NOTS TP 2692
REVISION 2
OCTOBER 1965

INSTRUMENT OPERATIONS

ON SYSTEMS DEVELOPMENT DEPARTMENT RANGES

U. S. NAVAL ORDNANCE TEST STATION, CHINA LAKE, CALIFORNIA

U. S. NAVAL ORDNANCE TEST STATION

AN ACTIVITY OF THE BUREAU OF NAVAL WEAPONS

J. I. HARDY, CAPT., USN
Commander

WM. B. MCLEAN, PH.D.
Technical Director

FOREWORD

The firing of a test on any Systems Development Department range calls for the close teamwork of several of the departmental divisions. For instance, a test at SNORT, which is the province of the Supersonic Track Division, also calls for specialized services from the Project Engineering, Assessment, Instrument Development, and Instrument Operations Divisions.

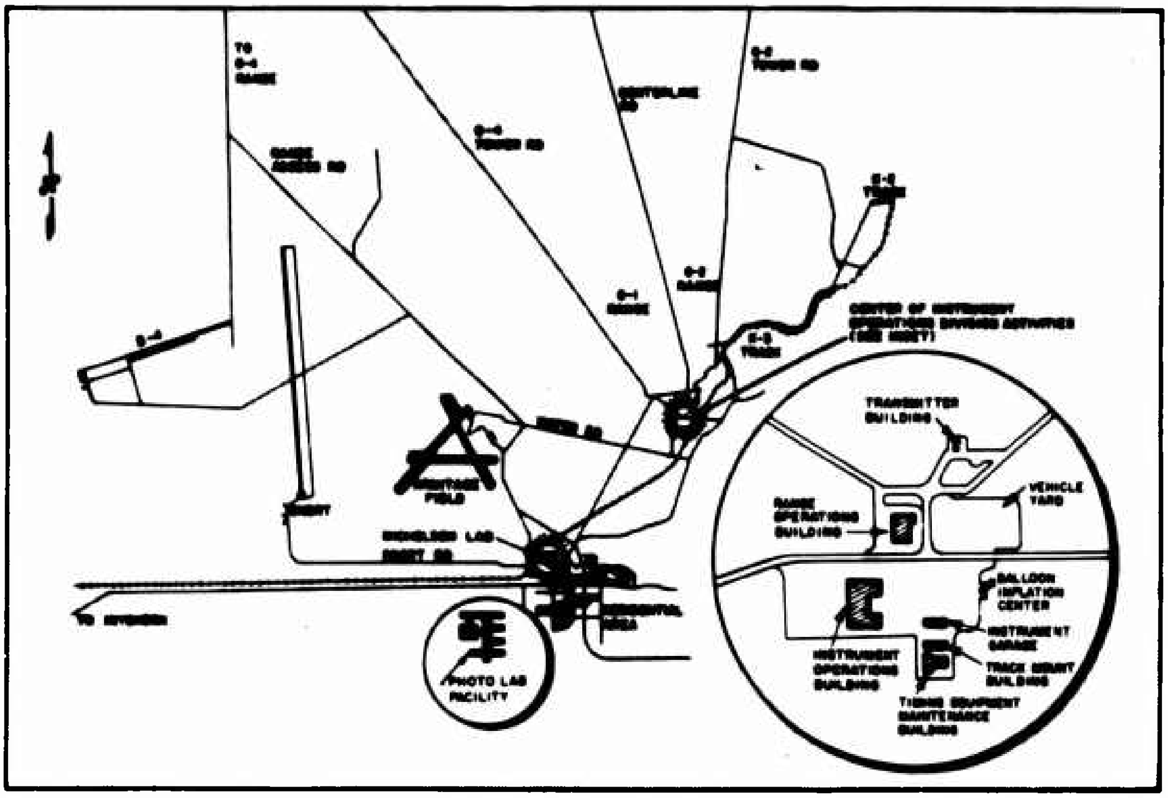
This report, which describes the role of the Instrument Operations Division in the overall Departmental function, is Revision 2 of NOTS TP 2692 dated 1 June 1961.

Released by
L. G. GARMAN
Instrument Operations Div.
October 1965

Under authority of
IVAR E. HIGHBERG, Head
Systems Development Dept.

This report, published by Systems Development Department, is the approved version of 30 MS 708; it is the second revision of NOTS TP 2692 published in June 1961 and revised in July 1963. Original printing, 500 copies.

CONTENTS



Main Station Areas Served by Instrument Operations

INTRODUCTION

The Systems Development Department is responsible for conducting development and test programs for the Bureau of Weapons, its agencies and contractors. One of the primary program requirements is the gathering of complete and accurate data to meet complex and stringent specifications. This information is compiled from photographic and electronic records. The Instrument Operations Division provides and operates the major portion of the Department's facilities that produce these records.

To accomplish the various tasks which comprise this job, the Instrument Operations Division is organized into five branches, each responsible for a specific segment of overall instrument operations. These branches include the Photographic Laboratory Branch, the Optical Instrumentation Branch, the Timing and Telemetry Branch, the Metric Electronics Branch, and the Atmospheric Studies Branch. The branch names imply the various aspects of the Division mission that they handle.

PHOTOGRAPHIC LABORATORY BRANCH

This centrally located laboratory, situated in Wing 1 of Michelson Laboratory, serves all Station Departments. Its complement of approximately 36 people provides extensive in-house photographic services in the still and motion-picture fields as well as in the areas of specialized consultation and photographic research. The Branch is divided into four sections--the General Services Section, the Process Control Section, the Motion-Picture Processing Section, and the Special Services Section, each of which is headed by a specialist in his particular field.

