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Operation SNOW BALL

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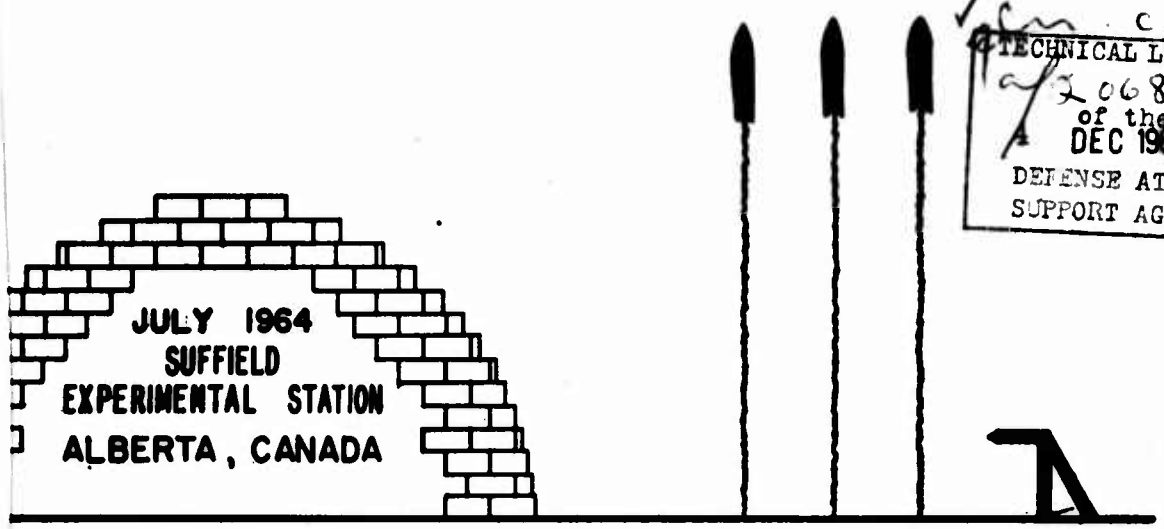

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UNITED STATES PARTICIPATION WITH CANADA AND GT. BRITAIN IN A NUCLEAR WEAPONS EFFECTS 500-TON HIGH EXPLOSIVE EXPERIMENTAL PROGRAM

PROJECT SUMMARIES

Foreign Nat:
Canada and Great Britain

SEPTEMBER 1963

HEADQUARTERS
DEFENSE ATOMIC SUPPORT AGENCY

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1. Enclosed herewith are 4 copies each of DASA 1418 Rev. and DASA 1418A-Rev. to be forwarded to DDC for introduction into their system as open publication.

DASA 1418 Rev. supersedes DASA 1418, although that report was never sent to DDC.

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2. Enclosed also are copies of covers of the following publications:

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Paul R Laplante
for R. G. NILES
Chief, ISCM

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HEADQUARTERS
DEFENSE ATOMIC SUPPORT AGENCY
WASHINGTON 25, D.C.

OPERATION
SNOW BALL

DEPARTMENT OF DEFENSE

PROJECT SUMMARIES

[redacted]

Statement A
Approved for public release;
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Program 1 - Air Blast

Project No.	Title	Agency
1.1	Basic Blast Studies	BRL
1.2	Blast Patterns in Tunnels	BRL
1.3	Evaluation of New Air Blast Instrumentation and Techniques	BRL
1.4	Effects of Blast on Simulated and Actual Missiles	BRL
1.5	Effects of Impulsive Loading on R/V's	BRL/PA
1.6	Response of Objects and Equipment	BRL
1.7	Effects of Blast on Water Storage Containers	ERDL
1.8	Instrumentation Development	NOL
1.9	Blast Effects on Space Vehicle Structures	NASA
1.10	Nike Metal Space Radome Dynamic Response	BTL
1.11	Nike TTR Main Reflector Hardness Capability	BTL
1.12	Blast Test of TD-2/TH Horn Reflector Antenna	BTL
1.13	Test of Hardened Windows for Communications Antenna Feedhorns	BTL
1.14	Early Explosion Phenomenology Measurements	NOL
1.15	Rocket-Borne Free Air Measurements	NOL
1.16	Special Gauge Development Tests	SRI
1.17	Vulnerability of Missile Transporting and Erecting Equipment	D&PS
1.18	Exposure of Mine Warfare Items	D&PS

[redacted]

OPERATION SNOW BALL

The U. S. has participated with the Canadians in their blast and shock program since the initial invitation given to the Ballistic Research Laboratories through Dr. Lampson by Dr. Longair of the Canadian Defence Research Board. The first participation in 1959 was bipartite with the U. S. and Canada making basic blast and shock measurements from the detonation of a 5-ton TNT charge placed on the surface. The charge consisted of stacking cast TNT blocks, 12" x 12" x 4" weighing approximately 33 pounds, in the shape of a hemisphere.

The second participation in 1960 was tripartite with the U. S., Canada and Great Britain making blast measurements along a common blast line. There were also a number of effects targets exposed to the 20-ton TNT detonation. This shot was again a simulated hemisphere consisting of the cast TNT blocks stacked on the surface.

