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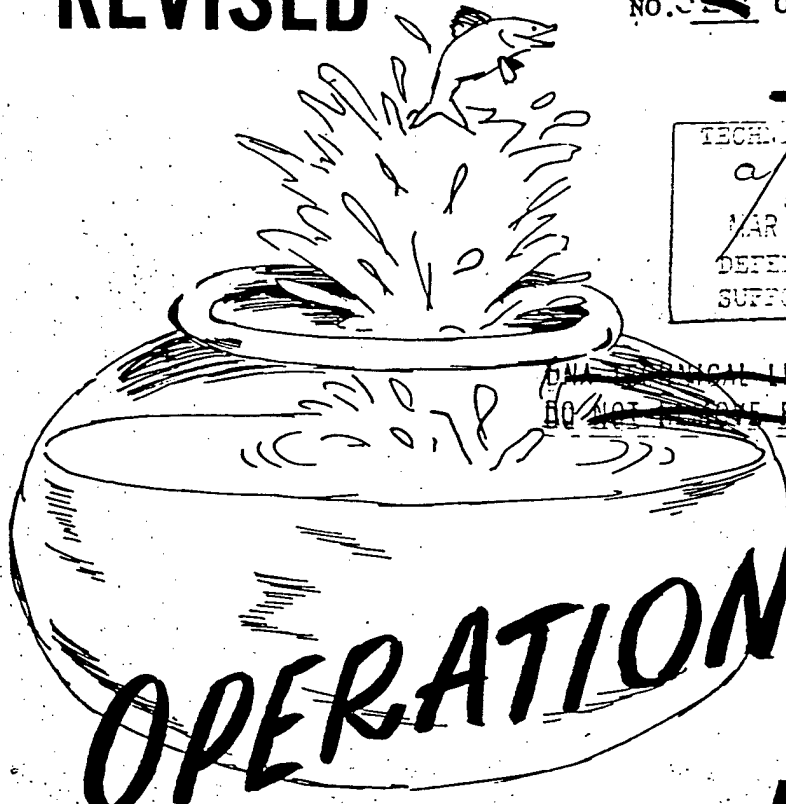
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FISH BOWL [U]

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WEAPONS EFFECTS PROGRAM

Spring 1962

Johnston Island

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DEFENSE ATOMIC SUPPORT AGENCY
WASHINGTON 25, D.C.

ADDRESS REPLY TO:
THE CHIEF, DEFENSE ATOMIC
SUPPORT AGENCY

DASATP/984

22 March 1962

SUBJECT: DOD Weapons Effects Program, Operation FISH BOWL, Revised (U)

TO: SEE DISTRIBUTION

1. Reference SECRET-RD letter, DASATP/984, DASA 58629, Defense Atomic Support Agency, 26 December 1961, subject: "DOD Weapons Effects Program, Operation FISH BOWL (U)."

2. Reference distributed an approved FISH BOWL document. Changes in experimental scope, funding adjustments, modifications required by subsequent operational considerations, addition of Service funded and other experiments, deletion of those experimental projects which could not be readied in time, and a requirement for broader distribution have necessitated issuance of a revised document.

3. Inclosure 1 hereto is a revised FISH BOWL document superseding that document distributed by reference. Inclosure 2 is a copy of the forwarding letter of the superseded document, included since its provisions are still applicable. The superseded document is to be destroyed. Report of destruction is not required by this headquarters.

Robert H. Booth

2 Incls

1. Revised Operation FISH BOWL Program Book, SEC-RD
2. DASA Ltr, DASATP/984
26 Dec 1961, UNCL. w/o Incl

ROBERT H. BOOTH
Major General, USA
Chief

DISTRIBUTION:

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ADDRESS REPLY TO:
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DASATP/934

26 December 1961

SUBJECT: DOD Weapons Effects Programs, Operation FISH BOWL (U)

TO: SEE DISTRIBUTION

1. Reference is made to the following:

a. Memorandum, JCS to Chief, AFSWP, 24 April 1953, subject:
"Atomic Weapon Testing Outside the Continental United States."

b. Letter, SWPWT/960, this headquarters, 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."

2. Hereafter, where appropriate, the term Defense Atomic Support Agency (DASA) has been substituted for Armed Forces Special Weapons Project (AFSWP) in view of the redesignation in 1959 of AFSWP as DASA.

3. The Joint Chiefs of Staff, in reference 1a, approved the following general policy relative to field tests of atomic devices and weapons:

For tests involving nuclear detonations participated in or conducted by agencies of the Government of the United States, the Chief, DASA will exercise within any task force organization, technical direction of weapons effects tests of primary concern to the Armed Forces and the weapons effects phases of developmental or other tests of atomic weapons.

4. By reference 1b, Chief, DASA, to insure the technical direction of weapons effects tests conducted outside the continental United States pursuant to the policies outlined above, augmented the responsibilities of Commander, Field Command, DASA to include 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 the execution of these functions, the Commander, Field Command, DASA will represent the Chief, DASA for coordination with the Atomic Energy Commission, its contractors and other Government agencies obtaining experimental data to satisfy Service and/or DOD requirements. The

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DASATP/984

SUBJECT: DOD Weapons Effects Programs, Operation FISH BOWL (U)

Deputy Chief of Staff, Weapons Effects Tests, Field Command, DASA is responsible to the Commander, Field Command, DASA for the execution of the functions of Field Command, DASA outlined above. Direct communication, relative to matters associated with the technical direction of weapons effects tests is authorized between Field Command, DASA and the participating agencies sponsored by the Department of Defense.

5. Information on the approved military weapons effects test projects for Operation FISH BOWL is contained in Inclosure 1, "Operation FISH BOWL, Weapons Effects Programs." The minor project modifications required by operational necessity may be authorized by the Commander, Field Command, DASA. Significant changes in projects or addition of new projects will be cleared with Chief, DASA. The funding estimates for each project were reviewed by the Secretary of Defense and the approval received was such that the DASA cost in RDT&E funds has been fixed. This means that for each project in Operation FISH BOWL the approved DASA cost is a ceiling figure. Each agency must take appropriate action to insure that individual project costs do not exceed the approved level of support.

6. With the exception of advance RDT&E funds already released to sponsors of organizations, funds will be obtained from the Commander, Field Command, DASA. He is authorized to administer both the advance funds already released by the Chief, DASA, and the funds to be released by the Commander, Field Command, DASA. Further, the Commander, Field Command, DASA is authorized to withhold for purposes of control and for on-site project expenses a portion of the RDT&E funds budgeted for each project, issuing funds from appropriate available sources as the progress of the program and projects dictates. Reports relative to the status, expenditure and obligation of funds will be required by the Commander, Field Command, DASA who will advise project agencies of these requirements. The instructions relative to reports covering funds advanced by the Chief, DASA, remain in effect.

7. The Commander, Field Command, DASA, will issue instructions relative to project progress and status reports. The preparation, submission and review of the drafts of both the preliminary and final program and project reports and the distribution of the published reports will be under the supervision of the Commander, Field Command, DASA.

8. Individual program and project personnel, both civilian and military, associated with the DOD Weapons Effects Program, will be subject to the control and orders of the Commander, Field Command, DASA

DASATP/984

SUBJECT: DOD Weapons Effects Programs, Operation FISH BOWL (U)

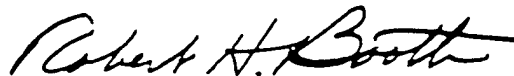
from the time they report for duty, temporary duty, or detached service with the military weapons effects test organization, and continuing until released therefrom as individuals or in groups. The details as to time and place of reporting will be arranged directly between the Commander, Field Command, DASA and the appropriate agencies. The technical direction exercised by the Commander, Field Command, DASA over both civilian and military personnel associated with the DOD Weapons Effects Programs will commence immediately and terminate upon approval of the final technical report for the applicable project or program. Personnel administration of individuals will be in accordance with pertinent Service directives.

9. While within the designated test area, the Commander, Joint Task Force Eight (JTF-8) will exercise operational control over all personnel associated with the DOD Weapons Effects Programs and the equipment and material in their possession.

10. The Commander, JTF-8, will exercise control over visits of DOD personnel, both civilian and military. The arrangements for entry of such personnel into the designated test area will be subject to his instructions.

11. The handling of public relations and security matters associated with the DOD Weapons Effects Programs for Operation FISH BOWL will be in accordance with instructions from the Commander, JTF-8.

12. The technical control and supervision of joint AEC-DOD projects will be in accordance with agreements between the Commander, Field Command, DASA, and the sponsoring AEC agency.



ROBERT H. BOOTH
Major General, USA
Chief

1 Incl
Operation FISH BOWL, Weapons
Effects Programs, SECRET-RD

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SUBJECT: Supplemental Projects for Operation FISH BOWL

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1. Reference SECRET-RD (UNCLASSIFIED when separated from Inclosure) letter, DASATP/984, Defense Atomic Support Agency, 22 March 1962, subject: "DOD Weapons Effects Program, Operation FISH BOWL, Revised (U)."

2. Attached hereto as Inclosure 1 through 6 are new projects approved for implementation in Operation FISH BOWL and to be included in the Operation FISH BOWL Planning Document distributed by reference.

FOR THE CHIEF:

ARTHUR MOREAU

6 Incls

- 1. SECRET - 1 pg entered as page 11-1 Project No; 4.1
- 2-6 CONFIDENTIAL entered as pages 33-1 through 33-5.

