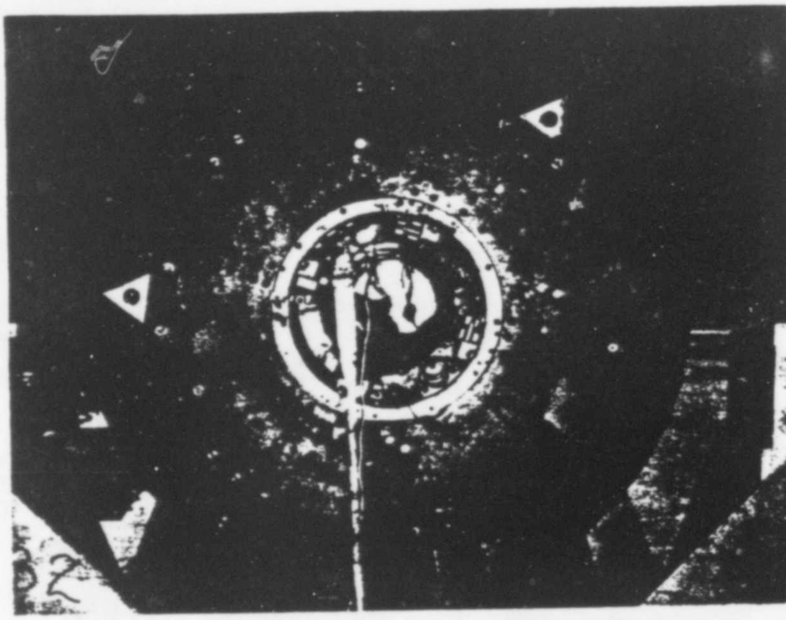

Figure 6.9 Instrument array, Project 8A.3. (DASA-26-5986-62 photo)

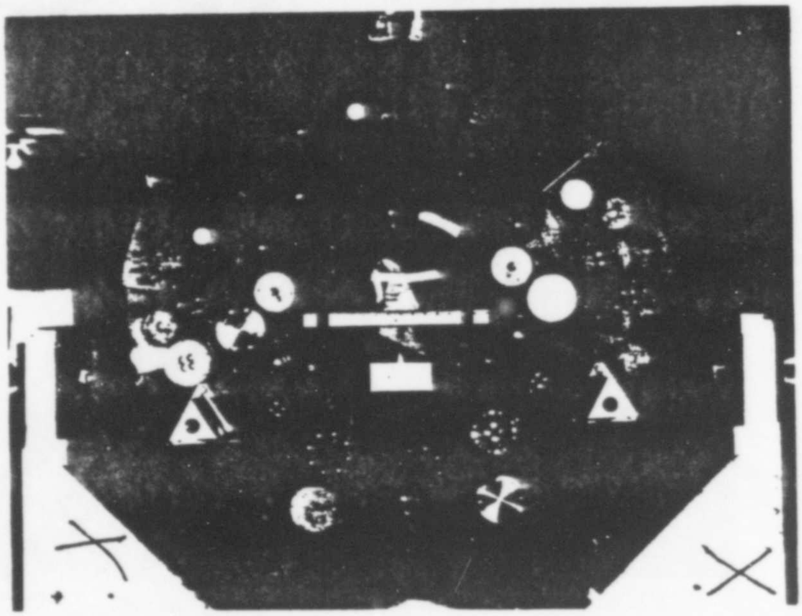

Figure 6.10 Instrument array on base of pod, Project 8B. (DASA-26-6246-62 photo)

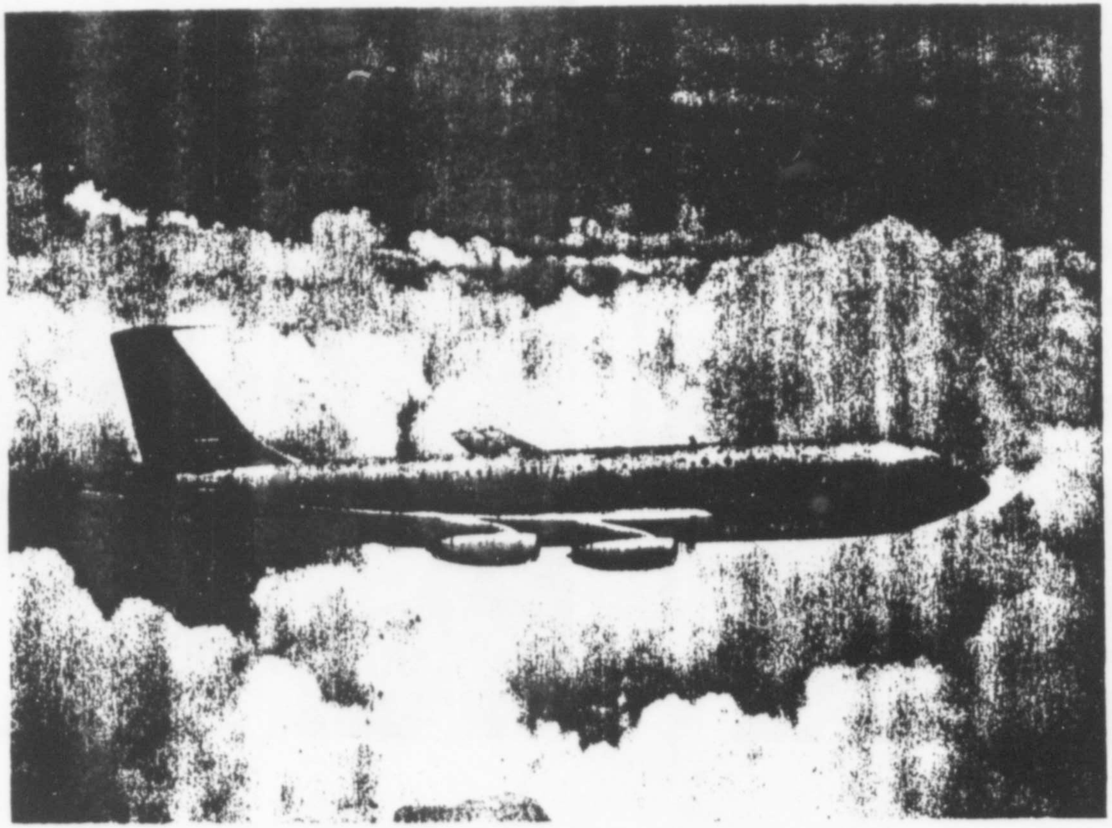

Figure 6.11 Optical infrared aircraft, KC-135.
(DASA-26-14526-62 photo)

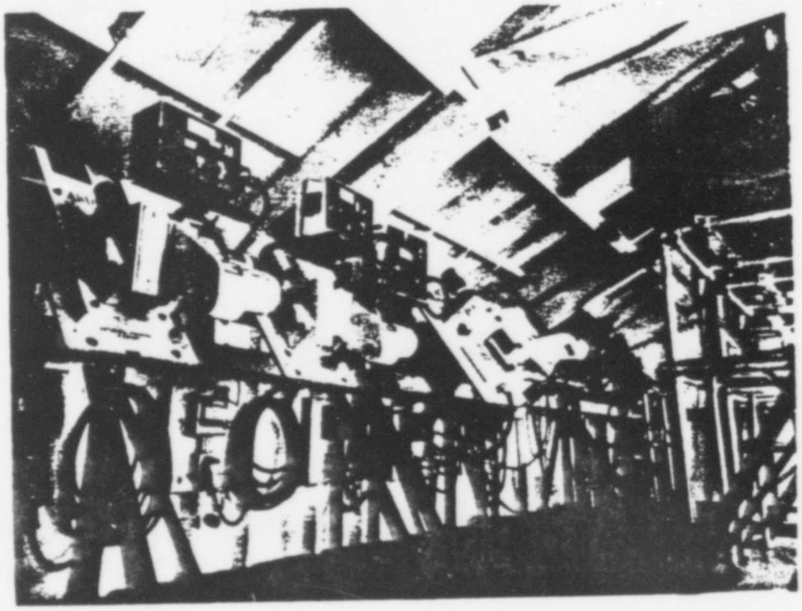

Figure 6.12 Interior of DOD photo station, Johnston Island. (DASA-26-6656-62 photo)

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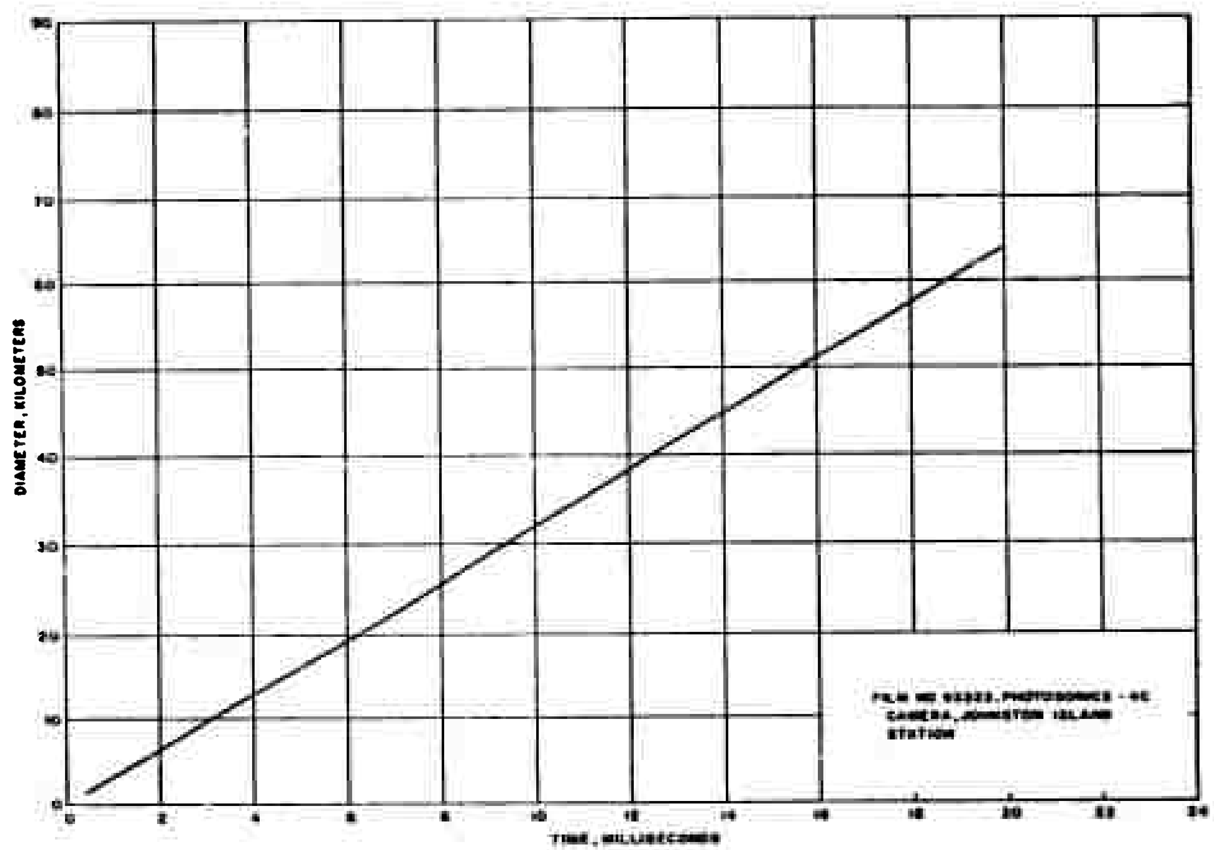

Figure 6.32 Debris diameter versus time, Shot Star Fish.

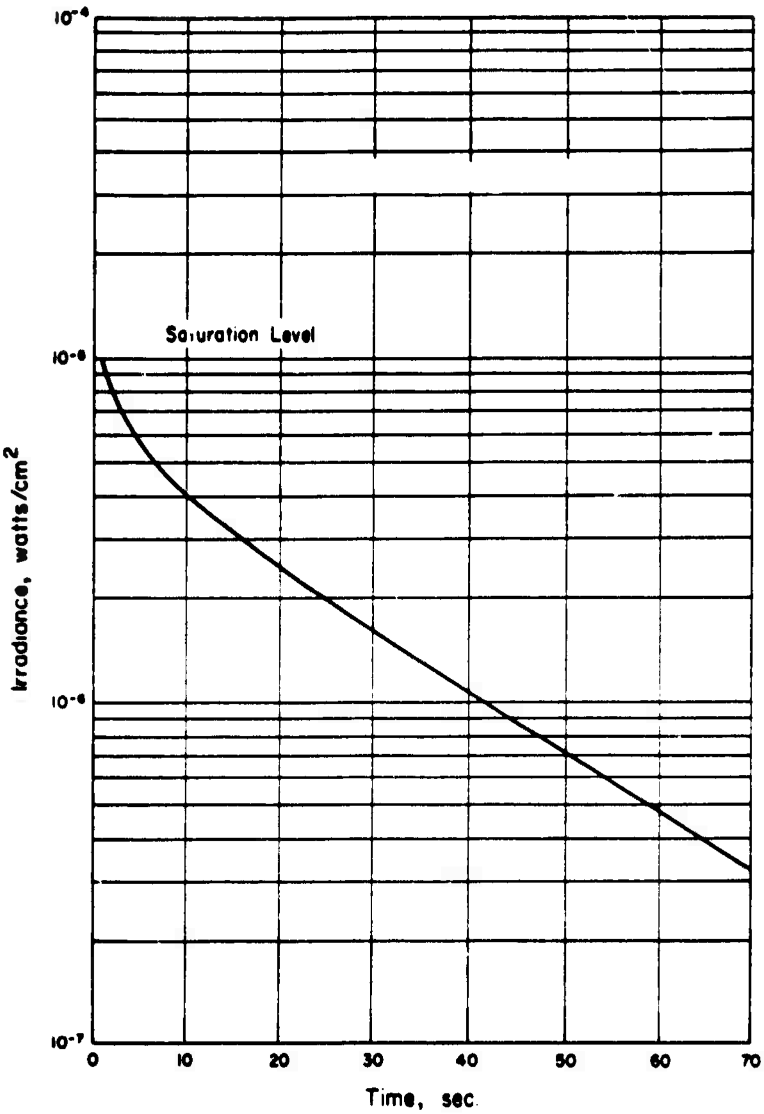

Figure 6.33 Irradiance versus time, 4.8 to 5.5 microns, Shot Star Fish.

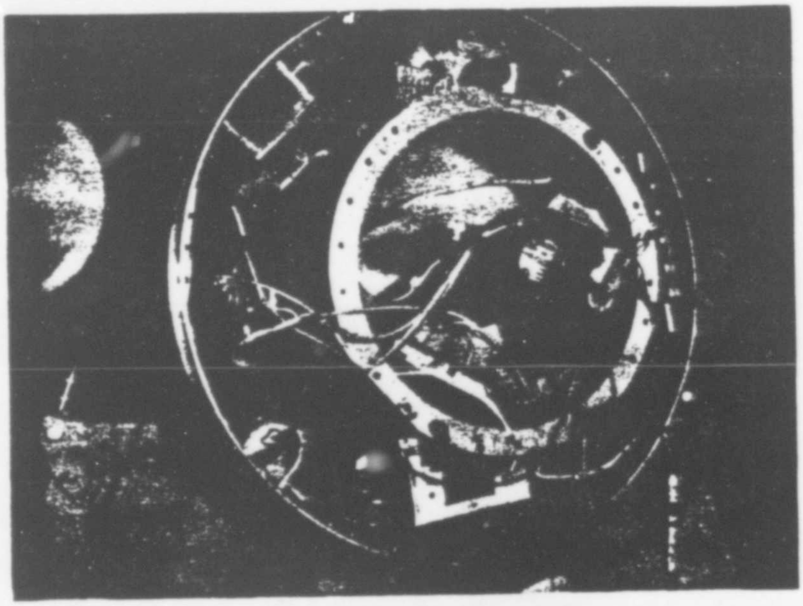

Figure 6.34 Blast instrument installation, Project 1.1. Also shows flywheel motor, tracking transponders and battery power supply. (DASA-26-5916-62 photo)

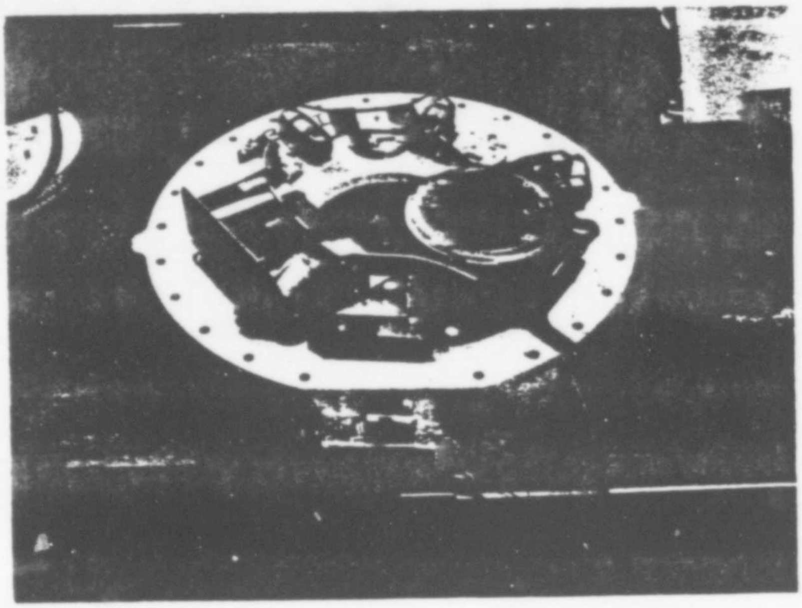

Figure 6.35 Accelerometer installation, Project 1.1. (DASA-26-5963-62 photo)

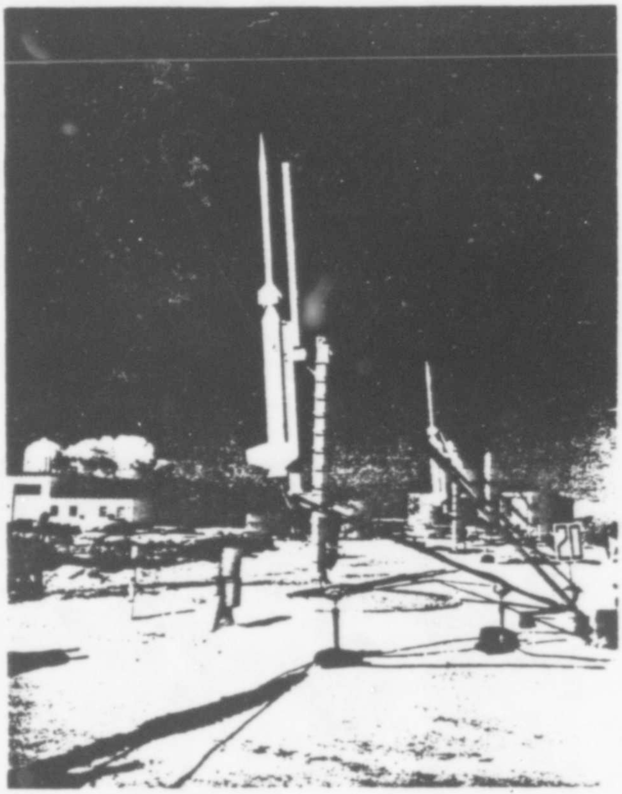

Figure 6.36 Nike-Cajun rocket with falling sphere payload. (DASA-26-5981-62 photo)

Chapter 7

SUMMARY

Overall, Operation Dominic was very successful in that the great majority of the scientific objectives were achieved. In reviewing the operational, logistic, and fiscal aspects of the operation, it is obvious, however, that considerable improvement can be made in any similar future operation. Many of the problem areas were recognized at the time, but action for improvements could not be taken because of imposed time limitations. It is interesting to note that a previous plan to execute a similar operation stated that a minimum of 18 months would be required for the preparation phase.

A major deficiency noted was the lack of early coordination between Headquarters DASA, Washington, D. C., and the Weapons Effects and Tests Group (WET) at Sandia Base, New Mexico. This was basically due to the extremely compressed time schedule, not due to any lack of channels or to personalities. Early coordination is essential if the group fielding the DOD experiments is to understand thoroughly the basic objectives of each program. This understanding is necessary for the basis of decisions made in the field concerning each project.

The Fish Bowl program (events) and schedules were changed throughout the operation because of changing technical requirements and operational interactions and difficulties. Such changes must be expected in any future operation and allowances made during the planning phases to allow flexibility.

7.1 ADMINISTRATION AND SUPPORT

It is of primary importance that properly trained personnel are available in a large operation such as Dominic. Augmentation of WET by inadequately skilled personnel is extremely detrimental to the DOD in general. High standards for personnel are essential if the DOD scientific group is to maintain the respect of the national scientific community and successfully achieve the assigned missions.

Because of the late arrival of key personnel on augmentation, the administrative effort suffered in that organization, job training and orientation had to be accomplished rapidly before deployment. Insufficient time was available to smooth out standing operating procedures (as indicated in the discussion in Chapter 2) for classified document control, postal services, orders, and pay and allowances services.

Security problems were complicated by personnel arriving in the Pacific without proper clearances. Some personnel were not properly oriented on security, resulting in security violations that could have been avoided. Classification of photography remained a problem throughout the operation, because all photographs were classified Secret Restricted Data until reviewed by an authorized classification officer. Too few classification officers were assigned, resulting in voluminous documentation to control Secret Restricted Data photography.

Public releases were centrally controlled during Operation Dominic, resulting in ill feeling on the part of governments in the Southern Conjugate Area. Planning in the future must provide for the timely furnishing of releases to the various governments. Although this was not their responsibility, personnel of TU 8.1.3 were expected to provide releases and to placate the governments when releases arrived late or from other than official sources.