In 1961 a 100-ton TNT hemispherical charge was detonated and again basic air blast measurements, as well as ground shock and target response projects were sponsored by DASA. This test was tripartite and the three countries have exchanged the results obtained to the mutual benefit of all participants.

The test being planned for July 1964 will be a 500-ton charge consisting of 30,600 cast TNT blocks weighing approximately 32.5 pounds. These will be stacked on the surface in the shape of a hemisphere. The charge will be detonated at the Suffield Experimental Stations Blast Range near Ralston, Alberta, Canada. This test will be a tripartite participation and the U. S. phase of the cooperative effort has been named Operation Snow Ball. The detonation of a TNT charge this size will provide an air blast environment for a number of experiments simulating the air blast from a 1 Kt nuclear surface burst.

The U. S. phase of the operation includes projects organized in six programs as follows:

Program 1 - Air Blast
Program 3 - Underground

Program 6 - Electromagnetic
Program 7 - Fallout
Program 9 - Technical Support

Brief project descriptions including funding estimates and project officers names and addresses are presented on the project sheets contained in this program book for convenient reference of those concerned.

[redacted]

SNOW BALL
Program 1 - Air Blast

Project No: 1.1

Title: Basic Blast Studies

Objective: This project has two objectives. One is to measure and analyze the basic blast phenomena from a multi-ton TNT detonation. This is a continuation of a program of basic blast studies being conducted at BRL. The second objective of this project is to make available free-field blast parameters to certain effects projects.

Experimental Plan:

A blast line will be established to measure blast wave propagation in the region from 3000 psi to 0.01 psi. In addition, a microbarograph station will be located at Base Camp, SES. Both electronic and self-recording instrumentation will be used in the blast line. The electronic system will consist of new high frequency pressure transducers and small, self-contained seven-channel tape recorders. The self-recording system will consist of the standard BRL self-recording pressure-time gages. A limited number of self-recording gages will be placed in different sectors but at the same radial distance to check the symmetry of the blast wave. Measurements to be obtained are overpressure versus time, dynamic pressure versus time, duration and impulse of the positive overpressure phase, duration and impulse of the dynamic pressure, and arrival time of the shock front. Additional electronic measurements of overpressure versus time will be made at selected locations in support of Project 4.1.

Project Agency: Ballistic Research Laboratories

Project Officer: John H. Keefer
EKB, TBL, BRL
Aberdeen Proving Ground, Maryland
Phone: 301, 272-4000, Ext. 31258

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.2

Title: Blast Patterns in Large Model Tunnel Systems

Objective: To check the scaling procedure which permits small model shock tube data to be extrapolated to prototype tunnel complexes.

Experimental Plan: The experiment will comprise the exposure of a long straight tunnel and a tunnel complex to the blast wave from 500 tons of TNT. The tunnels will be at a scale factor of 5, as compared to 30 or more for most shock tube tests, and the entrances will be placed in about the 100 psi region. The tunnels will be constructed of pipe varying from 12 to 48 inches in diameter, and will incorporate one or more chambers 24 to 48 inches in diameter and several feet long. Pressure-time histories will be recorded at critical locations in the tunnels. Data obtained will be used to verify scaling techniques now being used for shock-tube tests of model tunnel-chamber complexes and the predictions for the full-scale prototype.

Project Agency: Ballistic Research Laboratories

Project Officer: George D. Teel
EKB, TBL, BRL
Aberdeen Proving Ground, Maryland
Phone: 272-4000, Ext. 46104

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No: 1.3

Title: Evaluation of New Air Blast Instrumentation Developments and Techniques

Objective: The objectives of this project are listed as follows:

(1) To test and evaluate redesigned self-recording instrumentation. This will consist of accelerometers, shock-isolated pressure-time gages and associated gage initiation and timing techniques.

(2) To field test new types of electronic transducers.

(3) To confirm suitability of new electronic recording components for use in a severe shock environment.

(4) To field test modifications to existing transducers.

(5) To field test improved calibration equipment and techniques.

Experimental Plan: Experimental plans for the separate areas of investigation are as follows:

(1) Prototype self-recording accelerometers will be placed in the 50 and 100 g range. New improved versions of the miniature shock-mounted pressure time gages at distances similar to blast line stations in the high pressure region.

(2) High frequency response, high pressure electronic transducers modified to overcome severe environmental effects will be field tested. New techniques in shock mounting miniature recorders in close-in positions are also planned for this test.

Project Agency: Ballistic Research Laboratories

Project Officer: Daniel P. LeFevre and Louis Giglio-tos
EKB, TBL, BRL
Aberdeen Proving Ground, Maryland
Phone: 301, 272-4000, Ext. 40138 or 47161

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No: 1.4

Title: Effects of Blast on Simulated and Actual Missiles

Objective: To obtain data in the high impulse region on the magnitude of the blast loading required to cause damage to missiles by crushing, overturning, or accelerations while in the launch, transport, or storage configuration; and to acquire additional data necessary for the validation or adjustment of established empirical relations and theories.