CWO, W-4, USA

Asst Adj Gen

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FISH BOWL

1. This document is a military weapons effects program for Operation FISH BOWL, a high altitude test to be conducted at Johnston Island in the spring, 1962. The Operation consists of three (3) shots:

- a. System proof test - 1 May 1962 - non-nuclear.
- b. BLUE GILL - 1 June 1962 - [REDACTED]
- c. STAR FISH - 15 June 1962 - 1.45 MT at 400 Km.

2. The warheads and instrumentation pods will be carried to altitude by suitably modified Thor boosters. The tests will be conducted under the operational control of JTF-8.

3. The purpose of the Operation is to satisfy urgent JCS stated requirements for weapons effects data. The data sought concerns:

- a. ICBM kill mechanisms and vulnerability.
- b. Penetration aids.
- c. Retaliatory force capabilities.
- d. AICBM effectiveness.
- e. Early warning systems.
- f. Intelligence satellites.
- g. Communications and control.

4. The physics information to be obtained in seeking answers to the above lies in the areas of:

- a. Debris location.
- b. Debris charge.
- c. Production and loss of electrons in the fireball.
- d. Production and loss of electrons in the ionosphere.
- e. Electromagnetic noise.
- f. Absorption and refraction of electromagnetic waves.

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- g. Nuclear, thermal and X-radiations output and damage mechanisms.
- h. Electromagnetic pulse output and damage mechanisms.
- i. Ultra-violet through infra-red radiations output, damage and attenuation.

5. Requirements on burst times are as follows:

a. It is essential that the burst occur during the hours of darkness at burst altitude.

b. It is highly desirable that:

(1) There be no cloud cover over Johnston Island or Ships S-1 through S-4 at burst time.

(2) The burst occur between one and two hours prior to morning astronomical twilight at the burst altitude.

c. It will be beneficial for experiments if, at time of burst:

(1) There is not cloud cover over Maui or S-5.

(2) The moon is set.

(3) There is no cloud cover over Tutuila and Tonga.

d. It is required that time of burst be selected so that neither burst damages the operational satellites of FISH BOWL Project 6.12; INJUN, TRANSIT, and S-16.

6. Ship locations:

a. For STAR FISH, instrument ships will be located as follows:

<u>Ship</u>	<u>Range</u> (Km from surface zero)	<u>Bearing</u> (Magnetic from surface zero)
S-1	575	180°
S-2	275	000°
S-3	575	065°
S-4	275	270°
S-5	575	000°

b. For BLUE GILL, Ship S-5 will be located 250 kilometers magnetic north of burst surface zero and Ships S-1 through S-4 will be within 50 kilometers of surface zero. The final location of Ships S-1 through S-4 will be determined by Projects 6.1a and 6.1c.

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c. For BLUE GILL, Ships S-1 through S-5, are required to be in position seven (7) days prior to burst time for background measurements. After BLUE GILL, ships are required to remain in location for seven (7) days for background measurements and then move to their STAR FISH positions for background measurements for seven (7) days. After STAR FISH the ship's are required to remain in position for seven (7) days for background measurements. If movement and replenishing of ships between BLUE GILL and STAR FISH prevents obtaining the desired background measurements the background time reduction should be made at the expense of BLUE GILL time.

7. The appropriate land based instrumentation will take measurements from at least seven (7) days prior to the first event until seven (7) days after the second event. It is desirable to take measurements with some instrumentation, such as the Granger Sounders (Project 6.11) until 30 days after the last event.

8. In the event the AEC sponsored and funded high altitude event, URRACA, is approved for conduct, the DASA will make such military weapons effects measurements with FISH BOWL Project equipment as can be funded.

9. Headquarters, DASA will be advised of any significant Program changes necessitated by site non-availability, failure to obtain material, support, etc. Headquarters, DASA will be given the opportunity to select alternate solutions.

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FISH BOWL

Program Summary

<u>Program</u>	<u>Title</u>	<u>Total Cost Estimate</u> (in thousands)
1	Blast and Shock Measurements	\$ 215
2	Nuclear Radiation and Effects	250
6	Electromagnetic Phenomena and Effects of Nuclear Weapons on Military Equipment	17,083
7	Proof Test of Service Operational Equip- ment (Service Funded)	(Service funded)
8	Thermal Radiation and Effects	5,512
9	General Support	<u>23,046</u>
TOTAL Funded Technical Cost of Operation FISH BOWL		\$ 46,106

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FISH BOWL

PROGRAM 1.- Blast and Shock Measurements

Operational Requirements:

Determine the effects of air blast from a high altitude nuclear detonation on re-entry vehicles under dynamic flight conditions.

Objectives to be attained:

a. Determine the air blast loading from a high altitude nuclear burst on simulated R/V's while in flight.

b. Determine the response of re-entry vehicles to blast loads superimposed upon aerodynamic loads.

c. Determine the characteristics of the blast wave from high altitude nuclear detonations at various distances along radial paths from the burst point.

d. Determine the characteristics of the air blast at the earth's surface, resulting from a high altitude nuclear burst.

Program Summary

<u>Project Number</u>		<u>Estimated Cost (Thousands)</u>
1.1	High Altitude Air Blast Measurements	205,000
1.2	Shock Photography	<u>10,000</u>
	Total	\$215,000

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FISH BOWL

Program 1 - Blast and Shock Measurements

Project No. 1.1

Title: High Altitude Air Blast Measurements

Objective:

To determine close-in air blast phenomena, ground surface air blast phenomena and in-flight missile response from high altitude nuclear detonations. Blast effectiveness, early blast-thermal interaction and missile response will be determined.

Experimental Plan:

Pod borne instrumentation will be carried aloft by the weapon missile carrier. For the BLUE GILL shot, blast measurements to be made on three pods include peak pressure, peak acceleration, pressure-time and tri-axial acceleration-time. Blast measurements and missile response measurements will be obtained by mechanical gages and the pods will be recovered to obtain the data. The orientation and velocity of the pods at time zero are critical in that the position chosen for the most distant pod, based on thermal considerations, may not allow the pod to be immersed in the blast wave. For the STAR FISH shot tri-axial acceleration-time measurements will be made on three pods and one of the pods will contain a pressure-time gage. The pods will be recovered to obtain the recorded data. In each of the shots, pressure gages will be located at various ranges from ground zero on the surface and near surface level to obtain ground surface blast effects.

Project Agency: BRL

Project Officer: Mr. Russell C. Wise

Estimated Cost: \$205,000

Shot Participation: STAR FISH and BLUE GILL

Tracking Accuracy: + 150 feet with respect to burst.

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FISH BOWL

Program 1 - Blast and Shock Measurements

Project No: 1.2

Title: Shock Photography

Objective:

To obtain photographic data from which time of arrival and peak over-pressure of the blast wave in the close-in region for high altitude nuclear explosions can be determined.

Experiment Plan:

Fireball photography will be taken for diagnostic purposes, i.e., determining yield and/or asymmetries peculiar to the device being tested, as well as for documentary purposes. Since the shock front is the leading edge of the fireball after hydrodynamic separation, shock wave velocity in the close-in region can be determined from radius time measurements of fireball growth. The peak pressure can then be calculated as a function of distance by means of the Rankine-Hugoniot shock relations. Such information can be used to give an estimate of the blast equivalence. This is particularly important at high altitude where it is difficult to make close-in measurements with pods or canisters except on a balloon dragline for a low yield device. Since the shots proposed are large in yield and will be delivered by missiles, photo-optical measurements offer a feasible and economic method of documenting the early time history of the nuclear detonation. In the thin, rarefied upper atmosphere, entirely new and unexplained phenomena may be expected to occur. From the limited data obtained on the high altitude shots of Operation HARDTACK, it is known that the normal (sea-level) growth of the fireball is significantly affected by the physical and chemical structure of the earth's atmosphere. However, it is not known how the mechanism of shock formation changes from the normal hydrodynamic means to a more involved process as a function of altitude. By determining the pressure-distance relation in the strong shock region (both prior to and following break-away, if possible) for various yields at different burst heights, it is hoped to obtain a fundamental knowledge of this process. Participation is required for correlation with blast measurements on pods and at the surface. This project will work with EG&G to develop a coordinated camera plan on all shots of interest to insure adequate coverage to meet objectives of the Blast and Shock Program. Both air-borne and ground stations are desirable, however, if aircraft are not available, then a minimum of cloud cover is required. Data reduction and analysis of photography are not funded within the scope of this project. Photography is included in Program 8.

Project Agency: Naval Ordnance Laboratory, Silver Spring, Maryland

Project Officer: Mr. Peter Hanlon; Phone 301-495-8117, Home WI 8-9160

Estimated Cost: \$10,000

Shot Participation: STAR FISH and BLUE GILL.

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FISH BOWL

Program 2 - Nuclear Radiation and Effects - Summary

Operational Requirements:

Determine the gamma and neutron free field environment from a nuclear detonation in which military weapons systems must operate.

Objectives to be Attained:

1. To measure the neutron flux as a function of distance from nuclear devices detonated at high altitude.
2. To measure the gamma radiation as a function of distance from nuclear devices detonated at high altitudes.