7.2 OPERATIONS

The technical operations centers (TOC's) established at Johnston Island and Hickam AFB were essential to the success of the operation. Future plans should contain detailed plans for TOC's and should provide for adequate communications. The Dominic TOC's were originally conceived to be modest installations, but by necessity soon grew into complex centers.

Great care should be exercised in the future to obtain shot-time locations, speeds, courses, headings, and altitudes (aircraft) of aircraft and ships participating in the scientific collection effort. The procurement of this data was difficult in Dominic, in spite of preevent requests. Positioning criteria for both ships and aircraft must be realistic and must be thoroughly coordinated between the technical and operational personnel.

Greater care should be exercised in the small rocket program to insure closer conformity with established safety criteria. This will require better storage facilities, safe separation distances between launchers and other facilities, and better management. This last item ideally could be provided by utilizing a single agency to operate a small rocket control center, supervise rocket assembly, etc.

Readiness reporting became more satisfactory as communications improved. If the status of remote stations is to be considered when event time nears, rapid communications must be available. Simple voice codes were used during the Fish Bowl Series, greatly simplifying operations. Greater use of these codes should be considered in the future.

The tracking system used by TU 8.1.3 was extremely slow in producing usable data. Redundancy should be provided in the system to insure obtaining positioning data. Computer programs should be written prior to deployment. In Dominic, the original concept of data reduction long after completion of the operation was quickly discarded. Data reduction, especially in the tracking project, must be rapid to permit early evaluation of results. The equipment used in Dominic appeared satisfactory, but should be improved.

Clear lines of authority are needed in remote areas such as the Southern Conjugate Area. Control in that area was almost nonexistent due to lack of firm policies. Duties delegated to local project personnel must be clearly understood. Consideration should be given to more formal relationships with other governments in order to prevent ill feelings over relatively small matters. This is important where great interest exists in test programs. Where possible, early notification of pending tests to local government officials is desirable, along with description of the expected visible effects of the tests.

Equipment sent to remote locations must be thoroughly inspected and repaired prior to shipment. It is costly to airlift replacement equipment when simple precautions can prevent operating under pressure resulting from equipment malfunctions.

Participation on the AEC developmental events on Christmas Island again demonstrated the problems of fielding experiments with unproven equipment. This was shown by the extreme problems that developed with the Project 7.3 aircraft, due to the rush to deploy to the test area without proper preparation.

Although communications were ultimately satisfactory during Dominic, they should be improved in any future operation and should be phased in earlier in the preparation period. The use of makeshift systems is to be discouraged because of low reliability.

7.3 SPECIAL INTEREST AREAS

The pods as used for instrument carriers in Dominic were marginal in performance. Stabilization was unsatisfactory, resulting in much lost data. No pod system should be considered for use in a future operation without complete testing, to include satisfactory instrumented test flights. It is apparent from Dominic experience that instrumented pods are practicable and that they can be used to collect data not otherwise obtainable.

High-performance aircraft can be modified to serve as excellent instrument platforms, if exacting positioning is not required. The ability to fly over existing high cloud layers was of great benefit to the optical programs. Modification of modern stressed-skin aircraft is a complex engineering job, and adequate time must be programed for such modification if premium time rates are to be avoided by contractors.

7.4 SCIENTIFIC ACTIVITY

The experiments fielded in the Fish Bowl Series, in particular, and Operation Dominic, in general, were very successful. In spite of the great distances involved and the sometimes marginal communications, the various projects were able to measure the effects as programed. The greatest loss of data was in those projects depending on pod performance. These projects were able to fulfill some objectives, but did not in all cases obtain acceptable results.

For detailed scientific results, the reader is referred to the quick-look reports published by Joint Task Force EIGHT and by the DASA Data Center, Santa Barbara, California; and the POR's published by DASA (Appendix A).

Appendix A

LIST OF PROJECT OFFICERS REPORTS

Project Number	Title	POR (WT)' Number
OPERATION DOMINIC, SHOT SWORD FISH		
1.1	Underwater Pressures (NOL)	2000
1.2	Surface Phenomena (NOL)	2001
1.3a	Effects of Underwater Nuclear Explosions on Sonar Systems at Close Range (NEL)	2002
1.3b	Effects of an Underwater Nuclear Explosion on Hydroacoustic Systems (NEL)	2003
2.1	Radiological Effects from an Underwater Nuclear Explosion (NRDL)	2004
3.1	Studies of Shock Motions of Hull and Equipment (DTMB)	2005
9.1	Ship Damage Assessment and Technical Support of Test Elements (BuShips)	2006
	Scientific Director's Summary Report (DTMB)	2007
OPERATION DOMINIC, FISH BOWL SERIES		
1.1	Blast Measurements at Various Distances from High-Altitude Nuclear Detonations (BRL)	2010
1.2	Shock Photography (NOL)	2011
2.1	External Neutron Flux Measurements (NDL)	2012
2.2	Gamma Radiation Measurements (NDL)	2013
2.3	Alpha Contamination Monitoring (NDL)	2052
6.1	Fireball Attenuation (ELRDA/AFSWC)	2015
6.2	Gamma-Ray Scanning of Debris Cloud (BRL)	2017
6.3	D-Region Physical Chemistry (BRL)	2018
6.4	E- and F-Region Physical Chemistry (AFCRL)	2019
6.5a	Ionospheric Soundings and Magnetic Measurements (AFCRL)	2020
6.5b	Ionospheric Measurements in Southern Conjugate Area (IIT)	2021
6.5c	Vertical Ionospheric Sounding Measurements (NBSCRPL)	2022
6.5d	Effects of Thermonuclear Radiation on the Ionosphere (RPA)	2023
6.5e	Magnetic Measurements (SRDL)	2024
6.6	Long-Term Debris History (GCA)	2025
6.7	Debris Expansion Experiment (AFSWC)	2026

Project Number	Title	POR (WT) Number
6.8	Riometer Measurements (AFCRL)	2027
6.9	Radar Clutter Measurements (SRI)	2028
6.10	High-Altitude Nuclear Detonation Effects on Ionospheric Properties (AFCRL)	2029
6.11	HF Communication Experiment (SRDL)	2030
6.12	Piggyback Satellite Packages (AFCRL)	2031
6.13	RF Measurements and Optical Measurements (AMCD)	2032
7.2	Radiofrequency Radiometry (MITLL)	2034
7.4	Communication Propagation Investigation Equipment (ASD)	2044
8A.1	High-Altitude Nuclear Detonation Optical-Infrared Effects (AFCRL)	2035
8A.2	Optical Phenomenology of High-Altitude Nuclear Detonations (EG&G)	2036
8A.3	Structural Response to Thermal Radiation from High-Altitude Fireball (ASD)	2037
8B	Nuclear Weapon X-Ray Effects as Measured by Passive Instruments (AFSWC)	2038
8C	Reentry Vehicle Tests (AFSWC). POIR is considered final.	2039
9.1a	Atmospheric Properties (AFCRL)	2040
9.1b	Ionospheric Wind Measurements (AFCRL)	2051
9.4b	Pod and Recovery Unit Fabrication (AFSWC)	2041
9.6	Tracking and Positioning (Cubic)	2042

OPERATION DOMINIC, CHRISTMAS AND FISH BOWL SERIES

4.1	Production of Chorioretinal Burns by Nuclear Detonations and Tests of Protective Devices and Phototropic Materials (AFSAM)	2014
7.1	Electromagnetic Signal, Underwater Measurements (KN)	2033

OPERATION DOMINIC, CHRISTMAS SERIES

4.2	Photoelectric and Psychophysical Measures of Nuclear Weapons Flashes (NADC)	2016
7.3	Microwave Attenuation Due to Nuclear Burst (ELRDA)	2043
7.5	Thermal Radiation from Air Burst Nuclear Weapons Incident on Low-Altitude Aircraft (ASD). Published as ASD-TDR-62-823; available from Defense Documentation Center (formerly ASTIA), Arlington Hall, Arlington 12, Virginia	

Operation Dominic: Organizational, Operational, Funding, and Logistic Summary — 2053

Appendix B

MAPS OF PACIFIC ISLANDS

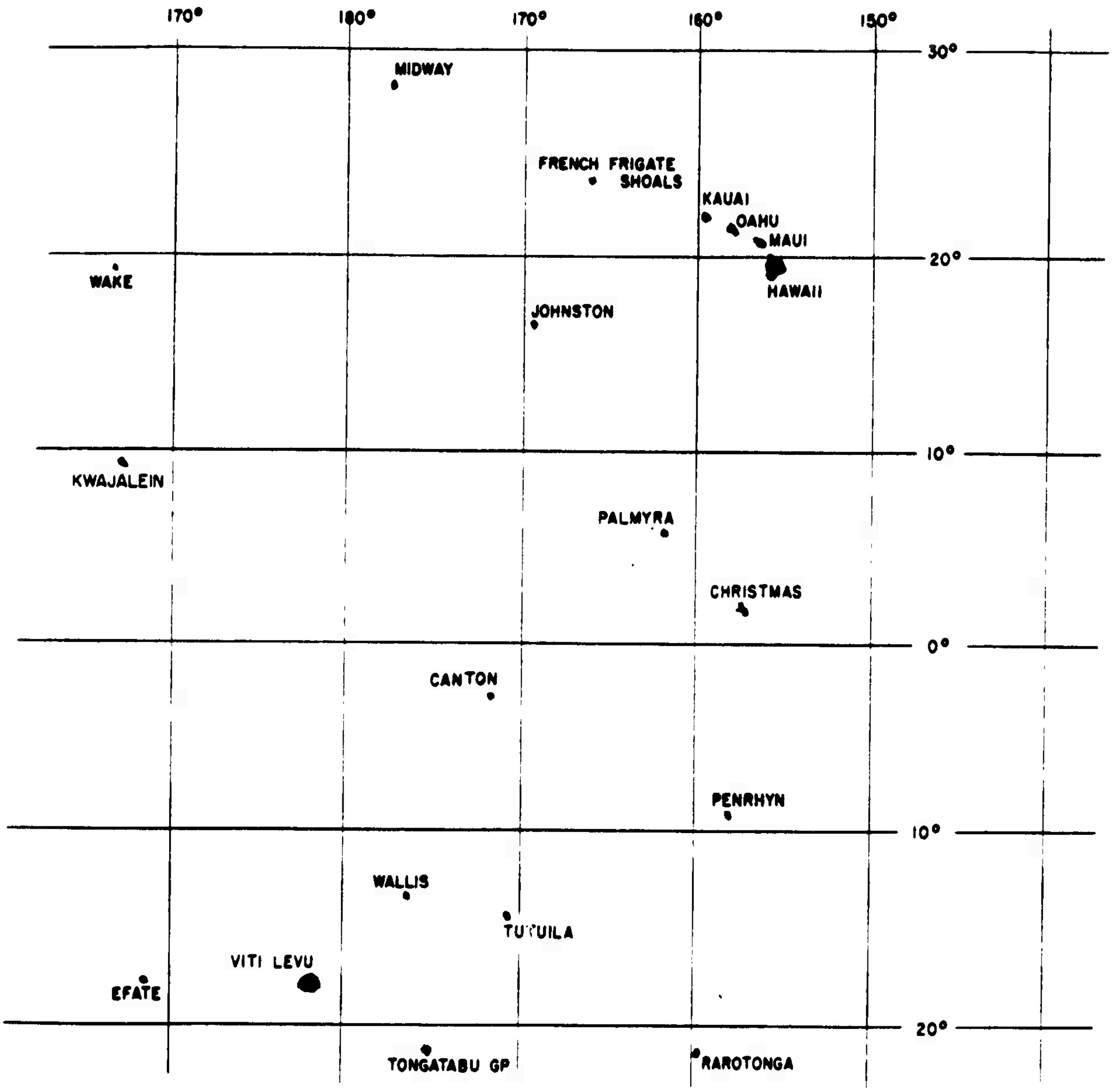

Figure B.1 Pacific Ocean area.

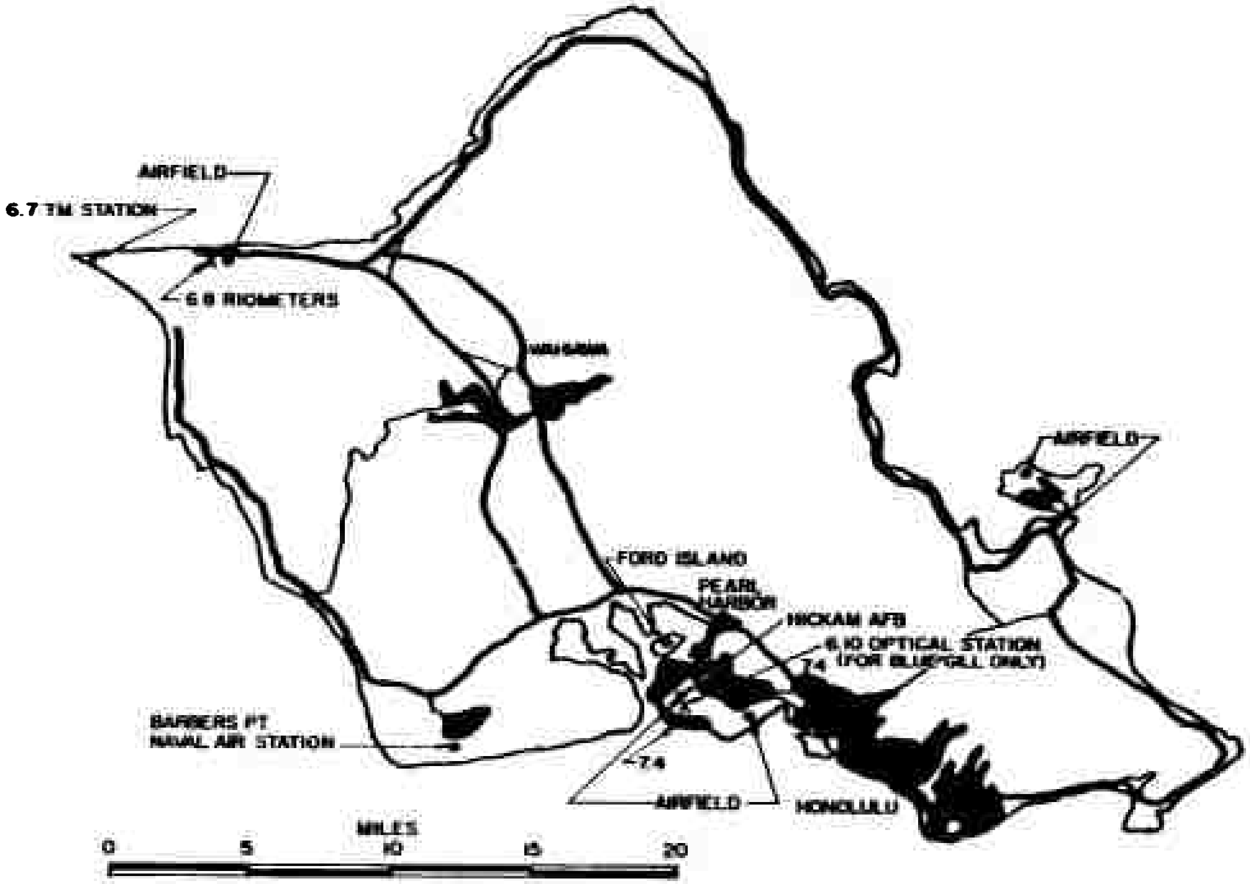

Figure B.2 Ohau.

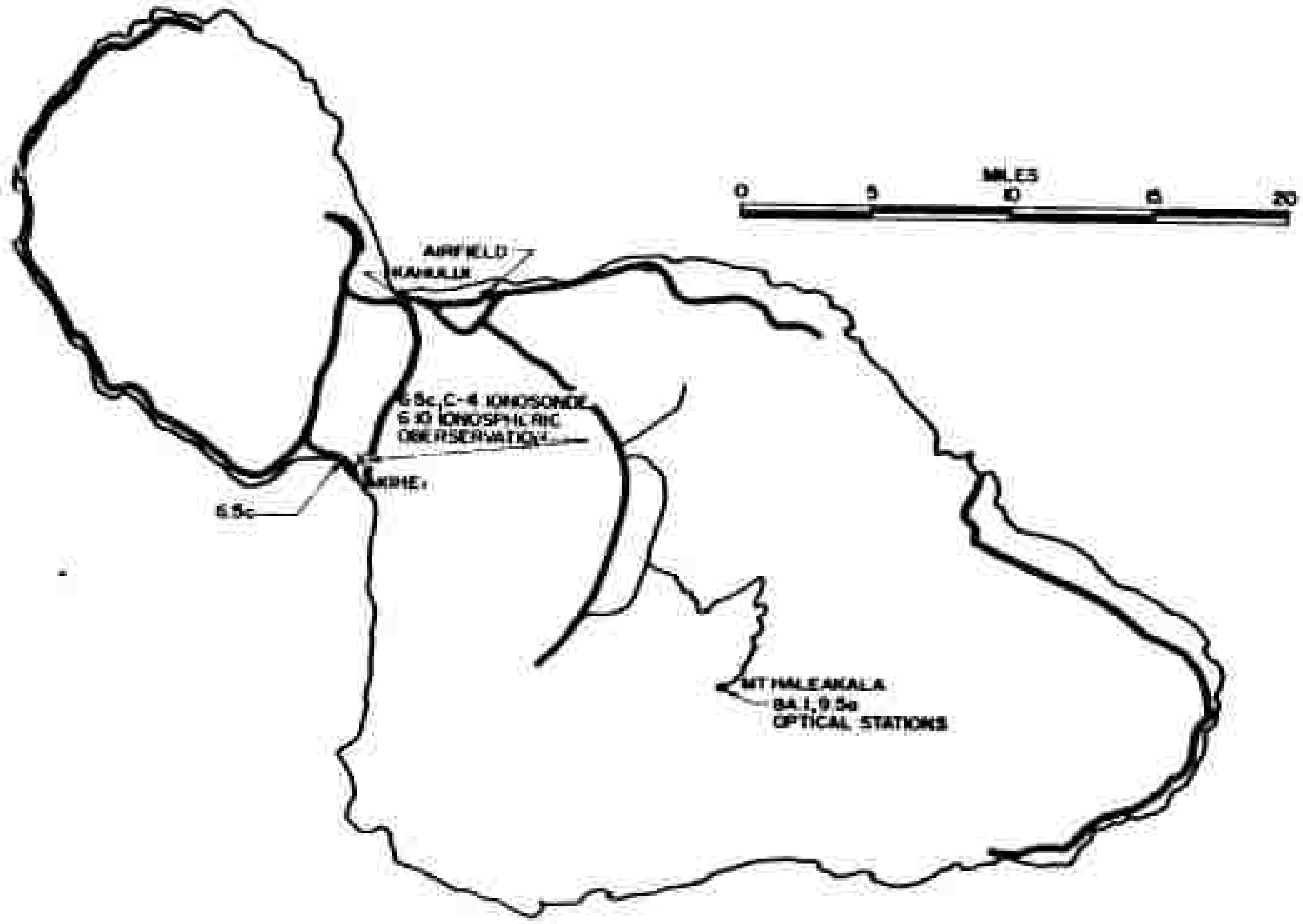

Figure B.3 Maui.

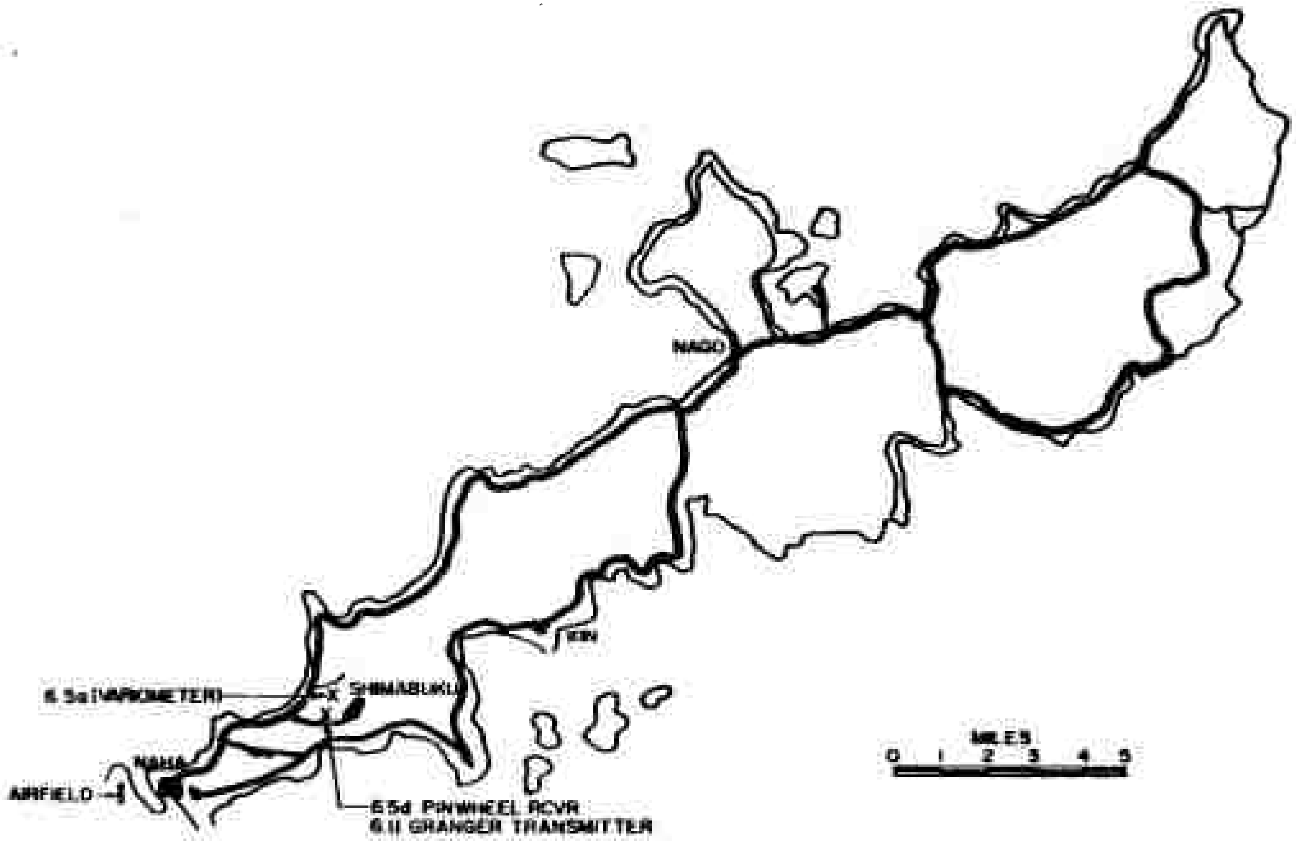

Figure B.4 Okinawa.