Experimental Plan:

It is planned to place three (3) missiles of each representative type (expected to have a minimum of three types), one of which will be instrumented, at three (3) pressure levels. The farthest and closest missiles of each type will be located at pressure levels predicted to give "no damage" and "damage" results respectively. The intermediate missile (instrumented) will be positioned at a pressure level based on a "possible damage" prediction.

Four (4) basic thin-walled cylindrical shells with various constraints will be used to simulate missile bodies. The constraints include: rigidly supporting or freely suspending the shells, orienting them either with the center line of the shell at 0° or 90° to the explosive charge, pre-pressurizing, or adding stiffeners. Nineteen of these shells will be positioned at 3 radii where it is expected they will receive no permanent deformation, slight deformation, and considerable permanent deformation. In addition, four (4) shells will be instrumented with strain gages to measure details of response and two (2) very thick walled cylinders will be instrumented with pressure transducers to measure details of loading.

There will also be 12 missile models designed for obtaining data on overturning.

Project Agency: Ballistic Research Laboratories.

Project Officer: Orlando T. Johnson
Ballistic Research Laboratories
Aberdeen Proving Ground, Md.

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No: 1.5

Title: Effects of Impulsive Loading on Re-entry Vehicles

Objective: To determine the loading and response of simulated re-entry vehicles by measurements of pressure-time and the resulting strain-time on a group of representative R/V models. In addition to obtain data on the deformation of uninstrumented models and actual R/V's in order to validate or improve developed prediction methods.

Experimental Plan:

Instrumented and uninstrumented models and actual R/V's will be located at several different pressure levels of interest. It is anticipated that there will be (40) channels of recording available for four instrumented models which will be located in the 15 to 60 psi region. In addition, there will be twenty (20) uninstrumented models located in the 10 to 110 psi region. There will be some actual re-entry vehicles, the number depending upon availability, located at pressure levels to be determined later.

Project Agency: BRL (Picatinny Arsenal)

Project Officer: Mr. Weinstein
Picatinny Arsenal

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No: 1.6

Title: Drag Loading and Response of Simple Objects and Military Equipment

Objectives: The objectives of this project are to measure and correlate free-field loading parameters and drag forces experienced by simple objects with the response of simple objects and military equipment.

Experimental Plan:

Simple objects will be mounted at the 50, 30 and 15 psi levels so that the radial drag forces produced by blast can be measured and electronically recorded. Identical objects will be placed so that their motion can be photographically recorded. At the same location free-field measurements will be made of stagnation pressure, total drag force per unit area and overpressure. Military vehicles will be exposed so that their motion can be photographically recorded. In addition, any damage occurring to the vehicles will be observed and recorded. The vehicles used will be 1/4 ton trucks and possibly armored personnel carriers. Electronic recording will be performed for Project 1.17 also.

Project Agency: Ballistic Research Laboratories

Project Officer: Noel H. Ethridge
Ballistic Research Laboratories
Aberdeen Proving Ground, Maryland

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.7

Title: Effects of Blast on Water Storage Containers

Objectives: The objectives of this project are (1) to determine the vulnerability to blast of current military water storage tanks and experimental pillow-type water storage tanks, and (2) to determine the contamination of water stored in field-type tanks resulting from airborne particulate matter.

Experimental Plan: Several current military standard and experimental water storage tanks will be installed at three locations on a radial line from ground zero. The tanks will be filled with water and covered, (although one or two may be left uncovered), typical of a field distribution tank containing a drinking water supply. At the first site, one 1500-gallon military tank (right cylindrical type), one experimental tank (pillow-type), and one lister bag will be installed at an overpressure location of 10 psi. The tanks will be partially protected by an earthen bunker. The second site will be at an overpressure location of 5 psi. Military standard cylindrical type tanks, experimental pillow-type tanks, and a lister bag filled with water will be installed at ground level without bunker protection. A cylindrical type tank will be located in the 20-30 psi region to observe this type tank in failure. High speed photography will be used to determine response of the tanks to air blast.

With field laboratory apparatus, physical and chemical characteristics of water placed in the test tank will be made prior to the test shot and repeated after shot to determine changes in water quality.

Project Agency: Engineer Research & Development Laboratories
Fort Belvoir, Virginia

Project Officer: Don C. Lindsten
Sanitary Services Branch, ERDL
Fort Belvoir, Virginia
Phone: 339-5500, Ext. 62275

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.8

Title: Instrumentation Development

Objective:

a. To utilize a 500-ton HE explosion as a simulation technique for obtaining the performance characteristics of a prototype self-contained, pressure-time instrumentation system designed to operate in nuclear burst environments.

b. To obtain pressure-time records within the high pressure and fireball regions of the 500-ton HE detonation. (These data will in large part form the basis for evaluating a. above.)

Experimental Plan: Prototype instrumentation will be placed at distances of approximately 350, 500, and 800 feet (corresponding to 100, 40, and 15 psi) along a single radial line from ground zero. This instrumentation will be a self-contained, canister housed, electronic measuring and recording system using pressure sensors, magnetic tape recording, and frequency modulating signal treatment. At each station the canister will be suspended six feet above the surface on 10 foot guyed towers. The longitudinal axis of the canister will be aligned radially with the charge. The pressure-time data obtained within the canister will serve in the large degree as a measure of the adequacy of the design. Visual inspection of the structural response of the canister and its contents will also serve as a basis for any necessary future design changes in the system.