Program 2 Summary

<u>Project Number</u>	<u>Title</u>	<u>Estimated Cost</u>
2.1	External Neutron Flux Measurements	\$175,000
2.2	Gamma Radiation Measurements	<u>75,000</u>
	TOTAL	\$250,000

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FISH BOWL

Program 2 - Nuclear Radiation and Effects

Project No: 2.1

Title: External Neutron Flux Measurements

Experimental Plan:

The objective of this project is to measure the neutron flux as a function of distance from high altitude bursts. Measurements will be made using a threshold/activation detector system. Each detector array will be sealed in a cylindrical metal shell about 3 inches in diameter, 5 inches long, and weighing approximately 1 pound. Five detector packages (4 separated by 90° intervals around the pod periphery and one on the instrument face plate) will be incorporated into each of the three pods on both the STAR FISH and BLUE GILL events.

The threshold/activation detector system requires analysis of the samples subsequent to exposure. Therefore, the instrument packages must be recovered. Due to the rapid decay of fission products formed in some of the foils, the instrument packages must be returned to the project trailer laboratory within 6 hours after detonation. If analysis is delayed more than 12 hours it can be expected that most data will be lost.

For the STAR FISH event detector design will be coordinated with AFSWC (Claude M. Gillespie) to insure compatibility with pod design and to insure that provision is made for rapid removal of the instrument packages from the pod during the recovery operation. Pods will be at 7.5, 10 and 14 KM. Hardening will be accomplished by CONVAIR, San Diego (C. L. Bates).

For the BLUE GILL event detector design will be coordinated with American Science and Engineering Company (Dr. Martin Annis) for the 2500' and 2,000' pods and BRL (Julius Meszaros) for the 4,000' pod to insure compatibility with pod design and to insure that provision is made for rapid removal of the instrument packages from the pods during the recovery operation. In each instance for the BLUE GILL event, coordination with the above listed laboratories should be effected through ASRMDS-12, ASD, Wright-Patterson AFB (Capt F. Adams).

Project Agency: NDL

Project Officer: Mr. John Kinch, Phone: Edgewood Md. 1000 Xt 24251;
Home: 301-837-7425

Estimated Cost: \$175,000

Shot Participation: STAR FISH and BLUE GILL

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FISH BOWL

Program 2 - Nuclear Radiation and Effects

Project No: 2.2.

Title: Gamma Radiation Measurements

Experimental Plan:

The objective of this project is to measure the initial gamma dose as a function of distance from high altitude bursts. Primary gamma dose measurements will be made using film and glass microdosimeters. Secondary measurements using chemical dosimeters such as formic acid will be made as appropriate within budget limitations. Detectors will be sealed in a small metal shell about $2\frac{1}{2}$ x $2\frac{1}{2}$ x 3 inches and weighing about 1 pound. A maximum of three detector packages will be incorporated into each of the three pods on both STAR FISH and BLUE GILL.

The gamma detectors require analysis immediately subsequent to exposure; therefore, instrument packages must be recovered as soon as possible after detonation.

Further experimental work on the effects of fast neutrons on very high range film and glass dosimeters is necessary. This work can be conducted either before or after the field tests at a pulse reactor facility. The neutron sensitivity of the formic acid dosimeter is already well known. The US Army Signal Corps will process the films.

For the STAR FISH event detector design will be coordinated with AFSWC (Claude M. Gillespie) to insure compatibility with pod design and to insure that provision is made for rapid removal of the instrument packages from the pod during the recovery operation. The pods, to be at 7.5, 10 and 14 Km, will be hardened by CONVAIR, San Diego, (C. L. Bates).

For the BLUE GILL event detector design will be coordinated with the American Science and Engineering Company (Dr. Martin Annis) for the 2500' and 6000' pods and BRL (Julius Meszaros) for the 4,000' pod to insure compatibility with pod design and to insure that provision is made for rapid removal of the instrument packages from the pods during the recovery operation. In each instance for the BLUE GILL event, coordination with the above listed laboratories should be effected through ASRMDS-12, ASD, Wright-Patterson AFB, (Capt F. Adams).

Project Agency: NDL

Project Officer: Mr. John Kinch, EDgewood Md. 1000 Xt 24251; Home: 301-837-7425

Estimated Cost: \$75,000

Shot Participation: STAR FISH and BLUE GILL

FISH BOWL

Program 4 - Bio-Medical

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DEFENSE ATOMIC
SUPPORT AGENCY

Project No: 4.1

Title: Retinal Burn and Protective Device Study

Objective:

1. To determine distance at which retinal burn may be dangerous.
2. To test the effectiveness of protective devices exposed to high-altitude nuclear detonations.
3. To measure the thermal radiation emitted in the visible spectrum as a function of wave-length and time.
4. To obtain sufficient experimental data to permit evaluation of prediction methods and models.

Experimental Plan:

Animals will be exposed from stations at various distances from shot locations to determine if retinal burns are produced. Experimental protective devices will be tested at the same stations to permit evaluation of their effectiveness. Measurement of thermal radiation in the visible spectrum by means of calorimeters and spectrometers will provide a standard against which the protective devices, animal specimens and two theoretical models may be compared. Comparison of the experimental results with the physical measurements will permit determination of safe separation distances for retinal burn danger for protected and unprotected personnel in situations wherein viewing a nuclear detonation is possible.

On BLUE GILL, Stations will be located on Johnston Island and in five C118 aircraft at 20,000 to 25,000 feet altitude at distances from ground zero of 35, 50, 75, 100 and 150 nautical miles.

On STAR FISH, Stations will be located on Johnston Island and Maui and in four C118 aircraft at 20,000 to 25,000 feet altitude at distances from ground zero of 200 (DAMP Ship Vicinity), 300 (Instrument ship S-5 vicinity), 500 French Frigate Shoals vicinity) and 700 (South of Oahu) nautical miles.

Project Agency: Aerospace Medical Division, Brooks AFB.

Aerospace Medical Research Laboratory, Wright Patterson AFB; Naval Material Laboratory; National Cash Register Company.

Project Officer: LCol Ralph Allen, USAF, AMD, Brooks AFB; Ph: LEigh 2-8811, Ext 23251

Estimated Cost: \$250,000 (includes DOMINIC Participation)

Shot Participation: STAR FISH and BLUE GILL. This project will also participate in two DOMINIC shots to be selected.

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Operational Requirements:

To determine the effects of high altitude nuclear bursts on electromagnetic waves, especially the impact on radar and communications systems.

Objectives to be attained:

- a. To measure the EM pulse produced.
- b. To measure the ionization produced in the ionosphere as a function of space and time.
- c. To measure the EM noise produced.
- d. To measure the attenuation, refraction, phase, and scattering effects on EM waves.
- e. To measure burst auroral region effects.
- f. To measure the trapped artificial electron shell and its effects.
- g. To obtain an understanding of the phenomenology of high altitude nuclear detonations and the related effects on EM waves, so as to be able to extrapolate in yield, altitude, and position in the earth's magnetic field from those tested to others of military interest.

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

- Summary -

<u>Project No.</u>	<u>Title</u>	<u>Estimated Cost</u> (Thousands)
6.1	Radar Propagation Through Fireball	\$ 3,180
6.2	Rocket-Borne Gamma Ray Scanner	1,256
6.3	D-Region Physical Chemistry	2,500
6.4	E-F Region Physical Chemistry	1,486
6.5	Ionospheric Soundings and Magnetic Measurements	1,014
6.6	Debris Tracking by Surface Resonant Scattering Equipment	350
6.7	Magnetic Containment	2,600
6.8	Riometers	500
6.9	Surface Radar Observations	1,012
6.10	Air-Borne Ionospheric Observatory	200
6.11	HF Communications Simulation Experiment	2,100
6.12	Piggy-Back Satellite Packages	750
6.13	DAMP Ship	<u>135</u>
	TOTAL	\$ 17,083

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.1a

Title: Radar Propagation Through Fireball

Objective:

To determine the early time refractive and absorptive effects on Kmc/s frequencies through the fireball and the highly disturbed region around the fireball.

Experimental Plan:

Three Nike-Cajun rockets will be fired southward from Johnston Island so as to apogee over the burst area. These rockets will carry nominal 1, 5, and 10 Kmc CW transmitters. Rocket trajectories will be obtained by CUBIC Corporation. Receiving stations will be established on Johnston Island and ships S-1 through S-4 to obtain signal amplitude measurements. In addition, an interferometer will be installed at Johnston Island to obtain phase measurements. Three backup rockets will be available for immediate launch in the event of failure of any of the primary rockets; backup rockets remaining will be fired during the 5-10 minute interval after burst.

Shot Participation: BLUE GILL

Project Agency: WSSSA

Project Officer: Mr. George Roberts

Estimated Cost: \$3,180,000

Project No. 6.1b has been cancelled.

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.1c

Title: Radar Propagation Through Fireball

Objective:

To provide theoretical guidance in the design of an experiment to determine the early time refractive and absorptive effects on km/s frequencies passing through the fireball and the highly disturbed region around the fireball. To provide the necessary analysis and data interpretation to assist in preparation of the experimental reports.

Experimental Plan:

None. Project officer and one assistant will be on site during the project 6.1a experiment but will have no experimental equipment. Project officer will assist in data reduction necessary for writing the interim test report.

Shot Participation: BLUE GILL

Project Agency: AFSWC

Project Officer: Lt. J. D. Garcia, CH 7-1711 Xt 3979.