Branch personnel include photographers, technologists, a physicist, technicians, mechanics, four military, and several clerical support personnel. Customer services are available through the Receiving and Distribution Office, Room 1110.

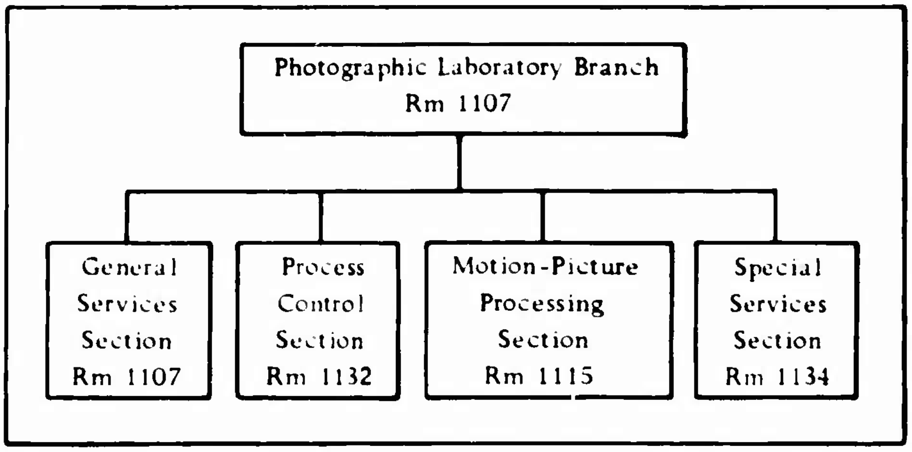


FIG. 1. Negative, Slide, and Photo File System.

FIG. 2. On Location With 70mm and 16mm Cameras.

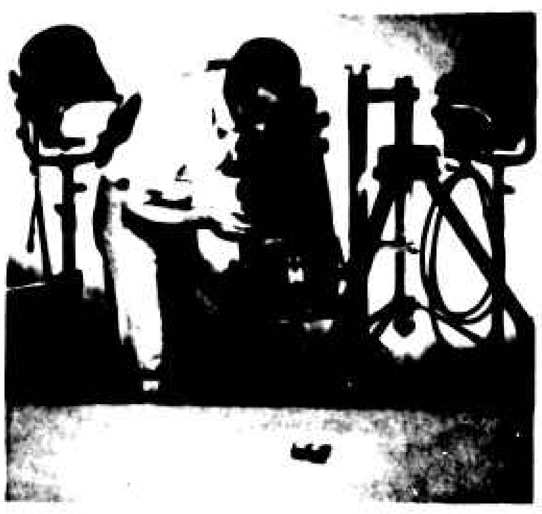


FIG. 3. Typical Setup Showing Miniature Electronic P.ckage Being Photographed.

GENERAL SERVICES

This Section provides services related to still and documentary motion-picture photography. A strategic part of their services centers around a detailed reference file (Fig. 1) maintained for use in locating more than 150,000 official photographs or slides, about half of which are retained in-house. The rest are placed in a depository in Bell, California, where they can be recalled as needed, usually within 24 hours.

The file system consists of subject index cards filed and cross-filed alphabetically under one or more titles according to captions supplied by the customer. It provides a prompt and accurate retrieval system, limited only by the accuracy and completeness of the information received from the originator of the photo.

Camera Coverage

Photographers are available for field and studio assignments for camera coverage in black-and-white (B&W) or any of the color materials. Documentary still-camera coverage is furnished on film sizes from 35mm to 8x10 inches. Speciality services include remote operation of up to four Speed-Graphic cameras and time-lapse photography (double-frame 35mm) with a minimum interval of one fr/sec for a total of 420 frames. Motion-picture coverage up to 64 fr/sec on 16mm film and up to 20 fr/sec (either pulsed or cine) on 70mm film is available (Fig. 2). Macro- and microphotography are also available.

In the studio (Fig. 3), objects up to 15 feet long can be photographed in negative sizes up to 8x10 inches with any of the equipment normally used in field operations, or with cameras that can be adjusted for maximum correction of distortion and focus. Color transparencies up to 8x10 inches in size can be furnished from copy sizes up to 47x56 inches.

Transparencies and negatives are also made from original art work or copy using a precision graphic arts type copy camera capable of a 1/7th diameter reduction to a 3-diameter enlargement of original copy (Fig. 4). A 32x36-inch transparency opening in the copy board permits trans-illumination of other than opaque materials. Black-and-white transparencies and negatives up to 20x24 inches in size can be made from copy measuring not over 40x48 inches. In special cases, 20x24-inch negative size is obtainable from copy measuring up to 48x72 inches. Color transparencies up to 8x10 inches in size can be produced from like copy.

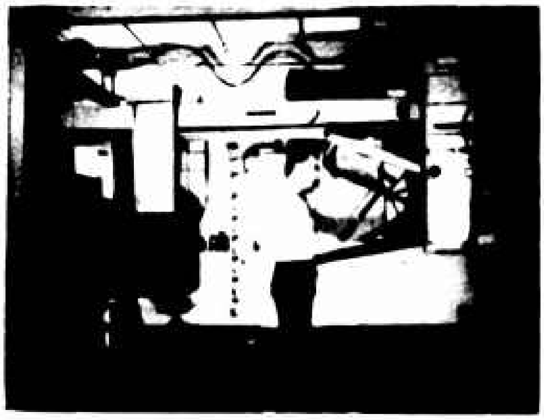


FIG. 4. Precision 31x31-Inch Copy Camera.