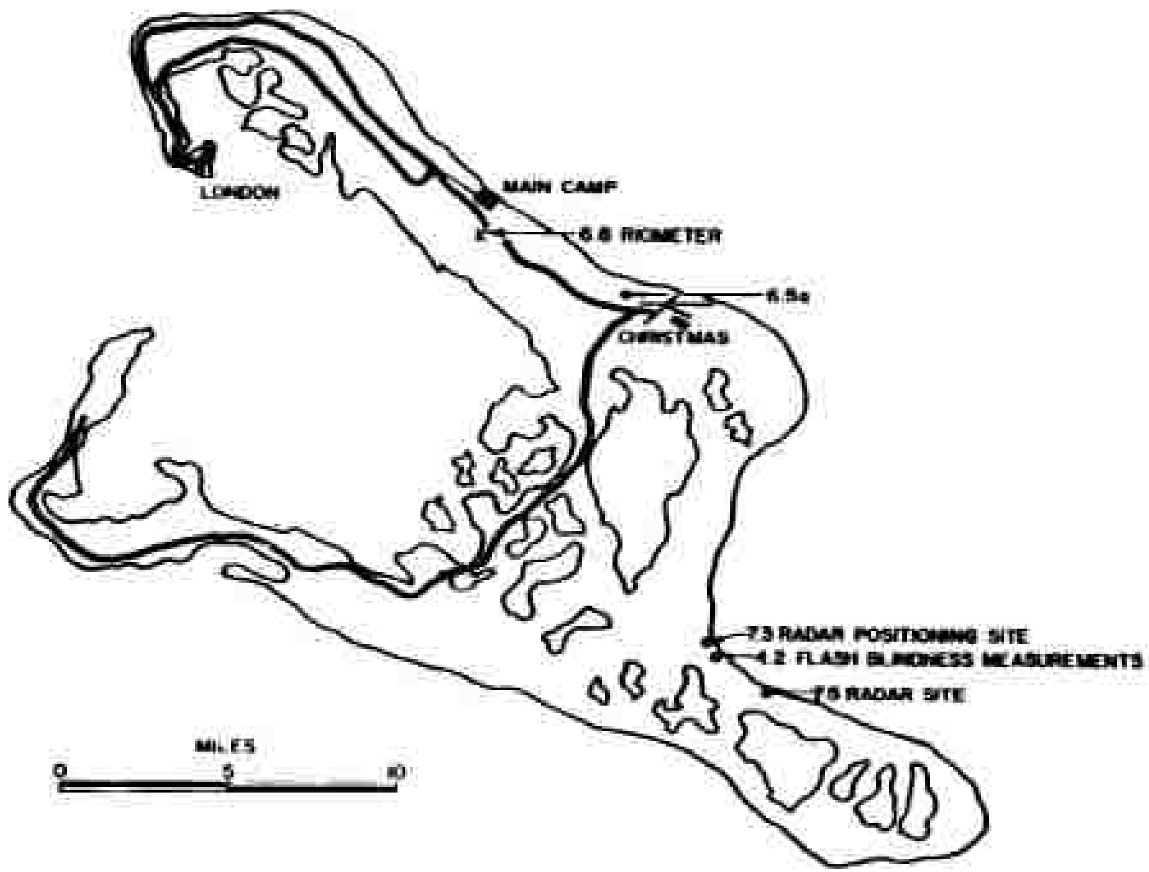

Figure B.5 Christmas Island.

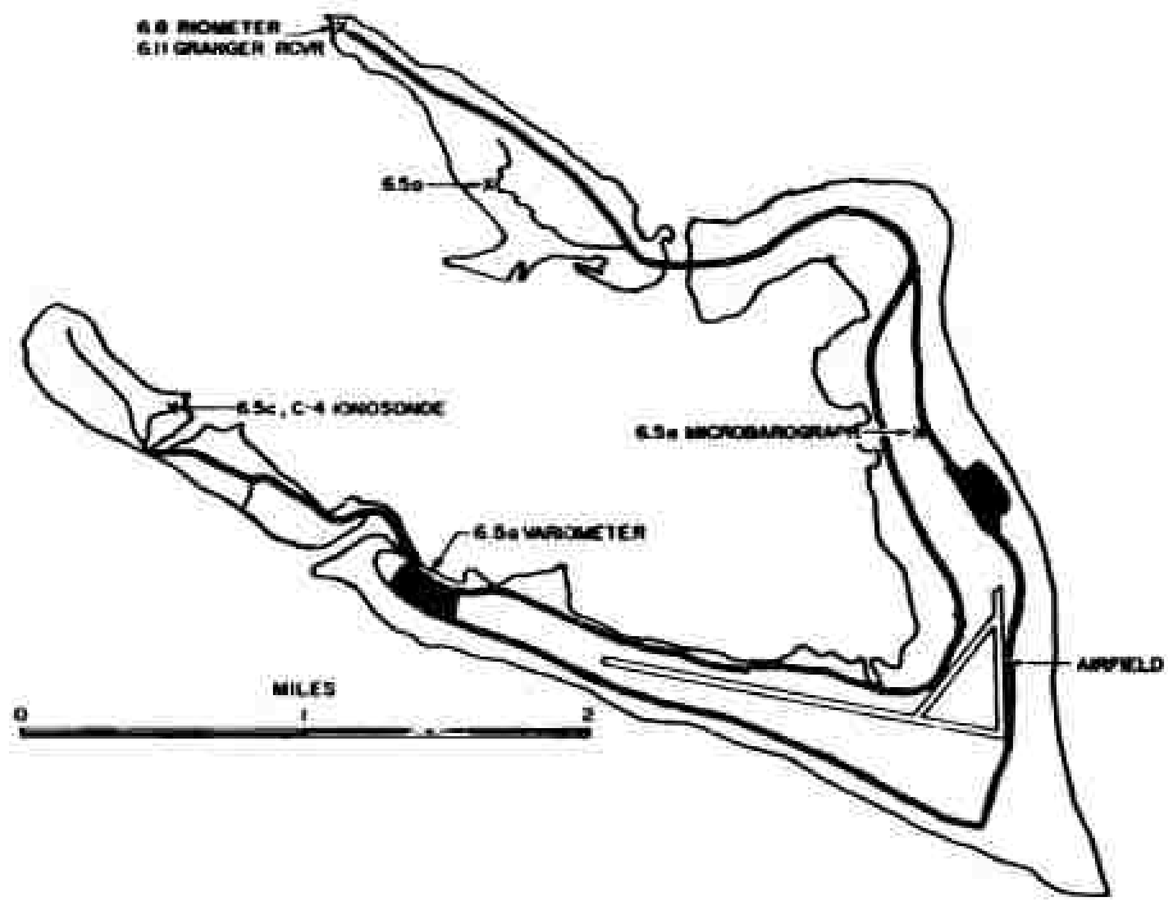

Figure B.6 Wake.

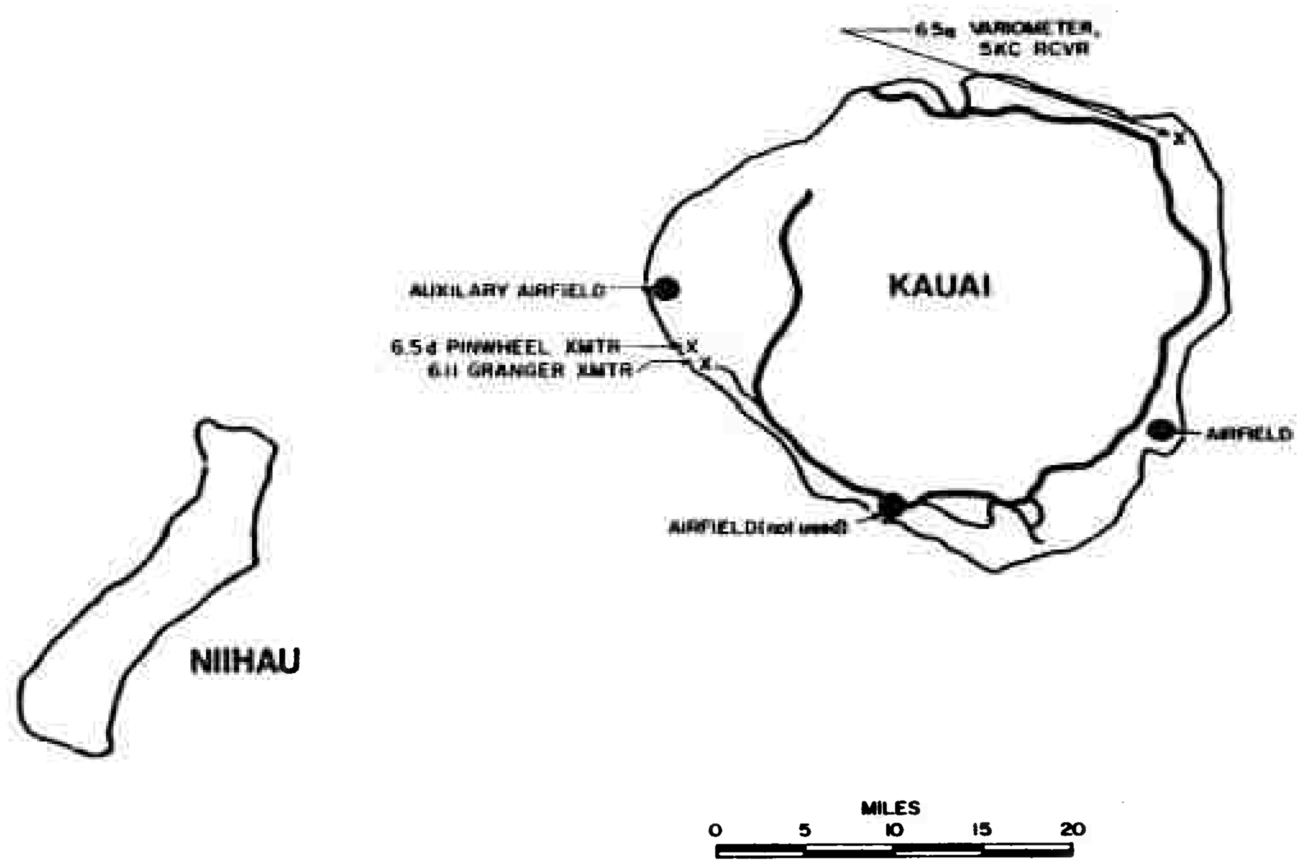

Figure B.7 Kauai.

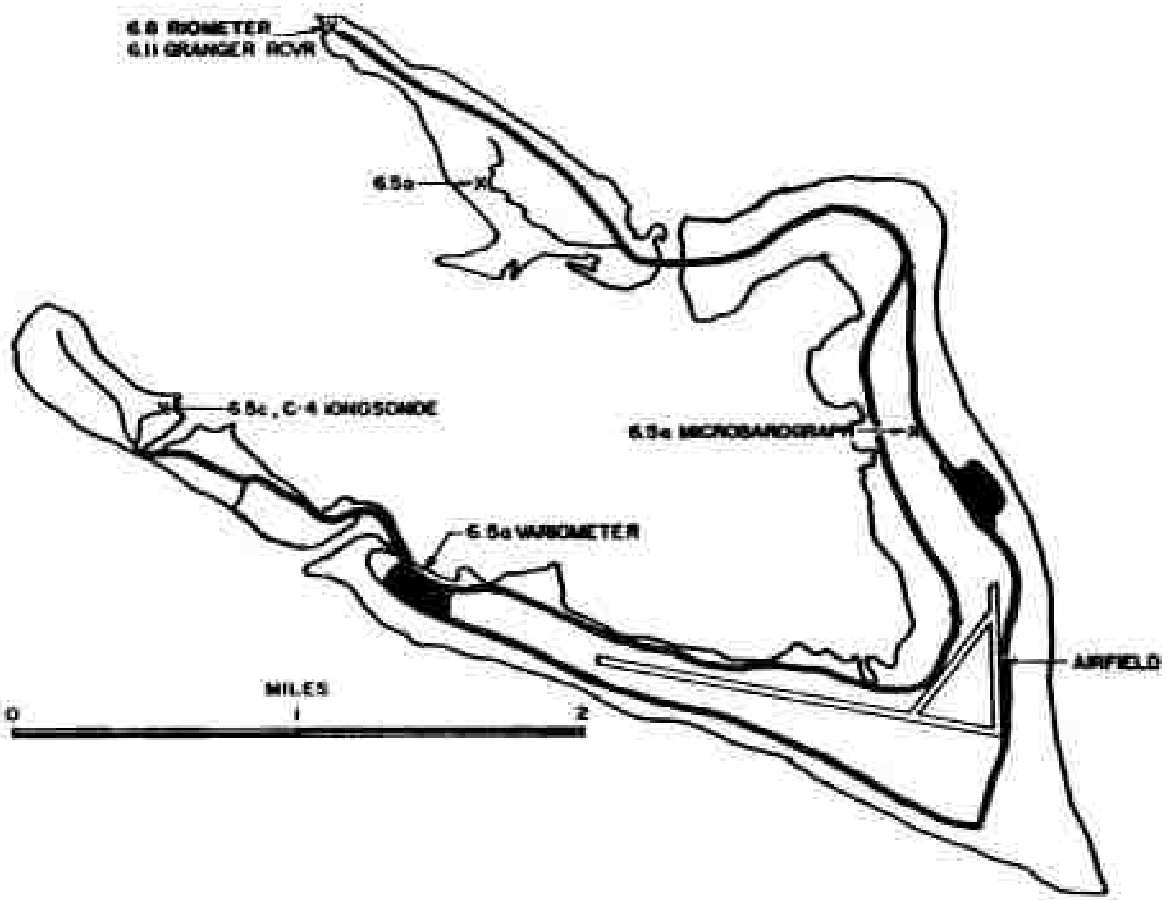

Figure B.6 Wake.

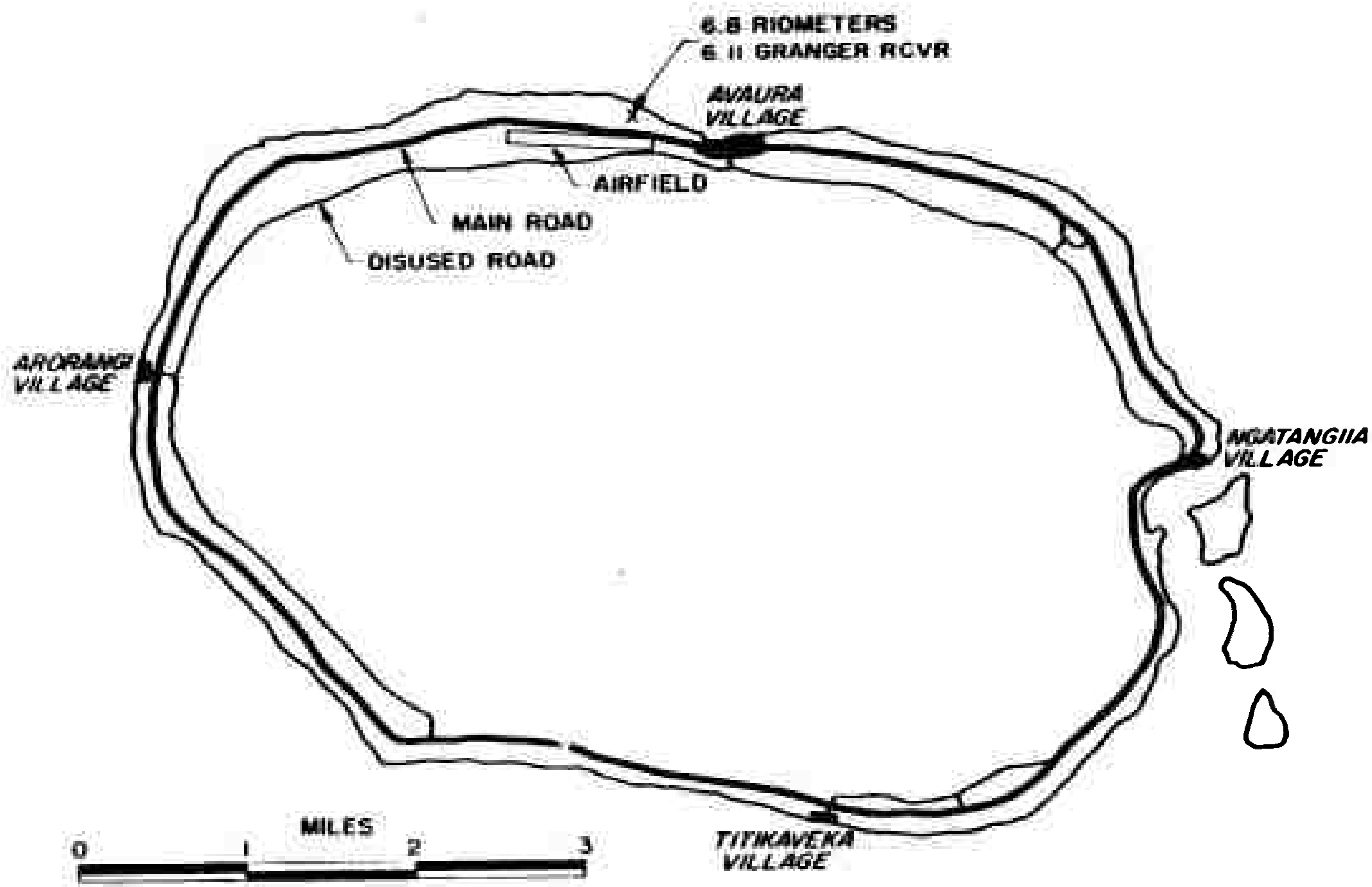

Figure B.8 Rarotonga.

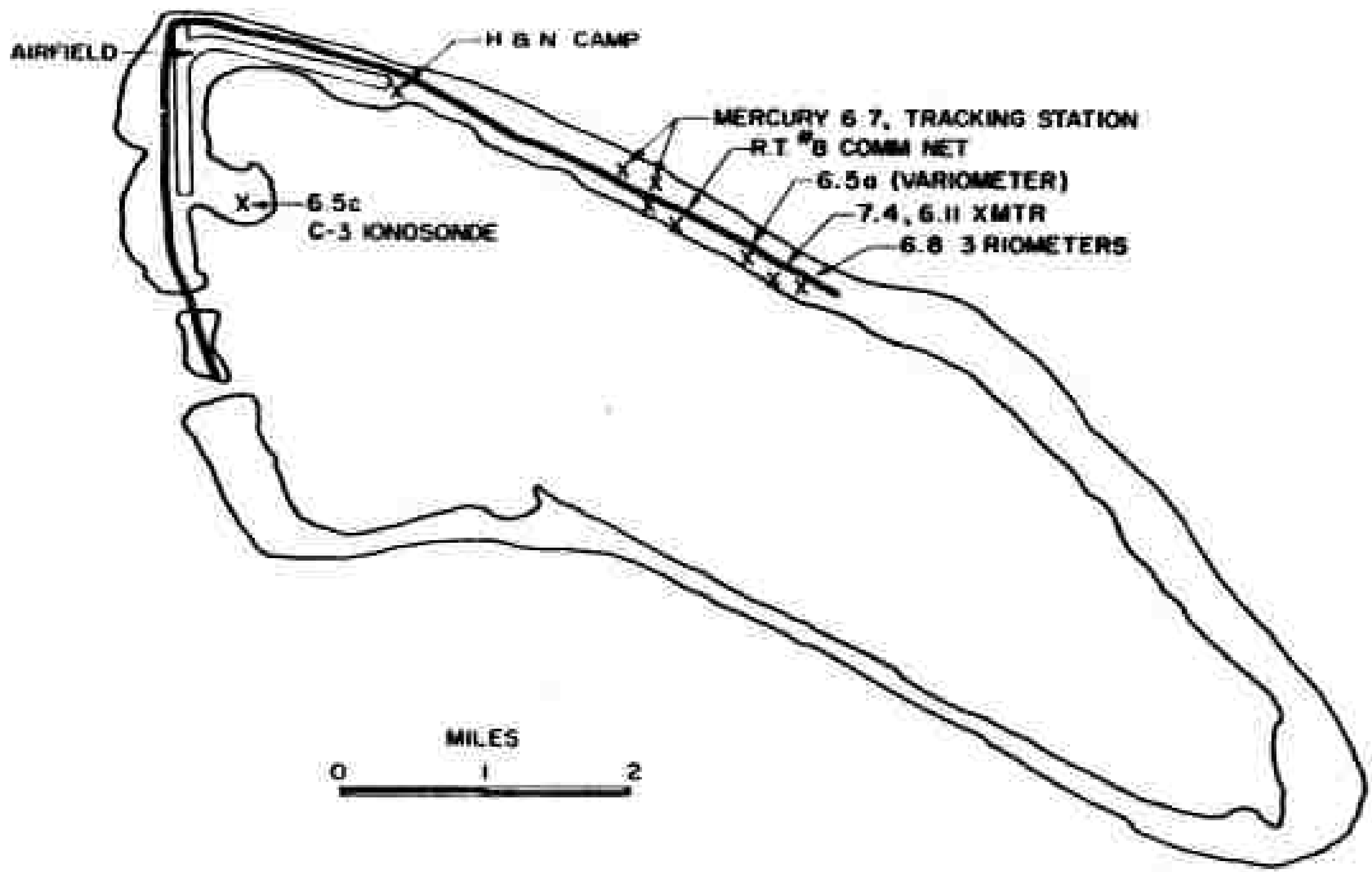

Figure B.9 Canton.