Project Agency: Naval Ordnance Laboratory, White Oak, Maryland

Project Officer: J. F. Bampfield
U. S. Naval Ordnance Laboratory
White Oak, Maryland
Telephone: 495-8116
IDS: 194-8116

SNOW BALL

Program 1 - Air Blast

Project No.: 1.9

Title: Blast Effects on Space Vehicle Structures

Objective: To determine the circumferential external pressure distribution versus time as the blast wave passes by a cylindrical vehicle and to measure resultant deflection and stress in a typical space vehicle structure.

Experimental Plan:

It is planned to set up one tank to simulate a launch vehicle configuration and measure circumferential external pressure distribution versus time as the blast wave passes. Strain gages will be used to determine stresses and panel deflection. The tank will be situated about 6,750 feet. The immediate area of the tank, approximately a 150 ft. radius, should be clear of high obstacles.

Project Agency: George C. Marshall Space Flight Center

Project Officer: Mr. Nathan Showers
Code R&VE
George C. Marshall Space Flight Center
Huntsville, Alabama
Telephone: 536-0756

Sponsoring Agency: National Aeronautics and Space Administration
Washington 25, D.C.

Monitoring Officer: Mr. Norman G. Peil
Code MLO
NASA Headquarters
Washington 25, D. C.
Telephone: DU 2-7259

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.10

Title: Nike Metal Space Frame Radome Dynamic Response

Objective: To determine the dynamic response of the Nike Metal Space Frame Radome to air blast. This information will be used to extend design and scaling techniques applicable to the MSFR and universally applicable to shell type structures.

Experimental Plan: Three or four MSFR models, approximately 7.42 feet in diameter will be placed at the 10 psi radius from GZ. These models will be instrumented to obtain strain, pressure, and acceleration data. High speed movie camera coverage will be utilized to obtain gross model motion. A total of 100 channels of recording will be required.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. M. J. Grubelich
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 3107

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.11

Title: Nike TTR Main Reflector Hardness Capability

Objective: To determine the vulnerability of reflector petals without radome protection to air blast.

Experimental Plan: Two petals (1/16th section) with suitable dummy panels to simulate half dishes will be located at 2 and 3 psi radius from GZ. Twenty-four (24) strain gages will be mounted on each petal.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. M. J. Grubelich
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 3107

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SNOW BALL

Program 1 - Air Blast

Project No.: 1.12

Title: Blast Test of TD-2/TH Horn-Reflector Antenna

Objective: To investigate vulnerability of antenna to air blast and verify adequacy of the final design.

Experimental Plan: A modified (hardened) antenna will be located in the 2 psi overpressure region on a support tower. Antenna pressurization measurements will be made before and after the test. High speed photographic coverage will be obtained during the test. These techniques in addition to visual examination of the antenna will enable evaluation of hardness at this overpressure level.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. R. J. Skrabal
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 2124

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.13

Title: Test of Hardened Windows for Communications Antenna Feedhorns

Objective: To investigate the response of hardened windows for communications antenna feedhorns.

Experimental Plan: Production window mounts will be employed to hold beryllium windows, and will be installed in prefabricated concrete slabs oriented vertically and backed up by earth. Each of the windows will be instrumented to acquire strain information in a pattern on the protected side. Range data on pressure will be used. No acceleration information or camera coverage will be needed. This project will be located in the 50 psi overpressure region.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. H. A. Wells
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 2876

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.14

Title: Early Explosion Phenomenology Measurements

Objective: To determine the basic, close-in explosion phenomena whereby shock waves in air are created by a large explosion and to compare these phenomena with those from small chemical explosions for understanding nuclear-simulation capabilities.

Experimental Plan:

Instrumentation will be provided by Denver Research Institute (DRI) personnel. Analysis and interpretation of the experimental records and preparation of a final report will be accomplished by NOL personnel. The following instrumentation would be placed at one location from the explosion (at a distance to be selected Later): a. Time-resolved Spectroscopy; b. Photocell Measurements; c. Photographic Measurements; d. Pressure Measurements.

Project Agency: U. S. Naval Ordnance Laboratory
White Oak, Silver Spring, Maryland

Project Officer: Mr. J. F. Bampfield
U. S. Naval Ordnance Laboratory
White Oak, Silver Spring, Maryland
Phone: 495-8116

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.15

Title: Rocket-Borne Free Air Measurements

Objective: To test an electronic rocket-borne instrumentation system which has been developed to up-date mechanical systems used in past experiments.

Experimental Plan: Six instrumented Falcon rockets containing Ultradyne magnetic sensing gages will be launched from a position approximately 10,000 feet from ground zero at Z-1 minute. The trajectories will be such that pressure-time measurements will be obtained in the 4-10 psi region. The data will be tape recorded in the rockets. Apogee will be at approximately 900-1300 foot altitude. The motor will be jettisoned after burn-out, and recovery of the instrumentation system will be accomplished by parachute.