Translucent or transparent line originals up to 30x40 inches in size can be reproduced on Cronaflex using a contact printing method. Cronaflex is a stable, thin-base film that will accept pencil or ink additions or corrections.

Duplicate slides and transparencies can be produced in any of the sizes listed for B&W still photographic work up to 20x24 inches in size. Color duplicates (Fig. 5) are available in sizes from 35mm to 8x10 inches.

FIG. 5. Slide Duplicator for 2x2-Inch and 35mm Slides.

This Section also provides in-house processing of 35mm Ektachrome and Ektacolor in 20 or 36 exposure cassette loads and offers specialized consultation services on camera coverage, print production, still-camera film processing, etc.

Still Printing

The still-printing facility, staffed with five technicians, provides B&W and color printing, slide binding (Fig. 6), and other closely associated services.

FIG. 6. Semiautomatic 35mm Slide Binding Machine.

Black-and-white contact prints are produced in sizes up to 20x24 inches and enlargements up to 30x40 inches from negative sizes up to 10x10 inches. Production of B&W prints has been enhanced by the recent installation of a roll paper processor and automatic trimmer (Fig. 7). Used in conjunction with roll paper easels (Fig. 8) and negatives up to 4x5 inches in size, rapid service can be provided on 8x10½-inch thin weight matte (ad type) or 8x10-inch glossy finish paper. Prints can be made with a binding edge to make them suitable for inclusion in reports. In the near future, a service for making contact prints from long rolls of Bowen (5½-inch wide) and certain aerial films will be available. Standard lantern slides (3¼x4 inches) or 2x2-inch slides are prepared in B&W or color. Limited color printing (Fig. 9) is available on Kodak Ektacolor professional paper (formerly Type C) in sizes up to 16x20 inches. Toning of B&W prints is available upon request.

Camera Repair

Service and repair of Speed-Graphic, Retina SLR, and Polaroid cameras, certain 16mm movie cameras, and commonly used types of aerial cameras are provided by trained Navy personnel. A limited supply of spare parts is maintained, and special equipment, such as the shutter testing equipment shown in Fig. 10 is on hand to check shutter action, range-finder operation, and synchronization.

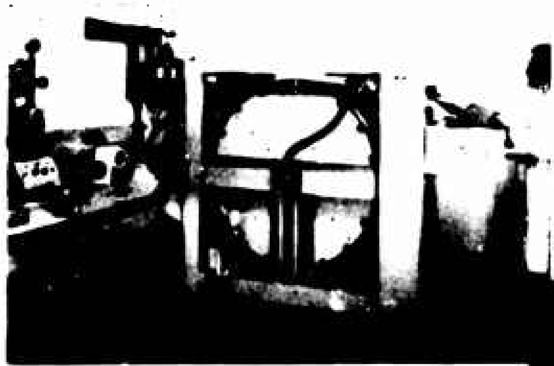


FIG. 7. Continuous Black-and-White Roll Paper Print Processor and Trimmer.

FIG. 8. Black-and-White Roll Paper Printing Easel.

FIG. 9. Color Printing Enlarger and Associated Equipment.

FIG. 10. Camera Shutter Testing Equipment.

PROCESS CONTROL

This Section, staffed with a physicist and technicians, uses sensitometric and chemical analyzing procedures to provide the accurate process control needed to maintain high quality photographic production (Figs. 11 and 12). Specialized equipments, such as an E.G. & G. flash sensitometer, a Herrnfeld control sensitometer, a Westrex Model RS1100-G color densitometer, a MacBeth-Ansco color densitometer, and a Beckman Model DU spectrophotometer, are used both in process control and in the investigation of exposure and processing techniques and photographic materials. Microdensitometric readings of special field tests can also be provided on request.

To obtain maximum photographic data, it is necessary to consider the sensitometric characteristics of a variety of film/exposure/process combinations. Personnel in this Section are available for advance planning consultation to determine the best techniques and the most suitable film/exposure/process combinations to be used for specific types of coverage.

FIG. 11. Automatic H&D Sensitometric Curve Plotter.

FIG. 12. Titration Units and pH Meter.

FIG. 13. Negative-Positive Spray Processor for 16mm and 35mm B&W Films.

FIG. 14. Reversal Processor for 16mm and 35mm B&W Films.

The motion-picture processing facility employs large commercial type equipment for the continuous processing of motion-picture films. All types of 16mm and 35mm B&W motion-picture films are developed in a continuous processor (Fig. 13) utilizing spray application of solutions to produce uniform results at speeds up to 125 feet per minute with a dry-to-dry cycle of approximately 7 minutes. Standard high-contrast or low-contrast processing is used for line work or continuous tone, together with reduced or prolonged development processing when camera exposure problems are known to exist. Continuous machine methods are also used to process B&W films wider than 35mm and up to 12 inches in width. Films with or without sprocket perforations can be handled at speeds up to 20 feet per minute. Black-and-white reversal processing (Fig. 14) is also obtainable in 16mm and 35mm sizes.

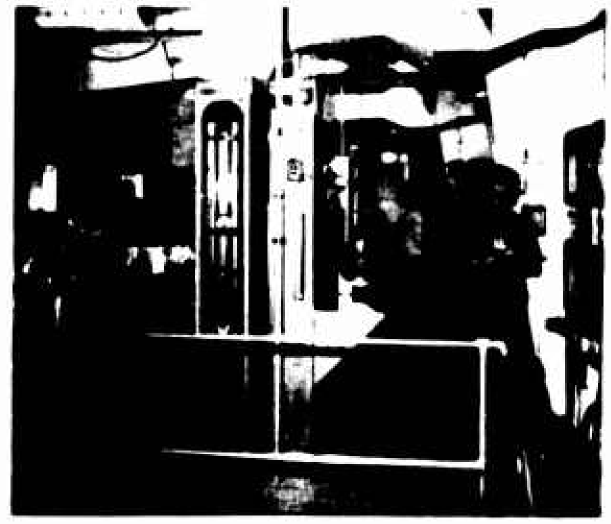


FIG. 15. Three-Machine Color-Processing Facility.