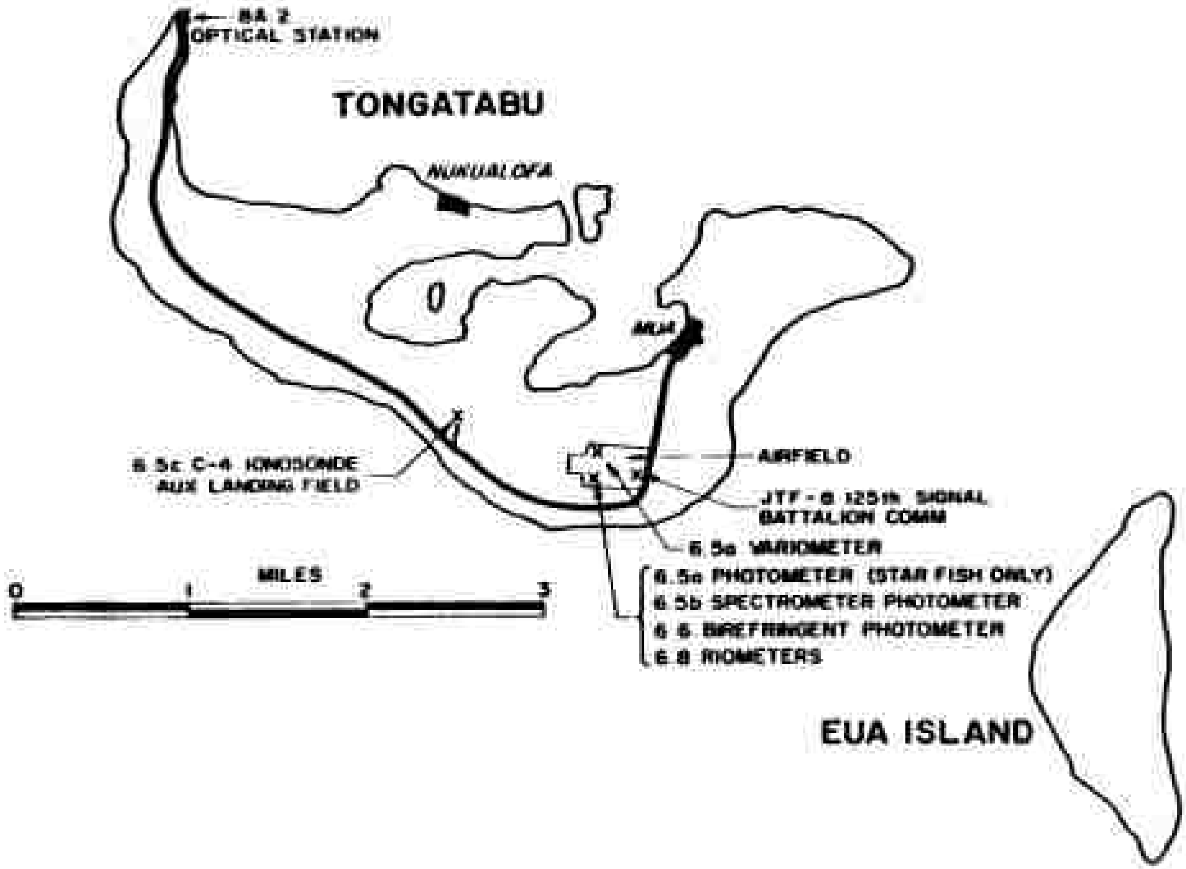

Figure B.10 Tongatabu.

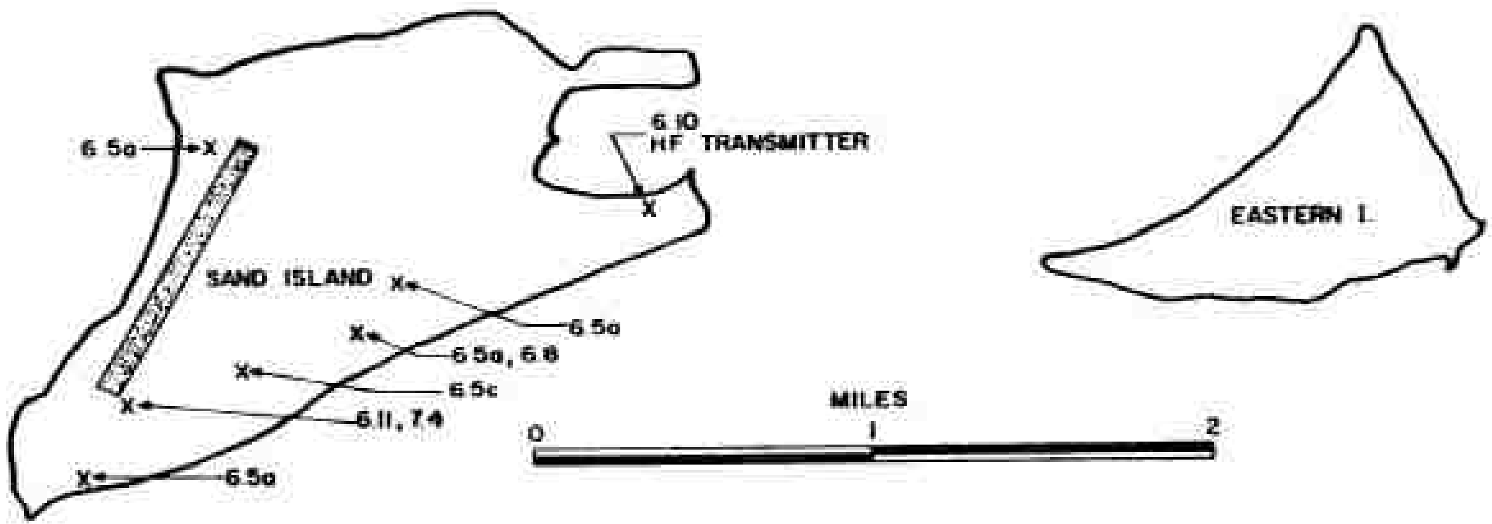

Figure B.11 Midway.

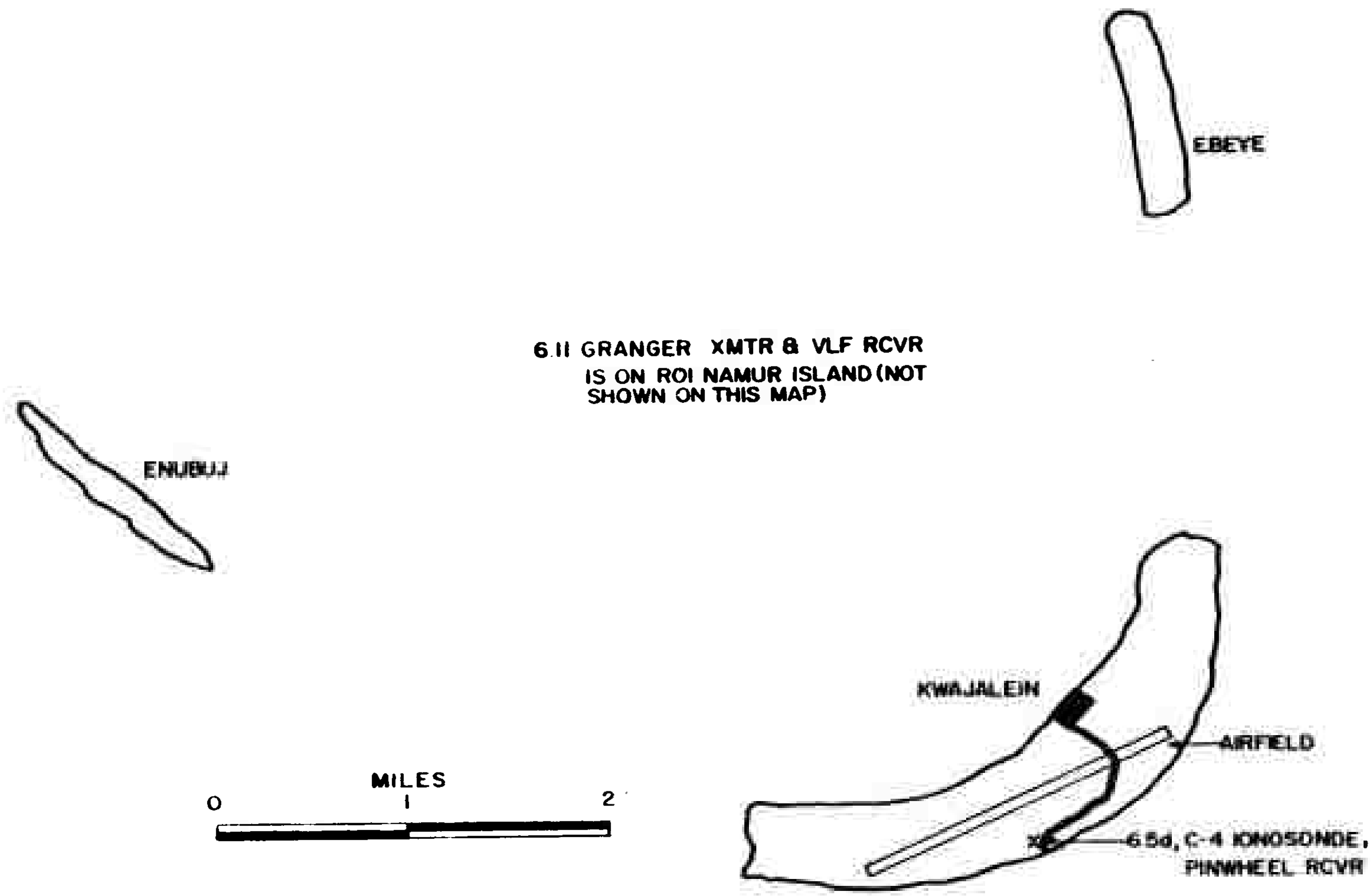

Figure B.12 Kwajalein Atoll.

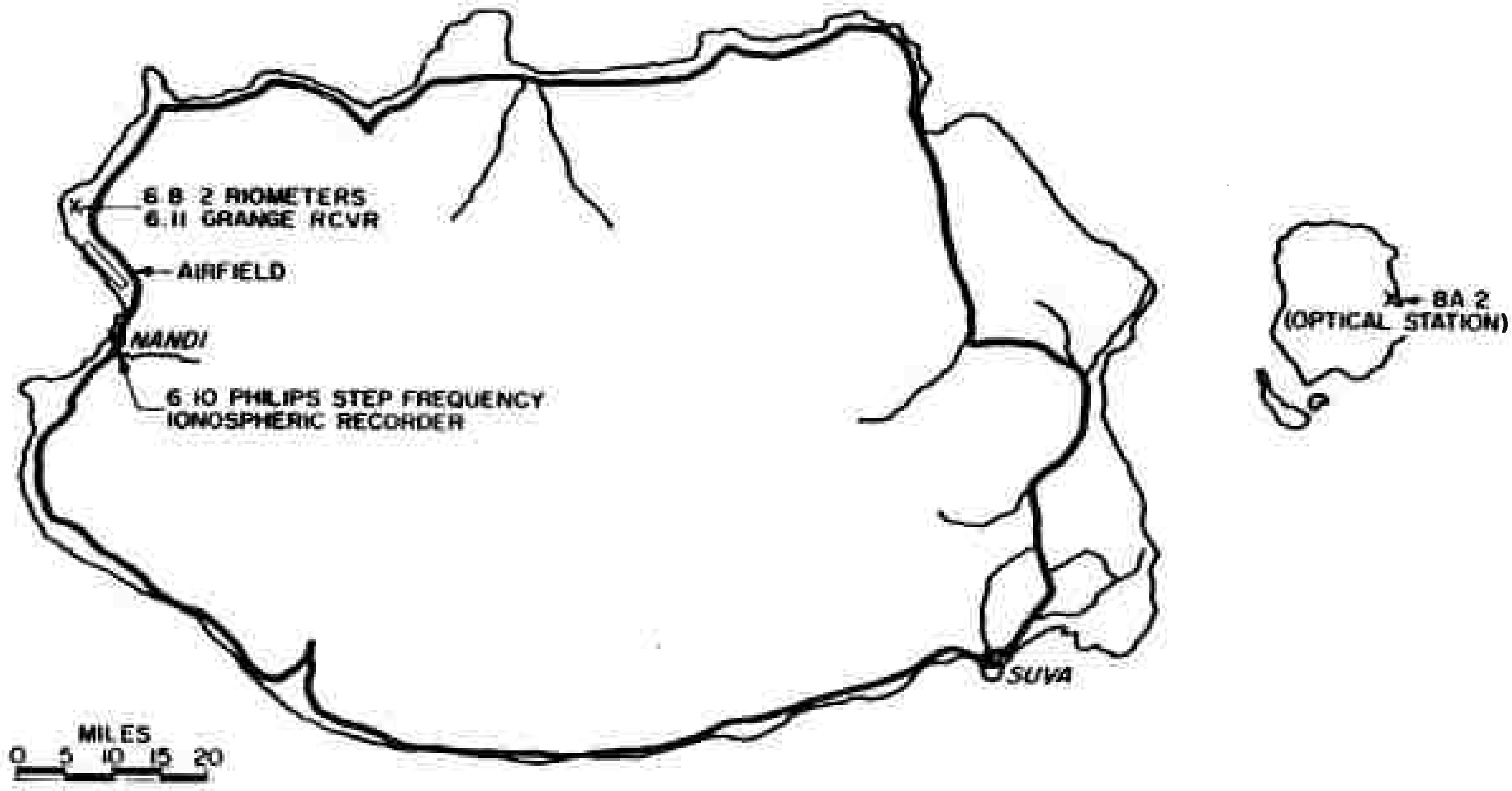

Figure B.13 Viti Levu.

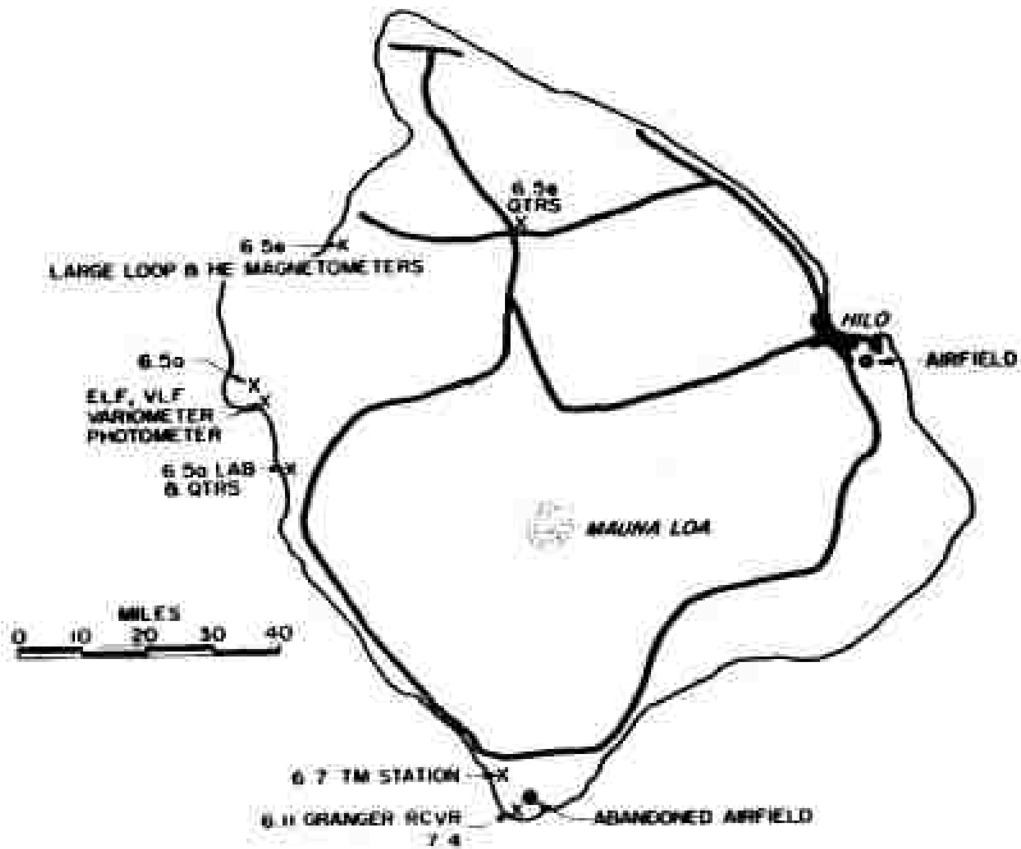

Figure B.14 Hawaii.

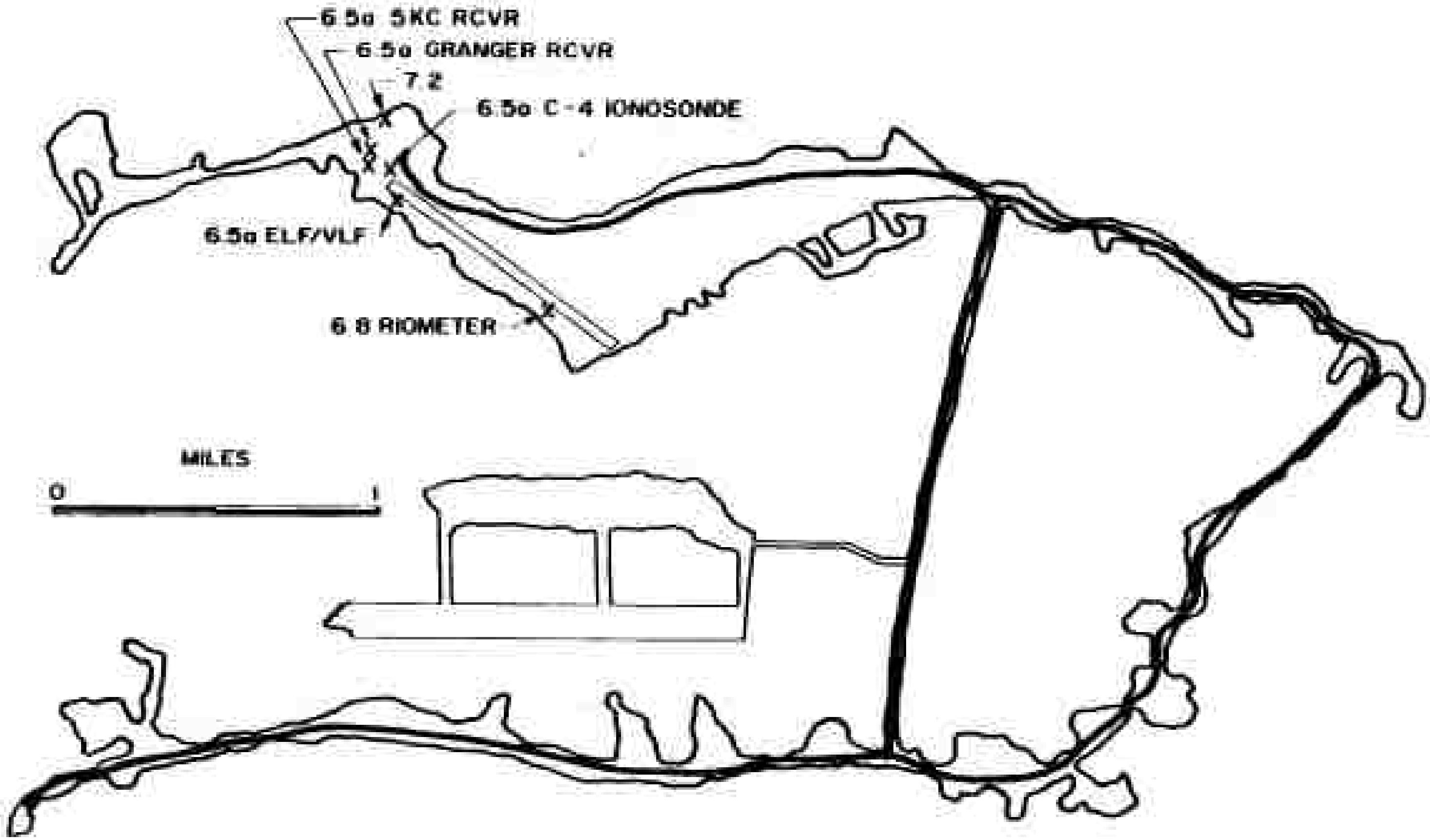

Figure B.15 Palmyra.