Project Agency: U. S. Naval Ordnance Laboratory
White Oak, Silver Spring, Maryland

Project Officer: Mr. J. F. Bampfield
U. S. Naval Ordnance Laboratory
White Oak, Silver Spring, Maryland
Phone: 495-8116

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No: 1.16

Title: Special Gauge Development Tests

Objective: To test special gauges developed to measure dusty blast wave parameters in a nuclear environment under supersonic flow conditions at very high pressure levels to the dynamic effects of a 500-ton HE detonation and to obtain electronic measurements of wave form characteristics.

Experimental Plan: Prototype instrumentation will be positioned at various pressure levels up to 500 psi to measure particular blast wave parameters as a function of time. The sensors to be employed will consist of pressure probes (such as the SRI-MAD gauges for measurement of air and dust) which will measure independently the total pressure of the air phase and the momentum flux of the suspended dust; devices capable of obtaining representative samples of suspended dust; devices capable of measuring directly the total drag force on a bluff body of simple shape; and devices for measuring the shear force of dusty air blast at the ground surface. Fifteen recording channels will be provided by Project 1.6.

Project Officer: Mr. T. D. Witherly

Project Agency: Stanford Research Institute

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.17

Title: Vulnerability of Missile Transporting and Erecting Equipment to Simulate Nuclear Blasts

Objective: The objectives of this project are (1) to determine the vulnerability of missile transporting and erecting equipment to the blast of a simulated nuclear weapon in conformance with requirements of OSWD 61-3, and to make recommendations for design changes if any, and (2) to obtain input data for the solution of the blast vulnerability information required by OSWD 61-1.

Experimental Plan:

Specific items of equipment will be placed at selected overpressures to determine the vulnerability levels to compare with those prescribed in OSWD 61-3. The number of items will depend to a considerable extent upon availability. Damage assessors will document all damage both in written form and photographically. Recommendations for design improvements will result.

Project Agency: Development and Proof Services

Project Officer: John A. Feroli
U.S. Army Development & Proof Services
Aberdeen Proving Ground, Maryland
Phone: 272-4000, Ext. 44174

[redacted]

SNOW BALL

Program 1 - Air Blast

Project No.: 1.18

Title: Exposure of Mine Warfare Items to Simulate Nuclear Blast

Objective: The objectives of this project are (1) to determine the relative resistance of various U.S. mine fuzes to the air blast created by the detonation of a very large HE charge (500 ton) (2) to provide a comparison between the effects of actual and simulated atomic detonations upon standard U.S. mine warfare hardware

Experimental Plan:

Current standard and developmental fuzes will be tested at various distances from ground zero. It is proposed to test approximately 350 items in a pressure range from 20 psi down to 5 psi overpressure. After the detonation all items will be inspected to determine if functioning or damage occurred.

Project Agency: Development and Proof Services

Project Officer: John A. Feroli
U.S. Army Development and Proof Services
Aberdeen Proving Ground, Maryland
Phone: 272-4000, Ext. 44174

[redacted]

PROGRAM 3 - UNDERGROUND

Project	Title	Agency
3.1	Crater Measurements and Earth Media Determinations	WES
3.2	Model Structure Studies	WES
3.3	Effects of Air Blast and Induced Ground Shock on Earth Walls and Excavations	ERDL
3.4	Response of Buried Structures to a Traveling Wave	NCEL
3.5	Close-in Ground Shock Profile and Pressure Measurements	SANDIA
3.6	Ground Motion Studies	WES
3.7	Measurement of Permanent Horizontal and Vertical Motion with Depth	AFWL
3.8	Evaluation of Reinforced Concrete Manhole Design	BTL
3.9	Dynamic Response of Soil-Foundation Systems	BTL
3.10	Response of Buried Cable to Blast Induced Ground Motion	BTL
3.11	Test of Blast Valves for Hardened Installations	BTL

[redacted]

SNOW BALL

Program 3 - Underground

Project No.: 3.1

Title: Crater Measurements and Earth Media Determinations

Objective: The general objectives of this project are to obtain measurements of the various crater profiles and zones of similar disturbance. Specific objectives include: (1) measurements of the apparent crater lip, (2) measurements of the true crater, (3) delineation of underlying zones of deformation, (4) a survey of the lip area to determine the extent to which the lip formation is dependent upon upthrust or fallback, and (5) an estimation of the plastic-elastic response envelope.

Experimental Plan:

The apparent crater will be measured using conventional surveying techniques. The true crater will be determined by using the colored-sand-column procedure. Soil samples will be obtained and analyzed by WES personnel during the borehole drilling operations.

The column array will be located from zero feet to 250 feet and from a depth of 80 feet at GZ to 10 feet at a distance of 250 feet from GZ.

All boreholes will be approximately 5 inches in diameter and located along a single azimuth through GZ.

After the shot (D+5), or thereabouts, the colored-sand-columns will be exposed and surveyed.