Color motion-picture film processing services (Fig. 15) are limited to 16mm, 35mm, or 70mm films which are compatible with the Anscochrome 80° processing chemistry and procedures. The 70mm film size must have the Type I (0.234-inch) pitch perforation. In addition to normal processing for producing the manufacturer's suggested exposure index, the customer can obtain special processing to help compensate for known exposure problems. Normally, the special processing will be limited to a controlled one f/stop compensation for underexposure since appreciable picture degradation can be expected when this speed is exceeded.

Motion-picture duplication in B&W or color (Anscochrome color print stock) is provided from any 16mm or 35mm original except those with optical or magnetic sound track (a usable, but not perfect, duplication can be made in-house from the optical). Contact prints (Fig. 16) or optical prints (Fig. 17) with options of enlargement or reduction within the 16mm and 35mm sizes are also available. Many special effects such as fades, dissolves, spins, multiple stop-motion and skip framing, wipes, and others are available in optical printing. Titling can also be added.

FIG. 16. Continuous Contact Motion-Picture Printers.

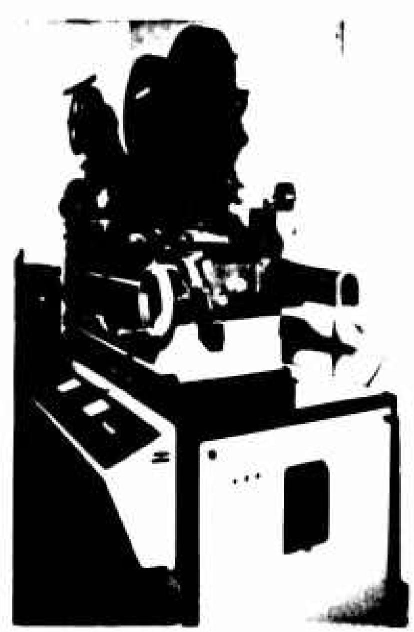


FIG. 17. Optical and Special Effects Motion-Picture Printer.

Under normal conditions, 24-hour service is provided on all B&W and color original processing. In many instances, depending on the time the film arrives at the photo lab, film will be in and out during the normal work hours of 0730 to 1630. Duplication and optical special-effects printing may require up to three days additional processing time, contingent upon the current workload and the complexity of the services requested.

SPECIAL SERVICES

This Section produces reticles and other precision patterns on glass for optical systems or for use as master plates for microminiaturized electronic circuitry. Photosensitive materials can be applied to almost any substrate to produce a photographic image for further processing such as chemical milling, etch-and-fill, etc. Tags, nameplates, operating instructions, circuit diagrams, special rules or scales, instrument dial faces, and whole electronic panels can be produced on sensitized aluminum, and anodized. Sizes greater than 8x10 inches can be special ordered. Five image colors and several background tones are available.

The diverse capabilities of the Special Services Section include vacuum evaporation of aluminum or other organic materials, microphotography, photomicrography and photomacrography, precision measuring and drawing, and technical photographic trouble-shooting. To carry on this work the Section has an impressive array of technical equipment such as a research microscope, a binocular microscope, a $3\frac{1}{2}$-inch traveling microscope, a micromanipulator, a wide selection of illuminators, and a vacuum chamber capable of 10^{-5}mm Hg in which substrates to 6-inch diameter can be aluminized.

FIG. 18. Precision Microminiaturization Camera.

The recent addition of a precision microminiaturization camera (Fig. 18) permits tolerances to ±0.0001 of an inch on 20x reductions from original drawings when stable base films or glass are used to produce the reduction. Another recent addition is a photomicrographic camera and profile projector (Fig. 19) that will increase the variety of services available from this section. The inset shows a 4x actual size view of a miniaturized five transistor amplifier. This equipment has many unique features for producing detailed photographs of extremely small objects. It represents one of the latest advances in this type of photographic equipment and provides the Station with extended capabilities in this field.

FIG. 19. Photomicrographic Camera and Profile Projector.

Requests for Service

The customer service desk, located in Room 1110 of Michelson Laboratory is the focal point for handling requests for all photographic services, including those not performed in-house. Processing and duplication of B&W and the Anscochrome family of color motion-picture films are handled in Room 1115.

OPTICAL INSTRUMENTATION BRANCH

The functions performed by the Optical Instrumentation Branch are divided into areas of Operations, Applied Engineering, and Evaluation and Analysis. This division of effort is reflected in the organization of the Branch. There are four operational sections--Precision Orientation, Tracking Mounts, Cinetheodolites, and Special Applications--an Applied Engineering Section, and an Evaluation and Analysis Section.

The primary mission of the Branch is to gather optical experimental data. In support of this effort, the Branch procures, maintains, repairs, modifies, develops, evaluates, and calibrates the optical instruments used. High-speed electronic computers such as the IBM 7094 and 1620 are used in the development, modification, calibration, evaluation, and analysis of the instruments.

Branch personnel number about 40. Engineers, physicists, mathematicians, and a technologist make up about one-fourth of the group, there are approximately 20 technicians, and the rest are range equipment repairmen, range trackers, and a clerk-typist.