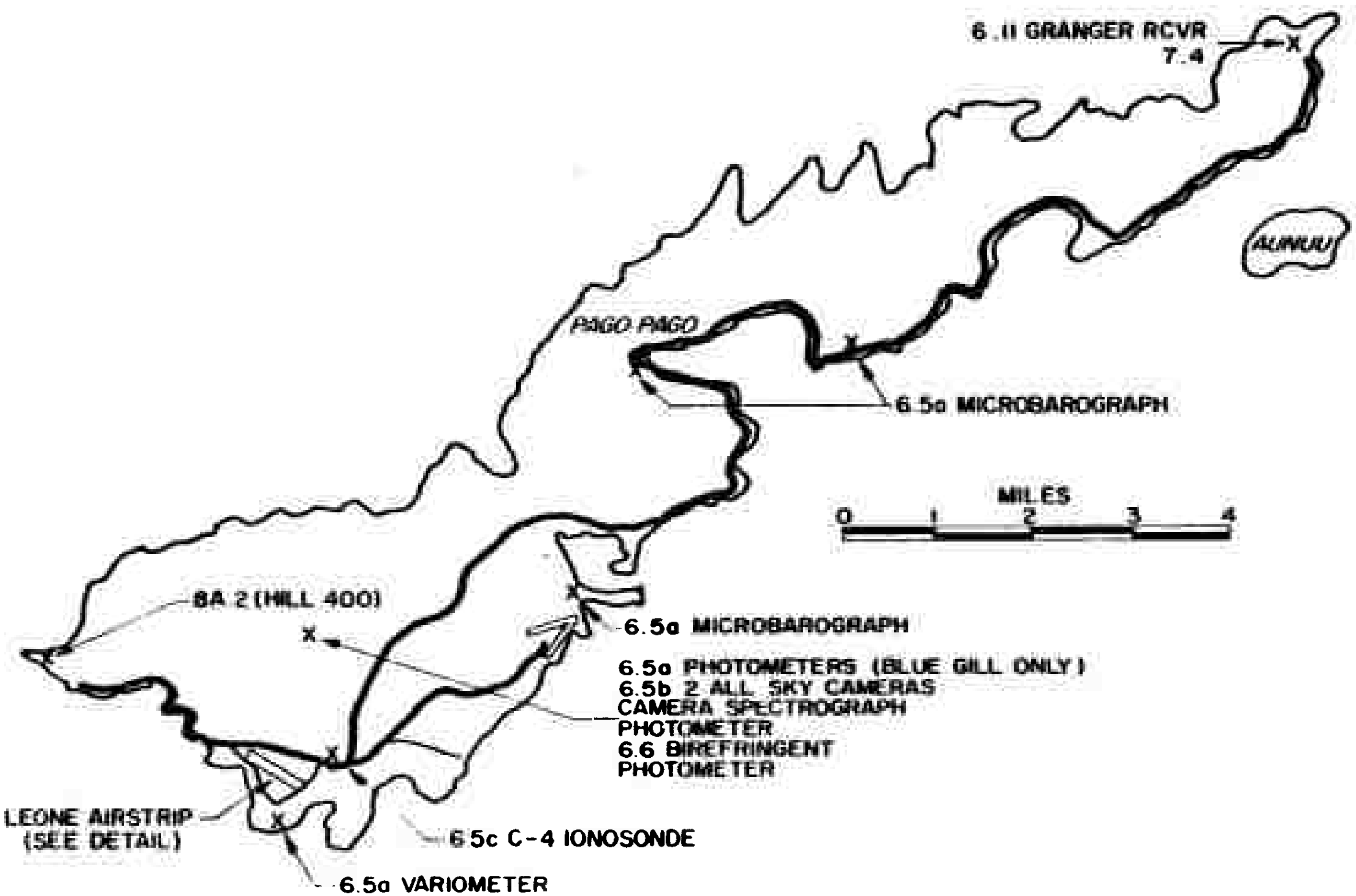

Figure B.16 Tutuila.

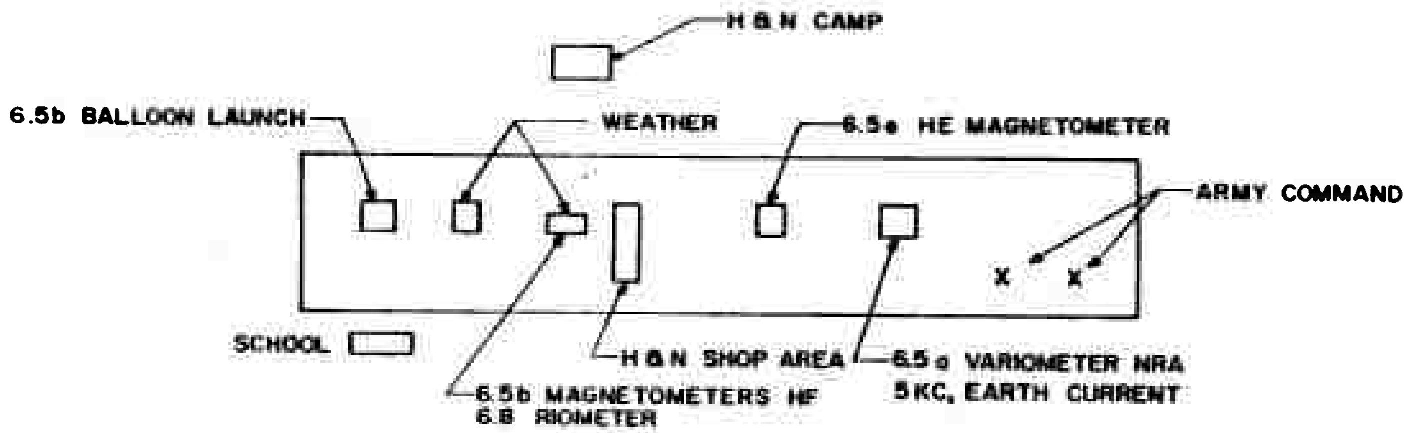

Figure B.17 Tutuila, Leone Airstrip detail.

APPENDIX C TYPICAL WEATHER SOUNDING SCHEDULE

18 June 1962

Star Fish RAWINSONDE and PIBALL Schedule

Release Time		Type of Release
D-DAY:	0100	RAWINSONDE sounding.
	0700	RAWINSONDE sounding.
	1300	RAWINSONDE sounding.
	1600	RAWINSONDE sounding with double-theodolite trackout.
	1645	Double-theodolite PIBALL sounding.
	1730	Double-theodolite PIBALL sounding.
	1815	Double-theodolite PIBALL sounding.
	1900	RAWINSONDE sounding with double-theodolite trackout.
	1940	Double-theodolite PIBALL sounding.
	2045	Double-theodolite PIBALL sounding.
	2110	Double-theodolite PIBALL sounding.
	2140	Double-theodolite PIBALL sounding.
	2210	RAWINSONDE sounding with double-theodolite trackout.
	2225	Weather station evacuated.
D+ 1 DAY:		
	0100	RAWINSONDE sounding with double-theodolite trackout.
	0400	RAWINSONDE sounding with double-theodolite trackout.
	0445	Double-theodolite PIBALL sounding.
	0530	Double-theodolite PIBALL sounding.
	0700	RAWINSONDE sounding with double-theodolite trackout.
	1000	RAWINSONDE sounding.
		End of Special Star Fish meteorological soundings.

Appendix D

SHIP POSITION DATA

TABLE D.1 SHIP PARTICIPATION

Phase I		Phase II	
Station	Ship	Station	Ship
S-1	USS Oak Hill (LSD-7)	S-1	USS Summit County (LST-1146)
S-2	USS Fort Marion (LSD-22)	S-2	USS Henry County (LST-824)
S-3	USS Polk County (LST-1084)	S-3	USNS Harris County (T-LST-822)
S-4	USNS Point Barrow (T-AKD-1)	S-4	USNS Point Barrow (T-AKD-1)
S-5	USS Taylor (DDE-468)	S-5	USS Takelma (ATF-113)
DAMP	USAS American Mariner	S-6	USS Hassayampa (AO-145)
	M/V Acania	S-7	USS Hitchiti (ATF-103)
	SS Mauna Tele	S-8	USNS Petrarca (T-AK-250)
		DAMP	USAS American Mariner
			M/V Acania
			SS Hifofua

TABLE D.2 SHIP POSITION DATA, SHOT STAR FISH

Shot Data: Date and Time: 9 July 1962, 090009.0290 (Zulu); Yield: 1.15 Mt; Latitude N 16° 28′ 06.32″; Longitude W 169° 37′ 48.27″; Altitude, 400.09 km, 1,312,639 feet.

Johnston Island (Point John): Latitude N 16° 44′ 03.3″; Longitude W 169° 31′ 41.48″.

H-Hour Positions				Johnston Island		Shot	
Station	Ship *	Latitude North	Longitude West	Range km	Bearing °True	Range km	Bearing °True
S-1	Oak Hill	10° 28.5′	171° 28.5′	735	196.7	704	196.6
S-2	Fort Marion	18° 57.5′	169° 06.5′	253	010	285	011
S-3	Polk County	17° 57′	164° 24′	566	076	581	073.5
S-4	Point Barrow	16° 53′	172° 12′	289	273	283	279.3
S-5	Taylor	21° 33.0′	168° 50′	540	007.8	576	008.4
DAMP	American Mariner	19° 52.5′	168° 58.5′	357	009.5	390	010

Line-of-Sight and Burst Point Data:	
Azimuth from north	200° 17′ 28.74″
Elevation angle with refraction correction	85° 14′ 12.37″
Elevation angle without refraction correction	85° 14′ 07.91″
Slant range	1,316,906.5 feet
Slant range	401,394 meters
R/V Position:	
X (minus)	37,933 ± 132 feet
Y (minus)	102,594 ± 132 feet
Z (plus)	1,312,420 ± 50 feet

* H-hour position for M/V Acania in the Southern Conjugate Area: Latitude S 15° 35.2′ Longitude W 175° 40.3′

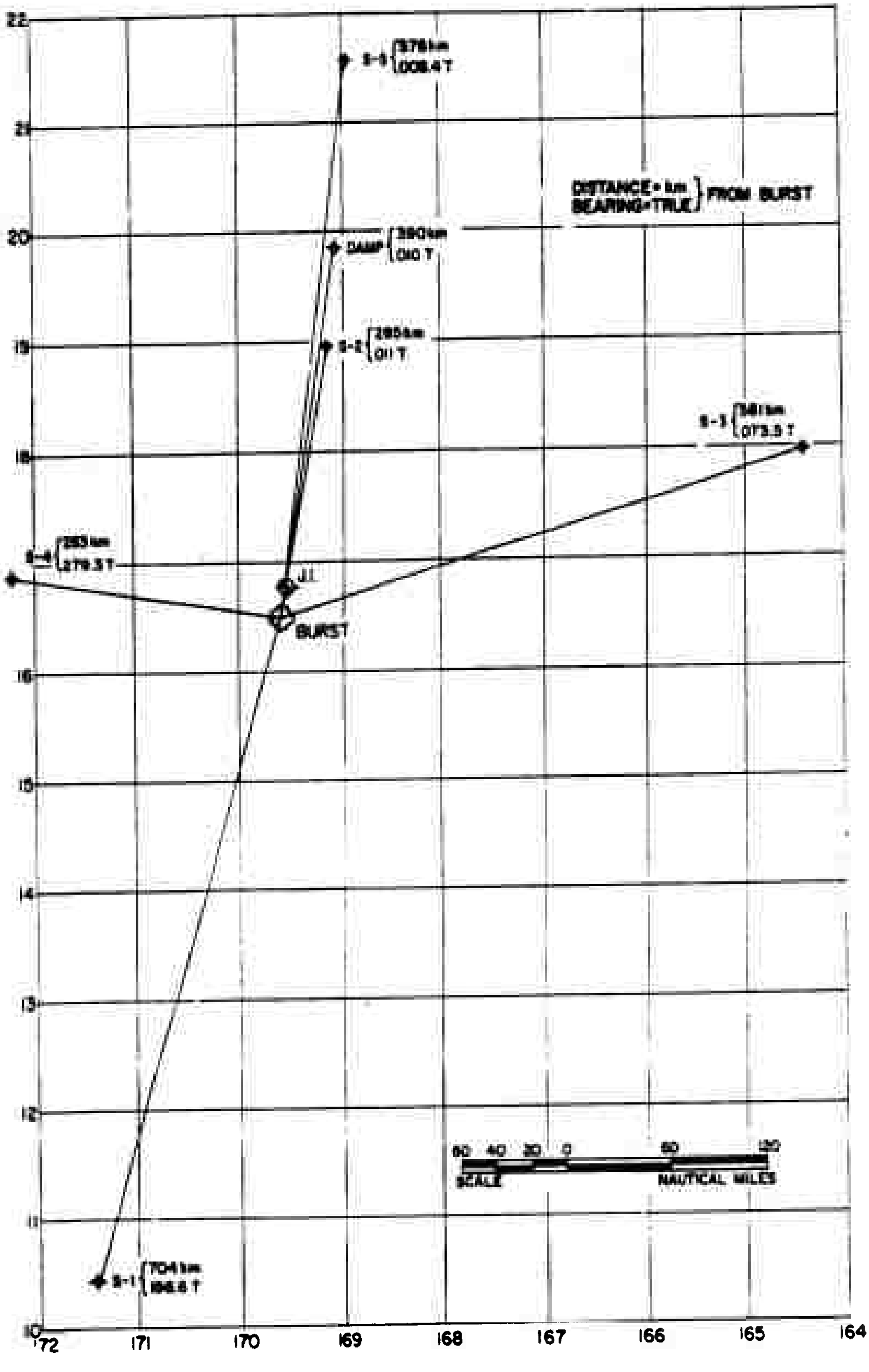

Figure D.1 Ship array, Shot Star Fish.

TABLE D.3 SHIP POSITION DATA, SHOT CHECK MATE

Shot Data: Date and Time: 20 October 1962, 083000.003 (Zulu); Latitude N 16° 04′ 20.57″; Longitude W 169° 36′ 35.95″;

Johnston Island (Point John): Latitude N 16° 44′ 03.3″; Longitude W 169° 31′ 41.48″.

	H-Hour Positions			Johnston Island	
Station	Ship*	Latitude North	Longitude West	Range km	Bearing °True
S-1	Summit County	12° 36′	170° 19′	Not computed	
S-2	Henry County	16° 05.5′	171° 01.5′	Not computed	
S-3	Harris County	15° 36′	168° 23.3′	Not computed	
S-4	Point Barrow	17° 37′	169° 21′	Not computed	
S-5	Takelma	22° 20.5′	168° 32.4′	Not computed	
S-6	Hassayampa	17° 23.5′	167° 59′	Not computed	
S-7	Hitchiti	19° 24.8′	169° 00.8′	Not computed	
S-8	Petrarca	17° 51′	170° 46′	Not computed	
DAMP	American Mariner	18° 27′	169° 11.2′	Not computed	

* H-hour position for M/V Acania in the Southern Conjugate Area: Latitude S 12° 27′
Longitude W 174° 56′

Page 229 deleted.

TABLE D.4 SHIP POSITION DATA, SHOT BLUE GILL

Shot Data: Date and Time: 26 October 1962, 095948.4753 (Zulu); Latitude N 16° 24′ 57.03″; Longitude W 169° 36′ 11.15″;

Johnston Island (Point John): Latitude N 16° 44′ 03.3″; Longitude W 169° 31′ 41.48″.

	H-Hour Positions			Johnston Island	
Station	Ship*	Latitude North	Longitude West	Range km	Bearing °True
S-1	Summit County	16° 12.55′	169° 40.20′	60.15	195
S-2	Henry County	16° 12.15′	169° 37.45′	59.80	190
S-3	Harris County	16° 10.45′	169° 41.00′	64.30	195.3
S-4	Point Barrow	16° 09.50′	169° 37.65′	64.60	189.7
S-5	Takelma	20° 45.8′	168° 48.0′	487	010.0
S-6	Hassayampa	18° 43′	167° 42.0′	326	038
S-7	Hitchiti	18° 57′	169° 08.1′	281	010
S-8	Petrarca	19° 13′	170° 30′	314	340.6
DAMP	American Mariner	17° 41′	169° 21′	135	010

* H-hour position for M/V Acania in the Southern Conjugate Area: Latitude S 13° 01′
Longitude W 175°

Page 231 deleted.

TABLE D.5 SHIP POSITION DATA, SHOT KING FISH

Shot Data: Date and Time: 1 November 1962, 121006.1263 (Zulu); Latitude N 16° 06′ 48.61″; Longitude W 169° 40′ 56.02″;

Johnston Island (Point John): Latitude N 16° 44′ 03.3″; Longitude W 169° 31′ 41.48″

H-Hour Positions				Johnston Island	
Station	Ship*	Latitude North	Longitude West	Range km	Bearing °True
S-1	Summit County	15° ~~01′~~ 27.75′	169° ~~50′~~ 57.1′	146.41	196
S-2	Henry County	16° 49′	169° 31.5′	9.27	002
S-3	Harris County	15° 27.1′	169° 41.5′	143.63	187
S-4	Point Barrow	15° 33.2′	169° 45.5′	134.73	191
S-5	Takelma	30° 03.75′	166° 42.35′	Not computed	
S-6	Hassayampa	21° 11′	168° 36′	Not computed	
S-7	Hitchiti	18° 57′	169° 08.7′	Not computed	
S-8	Petrarca	16° 40′	172° 10′	Not computed	
DAMP	American Mariner	17° 35′	169° 21′	Not computed	

* H-hour position for M/V Acania in the Southern Conjugate Area: Latitude S 12° 08′, Longitude W 174° 50′

Page 233 deleted.

TABLE D.6 LOCATIONS OF SHIPS AFTER SHOT KING FISH

Date: 1 November 1962 W. Range and bearing were computed from shot ground zero.

Station	Time W	Range km	Bearing °True	Latitude North	Longitude West
S-1	0800	207	200	15° 06′	170° 09′
	1200	268	193	14° 26′	170° 05′
	2000	337.3	190	13° 47′	170° 3.5′
S-2	0600	94.5	337	16° 54′	170° 01.5′
	1900	237	299.5	17° 09′	171° 38.5′
S-3	No significant changes subsequent to H-hour before returning to Johnston Island.				
S-4	0800	101.93	142	15° 24′	169° 06′
	1200	153.83	126	15° 18′	168° 31′
	2000	266.8	116	15° 03′	167° 26′
S-5	No significant change from H-hour through second twilight.				
S-6	0800	544.9	10.5	20° 54′	168° 45′
	1200	574.5	12	21° 08′	168° 33′
	2000	585.6	10	21° 15′	168° 44′
S-7	No significant change from H-hour through second twilight.				
S-8	0800	352	283	16° 50′	172° 52′
	1200	354	279	16° 37′	172° 55′
	2000	430	280	16° 49′	173° 37′
DAMP	Ship remained at H-hour position.				

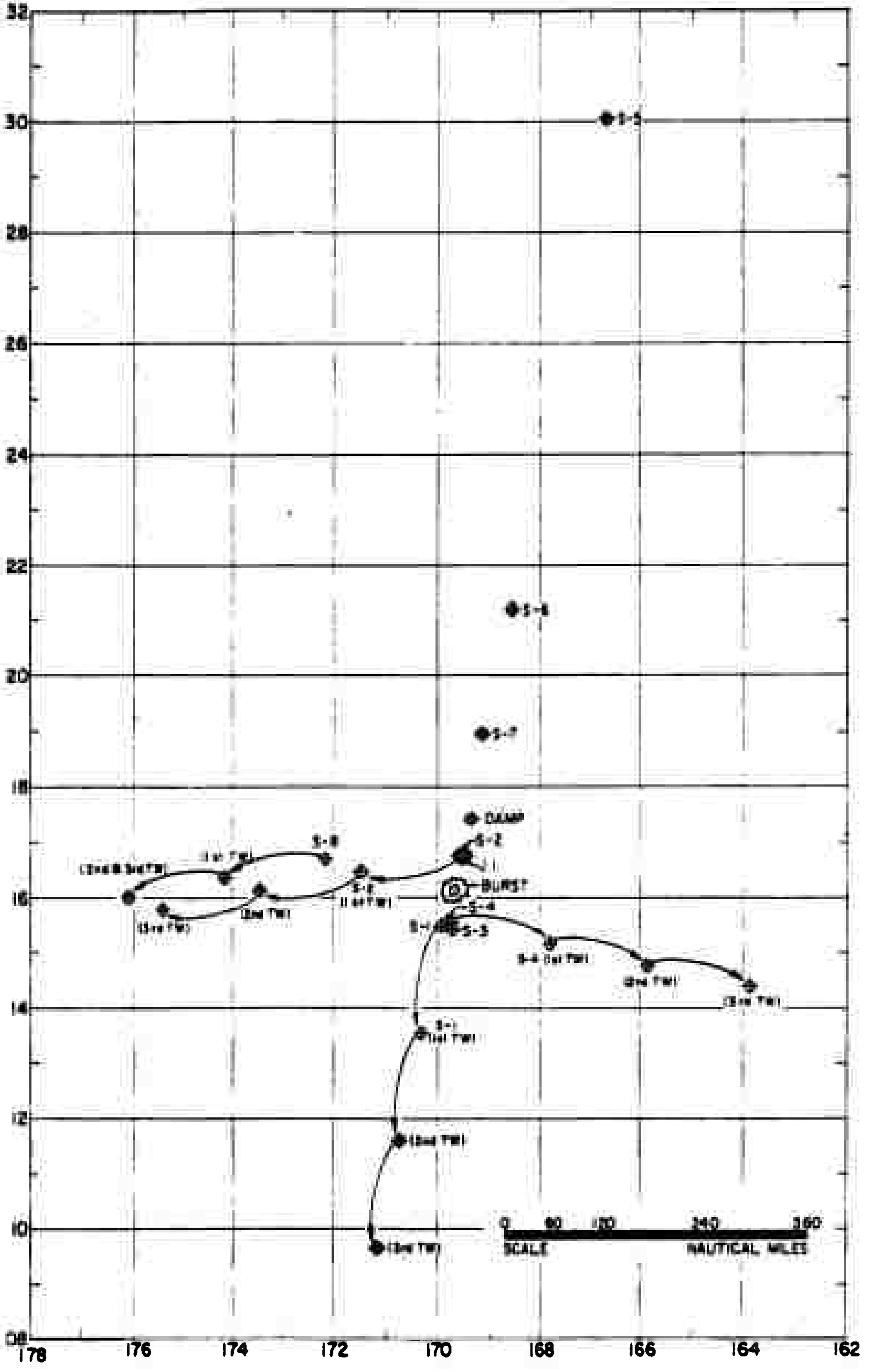

Figure D.5 Ship array, post H-hour, Shot King Fish.