Estimated Cost: No funds

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.2

Title: Rocket-Borne Gamma Ray Scanner

Objective:

To map the debris cloud with near vertical trajectory rockets carrying a gamma ray detector.

Experimental Plan:

The location of the debris as a function of altitude will be measured by gamma ray detectors carried aloft in near vertical trajectories. The ascending rocket will be spun to allow the field of view of the detectors to sweep across the debris cloud. Two Honest John-Nike rockets will be used for BLUE GILL and two Javelin rockets used for STAR FISH. Each instrument package will have a three frequency, lock on, propagation experiment. * C-Band beacons with antennas and tracking will be provided by Project 6.13, . DAMP Ship.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: BRL

Project Officer: Mr. Warren Berning

Estimated Cost: \$1,256,000

* Surface Support and Telemetry are provided by Project 6.3.

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.3

Title: D-Region Physical Chemistry

Objective:

To measure electron and ion densities and content, prompt X-ray flux, delayed gamma and beta ray flux, positive ion species, electron temperature, and EM wave attenuation in and through the D-region.

Experimental Plan:

By use of rocket borne instrumentation, measurements will be made before, during, and after each shot. For BLUE GILL, 2 Nike-Cajun and 4 Honest John-Nike rockets will be used. For STAR FISH, 2 Nike-Cajun and 2 Honest John-Nike rockets will be used. The Nike-Cajun packages will include mass spectrometers and an aspect sensor. The Honest John-Nike packages will contain:

RF impedance probe

Ion trap

Beta flux meter

Gamma flux meter

Three frequency, lock on propagation experiment. (Not carried on STAR FISH)

Aspect sensor

Packages in the air at burst time will also carry prompt radiation detectors.

This project provides the ground receiving station and telemetry equipment support for Projects 6.2, 6.3 and 6.4. It also furnishes launchers for projects 6.2, 6.3, and one launcher for 6.4.

Any reduction in number of rocket firings because of package failures, etc. will be made from the STAR FISH event.

To expedite dispersal of funds, DASA distributed some of the project funds directly to GCA, EOS, and AFCRL, in accordance with agreement between Hq, DASA and Mr. Berning. However, Mr. Berning has authority for direction of all aspects of this project, and accordingly has both the authority and responsibility to direct and manage the work done by these other activities under this project.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: BRL

Project Officer: Mr. Warren Berning

Estimated Cost: \$2,500,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.4

Title: E and F-Region Physical Chemistry

Objective:

To measure the ionizing radiation, the ion species, the electron and ion densities, and the attenuation of EM waves in and through the E and F regions.

Experimental Plan:

By use of Javelin rocket borne instrumentation, measurements will be made before, during, and after the STAR FISH burst. Three rockets will be fired. The first rocket fired for STAR FISH carries the following equipment:

Mass spectrometer

Beta flux meter

Gamma flux meter

Langmuir probe

Three frequency, lock-on propagation experiment

Aspect sensor

The second and third rockets fired for STAR FISH carry the same instruments, but with a retarding potential probe substituted for the mass spectrometer.

The ground receiving equipment is being provided by Project 6.3.

Shot Participation: STAR FISH

Project Agency: AFCRL

Project Officer: Dr. Wolfgang Pfister

Estimated Cost: \$1,486,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.5a

Title: Ionospheric Soundings and Magnetic Measurements

Objective:

To make measurements of HF/VHF disturbances, ELF-VLF effects 5 Kc/S noise, and hydromagnetic waves using a variety of equipment available to AFCRL.

Experimental Plan:

This project will provide and operate the equipment at the locations shown below:

<u>Site</u>	<u>Equipment</u>	<u>Site</u>	<u>Equipment</u>
Hawaii	Photometer (3914, 5577, and 6300A ^o) ELF-VLF receiver 5 Kc/S receiver Earth current Variometer	Tutuila	5 KC receiver VLF receiver Variometer Earth Current Microbarograph
Palmyra	Loran C receiver C-4 Ionosonde Granger receiver 5 KC receiver Earth current Variometer Photometer (3914, 5577, and 6300A ^o) Radio Star Interferometer	Canton Atoll	Variometer
		Okinawa	Variometer
		Wake	Variometer Microbarograph
		Kawajalein	Microbarograph
Midway	Granger Transmitter Variometer Microbarograph ELF-VLF receiver Loran C receiver	Adak	Microbarograph

Existing sites will be operated during the tests.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: AFCRL

Project Officer: Dr. Phillip Newman; phone CR 4-6100, Ext 3710

Estimated Cost: \$214,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.5b

Title: Ionospheric Soundings and Magnetic Measurements

Objective:

To make detailed measurements on the propagation of radiation and debris into the southern auroral region and various effects produced.

To alert existing world-wide geophysical installations and correlate the data obtained from these agencies.

Experimental Plan:

Mobile trailer based field experiments will be located at Tutuila and Tongatabu. These field stations will incorporate VLF, HF, VHF (Satellite), Riometers, Earth Current, Magnetometers, Spectrophotometers, all sky camera, 35mm photography, 35mm Spectroscopy and ionosonde measurements.

Balloon borne NAI detectors to measure debris gamma in the conjugation area will be launched from Tutuila.

A series of University and IGY stations located at key positions throughout the world will be implemented to obtain a variety of geophysical data associated with these tests.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: ARF

Project Officer: Dr. Clint Stone; Phone: CA 5-9600, XT 2362.

Estimated Cost: \$400,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.5c

Title: Ionospheric Vertical Sounding

Objective:

To make measurements with ionosondes in the burst and burst auroral regions to determine the:

- a. HF Blackout caused by ionization in the D-region.
- b. Increases in F-region electron density
- c. Distortions in the E-F region.

Experimental Plan:

The locations of the ionosondes have been selected in coordination with those in Projects 6.5a and 6.5d..

An ionosonde and operator for each Tongatabu and Tutuila will be provided to work with ARF (6.5b). The Canton Atoll and Maui ionosondes will continue to be operated for this operation. Ionosondes will be provided and operated at Wake, Midway and French Frigate Shoals.

Shot participation: BLUE GILL and STAR FISH

Project Agency: CRPL

Project Officer: Mr. William Utlaut

Estimated Cost: \$150,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.5d

Title: Ionospheric Soundings

Objective:

To determine ionospheric changes in the test area due to high altitude nuclear detonations and to operate a Pinwheel experiment.

Experimental Plan:

Vertical ionospheric sounders will be operated on Johnston Island and Kwajalein, and an oblique pinwheel experiment will be established with transmitters on Maui and receivers in Adak and Okinawa.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: USARPA

Project Officer: Mr. F. H. Dickson, Scientific Director USASRPA
Ph: Ft. Monmouth LI 2-4000 X 51957

Estimated Cost: \$100,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.5e

Title: Hydromagnetic Wave Measurements

Objective:

To examine the magnetic field changes and hydromagnetic wave propagation from high altitude nuclear detonations.

Experimental Plan:

A large loop magnetometer will be placed on Hawaii. Metastable helium magnetometers will be placed on Hawaii, Tutuila, and in Texas.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: USASRDL

Project Officer: Dr. Hans Bomke, Ext 61422

Estimated Cost: \$150,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.6

Title: Debris Tracking by Surface Resonant Scattering Equipment

Objective:

To determine, in the burst area, the southern burst auroral area, and the northern burst auroral area:

- a. Horizontal distribution of debris
- b. Degree of ionization of debris
- c. Vertical distribution of debris

Experimental Plan:

A fast, four barrel interference photometer will be placed on Johnston Island and Ships S-2 and S-4. Filters to measure Ba⁺, Ba, Li, and Zr will be used.

A birefringent, rotating turret photometer will be placed on Tonga, Tutuila, French Frigate Shoals, and Ships S-1 and S-5. Filters for li, Ba, Ba⁺, Zr, and Zr⁺ will be used.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: GCA

Project Officer: Dr. Edward R. Manring; CR 4-9000, Ext 214

Estimated Cost: \$350,000

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.7

Title: Debris Expansion

Objective:

To measure the debris expansion, both along and normal to the geomagnetic field.

Experimental Plan:

By means of 5 instrumented rockets the expansion of debris and the interface between the ambient geomagnetic field and the expanding charged debris will be made, along with measurements on the inside of the bubble. Three rockets will be spaced at various distances above the burst and perpendicular to the magnetic field, with another rocket below the burst and the last rocket along the magnetic field line about 1,000 km at burst time. Data will be received by FM-FM telemetry stations located on Canton Atoll, French Frigate Shoals and Oahu.

Instruments in each rocket will be identical and consist of:

Rubidium vapor magnetometer

3 Faraday cups

Hall probe

Solid state beta detectors

Geiger tubes

Shot Participation: STAR FISH

Project Agency: AFSWC

Project Officer: Lt William A. Whitaker, CH 7-1711, Ext 3277

Estimated Cost: \$2,600,000

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.8

Title: Riometers

Objective:

To determine cosmic noise absorption with a grid of riometers covering the burst and burst auroral zones.