PRECISION ORIENTATION

The primary responsibility of the Precision Orientation Section is the operation of CZR-1 Bowen ribbon-frame camera units. Each unit is composed of three main parts: the camera, a precision mount to support the camera, and sufficient electrical and electronic-control gear to operate the instrument. The camera can be operated at 30, 60, 90, and 180 fr / sec giving a picture 5 1/4 inches long varying in height from 0.906 inch at 30 fr/sec to 0.151 inch at 180 fr/sec. A 10-inch-focal-length lens is standard; however, 5- and 24-inch lenses are available on several of the systems. The camera is supported in a precision three-axis mount; each axis is equipped with a scale reading to 0.005 deg. An instrument cabinet contains the control circuits and the range-timing receiver. The complete system is carried on a four-wheeled trailer (Fig. 20) making the unit mobile and requiring only a surveyed location and the 208-volt, three-phase power necessary for its operation.

An instrument array consisting of one or more CZR-1 systems is used for measuring position, velocity, acceleration, and attitude in track tests and that portion of free-flight tests in which the trajectory is predictable enough to permit the use of fixed-camera systems. Such tests include ground-launched missiles, terminal-trajectory determinations of impacting missiles, track-range tests involving high-speed sleds and ordnance launched from these sleds, fragment-velocity studies, and similar dynamic-testing situations. Figure 21 is a CZR-1 camera clip of a seat-ejection test. Normally, up to 20 CZR-1 Bowen camera systems are available for service on the NOTS ranges.

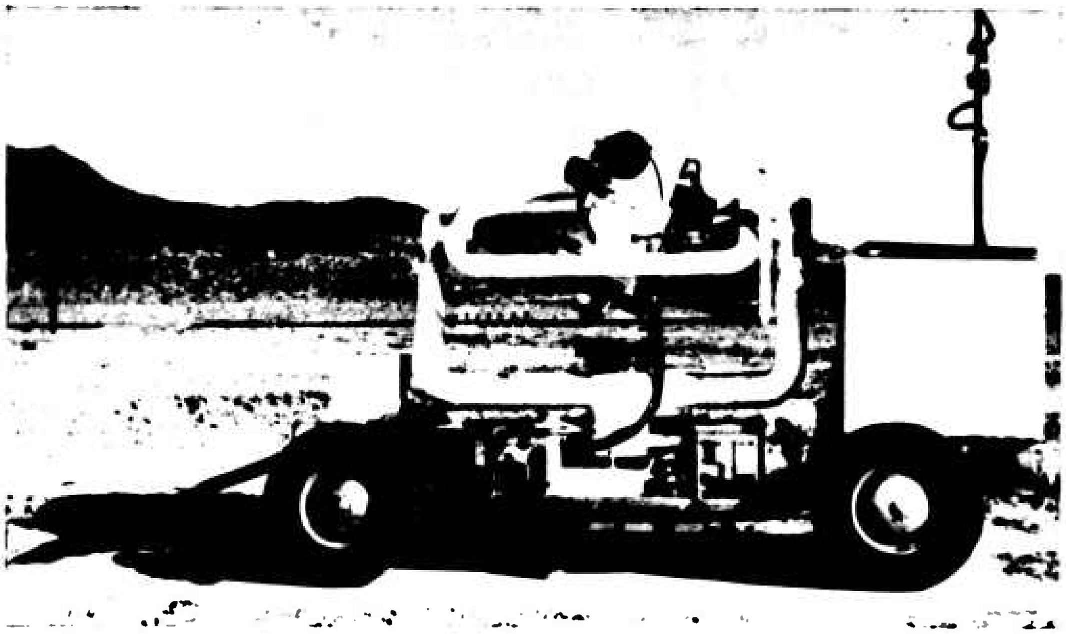


FIG. 20. CZR-1 Bowen Camera System Set Up Ready for Operation.

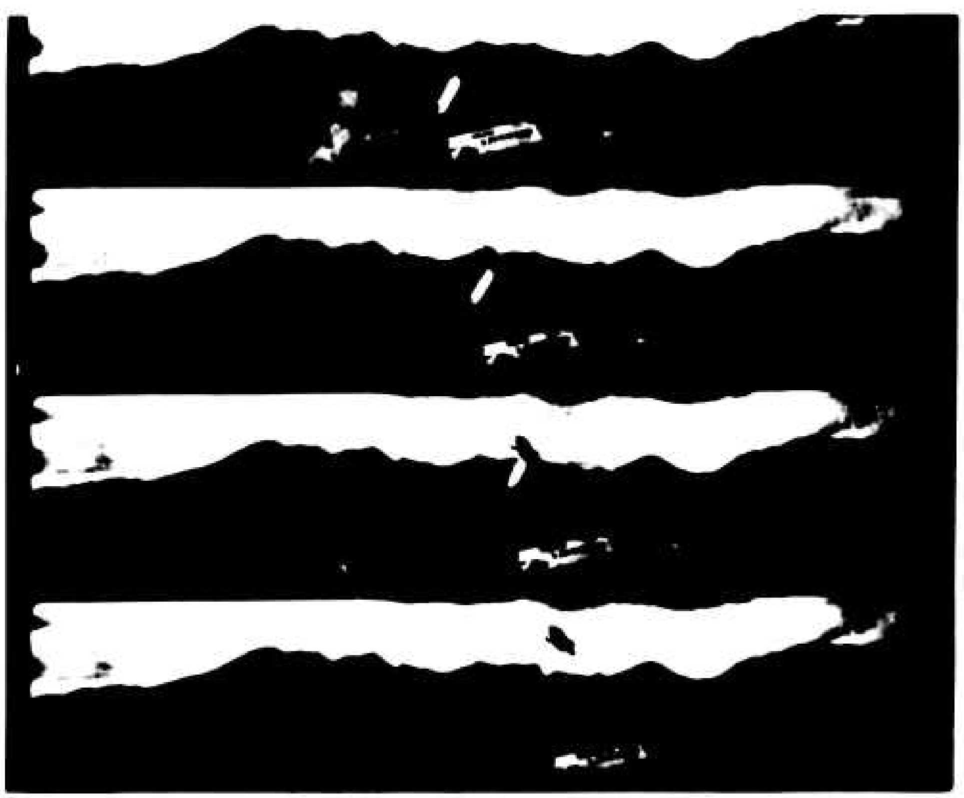


FIG. 21. CZR 1 Bowen Camera Record of Seat Ejection Test at SNORT. Note the range-coded timing along the left edge and the three fiducial crosses down the center of the frame for data assessment.