TABLE D.7 SHIP POSITION DATA, SHOT TIGHT ROPE

Shot Data: Date and Time: 4 November 1962, 073000.0678 (Zulu); Latitude N 16° 42′ 26.71″; Longitude W 169° 32′ 32.66″;
Johnston Island (Point John): Latitude N 16° 44′ 03.3″; Longitude W 169° 31′ 41.48″.

H-Hour Positions				Johnston Island	
Station	Ship *	Latitude North	Longitude West	Range km	Bearing °True
S-1	Summit County	16° 44′ 28″	169° 31′ 43″	0.493	359
S-2	Henry County	16° 47′ 42″	169° 30′ 36″	7.0	011
S-3	Harris County	16° 44′ 30″	169° 31′ 35″	0.72	017
S-4	Point Barrow	16° 48′ 36″	169° 29′ 42″	9.1	023
S-5	Did not participate in Shot Tight Rope				
S-6	Hassayampa	18° 30′	169° 10′	196.4	010
S-7	Hitchiti	17° 38.5′	169° 22′	100.5	010
S-8	Petrarca	16° 54′	170° 27′	100	280
DAMP	American Mariner	16° 49′	169° 30′ 31″	9.4	013

* H-hour position for M/V Acania in the Southern Conjugate Area: Latitude S 13° Longitude W 175°

Page 237 deleted.

TABLE D.8 LOCATIONS OF SHIPS AFTER SHOT BLUE GILL

Range and bearing were computed from shot ground zero.
Stations S-5 through S-8 and DAMP ship remained at H-hour position.

Station	Time	Range	Bearing	Latitude	Longitude
	W	km	°True	North	West
S-1	26 October 1962 W				
	0800	124	195	15° 20.8′	169° 54.5′
	1200	114	185	15° 24′	169° 42.7′
	2000	120	196	15° 22.4′	169° 55.0′
	27 October 1962 W				
	0800	126.5	193	15° 18.5′	169° 52′
	1200	Returned to Johnston Island anchorage.			
S-2	26 October 1962 W				
	0800	28	197	16° 10.8′	169° 40.6′
	1200	24	173	16° 12.1′	169° 34.2′
	2000	23	183	16° 12.6′	169° 36.6′
	27 October 1962 W				
	0800	25.5	181	16° 11.1′	169° 36.1′
S-3	26 October 1962 W				
	0800	102	084	16° 31′	168° 39′
	1200	134	078	16° 40′	168° 22′
	2000	107	080	16° 35.5′	168° 36.6′
	27 October 1962 W				
	0800	96	075	16° 38′	168° 43.5′
	1200	137	079	16° 38.7′	169° 20.1′
	2000	Returned to Johnston Island anchorage.			
S-4	26 October 1962 W				
	0800	103.5	302	16° 55′	170° 25′
	1200	107	305	16° 58′	170° 25′
	2000	92	295	16° 46′	170° 23′
	27 October 1962 W				
	0800	85	294	16° 43′	170° 20′
	1200	70	230	16° 00′	170° 07′
	2000	81	005	17° 05′	169° 34′

TABLE D.9 LOCATIONS OF SHIPS AFTER SHOT TIGHT ROPE

Date: 4 November 1962 W. Range and bearing were computed from shot ground zero.
Stations S-1 through S-4 and S-7: No significant position changes through second twilight. Station S-5 did not participate in Shot Tight Rope. Station DAMP ship remained at H-hour position.

Station	Time	Range	Bearing	Latitude	Longitude
	W	km	°True	North	West
S-6	0800	209.4	004	18° 33′	169° 25′
	1200	207.6	009	18° 32′	169° 15′
	2000	218.7	011	18° 35′	168° 55′
S-8	0800	92.7	287	16° 58′	170° 22′
	1200	105.6	282	16° 55′	170° 30′
	2000	126	293	17° 10′	170° 37′

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TABLE F.1 SMALL-ROCKET LAUNCH DATA, SHOT STAR FISH

Rockets launched from Johnston Island (total: 27). All data based on preshot planning and therefore approximate.

Time of Launch	Pad No.	Project ID	Rocket Type	Azimuth True	Elevation Apogee		Last Stage Impact Point	Type of Measurement
				deg	deg	nauti mi		
H − 2¾ hr	21	9.1	Nike-Cajun	155	85	74	33 naut mi	Winds with Na vapor
H − 30 min	20	9.1	Nike-Cajun	155	85	74	33 naut mi	Winds with Na vapor
H − 600 sec	19	6.4	Javelin	90	83	270	16.48°N, 162.48°W	X-, beta- and gamma-rays, ionization
H − 510 sec	25	6.7	XM 33	198	78	555	0.3°S, 172.6°W	Magnetic field and debris expansion
H − 500 sec	1	6.7	XM 33	10	85	715	24.4°N, 169.6°W	Magnetic field and debris expansion
H − 280 sec	2	6.7	XM 33	10	85	715	24.4°N, 169.6°W	Magnetic field and debris expansion
H − 206 sec	14	SJI 152	Nike-Apache	195	88	93	18 naut mi	X-ray
H − 201 sec	10	SJI 152	Nike-Apache	195	88	86	17 naut mi	X- and beta-rays
H − 200 sec	7	SJI 111	Nike-Apache	195	88	86	17 naut mi	X-ray, radiochemical sampler
H − 199 sec	9	SJI 151	Nike-Apache	195	88	86	17 naut mi	X-ray, radiochemical sampler
H − 196 sec	8	SJI 112	Nike-Apache	195	88	86	17 naut mi	X-ray, radiochemical sampler
H − 160 sec	24	6.7	XM 33	198	83	—	5.8°N, 172.2°W	Magnetic field and debris expansion
H − 140 sec	23	6.7	XM 33	198	78	555	0.3°S, 172.6°W	Magnetic field and debris expansion
H − 132.5 sec	13	SJS 151	Nike-Apache	195	86.5	95	33 naut mi	Radiochemical sampler
H − 90 sec	6	6.3	Honest John-Nike	120	85	48	25 naut mi	X-, beta-, and gamma-rays, ionization
H − 60 sec	16	6.3	Nike-Cajun	90	85	64	29 naut mi	Mass spectrometry
H + 220 sec	3	6.13	Speedball	10	84	124	75 naut mi	Radar jitter
H + 420 sec	18	6.3	Honest John-Nike	90	85	48	25 naut mi	X-, beta-, and gamma-rays, ionization
H + 420 sec	22	6.4	Javelin	120	80	237	11.47°N, 161.36°W	X-, beta-, and gamma-rays, ionization
H + 480 sec	15	6.3	Nike-Cajun	90	85	64	29 naut mi	Mass spectrometry
H + 710 sec	26	6.13	Speedball	190	82	124	98 naut mi	Radar jitter
H + 960 sec	17	6.4	Javelin	90	83	270	16.48°N, 162.3°W	X-, beta-, and gamma-rays, ionization
H + 1,200 sec	5	6.2	Javelin	15	80	345	27.09°N, 167.9°W	Gamma- and beta-photometry
H + 1,860 sec	7	6.13	Speedball	180	82	121	98 naut mi	Radar jitter
H + 2,400 sec	4	6.2	Javelin	15	80	345	27.09°N, 167.9°W	Gamma- and beta-photometry
H + 3,540 sec	11	SJS 152	Nike-Apache	195	86.5	95.4	33 naut mi	Radiochemical sampler
0549, D + 1	21	9.1	Nike-Cajun	155	85	74	33 naut mi	Winds with Na vapor

TABLE F.2 SMALL-ROCKET LAUNCH DATA, SHOT CHECK MATE

Rockets launched from Johnston Island (total: 10).

Time of Launch	Pad No.	Project	Rocket Type	Azimuth True	Elevation	Apogee, Time after Launch		Last Stage Impact Distance, Time after Launch		Type of Measurement
sec				deg	deg	km	sec	km	time	
−139	7	LRL SJI-121	Nike-Apache	190	78.3	165	368	77	188 sec	X-ray, radiochemical sampler
−137	8	LRL SJI-122	Nike-Apache	190	78.3	165	368	77	188 sec	X-ray, radiochemical sampler
−128	2	6.7	X-M33/254	187	83	1,060	588	1,230	18.3 min	Debris tracking
−123	1	6.7	XM-33/254	191	75	794	588	2,160	15.5 min	Debris tracking
−74	10	Sandia SJS-161	Nike-Apache	190	86	163	202	35	394 sec	Radiochemical sampler
−71	9	Sandia SJI-192	Nike-Apache	190	86	172	207	37	405 sec	Betas and gammas
−70	27	6.13	Nike-Apache	191	82	200	230	172	450 sec	Radar tracking
+ 500	28	6.13	Nike-Apache	191	82	200	230	172	450 sec	Radar tracking
+ 600	20	9.1a	Nike-Cajun	170	85	149	190	68.3	372 sec	Atmospheric drag
+ 1,020	29	6.13	Nike-Apache	191	82	200	230	172	450 sec	Radar tracking

TABLE F.3 SMALL-ROCKET LAUNCH DATA, SHOT BLUE GILL

Rockets launched from Johnston Island (total: 28).

Time of Launch	Pad No.	Project	Rocket Type	Azimuth True	Elevation	Apogee, Time After Launch		Last Stage Impact Distance, Time After Launch		Type of Measurements
sec				deg	deg	km	sec	km	sec	
1915 to 1925W	21	9.1b	Nike-Cajun	155	85	137	180	61.4	354	Winds by Na vapor
-312	3	6.13	Nike-Apache	190	82	234	230	204	470	Radar tracking
-195	22	6.1a	Nike-Cajun	191	83	122	170	76	336	Radar propagation
-190	23	6.1a	Nike-Cajun	191	83	122	170	76	336	Radar propagation
-180	26	6.13	Nike-Apache	190	82	234	230	204	470	Radar tracking
-120	19	6.3	Honest John-Nike	090	80	81.4	140	89	270	Gamma-, beta-, and X-ray, ion trap, impedance probe
-112	24	6.1a	Nike-Cajun	191	87	126	170	33.4	340	Radar propagation
-108	25	6.1a	Nike-Cajun	191	87	126	170	33.4	340	Radar propagation
-60	16	6.3	Nike-Cajun	100	80	109	150	104	287	Mass spectrometer
-40	9	SC	Nike-Apache	205	87.7	94	205	21.4	406.5	Beta- and gamma-flux
-28	8	SC	Nike-Apache	205	87.6	89.5	202	21.2	396	Radiochemical sampler
+ 166	10	SC	Nike-Apache	214	87.3	94	205	25.1	406	Beta- and gamma-flux
+ 178	7	SC	Nike-Apache	214	87	89	202	26.4	395	Radiochemical sampler
+ 180	27	6.13	Nike-Apache	190	82	126	241	110	470	Radar tracking
+ 290	1	6.1a	Nike-Cajun	191	87	126	170	33.4	340	Radar propagation
+ 300	6	6.3	Honest John-Nike	028	85	89	150	47	294	Gamma-, beta-, RF-impedance, ion trap
+ 360	15	6.3	Nike-Cajun	090	85	118	150	53.7	295	Mass spectrometer
+ 670	18	6.3	Honest John-Nike	090	85	89	150	47	294	Gamma-, beta-, and RF-impedance, ion trap
+ 900	5	6.2	Honest John-Nike-Nike	025	83	142	190	86	367	Gamma-scanner, Langmuir probe, photometer, 3-freq. beacon
+ 900	—	6.1a	Nike-Cajun	191	87	126	170	33.4	340	Radar propagation
+ 900	20	9.1a	Nike-Cajun	165	85	149	190	68.3	372	Atmospheric drag
+ 1,320	17	6.3	Honest John-Nike	120	80	81.4	140	89	270	Gamma-, beta-, and RF-impedance, ion trap
+ 1,320	28	6.13	Nike-Apache	190	82	234	230	204	470	Radar tracking
+ 1,860	4	6.2	Honest John-Nike-Nike	025	83	142	190	86	367	Same as + 900
+ 2,640	11	SC	Nike-Apache	145	88	82	193	16	378	Atmospheric density
+ 3,540	12	SC	Nike-Apache	145	88	82	193	16.1	378	Atmospheric density
0625 to 0635W	21	9.1b	Nike-Cajun	155	85	137	180	61.4	354	Winds by Na vapor
+ 13 hours	13	SC	Nike-Apache	145	88	82	193	16	378	Same as + 3,540

TABLE F.4 SMALL-ROCKET LAUNCH DATA, SHOT KING FISH

Rockets launched from Johnston Island (total: 29).

Time of Launch	Pad No.	Project	Rocket Type	Azimuth True	Elevation	Apogee, Time After Launch		Last Stage Impact Distance, Time After Launch		Type of Measurements
sec				deg	deg	km	sec	km	sec	
1905 to 1915W	21	9.1b	Nike-Cajun	155	85	137	180	61.4	354	Na vapor (winds)
−350	26	6.13	Nike-Apache	191	82	202	224	164	436	Radar tracking
−160	25	6.1	Nike-Apache	191	83	143	191	100	370	Radar propagation
−155	24	6.1	Nike-Apache	191	83	143	191	100	370	Radar propagation
−123	8	SC	Nike-Apache	191	70	118	172	248	340	X-ray
−120	1	6.2	Honest John-Nike-Nike	120	85	195	230	101	432	Gamma-ray
−120	17	6.3	Honest John-Nike-Nike	100	85	180	230	92	414	D-region physical chemistry
−101	7	SC	Nike-Apache	191	86	135	183	48	378	X-ray
−93	9	SC	Nike-Apache	191	70	117	170	241	335	Radiochemical sampler
−85	23	6.1	Nike-Apache	191	86	152	196	54.2	375	Radar propagation
−84	13	SC	Nike-Apache	191	86	172	205	69	403	X-ray
−84	10	SC	Nike-Apache	191	70	117	170	241	335	Radiochemical sampler
−80	3	6.1	Nike-Apache	191	86	152	196	54.2	375	Radar propagation
−60	19	6.4	Javelin	100	83	500	425	772	798	Beta- and gamma-rays
−30	12	SC	Nike-Apache	191	83	159	199	111	389	D-region characteristics
-0-	15	6.3	Nike-Apache	100	85	120	155	55	285	
+200	28	6.13	Nike-Apache	191	82	202	224	164	436	Radar tracking
+210	14	SC	Nike-Apache	191	80	174	195	35	407	Beta- and gamma-rays
+360	16	6.3	Nike-Cajun	090	85	120	155	55	282	D-region characteristics
+360	5	6.3	Honest John-Nike-Nike	021	85	184	230	94	419	D-region characteristics
+540	22	6.4	Javelin	145	83	488	425	784	790	F-region characteristics
+600	20	9.1a	Nike-Cajun	170	83	145	190	72	372	Atmospheric density
+780	2	6.2	Honest John-Nike-Nike	120	85	195	230	101	432	Gamma-ray
+810	18	6.3	Honest John-Nike-Nike	100	85	184	230	94	419	D-region characteristics
+1,010	29	6.13	Nike-Apache	191	82	202	224	164	436	Radar tracking
+1,500	4	6.2	Honest John-Nike-Nike	120	85	195	230	101	432	Gamma-ray
+1,960	27	6.13	Nike-Apache	191	78	216	232	226	452	Radar tracking
+2,400	6	6.3	Honest John-Nike-Nike	020	85	180	230	92	414	D-region characteristics
0630 to 0640W (postshot)	21	9.1b	Nike-Cajun	155	85	137	180	61.4	354	Na vapor (winds)

TABLE F.5 SMALL-ROCKET LAUNCH DATA, SHOT TIGHT ROPE

Rockets launched from Johnston Island (total: 7).

Time of Launch	Pad No.	Project	Rocket Type	Azimuth True	Elevation	Apogee, Time After Launch		Last Stage Impact Distance, Time After Launch		Type of Measurements
sec				deg	deg	km	sec	km	sec	
1902 to 1912W	21	9.1b	Nike-Cajun	155	85	137	180	61.4	354	Winds by Na vapor
−50	1	6.1	Nike-Cajun	203	84	107	160	57.4	317	Radar transmission
−50	24	6.1	Nike-Cajun	203	84	107	160	57.4	317	Radar transmission
−40	23	6.1	Nike-Cajun	200	81	104	157	85	314	Radar transmission
−40	25	6.1	Nike-Cajun	200	81	104	157	85	314	Radar transmission
+ 240	20	9.1a	Nike-Cajun	175	86	147	190	69	372	Atmospheric density
0635 to 0645W (postshot)	21	9.1b	Nike-Cajun	155	85	No second stage ignition				Winds by Na vapor

Appendix G

TECHNICAL OPERATIONS REPORTING PROCEDURES

HEADQUARTERS TASK UNIT 8.1.3 (FORWARD)
FIELD COMMAND, DEFENSE ATOMIC SUPPORT AGENCY
APO 105, San Francisco, California

30 September 1962

TEST DIRECTOR
MEMORANDUM 2-62

TECHNICAL OPERATIONS REPORTING PROCEDURES

1. General. The Technical Operations Center (TOC) on Johnston Island is the DOD Scientific Task Unit Headquarters (CTU 8.1.3). All scientific project status reports are received and evaluated in the TOC. Because of the many remote locations involved, a reporting procedure which will provide the required clarity, speed, and economy of effort is needed by the Task Unit and Commander in order to evaluate the status of assigned projects.

2. Purpose. This memorandum establishes guide lines for the implementation of this reporting procedure. The Scientific Reporting Network and the SUNSHINE Reporting System are the means whereby each project can maintain quick, direct, and unclassified communication with its Task Element Commander.

3. Applicability and Implementation. The reporting procedures are applicable to all scientific projects of this Task Unit. They are effective immediately.

4. TU 8.1.3 Scientific Reporting Network. The Scientific Reporting Network will consist of three separate and distinct loops. One loop comprises the northern and western Pacific stations, the second loop encompasses the southern Pacific stations, and the third loop will serve the immediate Johnston Island area.

a. The northern and western loops will consist of the following stations and associated projects:

LOCATION	PROJECTS
Adak	6.5d
Fairbanks	6.11
Hawaii	6.5a, 6.5e, 6.7, 6.11, 7.4, 8A.2
Kauai	6.5a, 6.5d, 6.11
Kwajalein	6.5d, 6.11, 7.4
Maui	6.5c, 6.10, 8A.1, 9.5a
Midway	6.5a, 6.5c, 6.8, 6.10, 6.11, 7.4
Oahu	1.1, 4.1, 6.7, 6.8, 6.10, 6.11, 7.4, 8A.1, 8A.2, 9.3, 9.5a
Okinawa	6.5a, 6.5d, 6.11
Palo Alto	6.5d, 6.11
Wake	6.5a, 6.8, 6.11, 7.4

Projects of this loop will report to the TU 8.1.3 Hickam Air Force Base Headquarters. Those projects located within the State of Hawaii will report over existing commercial facilities provided by the Honolulu Office of Holmes and Narver, Inc. The projects on Okinawa will utilize the facilities of one of the three military communications centers there (one Air Force and one Navy center at Naha AFB; one Air Force center at Kadena AFB). Projects located on Midway, Wake, Kwajalein, and at Adak will utilize the facilities of the existing military communication centers at each site. The 6.11 site at Fairbanks and the 6.5d and 6.11 sites at Palo Alto will channel their reports over the 6.11 HF radio network to one of their 6.11 Hawaiian stations for retransmission to the TU 8.1.3 Hickam AFB Headquarters. The Officer-In-Charge, Task Element 8.1.3.2, will evaluate all of these reports, summarize them, and then send a brief analysis to Commander, TU 8.1.3 on Johnston Island.

b. The southern Pacific loop will consist of the following stations and associated projects:

LOCATION	PROJECTS
Aircraft from Samoa	6.9
Aircraft from Nandi	6.10
Acania	6.8, 6.9
Canton	6.5a, 6.5c, 6.8, 6.11, 7.4
Palmyra	6.5a, 6.8, 7.2
Rarotonga	6.8, 6.11
Tongatabu	6.5b, 6.5c, 6.6, 6.8, 8A.2, 6.5a
Tutuila	6.5a, 6.5b, 6.5c, 6.5e, 6.6, 6.8, 6.11, 8A.2, 7.4
Viti Levu	6.8, 6.10, 6.11, 8A.2, 7.4
Christmas	6.8

The projects located on Canton, Palmyra, Tongatabu, and Viti Levu will report to the Officer-In-Charge, Task Element 8.1.3.4 at Tutuila over the established AN/GRC-26D radios operated by Army Communications Teams. The remaining projects of the southern Pacific loop will utilize radios inherent to their scientific equipment. Net control will be exercised at Tutuila. The TU 8.1.3 South Conjugate Coordinations Officer (OIC TE 8.1.3.4) has the responsibility for receiving, evaluating, and summarizing these reports and retransmitting a brief analysis to CTU 8.1.3 on Johnston Island.

c. The Johnston Island area loop will consist of the following stations and associated projects:

LOCATION	PROJECTS
Air Array:	
A-1	8A.1, 8A.2
A-2	8A.1, 8A.2
A-3	6.9
A-4	6.9
A-5 thru A-9	4.1
A-10 thru A-12	7.4
Ship Array:	
S-1	6.1a, 6.6, 6.8, 9.1b
S-2	6.1a, 6.6, 6.8, 9.1b
S-3	6.1a, 6.8
S-4	1.1, 6.1a, 6.6, 6.8, 9.1b
S-5 thru S-8	6.5a, 6.8

DAMP Ship	6.8, 6.13
Johnston	1.1, 2.1, 2.2, 6.1a, 6.1c, 6.2, 4.1, 6.3, 6.4, 6.5a, 6.5d, 6.6, 6.7, 6.8, 6.9, 6.13, 7.2, 7.4, 8A.1, 8A.2, 8A.3, 8B, 9.1a, 9.1b, 9.4b, 9.5a, 9.6
French Frigate Shoals (Tern)	6.5c, 6.6, 6.8

(1) Shipboard projects will report over ship-to-shore radio net directly to CTU 8.1.3 on Johnston Island; French Frigate Shoals is included on this net.