Experimental Plan:

Different riometer antennas and frequencies will be used. Riometers on Canton Atoll will also measure synchrotron noise. The Ship (S-5) riometers are magnetically conjugate to those on Tutuila. Wherever feasible, riometers will be carried overseas and operated by a Project 6.5, 6.6, 6.9 or 6.11 agency that is already going to the desired location. If the Efate, Raratonga, and Wallis sites are not available, readjustment will be made. It will then be especially important to place riometers on the Acania. Following is a list of sites, frequencies, and operating agencies:

<u>Site</u>	<u>Frequency (mc/s)</u>	<u>No of Riometers</u>	<u>Operating Agency</u>
Oahu	20,30,60	3	AFCRL (6.5a)
Johnston	30,60,120 (3 with different antennas)	5	AFCRL
S-1	30,60,120	3	GCA (6.6)
S-2	30,60,120	3	GCA (6.6)
S-3	30,60,120	3	SRI
S-4	30,60,120	3	GCA (6.6)
S-5	30,60,120	3	GCA (6.6)
French Frigate Shoals	30,60,120	3	GE
Midway	20,30	2	AFCRL (6.5a)
Canton Atoll	30,60,120	3	SRI
Fiji (Vita Levu)	30,60	2	SRI (6.11)
Acania	30,60,120	3	SRI (6.11)
Tutuila	30,60,120	3	AFCRL (6.5a)
Tonga	30,60,120	3	ARF (6.5b)
DAMP Ship	30,60,120	3	SRI
Palmyra	20,30	2	CRL (6.5a)

Shot Participation: BLUE GILL and STAR FISE

Project Agency: AFCRL

Project Officer: Mr. Samuel Horowitz

Estimated Cost: \$500,000

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.9

Title: Radar Clutter and Radar Physics Measurements

Objective:

To investigate radar clutter associated with high altitude nuclear explosions and to contribute to nuclear weapon phenomenology at high altitudes with radar and radio measurements.

Experimental Plan:

The installation at Johnston Island will consist of an HF sounder and radars at nominal frequencies of 20,30, 50,400, 900 and 1300 mc.

The M/V Acania and its associated multi-frequency radars along with an HF sounder will be located near Tutuila.

Two AEW aircraft with 425 mc radars will be operated in the Johnston Island area and two similar aircraft operated in the southern conjugate region. In correlation with Project 6.13 the DAMP ship, USAS American Mariner, will participate with multi-frequency radars in the Johnston Island area.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: SRI

Project Officer: Mr. Ray Leadabrand, DA 6/6200, Ext 2050

Estimated Cost: \$1,012,000

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.10

Title: Ionospheric Measurements on Atmospheric Tides

Objective:

To make ionospheric measurements by radar sounding and optical and electronic means from one KC-135 aircraft and ground based equipment at various locations.

Experimental Plan:

1. BLUE GILL - The aircraft will operate out of Hickam, AFB, Oahu, and take data in the burst area. Ground based equipment, operating in synchronization with the airborne equipment, will include an instrumented trailer on Oahu, HF receiving stations on Midway and Palmyra, and a VLF receiver at Kaena Point, Oahu for vertical phase recordings. Raw data will generally be recorded on film, magnetic tape, and paper-charts.

2. STAR FISH - Same as BLUE GILL except that the aircraft will operate out of Fiji International Airport and take data in the vicinity of the southern burst auroral region, and the instrumented trailer will be located at the Fiji International Airport.

3. Equipment -

- a. The airborne equipment consists of:
 - Phillips Step Frequency Ionospheric Recorder
 - 3 HF Receivers
 - All Sky Camera
 - Gamma Ray Counter
 - Visible Scanning Spectrometer
 - Infrared Scanning Spectrometer
- b. The trailer equipment consists of:
 - All Sky Camera
 - Phillips Step Frequency Ionospheric Recorder
 - 3 HF Receivers
- c. Additional ground based equipment:
 - Kaena Point - VLF Receiver
 - Midway - 3 HF Receivers
 - Palmyra - 3 HF Receivers

Shot Participation: BLUE GILL & STAR FISH

Project Agency: AFCRL

Project Officer: Roger W. Whidden; CR 4-6100, Ext 3103

Estimated Cost: \$200,000

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FISH BOWL

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.11

Title: HF Communications Simulation: Experiment

Objective:

To measure the blackout effects of high altitude nuclear explosions on HF Communications by using a grid of Granger Sounders.

Experimental Plan:

A network of Granger Sounders will be established to produce paths covering the burst and burst auroral regions. Transmitters will be operated in both the forward and backscatter modes. Existing equipment in Okinawa, California, and Alaska will be used. In addition, 3 transmitters and amplifiers and 6 receivers will be purchased. Data will be recorded to determine the attenuation of HF signals, mode structure and variation, multipath and pulse distortion.

In coordination with the DCA, the Pacific Scatter Communication System and selected military HF operational circuits in the Pacific area will be monitored.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: USA SRDL

Project Officer: Mr. Howard Kitts, Phone 535-1565

Estimated Cost: \$2,100,000

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Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.12

Title: Piggy-Back Satellite Packages

Objective:

To place piggy-back satellite instrument packages on Discoverer vehicles to measure long-time world-wide effects.

Experimental Plan:

Each of three identical packages will be mounted on the door of the Agena stage of Discoverer satellites. Each package is a self-contained unit with a command receiver, tape storage, and telemetry. Instrumentation includes:

- 2 Beta flux meters
- 1 Gamma ray flux meter
- 1 Radiometer at 4 Mc
- 1 Radiometer at 2 Mc
- 1 RF impedance probe
- 1 Ion trap probe

Command and telemetry stations will be provided at Hawaii, Vandenberg, New Boston, and Ascension Island.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: AFCRL

Project Officer: Capt. R. A. Bena, CR 4-6100, Ext 3616

Estimated Cost: \$750,000

Program 6 - Electromagnetic Phenomena and Effects of
Nuclear Weapons on Military Equipment

Project No: 6.13

Title: DAMP Ship

Objective:

To measure refraction, reflection and absorption at radar frequencies through, and in the vicinity of, the burst; to measure radar clutter and RF noise; to measure electron density in the atmosphere; and to measure the intensity, spatial distribution and duration of radiation in the infrared, visible and ultraviolet spectral regions.

Experimental Plan:

The DAMP ship will be located magnetic north of ground zero at a distance of 135 km for BLUE GILL and 410 Km for STAR FISH. For each event, 7 rockets carrying C-band radar beacons will be sequentially fired from Johnston Island toward the burst region and tracked from the DAMP ship. Electron line density measurements will be made by recording doppler and the known position from TRANSIT satellites. One C-band radar will measure radar clutter. RF noise level will be measured at UHF. Absorption measurements will be made by radiometers installed on the DAMP ship. The Mark II re-entry vehicle will be (skin) tracked from 250 Km down to burst for BLUE GILL; the burst formation and rise of the fireball will be tracked and/or mapped. Boresight films will be made for all tracked objects to obtain angular tracking jitter. Photometers, radiometers and special cameras will record the event from the DAMP ship.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: AOMC

Project Officer: Mr. J. Hagestrat

Estimated Cost: \$135,000, provided by ARPA.

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.1

Title: Electromagnetic Underwater Measurements

Objective:

This project will obtain measurements of the electromagnetic signals from nuclear detonations at large distances from beneath the sea surface as a means of indirect bomb damage assessment. These measurements will provide data on the effect of the air-water interface on transmission of electromagnetic signals from near surface and high altitude bursts.

Experimental Plan:

Electromagnetic signatures, as a function of time, will be measured above and below the ocean surface, at the same locations, at distances such that waveform shape is determined by both ground and skywaves. Since possible interference phenomena from water/ground interfaces render ground stations inadequate, measurements will be made from shipboard. Two Navy furnished ships will be stationed about ten miles apart at sea, about 800 to 1100 miles from the FISH BOWL and AEC detonations. The ships will measure and record data transmitted above the surface with VLF loop antennas and below the surface with antennas simulating present submarine receiving systems. Spheric background and calibration signals will be recorded before and after scheduled nuclear events.

Timing signals providing knowledge of shot time to within ten seconds is sufficient. Communications for determining changes will be required.

Project Agency: Kaman Nuclear, Colorado Springs, Colorado

Project Officer: Dr. Albert P. Bridges, Ph: MELrose 4-2826, Colorado Springs, Colorado.

Estimated Cost: \$56,000 plus GFE to be provided by Director, Special Projects Office, Department of the Navy, Washington 25, D. C., Cdr Alex Julian or Mr. D. R. Williams (SP-272); PH: OX 67174 or OX 67175.

Shot Participation: STAR FISH and BLUE GILL

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FISH BOWL

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.2

Title: Radiofrequency Radiometry

Objective:

To detect and measure:

(1) Synchrotron radiation from the vicinity of high altitude nuclear detonations.

(2) Thermal radiation at radiofrequencies from high altitude nuclear detonations.

Experimental Plan:

Synchrotron radiation at 50 and 100 MC will be measured with a polarimeter consisting of two rotating dipoles in a 28 foot paraboloidal reflector, dual low-noise figure receivers and a recorder. This experiment will be located on Palmyra to permit observation of the burst region without the undesirable attenuation of closer locations.

Thermal radiation at 3000 and 35,000 megacycles will be measured with radiometers employing a six foot paraboloidal antenna, receivers and recorders. This experiment will be housed in a trailer on Johnston Island to permit close-in, nearly vertical path measurements.

Support of stations at Palmyra and Johnston including minor construction, will be required.