TRACKING MOUNTS

The Tracking Mount Section operates powered mounts fitted with cameras having long-focal-length lenses to obtain detailed close-up pictures for missile-attitude measurements, intercept data, documentation, and the observation of component function on any of the NOTS ranges.

The basic instrument used by this Section is a camera-carrying modified M-45 machine-gun mount spring-mounted on a trailer fitted with stabilizing jacks and leveling devices (Fig. 22). Tracking rates up to 60 degrees per second are possible, although tracking beyond 40 degrees per second is seldom required. Each mount is powered by its own 30-kw diesel generator mounted on a 2½-ton truck which is also used as the prime mover for the mount. Radio-communication and timing equipment is on the trailer with the mount. The assembly is a complete, mobile unit (Fig. 23) requiring only access roads for transport, enabling its ready movement to meet changing data requirements.

FIG. 22. Small M-45 Tracking Mount.

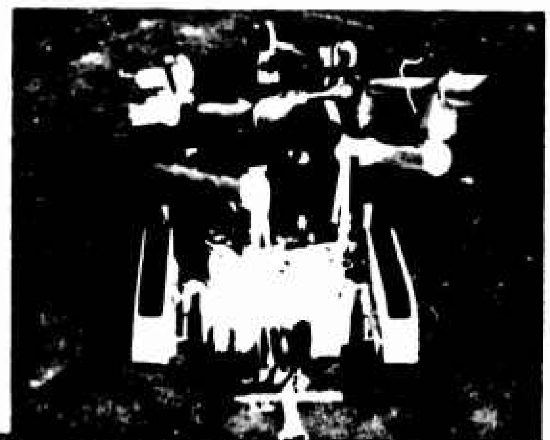


FIG. 23. M-45 Tracking Mount With Power Supply and Prime Mover.

Each mount is equipped with two arms designed for a variety of camera and lens combinations. The usual combination is a 35mm Mitchell camera on one arm for coverage of the entire flight, and a high-speed recording camera on the other for high frame-rate (up to 8,000 frames per second) studies of detailed motion, separation of booster from missile, seat ejections, etc. Lenses from 2 to 150 inches are available for either arm. Usually a 96-inch lens is used on one side and a 48-inch lens is used on the other. Cameras employed are the 70mm Mitchell and Photo-Sonics, 35mm Mitchell and Photo-Sonics, and 16mm Mitchell, Milliken, and Photo-Sonics, all of which are equipped to record 1,000-pps binary-coded timing.

Fourteen mounts are available for use on the NOTS ranges. Normally, a mount requires only one operator.

The Tracking Mount Section also operates and maintains the tracking-radar boresight systems (Fig. 24) used on the guided-missile ranges. The systems utilize 35 and 70mm cameras with lenses having focal lengths of up to 150 inches.

FIG. 24.

Radar Boresight Installation.

CINETHEODOLITES

The Cinetheodolite Section maintains and operates cinetheodolites to obtain trajectory and velocity data in tests of weapons and aircraft components. Ranges regularly instrumented with cinetheodolites are G-1, G-2, K-3, and other NOTS ranges. The mobility of the portable cinetheodolites and timing units, any of which can function either with or independently of a central control station, makes instrumentation of remote areas practicable.

Both the Askania and Naval Weapons Plant cinetheodolites feature (1) accurate positioning of the instrument and film plane with respect to a surveyed point, (2) a film plane on the lens axis, (3) binary-coded timing, azimuth, and elevation-dial readings, with the frame number photographed upon the film, (4) a synchronized pulse rate which ties all stations together precisely, and (5) a means of leveling and orienting the camera to within a few seconds of arc. The instruments can be equipped with any of a variety of lenses having focal lengths of 24, 44, 48, 72, and 88 inches--the lens selection being made according to station location and the experiment requirements.

FIG. 25. Permanent Askania Station With Astrodome and Air-Conditioning Equipment.

Of the Station's 47 cinetheodolites, 23 are housed in permanent air-conditioned astrodome stations (Fig. 25) situated in an array along either side of the guided-missile line of fire in such a manner as to cover both the G-1 and G-2 ranges.

These stations maintain constant temperatures, which limit physical changes in the instrument and hold lens distortion to a minimum. They are supplemented by additional downrange stations of a semipermanent nature that afford effective photographic coverage over a downrange distance of approximately 30 miles for the gathering of data on events ranging from ground level to above 70,000 ft altitude, and extending over a distance of about 45 miles.

The instruments are normally operated at 4 pulses per second but the rate can be increased to 5 or lowered to one or less as predetermined by test specifications. Each instrument is equipped with an interchangeable 20-power or 12-power telescope having an illuminated reticle for night tracking. Communication radios are installed in all active stations. Eight of the stations have been equipped with the new target acquisition system (TAS) to help align the telescope on a moving object.