Project Agency: Waterways Experimental Station

Project Officer: Richard A. Sager
U.S. Army Engineers, WES
Vicksburg, Mississippi
Phone: 636-3111, Ext. 243

[redacted]

SNOW BALL

Program 3 - Underground

Project No.: 3.2

Title: Model Structures Studies

Objective: The objective of this project is to measure and observe the response of various structural elements, i.e., beams and arches that are placed at various depths of burial and at various ranges from ground zero.

Experimental Plan:

Semi-circular reinforced concrete arches will be located at three (3) different ranges from ground zero corresponding to overpressure levels of 150 and psi. These structures will be instrumented to obtain transient acceleration, deflection, air pressure, earth pressure, and strain measurements.

Approximately thirty-six (36) beams with different depths of earth cover will be located at various pressure levels between 10 and 100 psi. Cracking and possible failure of these beams will be documented for use in conjunction with a laboratory program.

A geometry array of twenty-four (24) spheres of varying densities will be located for gross observation of the objects for use in conjunction with a blast loading generator experiment. These spheres will be of densities greater than, equal to, and less than the density of the soil at the test site.

Eighty-six (86) channels of instrumentation will be required for this experiment.

Project Agency: Waterways Experiment Station

Project Officer: Richard A. Sager, U.S. Army Engineers, WES
Vicksburg, Mississippi
Phone: 636-3111, Ext. 243

[redacted]

SNOW BALL
Program 3 - Underground

Project No: 3.3

Title: Effects of Air Blast and Induced Ground Shock on Earth Walls of Excavations.

Objectives: The objective of this project is to utilize the Canadian 500 ton HE detonation to proof-test theory now being developed defining the action and effects of air blast and induced ground shock that causes spalling and failure of excavated earth faces, including the variation and effects with soil type and state.

Experimental Plan:

Soil samples will be obtained from the SES test site and a laboratory analysis made to determine its characteristics. The technique developed from model studies will then be used to predict the damage to be expected at various overpressure at the site. Four excavations will then be located at each of 3 different overpressure regions (between 25-50 psi). These excavations shall consist of the following designs:

Design	Purpose of Design
A	Basic foxhole configuration
B	Vertical pressure magnification with ground shock
C	Vertical pressure magnifications without ground shock
D	Pure Ground shock

Pre-shot and post-shot photographs and wall measurements will be made to determine the amount of wall spallation or collapse.

Project Agency: Engineer Research & Development Laboratories

Project Officer: Richard A. Hobbs
Demolition and Fortifications Branch, ERDL
Fort Belvoir, Virginia
Phone: 765-7700, Ext. 61251

[redacted]

SNOW BALL

Program 3 - Underground

Project No.: 3.4

Title: Response of Buried Structures to a Traveling Wave

Objective: To investigate the response of buried models subjected to a traveling blast wave. Particular emphasis is to be placed on determining body motions and induced accelerations.

Experimental Plan:

Three semi-circular arches and one cylinder (having diameters of 30 inches and 24 inches respectively) will be tested. The arches will be placed at overpressures of approximately 45, 60, and 85 psi; the cylinder will be placed at approximately 300 psi with its longitudinal axis horizontal.

Instrumentation will be located to permit determination of the body motions and will consist of measurements of displacement of the footings and the crown of the arches. Similar measurements will be made on the cylinders. All instrumentation will be provided by the Laboratory.

The accelerometers will be used to obtain shock input data. Strain measurements are to be made on one arch only. The total instrumentation will consist of approximately 48 oscillograph channels plus the mechanical measurements.

Project Agency: Naval Civil Engineering Laboratory
Port Hueneme, California

Project Officer: Mr. J. Algood
Naval Civil Engineering Laboratory
Port Hueneme, California

[redacted]

SNOW BALL

Program 3 - Underground

Project No.: 3.5

Title: Close-in Shock Pressures and Shock Profile Measurements in Earth Below the Explosion

Objective: To obtain information on the explosive energy partitioned to ground shock, to determine attenuation of ground shock with distance from explosion center, to examine the nature of the explosion source with the aim of learning how the hydrodynamic disturbance generates the ensuing seismic wave, and to provide data needed for verification or refinement of theoretical calculations of surface-burst explosions.

Experimental Plan: The "resonance cable" technique will be utilized for this project. Four half-inch air dielectric cables, 100 feet long and shorted at one end, will be buried below the charge such that their position with respect to the explosion center is known. At the opposite end of the cables and at the point farthermost from explosion center, Colpitts oscillators will be attached. Since the position of the cables with respect to explosion center is known and the time of arrival of the earth shock at various positions on the cables is recorded, a continuous measurement of shock position versus time is obtained. The derivative of this curve provides shock velocity versus distance and if the Hugoniot of the medium is known, shock pressure versus distance may be inferred.

Project Agency: Sandia Corporation
Albuquerque, New Mexico

Project Officer:

[redacted]

SNOW BALL

Program 3 - Underground

Project No.: 3.6

Title: Ground Motion Measurements

Objective: The objective of this project is to measure the strong earth motion from this exceptionally large HE burst to provide information for the design of protective structures and for possible correlation and scaling with nuclear-weapon-induced ground shock.