(2) Projects aboard aircraft will report via the control aircraft (ABUSIVE), who in turn will report to the Johnston Island JCP. The TU 8.1.3 representative in the JCP will pass information to the TOC via hot line.

(3) Projects on Johnston Island wi.l report over the island hard-wire communications system.

(4) This proposed breakdown of the TU 8.1.3 Scientific Reporting Net provides the optimum in speed and reliability. Communications centers have been notified to expect message requirements from the projects co-located with them. These centers can send and receive both classified and unclassified traffic.

5. SUNSHINE Reporting System.

a. Each project of TU 8.1.3 will be required to give periodic reports to CTU 8.1.3 on Johnston Island concerning the status of its particular scientific effort. Such reports are of extreme necessity to the Commander in order for him to make quick, intelligent, and knowledgeable decisions concerning the overall Task Unit's readiness to achieve the scientific objective of Operation FISHBOWL. To facilitate the transmission, handling, receipt, analysis, and comparison of these reports from many projects, this memorandum describes a uniform procedure to be followed by all agencies of Task Unit 8.1.3 using the scientific reporting net.

b. All operational readiness reports from each project are hereby designated SUNSHINE Reports. These reports will be transmitted to CTU 8.1.3 Johnston Island as directed by the appropriate Task Element Commander. Initial complete report will be submitted at times filter center communications are established with changes submitted as they occur and when requested by CTU 8.1.3. At H minus 6 hours reports will be submitted hourly indicating change in status. If no change occurs negative reports will be submitted.

c. All SUNSHINE reports will consist of four items. Item One will be the phrase SUNSHINE. Item Two will be the project number. Item Three will be the project status, using the reporting code outlined in paragraph 5d. Item Four, if needed, will be any necessary clarification of the report. SUNSHINE Reports will be UNCLASSIFIED in their entirety. Any necessary classified information will be transmitted via separate message.

d. To utilize the SUNSHINE Reporting System, the following code will be used to describe each project's degree of readiness (Item Three of the report):

(1) Status ALPHA. Project completely ready. This status report indicates that the station anticipates excellent results should the test occur at the scheduled time.

(2) Status BRAVO. Equipment and personnel in readiness, but local weather conditions will degenerate the results of this experiment approximately 25 percent.

(3) Status CHARLIE. Equipment and personnel in readiness, but locat weather conditions will degenerate the results of this experiment approximately 50 percent.

(4) Status DELTA. Equipment and personnel in readiness, but local weather conditions prohibit this particular experiment from collecting any worthwhile data.

(5) Status ECHO. Equipment trouble, but only minor repairs are required that can be performed locally within six hours.

(6) Status FOXTROT. Equipment trouble, but only minor repairs are required that can be performed locally within six to twelve hours.

(7) Status GOLF. Equipment trouble, but only minor repairs are required that can be performed locally within 12 to 24 hours.

(8) Status HOTEL. Equipment trouble, but the repairs required can be performed locally in ____ days (this report will include the expected number of days until equipment will be back in operation).

(9) Status JULIETT. Major trouble with equipment, which will require parts and/or services from a rear area. This status report will include the piece of equipment involved, the parts and/or services required, the name of the rear area from which help is expected, and the name of the responsible person in that rear area.

(10) Status KILO. Personnel trouble. This status report indicates that some of the site's personnel are ill. However, sufficient knowledgeable persons are available to perform the work necessary to complete a valid experiment. This report will include the number of persons affected against the total number of knowledgeable persons assigned to the site, together with a brief description of the illness.

(11) Status LIMA. Personnel trouble. This status report indicates that sufficient illness exists at the site such that no valid data can be gathered. This is an emergency report and will include the same additional data as the KILO report plus all other pertinent details.

(12) Status MIKE. Indicates a lack of necessary support items, i.e., a power generator, an antenna stand, a reel of wire, etc., that will reduce the efficiency of the station. This status report will include a brief description of the item, when the item was scheduled to arrive, steps already taken to locate the item, and any other pertinent unclassified information.

(13) Status NOVEMBER. Indicates a situation that is not listed in the other SUNSHINE reports. This report will also require clarification, but only to the extent that unclassified information will be transmitted.

e. To make this reporting procedure more readily understandable, sample SUNSHINE Reports are as follows:

(1) SUNSHINE Project 8A.2 Status BRAVO.

(2) SUNSHINE Project 6.8 Status HOTEL 3 days.

(3) SUNSHINE Project 6.7 Status JULIETT. Tape recorder. Complete replacement required. Hickam AFB. J.J. Jones.

(4) SUNSHINE Project 6.6 Status KILO. 3 out of 10. Diarrhea.

(5) SUNSHINE Project 6.10 Status LIMA, 6 out of 7. Extreme skin infections. Locally hospitalized. Recovery two weeks. Replacement crew requested immediately.

(6) SUNSHINE Project 6.11 Status MIKE. 30 KW generator, 20 April. Wired to Lt Col Jones at Sandia Base 30 April. No reply.

(7) SUNSHINE Project 6.5c Status NOVEMBER. All food has spoiled. Request emergency shipment.

(8) SUNSHINE Project 6.5a Status NOVEMBER. Suspected sabotage in area. Details follow via classified message 252230Z.

(9) SUNSHINE Project 6.10 Status CHARLIE AND KILO, 3 out of 9. Extreme sunburn.

f. Normally, these messages will be transmitted with a priority precedence. A higher priority may be assigned if necessary. ALL SUNSHINE Reports sent subsequent to H−6 hours for an event will be given a precedence of Operational Immediate.

g. This reporting system is in effect upon receipt by each project. Queries concerning its implementation should be directed to the appropriate Task Element Commander.

Appendix H

REPORTS ON STATUS OF TECHNICAL AIRCRAFT

1. Test Director Memorandum 1-62 will be used to report aircraft status until the aircraft has become airborne for rehearsal or an actual event. A SUNSHINE report will be made for each participating aircraft, individually if other than Status ABLE, and collectively by projects if Status ABLE. Aircraft status (other than technical or scientific equipment) will be reported under Status MIKE. (TD 1-62)

2. Following takeoff, status reports will be submitted to the Aircraft Commander for transmittal to the Task Group 8.4 Air Operations Center in accordance with the following schedule:

a. As soon after takeoff as possible.

b. H–1 hour.

c. H–30 minutes.

d. On an "as necessary" basis when conditions change from the last report.

e. When any condition not provided for will affect the TU 8.1.3 scientific effort.

f. The degree of success will be indicated after event time (Status ABLE).

g. When aircraft departs station for landing point.

3. Status reports for airborne aircraft will be in accordance with the Attachment hereto. The reporting procedure will be as follows:

a. From the technical representative aboard the aircraft to the Aircraft Commander (AC).

b. From the AC via radio link to the TG 8.4 Air Operations Center (AOC).

c. From the AOC to TU 8.1.3 representative on the Iwo Jima (IJ).

d. From the IJ via radio link to the Technical Operations Center (TOC) in Bunker 405.

4. Reports will be unclassified and will consist of four items:

a. ITEM 1 – Aircraft call sign.

b. ITEM 2 – SUNSHINE.

c. ITEM 3 – Project status.

d. ITEM 4 – Clarification information.

NOTE: The only exception to the above will be for Project 8A.1 and 8A.2 aircraft. For these two aircraft, the words "point one or point two" will be used immediately following the aircraft call sign to identify whether the report concerns 8A.1 or 8A.2. The aircraft call sign, without this exception, will indicate both projects fall under the same report. Examples are:

Kettle One Point One. SUNSHINE ALPHA (8A.1).

Kettle Two Point Two. SUNSHINE CHARLIE (8A.2).

Kettle Two. SUNSHINE ALPHA (both 8A.1 and 8A.2).

5. It will not be necessary to identify the type report (H–1 hour, H–30 minutes, etc.) since time phasing of reports should indicate the type of report being submitted. Several status codes may be used in one report when necessary to adequately explain the conditions. In addition, two or more codes may be used, if necessary, to give the proper number. Examples are:

BRAVO CHARLIE adds to 75%.

ECHO FOXTROT adds to 30%.

VICTOR WHISKEY adds to 1 hour 30 minutes, etc.

6. To aid in clarification of the above procedures, the following examples are given (aircraft numbers and call signs may not be correct):

a. Inertia Two SUNSHINE ALPHA

Meaning: Project 7.4 on KC-135, #0341, ready to go and the aircraft is on the prescribed flight plan.

b. Kettle One Point One SUNSHINE CHARLIE

Meaning: Weather will degrade Project 8A.1 on KC-135, #3144, by about 50%.

c. Inertia Three SUNSHINE ECHO FOXTROT WHISKEY

Meaning: Project 6.10 on KC-135, #3131, is having equipment trouble so as to degrade data by 30%. Will require 60 minutes to remedy.

d. Lambkin One SUNSHINE SIERRA ZEBRA

Meaning: Project 4.1 on RC-121, #0547, is having aircraft difficulties so as to degrade data by 25%. Will be unable to remedy while airborne.

e. Caboodle One One SUNSHINE ABLE 5

Meaning: Project 4.1 on C-118, #07651, obtained approximately 50% of their data.

ATTACHMENT TO REPORTS ON STATUS OF TECHNICAL AIRCRAFT

AIRBORNE SUNSHINE REPORTS

Condition	Status Code	Criteria
Ready	ALPHA	Project is ready to go, to include positioning of the aircraft in accordance with flight plan.
Weather		Weather will degrade data by:
	BRAVO	25%
	CHARLIE	50%
	DELTA	No worthwhile data will be collected.
Technical and scientific equipment		Trouble with technical and scientific equipment will degrade data by approximately:
	ECHO	10%
	FOXTROT	20%
	GOLF	40%
	HOTEL	60%
	JULIETT	No worthwhile data will be collected.
Personnel		Personnel are incapacitated so as to reduce data by:
	KILO	25%
	LIMA	50%
	MIKE	No worthwhile data will be collected.
Unique situation	NOVEMBER	Indicates a situation not covered in this report. Briefly describe trouble. This will cause a reduction in data of:
	OSCAR	15%
	PAPA	30%
	QUEBEC	50%
Aircraft		Aircraft trouble will cause the project data to be degraded by:
	ROMEO	10%
	SIERRA	25%
	TANGO	50%
	UNIFORM	No worthwhile data will be collected.
Time required to repair or remedy the condition		The time required to repair or remedy the situation so that essentially all data can be obtained will be:
	VICTOR	30 min.
	WHISKEY	1 hour
	X-RAY	2 hours
	YANKEE	4 hours
	ZEBRA	Unable to repair or remedy the situation while airborne.
Success of mission		The approximate percentage of data obtained is as follows:
	ABLE 1	10%
	ABLE 2	20%
	ABLE 3	30%
	ABLE 4	40%
	ABLE 5	50%
	ABLE 6	60%
	ABLE 7	70%
	ABLE 8	80%
	ABLE 9	90%
	ABLE 10	100%

Appendix I

MINIMUM GO-NO-GO CRITERIA, SHOT BLUE GILL

This material was published by TU 8.1.3, 9 October 1962.

WEATHER

1. Cloud Cover.

a. Excellent "seeing" conditions are desired for Johnston Island photo station and the two KC-135 photo aircraft for the period shot time to about H + 30 minutes. At Johnston Island, recommend BLUE GILL be attempted only on days when no more than light high clouds and $^3/_{10}$ or less low and medium clouds are predicted during the firing window. This would provide good chance for success for Johnston Island surface optical stations. Aircraft should have little high cloud above their operating altitude (about 35,000).

b. DAMP ship, Project 6.13, need optical line of sight to flares expelled from their rockets. This requires a condition of very few clouds essentially along the line between the ship and shot point at elevation angles of 20 to 70° from the horizon. Fulfillment of DAMP ship requirement is not mandatory.

2. Ballistic Wind.

a. Launchers are adjusted based on ballistic wind reports available at H-75 minutes. If subsequent reports show ballistic wind changes greater than 5 knots or 15 degrees, holds as follows are necessary to adjust launchers for safety reasons: (1) at H-45 min - - - - Hold 30 Minutes. (2) at H-35 minutes - - - - Hold 30 minutes. (60 minutes if weather Pibal crews not permitted to stay out until H-30 minutes.)

b. There are infrequent wind conditions which would prevent Project 6.1a rockets from following desired trajectories. This could be a no-go condition. These conditions are described in a separate paper.

3. Magnetic Storms.

Project 6.9 (SRI) will obtain and provide forecast of magnetic storms. If major storm predicted, this is a no-go condition.

PODS

4. Tracking. Must have Sandia Corporation and Cubic on B-3. Check made at H - 30 minutes and H-17 minutes.

5. Stabilization. Must have 2 of 3 pods. Check at H-17 minutes.

6. Recovery. The two pods with stabilization OK must have recovery packages OK. Check pod recovery unit pressure at H-4 hr.

ROCKETS

7. 6.1A Radar Blackout. Project uses six rockets fired essentially in pairs (-195 and -190 seconds; -112 and -108 seconds; + 290 and + 900 seconds). One rocket of each pair must be in an operating condition and this will be known by H-5½ hours. Cubic tracking must be go on these rockets as well. Final check at H-45 minutes. In addition, a minimum of three of the four ships, the JI x-band receiver, and the JI L and C band interferometers must be operating.

8. 6.2, 6.3 Gamma Scanners and D-region Physical Chemistry.

a. Project has 8 rockets:

Rockets	Primary Experiment
2 Nike-Cajun	Mass spectrometer
4 HJ-Nike	Electron density radiation measure
2 HJ-Nike-Nike	Gamma scanner

b. Project needs six rockets, one HJ-N-N and five others, with experiment essentially ready. These six rockets need one telemetry and one tracking system in order. Honest John-Nike rocket experiments are considered go as long as one measurement of electron density and one of radiation are ready. Operation of every instrument is checked at H−8 hours and again between H−90 minutes and H−65 minutes. Correction of problems inside bird take at least 24 hours.

9. 6.13 Radar Refraction Jitter (H−4 hours).

Three of the four Nike Apaches must have C-band beacons operating and must be tracked by DAMP Ship radar (5700 Mc). Optical track of rockets from DAMP Ship is desirable. (See weather.)

COMMUNICATIONS

10. 3 of 4 Granger transmitters, Kauai, Okinawa, Kwajalein, and Canton must be going, and 6 of 8 receivers should be operable and synchronized.

RADAR CLUTTER

11. 86-foot SRI dish must be operable. One each RC-121 aircraft and equipment must be in position and ready in the Northern and Southern Conjugate Areas.

12. Sufficient ionosondes, riometers, photometers, etc., exist so that no particular go-no-go criteria is applicable here.

AIRBORNE IONOSPHERIC MEASUREMENTS

13. Readiness of 6.10 aircraft and equipment is desirable but not mandatory.

PHOTOGRAPHY-SPECTROSCOPY

14. Surface Stations. Appropriate cloud conditions necessary (see weather). Sufficient backup in surface stations measurements exists between LASL and DOD so that go-no-go are based on cloud conditions alone, except for major catastrophes affecting both LASL and DOD surface stations.

15. Aircraft. At least one DASA KC-135 must be in position and ready to record.

Appendix J

OPERATION EXPERIENCE SUMMARY, ENGINEERING AND CONSTRUCTION

(This report was prepared by an officer in the E&C Branch, TU 8.1.3.)

This report concerns areas of responsibility including: (1) criteria developments and design of facilities for Johnston Island and all other sites, and (2) construction at all other sites. All other areas are summarized by those primarily responsible.

As soon as construction and facility requirements could be determined, site selection on Johnston Island was coordinated with representatives from all users, AEC, H&N, and JTF-8. H&N acted as the overall coordinator and provided all members with a current scientific plot plan. This system was satisfactory because it funneled all requirements to a single point where scientific requirements, interference, restrictions, and construction feasibility could be analyzed. Later, TG 8.6 insisted on having this responsibility, but the larger portion of siting was completed and only minor consequences developed. Since Johnston Island is so small, the limited real estate available required maximum utilization of existing facilities, minor degradation on some experiments because of interference, and calculated safety risks.

It was necessary to make many long-distance telephone calls, trips, and inquiries to extract the details from the scientific agencies to insure that each facility was in the best possible location. Concurrently, construction criteria were being developed at a rapid pace and submitted to AEC, (TG 8.5) for H&N action.

In many cases where construction lead time was critical, design was started before the project submitted an E&R plan. Criteria were developed from Annex E of the E&R plan and from revisions, conferences, and telephone calls. The criteria for rocket launch pads were written in general terms, and the design details were resolved by meeting with the launcher manufacturers and the H&N Project Engineer. This procedure was highly satisfactory and proved itself in the timely construction and dual use of launchers by more than one project agency.

Requirements for sites other than Johnston Island were late and frequently changed because of: (1) late diplomatic approval on the use of foreign owned islands, (2) scientific and logistic suitability of available islands, (3) lack of the project's decision to request H&N support because of funding problems (to be explained later), (4) lack of firm control over projects to force timely decisions on requirements, or (5) lack of information concerning construction and logistic capabilities locally available at selected islands.

Project and TU 8.1.3 representatives made a survey trip to sites under consideration. The results varied from firm commitments and plans by some projects to indecision by other projects. Because of limited time and costs, every attempt was made to minimize H&N construction in support. Construction by local sources was arranged at Rarotonga, Viti Levu, Tongatabu, Tutuila, Canton, Wake, Midway, Kwajalein, Okinawa, Kauai, Maui, and Hawaii. If all requirements had been placed on H&N the costs would have been prohibitive and the readiness time would have been extremely doubtful. Furthermore, the local governments preferred not to have outside contractors, so that their own economy could benefit. There was also a concern about inflation, which would have been quite harmful to the small communities.

Generators proved to be the most troublesome items. Projects that originally planned to furnish their own power later required generators at remote locations on a crash basis. Many generators malfunctioned because of improper maintenance, improper switching on of the load before warmup, lack of load banks on generators with loads that were too small, and inferior design. Time would not permit major repairs, so replacements were used. Most projects had backup generators toward the end of the operation.

Land leases were the responsibility of TG 8.5; however, it was necessary in most cases to anticipate TG 8.5 negotiations and to make preliminary agreements for consummation by TG 8.5 at a later date. Land leases at Tutuila, Samoa were the most difficult to handle, because the property is jointly owned by the natives. In one case, 42 owners were involved at the Olotele Hill site without adequate land survey and descriptions. This was handled through the American Samoa Government Attorney General who negotiated through a "talking chief" who represented all of the owners. Leases in the future should be easier to obtain on Samoa because of the experience gained by all parties.

Construction activities at remote sites involved access roads, land clearance, instrument shelters, placement of vans, generators and fuel storage, and antenna erection. In camps, the activities involved walk-in reefers, water distillation plants, powerplants, septic tanks, tent messhalls, kitchens, latrines, and quarters.

On-site surveillance was essential during the construction, to meet readiness dates. Off-site H&N construction was late in the field, because user requirements were late as were consequently, the criteria. Field trips disclosed major deficiencies such as working crews in place without materials and tools or vice versa. The deficiencies were itemized and given to the H&N and AEC, Honolulu manager for crash action Followup field trips were still necessary to insure that corrective action had been taken.

In future operations, a completely mobile concept for islands, other than Johnston, should be adopted, and construction should be held to a minimum. The support contractor could design and procure trailers to serve all test needs at any test site. The trailers should be four-wheeled types and have simple-tongue hitch, leveling jacks, and dimensions compatible to C-124, C-133, and other transport aircraft. The trailers should be of the following types: water distillation, powerplant, maintenance (generator, plumbing, carpenter), living, kitchen, messing, laundry, and scientific.

In future operations, more time should be allowed for criteria development and construction. Strong program management should be exercised to insure timely submission of requirements and to minimize change. Local resources should be used for construction in remote areas.

Appendix K

EXPERIENCE REPORT, PROJECT 9.2, SHIP MODIFICATION

(This report was prepared by an officer in the E&C Branch, TU 8.1.3.)

TU 8.1.3 received the Fish Bowl program from CHDASA in late December 1961. Included in the Fish Bowl instrument locations were five positions on the high seas to be occupied by surface ships. The E&C Branch was assigned the responsibility of modifying these ships to receive the scientific instrumentation.

Since this ship modification project was a somewhat new E&C responsibility and because very little history and data from previous ship modification projects (premoratorium) was on record in WET, this experience report is submitted to document the background, procedures, and problems encountered in the Fish Bowl project. It is hoped that this information together with recommendations based on experience from this project will enable personnel assigned to any future operations to conduct the project more efficiently and smoothly. In addition to improving the next operation and aiding the personnel assigned to it, the information contained in this report may serve as a guide for picking qualified personnel for assignment to any future project.

The body of this experience report consists of a history of the ship modification program with emphasis on problems encountered, the solutions thereto, and/or recommendations for future operations. It should be noted that this report alone cannot possibly give a complete chronological history of Project 9.2. Anyone desiring to study the project in detail should use this report in conjunction with the complete E&C Project 9.2 files.