Project Agency: Massachusetts Institute of Technology, Lincoln Labs

Project Officer: Mr. James H. Pannell, Mass. Institute of Tech.,
Lincoln Laboratory, Lexington, 73, Mass. VO 2-3370
Ext 5744

Estimated Cost: All funds provided by Project Agency

Shot Participation: STAR FISH and BLUE GILL

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FISH BOWL

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.5

Title: VLF Monitoring Through Nuclear Environment

Objective:

To determine, through actual operating experience, the effects of high-altitude nuclear detonations on VLF communications. The essential role of VLF in command and control communications emphasizes the need for an experiment under an operational nuclear environment.

Experimental Plan:

This project will monitor and record VLF CW transmissions from the existing stations listed below. Schedules will insure continuous transmissions from 24 hours before each event to 48 hours after.

Transmitting Station

Receiving Stations

Balboa (Precise time and frequency transmission only)

Nav Comm Sta Guam, Japan, Phil
Nav Station, Midway
Selected JTF-8 Ships
Pacific Barrier Forces

Naval Radio Station, Jim Creek

Nav Comm Sta Guam, Japan, Phil
Selected Pac Flt ships including submarines

Naval Communications Station, Honolulu

Pacific Missile Range Facility, Kwajalein and selected NRL/NEL sites in Australia
Selected Pacific Security Group Activities

Naval Communications Station, Japan

Nav Comm Sta, Adak
Selected JTF-8 Ships
Nav Comm Sta Balboa and Honolulu

Where feasible, NEL will activate the OMEGA complex and monitor effects thereon during events. Coordination with JTF-8 will be required to select those ships for monitoring VLF broadcasts. Participating ships and stations require BLUE GILL and STAR FISH schedules and count-down information.

Project Agency: OPNAV (OP-94)

Project Officer: Capt L.R. Raish, OP 944 (OX 57706); LCDR R.C. Smith, OP 944 GC (OX 56595); Lt (jg) P.M. Banks, ONR (Code 418) (OX 64476 or 66969); Mr. V.G. Blasco, OP-94V30 (OX 60281)

Estimated Cost: All funding and resources will be provided by the U.S. Navy

Shot Participation: STAR FISH and BLUE GILL

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DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AT 12 YEARS.
DOD DIR. 5800.7

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FISH BOWL

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.6

Title: LF Monitoring Through Nuclear Environment

Objective:

To determine, through actual operating experience, the effects of high altitude nuclear detonations on LF communications. The essential role of LF to supplement VLF in command and control communications emphasizes the need for an experiment under an operational nuclear environment.

Experimental Plan:

This project will monitor and record LF RATT broadcasts, from the existing stations listed below, from 24 hours before each event to 48 hours after.

Transmitting Station

Receiving Station

Naval Communications Station, Honolulu

Naval Security Groups, Okinawa and Midway

Nav Comm Sta, Guam and Adak

Naval Communications Station, Guam

Selected JTF-8 Ships

Naval Station, Midway

Pacific Missile Range Facility, Kwajalein

Selected JTF-8 Ships

Nav Comm Sta, Honolulu, Japan

Coordination with JTF-8 will be required to select those ships for monitoring LF broadcasts. Participating ships and stations require BLUE GILL and STAR FISH schedules and count-down information.

Project Agency: OPNAV (OP-94)

Project Officer: Capt L.R. Raish, OP 944 (OX 57706; LCDR R.C. Smith, OP 944 GC (OX 56595); Lt (jg) P.M. Banks, ONR (Code 418)(OX 64476 or 66969); Mr. V. G. Blasco, OP 94V30 (OX 60281)

Estimated Cost: All funding and resources will be provided by the U.S.N.

Shot Participation: STAR FISH and BLUE GILL

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DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR. 5200.10

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FISH BOWL

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.7

Title: MF Ground Wave Monitoring Through Nuclear Environment

Objective:

To determine, through actual operating experience, the effects of high altitude nuclear detonations on MF ground wave communications. The essential role of medium frequency communications emphasizes the need for an experiment under an operational nuclear environment.

Experimental Plan:

Two ships, assigned to JTF-8, will monitor and record RATT and CW circuits established between each other. The circuits will operate in the 2 to 3 megacycle band, carrying continuous exercise traffic from 24 hours before each event to 48 hours after. Coordination with JTF-8 will be required to select two JTF-8 ships to monitor the MF circuits on a collateral basis. Participating ships require BLUE GILL and STAR FISH schedules and count-down information.

Project Agency: OPNAV (OP-94)

Project Officer: Capt L.R. Raish, OP 944 (OX 57706); LCDR R.C. Smith, OP 944 GC (OX 56595); Lt (jg) P.M. Banks, ONR (Code 418)(OX 64476 or 66969); Mr. V.G. Blasco, OP 94V30 (OX 60281)

Estimated Cost: All funding and resources will be provided by the U.S.N.

Shot Participation: STAR FISH and BLUE GILL

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DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR. 10

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FISH BOWL

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.8

Title: HF RATT Broadcast Monitoring Through Nuclear Environment

Objective:

To determine, through actual operating experience, the effects of high altitude nuclear detonations on HF RATT broadcasts.

Experimental Plan:

This experiment will determine, scientifically and operationally, the effects of high altitude nuclear bursts on high frequency, long haul ship to shore communications. All U.S. Navy ships copying the Honolulu Hotel Romeo Fleet RATT broadcast will monitor and record reception from 24 hours before each event to 48 hours after. In addition, the point-to-point long-distance circuits passing through the area between Honolulu-Balboa; Christ Church, New Zealand - Honolulu; Honolulu-Kwajalein; and Australia-Honolulu will be monitored. Participating ships and stations require BLUE GILL and STAR FISH schedules and count-down information.

Project Agency: OPNAV (OP-94)

Project Officer: Capt L.R. Raish, OP 944 (OX 57706); LCDR R.C. Smith, OP 944 GC (OX 56595); Lt (jg) P.M. Banks, ONR (Code 418) (OX 64476 or 66969); Mr. V.G. Blasco, OP-94V30 (OX 60281)

Estimated Cost: All funding and resources will be provided by the U.S. Navy

Shot Participation: STAR FISH and BLUE GILL

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DECLASSIFIED AFTER 12 YEARS.
DOD DIR. 5200.108~~

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FISH BOWL

Program 7 - Proof Test of Service Operational Equipment

Project No: 7.9

Title: Operational Effects of High Altitude Nuclear Detonations on Operating Shipboard Radars

Objective: To determine the direct effects of high altitude nuclear detonations on the operational capabilities and performance of present installed shipboard search radars.

Experimental Plan:

Ships currently attached to and operating with JTF-8 in the immediate test area and on the periphery will track targets of opportunity from shortly before detonation until after any phenomena attributable to burst effects have subsided. Radars of particular interest are:

1. Two-coordinate air search radars in the 200 MC band (SPS-29, SPS-37 and SPS-43).
2. Three coordinate air search radars.
3. Surface search radars.

Radarscope photography will be employed periodically to record representative conditions prior to, during and after each event until conditions return to normal. Scope photos will be annotated to identify all targets and phenomena appearing. Annotation will include:

- (1) Date and time.
- (2) Ships position.
- (3) Weather conditions including sea state.
- (4) Type radar and indicator.
- (5) Mode of operation (i.e., range scale, pulse width, ECCM techniques employed).

Coordination with JTF-8 will be required to select those ships which will participate, on a not-to-interfere basis, with their primary mission. Ships participating will require BLUE GILL and STAR FISH schedules and count-down information.

Project Agency: OPNAV (OP-94)

Project Officer: Capt L.R. Raish, OP-944 (OX 57706); LCDR R.C. Smith, OP 944 GC (OX 56595); Lt (jg) P.M. Banks, ONR (Code 418) (OX 64476 or 66969); Mr. V.G. Blasco, OP - 94V30 (OX 60281)

Estimated Cost: All funding and resources will be provided by the U.S. Navy

Shot Participation: STAR FISH and BLUE GILL

DOWNLOADED AT 3 YEAR INTERVALS;
DECLASSIFIED AT 12 YEARS.

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Program 8 - Thermal Radiation & Effects - Summary

Operational Requirements:

To determine the output of nuclear weapons as a function of (high) altitude of burst, and the interactions of this output:

- a. Directly on manned and unmanned weapons systems.
- b. In exciting the atmosphere in a manner which will affect electromagnetic communications, radar, optical surveillance, and guidance systems. These effects will be optically documented for the benefit of Programs 1, 6 and 8.

Objectives to be Attained:

- a. Determine the thermal energy emission as a function of (high) altitude.
- b. Determine the time-intensity and time-spectral relationships.
- c. Document the infrared space-time-intensity factors to investigate the blackout problem for optical (IR) surveillance, direction, and guidance systems.
- d. Determine the space-time-spectral intensity of the area near the shot and conjugate points for documenting debris trapping, ionization, and recombination rates for their effects on electromagnetic communications and radar systems.
- e. Gain a better understanding of the physical processes relevant to the above problems so that results can be extrapolated to military systems in different environments subjected to different weapon yields.