The stations equipped with TAS can acquire any target (missile, drone or aircraft) that carries a missile intercept data acquisition system (MIDAS) transmitter or that can be tracked by radar. MIDAS and radar can be used simultaneously as inputs to direct cine-theodolites to different items. The presentation to the operator at the instrument is a four-light display in the tracking telescope; two of the lights indicate elevation and the other two indicate azimuth. The operator acquires the target by training the instrument in the direction of the appropriate lights.

SPECIAL APPLICATIONS

This Section provides NOTS ranges and laboratories with specialized optical instrumentation and high-speed cameras for data coverage of high-speed events such as jet patterns, shock waves, missile launchings, warhead behavior, static firings, and schlieren effects. Figures 26, 27, 28, 29, and 30 are examples of several different types and sizes of cameras available through the Special Applications Section.

Optical instrumentation equipment available from the Special Applications Section includes:

16mm Cameras

Photo-Sonics 1B prism cameras, 400 to 1,000 frames per second, 100- to 1,200-ft film capacity.

Photo-Sonics 1C prism cameras, 1,000 to 4,000 frames per second, 400-ft film capacity.

Fastax WF-3 prism cameras, 1,000 to 4,000 frames per second, 100-ft film capacity.

Fastax WF-4 prism cameras, 1,000 to 12,000 frames per second, 100- to 400-ft film capacity.

8mm (1/2 frame 16mm) Fastax WF-1 prism cameras, 2000 to 12,000 frames per second, 100-ft film capacity.

FIG. 26. Three 16mm Rotating-Prism Cameras.

Mitchell pin-registered cameras, 16 to 120 frames per second, 100- to 1,200-ft film capacity.

Milliken DBM-5 pin-registered cameras, 4 to 400 frames per second, 100- to 1,200-ft film capacity.

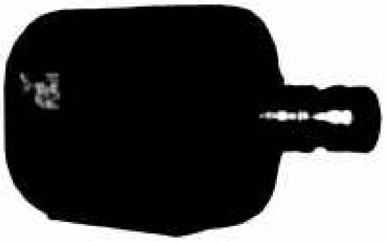


FIG. 27. 16mm Milliken Camera, Model DBM-5.

35mm Cameras

Fastax WF-8A fill frame prism cameras, 200 to 2,000 frames per second, 200- to 500-ft film capacity.

Fastax WF-5 prism cameras, 100 to 6,000 frames per second, 100-ft film capacity. Half frame. Removal of prism converts camera to ballistics-synchro streak camera.

FIG. 28. 35mm Mitchell Camera With Synchronous High-Speed Motor.

Photo-Sonics 4B prism cameras, 500 to 2,000 frames per second, 400- to 1,000-ft film capacity. Full frame. (One camera converted to staggered 16mm frame format, 8,000 frames per second, continuous writing time.)

Mitchell pin-registered cameras, 16 to 120 frames per second, 100- to 1,000-ft film capacity.

Automax G-1 intermittent-movement, cine-pulse cameras. Cine rate 16 frames per second pulse rate 0 to 10 frames per second, 100- to 400-ft film capacity.

Northridge Pulsemaster, pin-registered cine-pulse cameras. Cine rate 5 to 80 frames per second, pulse rate 0 to 12 frames per second, 200-ft film capacity.

Dynafax rotating-drum cameras. Up to 26,000 frames per second, 33-inch film strip. Takes 224 frames, 0.28-inch by 0.39-inch.

Total recording time 8.5 milliseconds with 1 to 5 microsecond shuttering speed at maximum speed.

FIG. 29. Dynafax High-Speed Camera.

70mm Cameras

Photo-Sonics 1A pin-registered cameras, 100 to 400 frames per second, 80-ft film capacity. Frame size 2.25 to 0.218 inches.

Photo-Sonics 1B pin-registered cameras, 360 frames per second, 100- to 1,000-ft film capacity. Frame size 2.25 by 0.218 inches. Mounted on 3-axis mount. 1/10,000-second shutter speed.

Photo-Sonics 10A pin-registered cameras, 20 to 80 frames per second, 100- to 1,000-ft film capacity. Frame size 2 1/4 by 2 1/4 inches.

Photo-Sonice 10B prism cameras, 180 and 360 frames per second, 100- to 1,000-ft film capacity. Frame size 2 1/4 by 2 1/4 inches.

FIG. 30. Photo-Sonics TV-1A Camera With Three-Axis Mount and Trailer.

Hulcher Model 102 sequence cameras, 5 to 20 frames per second, 100-ft film capacity. Frame size $2\frac{1}{2}$ by $2\frac{1}{2}$ inches.

Hulcher Model 100 sequence cameras, 5 to 25 frames per second, full frame $2\frac{1}{2}$ by 5 inches. 5 to 50 frames per second half frame, $2\frac{1}{2}$ by 2 1/4 inches. 100- to 1,000-ft film capacity.

APPLIED ENGINEERING

The major responsibility of the Applied Engineering Section encompasses the redesign, rebuilding, and maintenance of the M-45 and other special-purpose tracking mounts, as well as the short-range instrumentation engineering necessary to meet test requirements. Complete facilities for converting M-45 machine-gun mounts into optical-tracking mounts are located in the Lark building near the Instrumentation Laboratory. The facilities include a camera-repair shop, an electrical shop, a machine shop, and the M-45 shop.

This Section also supplies the engineering services for data-dial, launcher, and radar boresight applications on the ground ranges and aboard ships and aircraft connected with NOTS projects; it redesigns and modifies film readers to accept the latest in pin-registered transports and digital output; it conducts engineering feasibility studies on the field-use of optical data-gathering instruments, followed by the preparation of final engineering specifications based on the studies; and it designs control equipment for local or remote operation of instruments.