Experimental Plan:

Approximately thirty (30) recording channels will be used to obtain measurements of acceleration and particle velocity in the surface air overpressure region from 300 to 50 psi. Gages will be placed at depths of 5, 20, and 50 feet. All gages will be placed along a single radial blast line with one cannister containing all instruments at each station.

Project Agency: U.S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

Project Officer: Mr. G. L. Arbuthnot, Jr.
Nuclear Weapons Effects Division
U.S. Army Engineer Waterways Experiment Station
P.O. Box 631
Vicksburg, Mississippi

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SNOW BALL

Program 3 - Underground

Project No.: 3.7

Title: Measurement of Permanent Horizontal and Vertical Motion with Depth

Objective: To obtain measurements of permanent horizontal and vertical soil displacement with depth. This information will be compared with similar measurements previously obtained at NTS, in order to develop a technique for extending knowledge of dynamic behavior in desert soils to other soils of interest.

Experimental Plan:

A total of 8 flexible casing installations will be made, all to a depth of 30 feet, 4 each along two radii extending out from ground zero. The spacing of the individual installations will be the same along each radii. Installation will be placed at ranges corresponding to 300, 250, 200, and 100 psi. The casings, 3 inches in diameter, will be installed in six-inch diameter borings and back-filled to assure good coupling to the surrounding soil. The casing will be placed in from two to five foot long sections, with allowance for up to five inches relative morement between adjacent segments to permit vertical extension and compression of the casing. Permanent motions are measured by comparing the pre-shot and post-shot positions of the casing segments.

Project Agency: Air Force Weapons Laboratory

Project Officer: Lt. George V. Bulin
USAF, Air Force Weapons Laboratory
Kirkland Air Force Base, New Mexico

[redacted]

SNOW BALL

Program 3 - Underground

Project No.: 3.8

Title: Evaluation of Reinforced Concrete Manhole Design

Objective: To determine the response of reinforced concrete manhole structures to air blast. Information obtained concerning failure of these structures will be utilized in future design of such small underground structures.

Experimental Plan: Two manholes will be placed at distances from ground zero corresponding to 100 and 200 psi. These structures will be instrumented with strain gages, accelerometers, and displacement recorders. Visual examination of the manholes will be accomplished after the test.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. C. Shafer, Jr.
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 4306

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SNOW BALL

Program 3 - Underground

Project No.: 3.9

Title: Dynamic Response of Soil-Foundation Systems

Objective: To investigate the response of soil-foundation systems to dynamic blast loading. Information obtained will be correlated with information available on static loading in order to develop prediction techniques for dynamic response.

Experimental Plan: Three metal sails will be located atop simple reinforced concrete foundations. The sails will be instrumented with strain gages to measure the time history of force applied to the sails. Accelerometers will be located in the foundations to determine time history of displacement. Fourteen recording channels will be required. Characterization of the soil prior to the test will be accomplished by plate bearing and triaxial compression techniques. The static load-deflection characteristics will be determined and used to predict the response of the soil-foundation system to blast loads.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. H. A. Wells
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 2876

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SNOW BALL

Program 3 - Underground

Project No.: 3.10

Title: Response of Buried Cable to Blast Induced Ground Motion

Objective: To investigate cable tensile stress caused by blast induced ground motion. This information will serve as a basis for future design of hardened cable routes.

Experimental Plan: Two hundred and fifty feet of cable will be buried at a normal burial depth of three to four feet, oriented along a radial extending from approximately 300 psi to 50 psi. The cable ends will be anchored to simulate a longer cable length. Strain gages will be placed on the cable at three locations, and accelerometers will be placed near these gages to record ground motion. The information obtained will be analyzed to determine whether the tensile strength produced in the cable is relatively high and localized about the displacement or averaged to a lesser value over a longer length.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. R. F. Nicholson
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 4246

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SNOW BALL

Program 3 - Underground

Project No.: 3.11

Title: Test of Blast Valves for Hardened Installations

Objective: To investigate dynamic response of blast valves in order to evaluate the valve design.

Experimental Plan: One test valve will be installed at 50 psi radius from ground zero and one at 100 psi radius. Instrumentation at both locations will provide a record of the time history of the valve closing motion and on pressure at five locations within the cavities. In addition, high speed photography coverage will be obtained.

Project Agency: Bell Telephone Laboratories
Whippany, New Jersey

Project Officer: Mr. J. E. Ross
Bell Telephone Laboratories
Whippany, New Jersey
Phone: TUcker 7-1000, Ext. 2620

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PROGRAM 6 - ELECTROMAGNETIC PHENOMENA

Project	Title	Agency
6.1	Electric and Magnetic Field Transients	AFWL

[redacted]

SNOW BALL

Program 6 - Phenomena

Project No.: 6.1

Title: Electric and Magnetic Field Transients

Objectives: Determine the values of the electric and magnetic fields and their time derivatives associated with a chemical explosive detonation as functions of time, distance and geophysical locations. Determine the effects of the electric fields upon radial conductors as a function of time and distance.

Experimental Plan:

Two magnetic field components (B_v , $B\varphi$) and their time derivatives will be measured as a function of time at three locations. Also the radial component of the electric field will be measured at 3 stations. Time resolved measurements of the current induced in a radially oriented buried conductor will be made. In addition a number of passive peak current indicating devices will be installed along the length of buried conductor.