Program Summary

<u>Project Number</u>	<u>Title</u>	<u>Cost Estimate</u>
8A, _	Classical Thermal Effects	\$ 3,012,000
8B, _	X-Ray Effects	500,000
8C, _	Re-entry Vehicle Experiment	2,000,000
	TOTAL	\$ 5,512,000

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Program 8 - Thermal Radiation & Effects

Project No: 8A.1

Title: Infrared Blackout and Sky Background

Experimental Plan:

This project proposes to document the thermal energy output for high altitude detonations, the infrared "afterglow" blackout problem on MIDAS and other surveillance systems, and IR guidance and directing systems. Instruments will be mounted in 3 A/C (including the Project 6.10 A/C) as follows:

- a. Scanning spectrometers, both fast and slow, in varying wave-bands from 0.35 μ to 1.2 μ .
- b. Broad-band dispersion spectra, 8 bands, ranging between 0.18 and 5.0 μ .
- c. Black-body bolometers and calorimeters (H vs t).
- d. Broad-band infrared sky-mapper and filtered cameras to document spatial and temporal characteristics of the sky glow in the visible and especially the infrared spectra. Supplementary ground stations will be used in the burst and conjugate area.

Project Agency: AFCRL

Project Officer: Mr. Hervey Gauvin

Estimated Cost: \$695,000 plus A/C modification (including \$150,000 Preliminary)

Shot Participation: STAR FISH and BLUE GILL

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Program 8 - Thermal Radiation & Effects

Project No: 8A.2

Title: Optical Phenomenology and Technical Photography

Experimental Plan:

Phenomenology and weapon output for high altitude bursts are not understood. Knowledge is necessary for both Thermal and Electromagnetic effects purposes.

Shot Area: 3 A/C Stations including the Project 6.10 A/C plus supplementary ground stations.

Conjugate Area: Ground stations only.

Instrumentation will be distributed among the above stations to document changes in fireball size, output, and changes in spectral and temporal characteristics with heights of burst as follows:

1. High speed streak and framing cameras for energy distribution.
2. Medium and low speed technical photographic coverage to determine vertical asymmetries, hydrodynamic motion, debris shock and late time debris location.
3. Total thermal energy and power vs. time.
4. Similar measurements in auroral zones.

Project Agency: EG&G

Project Officer: Mr. Don Hansen

Estimated Cost: \$1,517,000 plus A/C modification

Shot Participation: STAR FISH and BLUE GILL

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Program 8 - Thermal Radiation & Effects

Project No: 8A.3

Title: Structural Response To Thermal Radiation from High Altitude Fireball

Experimental Plan:

For the ICBM kill problems in the altitude zone around 50 km, it is necessary to document the thermal response of materials considered for nose cones, re-entry vehicles, and similar high altitude vehicles.

Instruments (passive) will consist of:

- (1) Impulse and Ablation gages
- (2) Calorimeters and Temperature sensors
- (3) Accelerometer
- (4) Beacon and other recovery-assisting devices.

Recovery is essential (Ships and A/C).

Project Agency: ASD, Wright Field

Project Officer: Lt. Frank D. Adams, 35170, home 252-6853

Estimated Cost: \$800,000

Special Requirements: Tracking and positioning of pods and carrier at time of burst.

Shot Participation: BLUE GILL

Program 8 - Thermal Radiation and Effects

Project No: 8B

Title: Thermal Radiation and Effects

Objectives:

- Determine total X-ray Energy output.
- Determine the X-ray spectrum.
- Determine the X-ray induced total momentum on materials of interest.

Observe the X-ray effect on bare and countermeasured re-entry vehicle materials. Observe the low flux level X-ray effects on satellite and other space system materials.

Experimental Plan:

Passive instrumentation will be incorporated in three stabilized pods which will be oriented tail-on toward the burst at distances of 7.5, 10, and 14 km (i.e. fluxes of 50,100 and 150 cal/cm²).

X-ray spectrum instrumentation consists of K-edge filters and plated wedge detectors. The K-edge filters transmit X-ray wave lengths above the specified edge value. The transmitted energy is absorbed in a stack of alternating metal foil absorbers and plastic sheets. It is possible to determine the energy from observed depth of melted plastic. The plated wedge detector consists of a plastic cylinder with a conical section removed. The conical section is plated with a metal. The energy spectrum may be reconstructed by observing melt and vaporization depth.

Total X-ray flux will be measured in the most distant pod using a passive carbon calorimeter. Temperatures are measured by observing color, texture and shape changes in small drops of temperature sensitive paint placed in a carbon disk.

Total momentum will be determined as a function of material properties and incident flux using indented recorders. Each recorder consists of a piston with a conical end pointing towards an anvil resting in a cylindrical barrel of sample material. The impulse generated by x-ray exposure causes the piston to strike the anvil. The resulting indentation is a function of the impulse imparted to the sample. Sixty indenter recorders will be provided in each pod.

Pressure pulse history, effects on metallurgical samples and R/V composite sample, and effects on pod structure and surface materials will also be observed. Instrumentation consists of 2 fracture gages, 10 metallurgical samples, and six R/V samples per pod. Recovered pods will be compared with other pods subjected to X-ray simulation test procedures to check validity of present test techniques.

Shot Participation: STAR FISH

Project Agency: AFSWC

Project Officer: Capt. Gillespie, CH 7-1711, EX 3175

Estimated Cost: \$500,000

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FISH BOWL

Program 8 - Thermal Radiation and Effects

Project No: 8C

Title: Re-entry Vehicle Tests

Objective:

Determine the X-ray effects of a high-altitude (400 km) nuclear detonation (1.45 Mt) on passively instrumented operational re-entry vehicles to include:

- a. Positive determination of re-entry burn-up.
- b. Observation of the recovered vehicle for:
 1. Orientation and position at burst.
 2. Response of selected arming and fuzing components.
 3. Structural response.
 4. Momentum transfer.
 5. Structural damage.

Experimental Plan:

This project will be pursued in parallel with project 83. A decision to substitute one or two test configured Mark 5 - 5B-1 re-entry vehicles for STAR FISH pods will be made approximately two weeks prior to shot time. The R/V's, if selected, will be carried aloft by a Thor launch vehicle. If one R/V is used, deployment range is 10 km at a predicted X-ray flux of approximately [REDACTED]. If two R/V's are used, deployment ranges are 7.5 and 1 $\frac{1}{2}$ km with predicted fluxes of approximately [REDACTED]. The probability of 7.5 km R/V survival is marginal. The R/V's will be instrumented to the maximum extent possible within weight limitations. Measurements include: acceleration, strain, radiation fluxes and vectors, temperatures, impulse, effects on frangible fuze, and examination of R/V body. If tracking instrumentation cannot be incorporated, burst time pod location may be determined from trajectory programming within 7% of burst range. R/V's will be provided with an interior coating of pyrotechnic material to provide a distinctive signature if burn-up occurs on re-entry. Primary reliance on passive instrumentation requires post shot recovery of the R/V's. Recovery unit operation will be similar to BLUE GILL and STAR FISH pods.

Shot Participation: STAR FISH

Project Agency: AFSWC

Project Officer: Capt M. J. Rubenstein

Estimated Cost: \$2,000,000 (including support - ARPA funded)

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Program 9 - General Support

Program 9 contains support projects for Programs 1 through 8.

<u>Project Number</u>	<u>Title</u>	<u>Estimated Cost</u> (in thousands)
9.1	Atmospheric Parameter Profile	\$ 450
9.2	Ship Modification	1,000
9.3	Aircraft Modifications	800
9.4	Warhead and Pod Launch System	16,855
9.5	General Support for Programs 1-9	460
9.6	Tracking and Positioning of Pods & Rockets	3,081
9.7	Ship Rental	<u>400</u>
	TOTAL Program 9	\$ 23,046

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Program 9 - General Support

Project No: 9.1a

Title: Atmospheric Parameter Profile

Objective:

To determine the atmospheric density, temperature, pressure and composition of the upper atmosphere as a function of altitude from 20 to 100 KM at near shot time.

Experimental Plan:

The falling sphere method is to be used for the measurement of the density of the upper atmosphere. This consists essentially of the ejection of a sphere from a Nike-Cajun rocket and measurement of the drag on the sphere by means of a sensitive accelerometer inside the sphere. The density will be calculated from these measurements. The parameters desired, namely, temperature and pressure will be calculated from the density measurements by means of the hydrostatic equation and the equation of state. The temperature and pressure so determined will be accurate to about 10% at the lower altitudes and much better than this at the high altitudes. One flight will be made just prior to the test to obtain the desired measurements.

Project Agency: AFCRL

Project Officer: Dr. K. S. W. Champion

Estimated Cost: \$150,000 (See AF Proposal OAR-61-2576-54969-4)

Shot Participation: BLUE GILL and STAR FISH

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Program 9 - General Support

Project No: 9.1b

Title: Atmospheric Parameter Profile

Objective:

To determine the upper atmospheric winds and wind shears above, in, and below the 80 to 100 km altitude shear region in the vicinity of the burst region.

Experimental plan:

Firefly program techniques will be used. Nike-Cajun rockets launched from Johnston Island will make chemical releases covering the 70 to 150 km altitude region of the burst area for each shot at dawn and dusk bracketing shot times. If possible, releases will be initiated at altitudes as low as 50 km. Firefly program cameras for surface observations will be located at Johnston Island and on Ships S-1, S-2, and S-4.

Shot Participation: BLUE GILL and STAR FISH

Project Agency: AFCRL

Project Officer: Dr. K. S. W. Champion

Estimated Cost: \$300,000

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FISH BOWL

Program 9 - General Support

Project No: 9.2

Title: Ship Modification

Experimental Plan:

Modification of Ships used in Programs 1 through 8.