Early in January 1962, E&C called a meeting in Washington to discuss general policy and to get the first indication of what the projects required. Representatives of BUSHIPS, MSTS, JTF-8, FCDASA, NAVY OPS, H&N, and the projects were present. At that time it was decided that all technical construction requirements of the projects would be submitted to the E&C Branch, which would review, coordinate, and consolidate them for later submission to either BUSHIPS or COMSTS, depending upon the ships involved. (Five belonged to US Navy and one to MSTS.) BUSHIPS would decide in which yard the modifications were to be performed and authorize the yards to proceed. Thus, WET dealt with BUSHIPS rather than the yards during the early planning stages. COMSTS turned its portion over to MSTS PACAREA, which performed the design work and then let a contract to a civilian yard for the actual modifications. H&N was acting as architect-engineer for LASL and LRL for some modification work (later canceled when Christmas Island became available). H&N was represented at the first meeting at the request of WET. During this meeting, after the general scope of the program became known, WET decided that it would deal directly with the Navy and MSTS and would not require the services of an outside architect-engineer.

Shortly after the first meeting, six ships were assigned as the Fish Bowl instrument platforms. Assignment of ships was worked out between JTF-8 and the Navy with DASA supplying only technical recommendations.

The scope of work to be done was finally determined to be installation of antennas, photography equipment, and associated recording instrumentation on three LSD's, one LST, and two DDE's. LSD's were selected because of their relative stability. Original plans called for launching of small instrument rockets from the ships. This plan was dropped, but the stable platforms were still required by the Project 6.1a tracking antennas.

Following the first meeting in Washington, the E&C Branch started the all-out effort to obtain final criteria from the project agencies. After weeks of meetings, personal contact, telephone calls, TWX's and shipboard and shipyard visits, enough data was obtained to write a formal criteria letter to BUSHIPS and MSTS setting forth the details of work to be accomplished. It should be noted that the E&C staff must take the initiative of calling such meetings, and making trips, especially if a short time frame is involved. The person assigned to ship modification cannot expect information to come rolling in without doing a lot of coordinating, traveling, and inspecting. Shipboard trips and meetings with the design personnel of shipyards proved extremely profitable. Most of the projects had not been associated with ships at all so every chance to get aboard was most valuable to them. E&C did all coordinating of these inspections. During the planning stages, the shipboard visits were the most important single item for determining instrumentation location and mounting.

Following criteria collection, a comprehensive criteria letter was sent to BUSHIPS and COMSTS. This letter was all-inclusive, contained all known requirements, and was supplemented with numerous drawings and sketches. E&C stated the requirements, but left all design work and finish blueprints to the shipyard design staff. The shipyards were extremely happy with the criteria letter because of its completeness. In any future operation, every effort should be made to give all requirements under one cover, and all agencies involved should receive information copies.

Funding for the modifications was through BUSHIPS and COMSTS. They received estimates and bills from their respective yards and submitted a final bill to FCDASA.

Upon receipt of the FCDASA criteria letter, BUSHIPS assigned yards to perform the work. Two LSD's were modified at the Naval Repair Facility, San Diego, and the LST and two DDE's were modified in Pearl Harbor. MSTS let a contract to a civilian yard in San Francisco for modification of one LSD. The various yards did their own design work; thus, three separate, different sets of designs and plans resulted. The E&C project officer approved all plans and coordinated them with the project agencies. During the actual modification period at the shipyard, the E&C officer acted as coordinator between ship, shipyard, JTF-8, project agency, and TU 8.1.3. He also inspected all work, directed shipyard effort, and acted as a pusher to get things moving faster. In this area, more rank (LCDR or higher) would be very helpful. Although everyone cooperated, the author believes it would have been beneficial if a Navy captain from TU 8.1.3 had met with the directors of the yards concerned and discussed the program and explained the tight time schedule and the built-in uncertainties of the testing game.

Since the work was performed at three different installations, it meant the E&C man had to move between them to supervise all the jobs. This arrangement worked satisfactorily, because the Pearl Harbor work was scheduled after the West Coast work; however, if the program had been any larger, one man could not have handled it alone. It is highly desirable to have all the work done at one location, and in the future, every effort should be made to have one set of drawings and one yard do the work.

Shipyards are very complex and highly subdivided organizations. It is impossible to find one individual who can handle all problems that arise. Design people will not touch anything after it leaves the drawing board; workers blame design, destroyer planning people will not have anything to do with LST's, etc. Three identical stations have three separate work orders written if they happen to be on different types of ships. Since the yard is so complex, it is the author's belief that the ranking man at the shipyard should be approached by comparable rank in TU 8.1.3 and request that a yardman be assigned to the test modification work only. The officers in the shipyards are generally overworked and by necessity cannot devote enough time to the out-of-the-ordinary work required by the test program. This is especially true of the ship's superintendent. All were most helpful and cooperative, but the additional work imposed on them over and above their regular duties worked a hardship on them. It is realized people are hard to get, but proper high-level meetings should result in getting a man from the yard assigned to the special task of test modification.

During the planning, design, and actual shipboard modification work period, the E&C project officer was the only man connected with the testing program who came in contact with the yard or ship's personnel. There was a definite lack of communication or contact between JTF-8 (The Navy Task Unit) and the yard or ship's force. The personnel of the yard and the ship were naturally concerned with basic questions and operational matters. The captains of the ships were kept in complete darkness until the last moment. They were quite concerned about this lack of information and continually hounded the only one they knew from the test organization, the E&C man. Thus, the E&C man spent considerable valuable time trying to assist the skippers in getting answers to operational and logistic questions. Lack of answers to these questions also delayed modification work. For example, antennas could not be placed until it was determined if areas must be left clear for helicopters, etc. In any future operation, an effort should be made to have more lower level coordination between WET Operations Branch and the ship's company. Also, the Navy Task Unit and JTF-8 should keep the ships better informed. The E&C man cannot properly watch out for his modification work if he spends 50 percent of his time doing operational work.

One major problem concerned generation of power for the instrumentation. Since the ships had dc and the test equipment required ac, diesel generators were provided to supply power. This was acceptable because the operation, as originally planned, was to last only 6 to 8 weeks. As it turned out, the generators were operated and exposed to the elements for 6 to 8 months. They finally began to break down. In future operations, motor generators working off ship's power should be used if possible because of the unpredictable time duration of the tests.

Recording instrumentation was installed in both ship's compartments and in fabricated wooden structures fixed to the deck. The fixed wooden shacks proved to be far superior to the ship's compartments. They are easier to build, easier to alter for equipment mounts, easier to air condition, and cause less trouble to the ship. In the long run, it is much cheaper to build a wooden shack to the required design than to try to alter a steel compartment.

Rollup or removal of scientific instrumentation poses no problem, because the yard can simply be told to remove everything previously installed and return the ship to its original configuration. The projects will look out for their gear, and the ship's officers will naturally make sure their ship returns to its original condition, if not better.

Although there were numerous minor problems and a lot of crash efforts involved, all of the ships were instrumented satisfactorily and on schedule.

The following recommendations are based on the experience during Fish Bowl:

(1) In the task unit, a Navy officer should be in charge of ship modification.

(2) The officer should be a LCDR if the modification program is any larger than that for Fish Bowl.

(3) Submit good final criteria to the designers. Whenever practicable, delay submission until all criteria are compiled.

(4) To establish criteria, the officer should visit ships and yards to get information about instrument placement and location.

(5) Do everything possible to have all design and modification work done by one yard, not several.

(6) Wherever possible, avoid using ship's compartments for recording spaces. Use deck-mounted trailers or wooden shacks.

(7) Have one designer and one ship superintendent from the yard assigned to the test program work only.

(8) Have operations personnel maintain better liaison with the ships to avoid time-consuming questioning by skippers.

(9) Avoid use of portable diesel power generators whenever possible.

Appendix L

EXPERIENCE REPORT, ENGINEERING AND CONSTRUCTION, JOHNSTON ISLAND

(This report was prepared by an officer in the E&C Branch, TU 8.1.3.)

Preliminary Operations.

(1) The E&C representative should become familiar with project operations in general prior to arriving at site.

(2) The E&C job-site representative must know space requirements in detail. Stated space requirements from Annex E of E&R Plans proved invalid in most cases; some were too large, others too small. In general, projects require more space than allocated.

(3) In preliminary planning, avoid user-furnished material whenever practicable. Define clearly who is to furnish material—especially, the electrical instrument, timing, and similar cable.

(4) Have E&C representatives at jobsite in advance of starting construction. This helps establish good relationship with the architect-engineer (A-E) representatives and allows E&C personnel to become familiar with A-E personnel and their methods of operation.

(5) Avoid being overly austere on headquarters and similar facilities. Items such as soundproofing and air conditioning may prove to be necessities and must then be installed later. This later method is expensive and not completely effective.

(6) Try to establish realistic beneficial occupancy data (BOD's). During this series, no event was delayed because of construction; however, many BOD's were exceeded by 2 weeks or more.

(7) Plan to place all buried cable (cable trenches) in a conduit to protect them from corrosion, shrinkage, and coral wear.

(8) Plan to have a small-sized ozalid machine for E&C use.

Construction Operations.

Prior to arrival of projects.

(1) Periodic visits by a representative of programs is helpful during this period.

(2) Without exception, power requirements stated in E&R plans for Fish Bowl were understated. Power facilities should be designed to handle at least 50 percent more load than is requested for the primary sites, e.g., Johnston Island.

(3) Junction boxes and wiring for trailers at the primary site should not be installed until arrival of trailers. In most cases during Fish Bowl, users wanted to change positions, and the stated power requirements differed from what was required.

(4) On all major construction items, a user representative should be at each jobsite when construction begins.

(5) Have the A-E send copies of all drawings, sent for approval, to the E&C representative at the job site. These drawings should be marked "For Approval".

After arrival of projects.

(1) Expect numerous changes and/or new requirements. All of these can be expected to be accomplished on a crash basis.

(2) Modifications and repair of user-furnished material will consume a disproportionate amount of time and effort.

(3) At the primary site, provide a pool of portable power units ranging from 10 to 100 kw. Recommend numbers and types as follows: six 10-kw, four 15-kw, ten 30-kw, six 60-kw, and two 100-kw. At other sites, provide 100-percent backup power.

(4) At the primary site provide a pool of construction equipment and operators for field support purposes. Types and amounts must be based on stated requirements for field support but should include at least five forklifts.

(5) At the primary site and AEC contractor locations only, provide a means of easy communication on details of user requirements developed at jobsite. Use of mail-order catalogs or similar documents is recommended.

Appendix M

INSTRUMENTATION FOR MEASURING COMMUNICATIONS EFFECTS

TABLE M.1 VLF PROPAGATION INSTRUMENTATION

Frequency kc	Transmitter	Project/Sponsor	Receiver Sites
6	Noise	6.11	Hawaii, Wake, Viti Levu, Canton, Tutuila, Johnston, Kwajalein
6	Noise	NOL, Corona (7.5)	Corona
10.0	Noise	NOL, Corona (7.5)	Corona
10.2	Balboa, C.Z.	6.11	Kwajalein
10.2	Balboa, C.Z.	NEL, San Diego (7.5)	San Diego, Pt. Barrow, Forrest Port, N.Y., Thule (omega navigation system)
10.2/14.2	Oahu	6.11	Kwajalein
13.0	Arizona	NEL, San Diego (7.5)	GU Komelik, Castle Dome, Somerton, (13-kc ionospheric sounder system)
14.7	NAA (Maine)	NOL/NEL (7.5)	Corona/San Diego
15.0	Noise	NOL, Corona (7.5)	Corona
16.0	GBR (England)	6.5b	Tutuila, Tongatabu
16.0	GBR (England)	NBS, Boulder	College Alaska
17.4	NDT (Japan)	NOL, Corona (7.5)	Corona
18.0	NBA (Canal Zone)	6.5b	Tutuila, Tongatabu
18.0	NBA (Canal Zone)	6.11	Maui, Fairbanks, Hawaii, Palo Alto, Rarotonga, Okinawa, Tutuila, Viti Levu, Wake, Kwajalein, Midway, Canton
18.0	NBA (Canal Zone)	NBS/NEL (7.5)	Boulder, College Alaska, Maui/San Diego
18.6	NPG (Seattle)	NBS, Boulder	Boulder, College Alaska
18.6	NPG (Seattle)	NOL/NEL (7.5)	Corona/San Diego
19.8	NPM (Hawaii)	6.10/6.11/7.4	Palo Alto, Wake, Tutuila, Maui
19.8	NPM (Hawaii)	NBS, Boulder	Boulder, College Alaska, Midway
19.8	NPM (Hawaii)	6.5b	Tutuila, Tongatabu
19.8	NPM (Hawaii)	NOL/NEL (7.5)	Corona/San Diego
21.0	WWVL (Boulder)	NBS, Boulder	Fort Collins, Colorado (one-hop vertical path)
21.0	Noise	NOL, Corona (7.5)	Corona
22.3	NSS (Annapolis)	NBS/NEL (7.5)	Boulder/San Diego
27.0	Noise	6.11	Hawaii, Wake, Viti Levu, Canton, Tutuila, Johnston, Kwajalein

TABLE M.2 LF PROPAGATION INSTRUMENTATION

Frequency kc	Transmitter	Project/Sponsor	Receiver Site
46	10-kw airborne (KC-135) vicinity Johnston Island, 9000-foot antenna	7.4	Kwajalein, Canton, Viti Levu, Tutuila, Palo Alto, Fairbanks, Auburn, Wichita, Dayton, Midway, Wake, Hawaii, Johnston
46	10-kw airborne (KC-135) vicinity Johnston Island, 9,000-foot antenna	6.11	Kwajalein, Canton, Viti Levu, Tutuila, Palo Alto, Midway, Wake
49	Noise	7.4	Hawaii, Auburn, Dayton (BG and CM only)
51	Noise	6.11	Hawaii, Wake, Viti Levu
76	Johnston Island	USN	Hickam (balloonborne antenna at Johnston)
100	Loran-C	6.10	Oahu, Palmyra, Maui, Kauai, southern conjugate aircraft
120	Noise	6.11	Hawaii, Wake, Viti Levu
155	Guam (Ratt)	7.6	Hawaii, Japan, Ships
185	Honolulu (Ratt)	7.6	Guam, Adak, Ships
200	Noise	6.11	Hawaii, Wake, Viti Levu

TABLE M.3 HF PROPAGATION INSTRUMENTATION

Frequency Mc	Transmitter	Project/Sponsor	Receiver Site
4 to 64	Granger (Okinawa)	6.11	Viti Levu, Tutuila, Rarotonga, Hawaii, Palo Alto, Fairbanks
4 to 64	Granger (Kwajalein)	6.11	Viti Levu, Tutuila, Rarotonga, Hawaii, Palo Alto, Fairbanks, Midway, Wake
4 to 64	Granger (Canton)	6.11	Viti Levu, Tutuila, Rarotonga, Hawaii, Palo Alto, Fairbanks, Midway, Wake
4 to 64	Granger (Kauai)	6.11	Rarotonga, Wake, Midway, Fairbanks, Palo Alto, Kwajalein, Tutuila
4 to 64	Granger (Midway)	6.5a	Palmyra (one-hop reflection point over Johnston)
HF Operational Circuit	Melbourne	DCA/ACSD/USASRDL	Camp Davis
	Okinawa	DCA/ACSD/USASRDL	Hawaii
	Tokyo	DCA/ACSD/USASRDL	Hawaii, Camp Davis, Anchorage
	Anchorage	DCA/ACSD/USASRDL	Hawaii, Camp Davis
	Seattle	DCA/ACSD/USASRDL	Anchorage
	Australia, Canton, Wake	7.4	Hawaii
	Kwajalein, USA	7.4	Hawaii
4.7, 9, 15, 23	March AFB	7.4	Hawaii, Johnston, Kwajalein, two aircraft vicinity Johnston
4, 6, 9	Tongatabu	6.5b	Samoa (3-frequency phase-stable link)
12, 18, 30	Pinwheel (Kauai)	6.5d	Okinawa, Adak, Palo Alto
HF operational Ratt	Fleet broadcast	7.8	Selected US Navy ships
10, 15, 20	Midway	6.10	Southern conjugate KC-135 aircraft, Palmyra, Fiji

TABLE M.4 HF SOUNDERS

Frequency Mc	Project/Sponsor	Equipment	Location
5 to 26.5	USAF	Backscatter	Australia, Alaska, Puerto Rico, Roswell, Hawaii, Maryland, Pakistan
9.8 and 12.6	ARPA	Backscatter	Palo Alto
1 to 25	6.5d	Vertical ionosonde	Johnston, Kwajalein
0.25 to 20	6.5c	Vertical ionosonde	Maui, French Frigate Shoals, Tutuila, Wake, Canton
1 to 25	6.5c	Vertical ionosonde	Midway, Tongatabu
1 to 25	6.5a	Vertical ionosonde	Palmyra, Trinidad
1 to 25	6.10	Ionosonde	KC-135, Fiji
3 to 30	6.9	7-frequency HF-sounding radar	M/V Acania
3.3 to 50	6.9	7-frequency phase-path sounder	Johnston

Appendix N

INSTRUMENTATION FOR MEASURING RADAR EFFECTS

TABLE N.1 RADAR NOISE INSTRUMENTATION

Instrument	Project	Frequency Mc	Antenna	Sensitivity	Location
Radiometer	7.2	35,000	Parabolic 0.6° beam	T = 1°K	Johnston Island
Radiometer	7.2	S-band	Parabolic 3° beam	T = 3°K	Johnston Island
Radiometer	7.2	L-band	Array 10° × 20° beam	T = 5°K	Johnston Island
Radiometer	6.13	442	Parabolic 6° beam	NF = 5 db	USAS American Mariner
Radar	6.9	1210	Parabolic 0.7° beam	NF = 3 db	Johnston Island
Radar	6.9	850	Parabolic 1° beam	NF = 3 db	Johnston Island
Radar	6.9	398	Parabolic 2° beam	NF = 3 db	Johnston Island

TABLE N.2 RADAR CLUTTER INSTRUMENTATION

Frequency* Mc	Project	Peak Power kw	Antenna Beam Width deg	Band Width	PRF	Location
5825	6.13	3,000	0.8	2 Mc	285	USAS American Mariner
1300	6.13	2,000	2	1.2 Mc	285	USAS American Mariner
1210	6.9	30	0.7	6 Mc	75	Johnston Island
850	6.9	35	1	6 kc	75	Johnston Island
530	6.13	5,000	1 by 4	—	150	Kwajalein (ZAR)
425	6.13	5,000	2	—	1100 to 1500	Roi Namur (Tradex)
432	6.13	2,000	6	1.2 Mc	285	USAS American Mariner
426 to 443	6.9	1,500	10 by 18	200 kc	250	Five RC-121-D aircraft
398	6.9	35	2	6 kc	75	Johnston Island
370	6.9	20	5	6 kc	30	M/V Acania
140	6.9	50	13.5	6 kc	30	M/V Acania
32.5	6.9	100	45	6 kc	30	M/V Acania
3 to 19.5	6.9	7 to 30	60 to 90	10 kc	8.6 to 30	M/V Acania
3.3 to 50	6.9	7-frequency phase-path sounder	—	—	—	Johnston Island
27	6.9	1.8	Sensitivity 0.3 mv	—	12.5 to 50	Canton Island

* Approximate or nominal.

TABLE N.3 RADAR REFRACTION INSTRUMENTATION

Frequency * Mc	Project	Transmitter	Receiver
5775	6.13	Nike-Apache rocketborne 400-watt peak power transponder. 5700-Mc receiver.	AN/FPQ-4 precision monopulse tracking radar on DAMP ship.
4750	6.1	Nike-Cajun (Blue Gill and Tight Rope) Nike-Apache (King Fish) rocketborne 5-watt CW transmitter.	Interferometer array on Johnston Island.
950	6.1	Nike-Cajun (Blue Gill and Tight Rope) Nike-Apache (King Fish) rocketborne 5-watt CW transmitter	Interferometer array on Johnston Island

* Approximate or nominal.

TABLE N.4 DIRECT ATTENUATION MEASUREMENTS

Frequency * Mc	Project	Shot Participation	Transmitter	Receiver
9500	6.1	Blue Gill, King Fish, Tight Rope	Rocketborne 5-watt CW (4 to 6 per event)	Johnston Island and Ships S-1 through S-4
5775	6.13	All	Rocketborne 400-watt peak power transponder (1 to 7 per event)	AN/FPQ-4 precision Monopulse tracking radar on DAMP ship
4750	6.1	Blue Gill, King Fish, Tight Rope	Rocketborne 5-watt CW (4 to 6 per event)	Johnston Island and Ships S-1 through S-4
950	6.1	Blue Gill, King Fish, Tight Rope	Rocketborne 5-watt CW (4 to 6 per event)	Johnston Island and Ships S-1 through S-4
TM band	6.2, 6.3, 6.4	Star Fish, Blue Gill, King Fish	Satellite and rocketborne telemetry including GMD (1660 to 1690 Mc) and (37,148- and 888-Mc beacon)	Amplitude of these signals measured by receivers on Johnston Island

* Approximate or nominal.

TABLE N.5 INDIRECT ATTENUATION MEASUREMENTS

Frequency * Mc	Project	Shot Participation	Data
150 400	6.13	All	Electron line density from doppler measurements on signal from transit satellite. Approximately 20 passes recorded per event on Damp ship.
54 324 (phase coherent)	6.2	All	Electron line density from doppler, dispersive doppler and faraday rotation on signals from Transit IIA, Transit IVA, and Anna. Data recorded at Johnston Island and Aberdeen Proving Ground.
37 148 888 (phase coherent)	6.2, 6.3	Star Fish, Blue Gill, King Fish	Electron line density from doppler, dispersive doppler, and faraday rotation on signals from rocketborne 3-frequency phase-coherent beacon. Six rockets per event were monitored from Johnston Island.
3 12	6.3	Star Fish, Blue Gill, King Fish	Electron density from measurement of RF impedance of rocketborne antennas. Two to four rockets per event, monitored from Johnston Island.

* Approximate or nominal