Project Agency: Air Force Weapon Laboratory
Kirtland Air Force Base
Albuquerque, New Mexico

Project Officer: Capt. W. D. Henderson
AFWL/WLRPE
(505) CH 7-1711, Ext. 2385

Contracting Agency: Bell Telephone Laboratories, Inc.
Whippany Road
Whippany, New Jersey
Attn; J. K. Middaugh
(201) 887-1000, Ext. 3849

[redacted]

PROGRAM 7 - FALLOUT

Project	Title	Agency
7.1	Aerial Multi-Sensor Reconnaissance	USNRDL
7.2	Proof Test of Drone Sampling System	Northrop-Ventura

[redacted]

SNOW BALL

Program 7 - Fallout

OUT

Project No.: 7.1

Title: Aerial Multi-Sensor Reconnaissance HE Land Surface Detonation

Objective: To investigate feasibility of employing advanced multisensor aerial reconnaissance equipment in rapid detection, recording and assessment of crater and fallout debris distribution from an HE land surface detonation by acquisition of pre- and post-imagery of this event.

Experimental Plan:

Conventional cameras, for infrared imagery equipment, and side looking airborne radar will be utilized to obtain imagery of this event. Day and night pre-shot runs to obtain comparative imagery and instrument calibration will commence Z-2 days. Post-event flights start at approximately Z+30 seconds with successive runs continuing through Z+2 days. Altitudes will vary between 1000 and 5000 feet above the terrain.

Project Agency: U.S. Navy Radiological Defense Laboratory
San Francisco, California

Project Officer: Major R. T. Tolan
U.S. Navy Radiological Defense Laboratory
San Francisco, California
Phone: M18-6900, Ext. 355

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SNOW BALL

Program 7 - Fallout

Project No: 7.2

Title: Proof Test of Drone Sampling System

Objective: The objective of this project is to determine the reliability and effectiveness of a drone sampling system to include the sampler, the vehicle and the guidance system.

Experimental Plan: Two KD2R5 drones will be flown through the dust cloud at approximately 5,000 feet from H+2 minutes to H+5 minutes. The drones will be equipped with a sampler which will yield particle size distribution and association of the particles with their discrete location in the dust cloud produced by the explosion. The drones will be radio controlled and under continuous radar surveillance. Each drone is equipped with an auto pilot system which will insure maintaining a set course and altitude unless changed by command control. After traversing the cloud the drones will be returned to a recovery area and landed by parachute. In the event of malfunction or loss of control the drones will be immediately landed by parachute.

The sampling unit will collect approximately 120 samples in traversing the cloud. Each sample will be analyzed for particle size distribution and an effort will be made to determine their exact location in the cloud at the time of collection.

Project Agency: Northrop-Ventura
Ventura, California

Project Officer: Mr. Harold Barber

Sponsoring Agency: Defense Atomic Support Agency

Monitoring Officer: Captain R. P. Minx
Hq DASA

[redacted]

Program 9 - Technical Support

Project No.	Title	Agency
9.1	Documentary Photography	To be determined
9.2	Technical Photography	EG&G
9.3	Technical Services	BRL/DASA

[redacted]

SNOW BALL

Program 9 - Technical Support

Project No: 9.1

Title: Documentary Photography

Objective: To provide general photographic support to all U. S. projects.

Experimental Plan:

a. Project 9.1a Motion Picture Photography - a technical nuclear weapons effects film covering the major results of U. S. projects participating in Operation SNOW BALL. The film will outline test objectives, program highlights, operational factors, and overall results.

b. Project 9.1b. Still Photography - Documentary still photography will be provided in support of all projects as required for purposes of report preparation and general information.

Project Agency: To be determined.

Project Officer: To be determined.

[redacted]

SNOW BALL

Program 9 - Technical Support

Project No: 9.2

Title: Techn. al Photography

Objective: To provide technical photographic support to U. S. projects as required.

Experimental Plan:

High speed motion picture photography will be used to document the response of individual target items to blast loading following the detonation. The gross motion and/or a detailed time history of such displacement which may occur will be determined as necessary to meet project objectives. Special consideration will be given to dust effects in order to reduce obscuration where possible. This photographic coverage will be provided to individual projects on a reimbursable basis.

Project Agency: Edgerton, Germeshausen, & Grier, Inc.

Project Officer: To be determined.

rojects)

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SNOW BALL

Program 9 - Technical Support

Project No: 9.3

Title: Technical Services

Objective: To provide technical direction and administrative support in planning, program development and coordination of field activities for all U. S. projects.

Experimental Plan: A technical director with a small staff will provide technical services and administrative support in coordinating the overall participation of all U. S. projects in Operation SNOW BALL. This will include pre-test planning, development of E & R plans, determining support requirements, field implementation, and preparation of a preliminary summary report. Several program directors may be provided to assist the Technical Director in coordinating the field activities of U. S. projects prior to and during the execution phase of the operation.

Technical Director: Mr. Charles Kingery

Project Agency: Ballistics Research Laboratories/Defense Atomic Support Agency

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