Project Agency: FC/DASA

Project Officer: Cdr. W. D. Hall, 256-4411, Ext 41212

Estimated Cost: \$1,000,000

Shot Participation: STAR FISH and BLUE GILL

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FISH BOWL

Program 9 - General Support

Project No: 9.3

Title: Aircraft Modification

Experimental Plan:

Modification of aircraft to be used in Programs 6 and 8

Project Agency: AFCRL

Project Officer: Mr. Hervey Gauvin

Estimated Cost: \$800,000

Shot Participation: STAR FISH and BLUE GILL

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Program 9 - General Support

Project No: 9.4a

Title: Warhead and Pod Launch System

Objective:

To establish the capability, and to launch Thor missiles so as to effect detonations at specified points in space. In addition, instrumented pods and possibly MK-V re-entry vehicles will be placed at specified distances with respect to the detonations.

Experimental Plan:

The Space Systems Division, Air Force Systems Command (Task Unit 8.1.5) will provide and fire modified Thor missiles as carriers for the [REDACTED] warhead for STAR FISH and the [REDACTED] warhead for BLUE GILL. Three externally carried, recoverable, scientific instrument pods weighing 1,200 pounds each will be lofted for measurements on BLUE GILL. 3 pods or 1 pod and 2 MK-V R/V's will be carried on STAR FISH. Two back-up Thors will be procured and transported to Johnston Island. One complete launch system certification shot (less nuclear) will be conducted to proof test system design. Three pods (two instrumented for environmental and re-entry measurements) will be lofted and recovered on the proof shot. This project will support URRACA if it's approved.

Shot Participation: BLUE GILL, STAR FISH, and Certification Flight.

Project Agency: AFSC (SSD)

Project Officer: Colonel I. A. Meyer, Area 213-059-4661 Xt 3185

Estimated Cost: \$13,000,000

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FISH BOWL

Program 9 - General Support

Project No: 9.4b

Title: Pod and Recovery Unit Procurement.

Objective:

a. To provide scientific passenger pods as instrument carriers for Operation FISH BOWL Projects 1.1, 2.1, 8A.3, 8b and possibly 8c if approved.

b. To coordinate and consolidate project requirements for presentation to the pod contractor; General Dynamics/Astronautics.

c. To coordinate requirements for government furnished equipment not provided in the pod procurement contract.

Experimental Plan:

Fourteen pods and 13 recovery units will be procured (Three pods - BLUE GILL, three pods - STAR FISH, three back-up pods - BLUE GILL/STAR FISH, three pods - Certification flight, and two environmental test pods).

The environmental pods will be used for engineering design tests, recovery unit system tests, and practice recovery procedures. Two of the Certification pods contain telemetry and passive instrumentation to provide pod ejection times, loads, tracking, pod-burst ranges, and environmental temperature and vibrations during trajectory. All three Certification pods will be tracked and recovered.

Pod requirements of AFSWC, AFASD, and BRL will be consolidated so that a single pod design will be satisfactory to all agencies. The majority of instrumentation in these stabilized pods will be mounted on the rear bulkhead plate which will be facing towards the burst. Strobe lights, radio beacons, dye markers, chaff and radar reflectors will be incorporated in each pod to aid recovery operations.

Shot Participation: BLUE GILL, STAR FISH, and Certification Flight.

Project Agency: AFSWC (GD/A)

Project Officer: Lt A. J. Starnes, 247-1711 Xt 2366

Estimated Cost: \$2,055,000

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FISH BOWL

Program 9 - General Support

Project No: 9.4c

Title: Range Safety

Objective:

To provide for conduct of the missile firings of Operation FISH BOWL in such a way as to meet range safety criteria established by Commander, Joint Task Force Eight.

Experimental Plan:

Missile tracking, position prediction and destruct provisions meeting missile range and AEC nuclear safety requirements have been provided.

Shot Participation: BLUE GILL, STAR FISH and the Certification Shot

Project Agency: Pacific Missile Range

Project Officer: LCdr Philip Kwart, Missile Flight Safety Officer, TAD to JTF-8. LCdr Tom Ward, Range Safety Officer, TAD to JTF-8; PH: Oxnard, California, HUNter 6-8331, XT 7607

Estimated Cost: \$1,800,000

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FISH BOWL

Program 9 - General Support

Project No: 9.5

Title: General Support for Program 1 through 9

Objective:

To provide general support of technical programs as required.

Experimental Plan:

- a. Project 9.5a - Documentary Photography. A technical film report of the military effects programs will be produced. The film will outline the programs, show some of the highlights, and report general results. Some still photography for documentary purposes will also be taken. Estimated cost - \$211,000.
- b. Project 9.5b - Timing and firing. Timing signals and communications for the technical projects. Estimated cost - \$30,000.
- c. Project 9.5c - WT Reports. Weapons Test Reports on all projects will be printed and distributed to all interested project agencies and other authorized groups. Estimated cost - \$35,000.
- d. Project 9.5d - Data Analysis. A post-shot analysis of data will be conducted for purpose of identifying unanticipated phenomena. Estimated cost - \$108,000.
- e. Project 9.5e - Technical Services. Kaman Nuclear, a division of Kaman Aircraft Corporation, will provide technical assistance relative to the preparation, operational conduct and post-shot analysis of the two high altitude shots. Estimated cost - \$51,000.
- f. Project 9.5f - Miscellaneous General Support. For work not specifically covered in other projects and to provide a source of funds if any project has to be revised upward. Estimated cost - \$25,000.

Shot Participation: STAR FISH and BLUE GILL

Project Agency: FC/DASA

Project Officer: To be determined

Estimated Cost: \$460,000

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FISH BOWL

Program 9 - General Support

Project No: 9.6

Title: Tracking and Positioning of Pods and Rockets

Objective:

To provide positive 3 dimensional spatial location of pods, rockets and bursts at time of burst and shock arrival and track prediction to surface impact, where possible, of all instrumentation to be recovered.

Experimental Plan:

The Cubic Corporation, by use of DME, AME, and AGAVE, will provide X, Y, Z coordinates on approximately 70 objects in space during the course of the two tests and the system proof test.

Project Agency: FC/DASA, Cubic Corporation, San Diego, California

Project Officer: Cdr W. D. Hall, FC/DASA, Albuquerque, N. Mex.
256-4411, XT 41212

Estimated Cost: \$3,081,000

Shot Participation: STAR FISH and BLUE GILL

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Program 9 - General Support

Project No: 9.7

Title: Ship Rental

Objective:

To provide funds for leasing a laboratory ship containing instrumentation and facilities required for support of technical programs.

Experimental Plan: None

Project Agency: FC/DASA

Project Officer: To be designated

Shot Participation: STAR FISH and BLUE GILL

Estimated Cost: \$400,000

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Rocket Firings

BLUE GILL

<u>Project</u>	<u>Rockets</u>	<u>Launch Time</u>
6.1	3 Nike-Cajun	To be in positions around burst at burst time
6.2	Nike-Apache	T + 8 min
6.2	Nike-Apache	T + 30 min
6.3	Nike-Cajun	T - 3 min
6.3	Nike-Cajun	T + 15 min
6.3	Honest John-Nike	T - 2 min
6.3	Honest John-Nike	T + 5 min
6.3	Honest John-Nike	T + 12 min
6.3	Honest John-Nike	T + 20 min
9.1b	Nike-Cajun	Dusk before event
9.1b	Nike-Cajun	Dawn after event

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Rocket Firings

STAR FISH

<u>Project</u>	<u>Rockets</u>	<u>Launch Time</u>
6.2	Javelin	T + 20 min
6.2	Javelin	T + 40 min
6.3	Nike-Cajun	T - 1 min
6.3	Nike-Cajun	T + 10 min
6.3	Honest John-Nike	T - 1 min
6.3	Honest John-Nike	T + 5 min
6.4	Javelin	T - 10 min
6.4	Javelin	T + 8 min
6.4	Javelin	T + 18 min
6.7	5 Astrobee 1500	To be in positions around burst at burst time
9.1b	Nike-Cajun	Dusk before event
9.1b	Nike-Cajun	Dawn after event

FISH BOWL

9.1a	Nike-Cajun	Several rockets will be fired during Operation to establish ambient atmospheric conditions
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STAR FISH

1100 km

40N

30N

20N

10N

0

10S

20S

30S

40S

50S

150E

160E

170E

180 or 33

170W

160W

150W

140W

6.6 }
6.8 }

MIDWAY
6.10 6.8
6.5A 6.11
6.5C

F.F.S
6.5C
6.6
6.8

6.5d 6.7
6.5R 6.5A
6.5C 8A.1
6.10 6.11
6.8 6.12

OAHU
MAUI

WAKE
6.5C
6.8
6.11
6.5A

9.1b }
1.1 }

S-5

DAMP 6.13
JOHNSTON

S-3
6.8
8A.1

6.3-4
6.4-3
6.7-5
6.9

KWAJALEIN
6.5C
6.8
6.11
6.5A
6.5A

6.8 }
6.6 }

S-4
S-1

PALMYRA
6.10D
6.5A
6.8

6.5d
6.8
6.2-2
6.12
6.6
9.1b -1

CANTON
ATOLL

6.5C
6.5D
6.7
6.8

9.1a -1
8A.1
8A.2

FIJI
6.10

TUTUILA
ACANIA
6.9

6.5C 6.5A
6.6 8A.2
6.8 6.5R
6.5b

EFATE

TONGA
6.5C
6.8
6.5b
6.6
6.11

RAROTONGA

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