EVALUATION AND ANALYSIS

In addition to the services and facilities described above, the Optical Instrumentation Branch also has facilities available for the evaluation and analysis of complete optical instrumentation systems or any component thereof. For example, each error contributing to the overall degree of accuracy of an instrument system can be measured individually. These errors include random as well as bias errors and are measured using optical tooling (e.g., autocollimation, autoreflection, and precision level) techniques. The random errors are held to a minimum by machine-shop work or by the selection of proper bearings, etc., while the bias errors are measured and introduced as calibration constants for the instrument to insure maximum accuracy of data reduced from the system.

An optical bench, capable of handling lenses of up to 12-inch apertures and 100-inch focal lengths, is available for lens evaluation. These evaluations produce information on such items as focal length, flange-focal length, nodal-point position, resolving power, astigmatism, curvature of field, and color correction.

Continuing programs of evaluation of new instruments, development of calibration techniques, modification of operational procedures, and the changing of instrument-system components to meet data requirements are pursued by the Branch.

TYPICAL RANGE OPERATIONS

A recent ASROC-Terrier flight test is an example of a range operation involving the Optical Instrumentation Branch. For this one test, 10 Askania cinetheodolites, eight M-45 tracking camera mounts, and 14 CZR-1 Bowens were used. In addition, four cameras--a Photo-Sonics 1B high-speed, a 35mm Mitchell, and two TVR 70mm cameras--were used in the launch area. On another day, one test might require the same number of Askanias and M-45s on the G-1 range at the same time six to eight Bowen cameras were being used at the SNORT track, while the Special Applications Section might be operating five to 10 high-speed cameras on a static test of a rocket motor. This illustrates the scope of optical services that the Optical Instrumentation Branch is often required to supply in a single day.

To Request Service

Before services are requested formally, customers should contact Code 3063 personnel to discuss data requirements. Following this, representatives from Code 3063, the assigned project engineer (Code 301) and the requester should meet to work out the details of the specific optical instrumentation required to gather the necessary data.

TIMING AND TELEMETRY BRANCH

The Timing and Telemetry Branch is divided organizationally into three sections responsible for the development, maintenance, and operation of specific technical equipment. Figure 31 shows the physical location of this equipment.

The Timing and Control Section develops, maintains, and operates all timing and control equipment on the G-1, G-2, K-3, and Randsburg Wash ranges, and checks out and evaluates the NOTS instrument-positioning system.

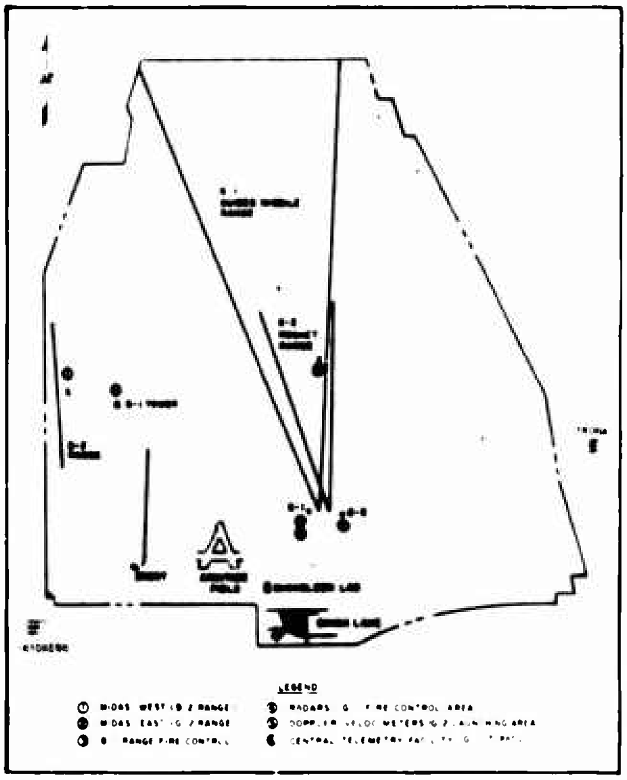


FIG. 31. Main Locations of Timing and Telemetry Equipment.

The Telemetry Section develops, maintains, and operates the central radio-telemetry facility at G-1, which is used for guided-missile and space-vehicle data gathering; mobile telemetry recording stations, as required; the missile airborne-telemetry facility; and the landline-telemetry equipment used in studies of blast, launcher parameters, missile shock and vibration, and missile temperatures.

In support of range electronic operations, the Engineering Support Section performs long-range planning for electronic system needs and performs short-term design and development of specific equipment. This Section also evaluates all Branch electronic equipment prior to its incorporation into range operating systems. At the present time, it is engaged in the long term development of equipment systems and techniques for the transfer of telemetry from VHF to UHF bands.

Of the 36 members of this Branch, 20 are electronics engineers and technicians; the others are mechanics and helpers in the various specialties.

TIMING AND CONTROL

Timing services are provided routinely, usually as specified in the experiment specification (ES) issued by the scheduling office; special arrangements are seldom necessary. See Appendix for sample ES. Timing data is transmitted throughout the working day. The central-station operator can accommodate requests for changes in the functions being transmitted or in instrumentation checkout procedures as required. When special frequencies, control functions, or receiving installations are required, the Head, Timing and Control Section, should be contacted.

The primary source of range timing is a 9-channel pulse-code-modulated (PCM) system. It is supplemented by a simpler version having a 4-channel capacity. All receiving-station timing equipment is compatible with either system. The PCM system provides an accurate time base for both optical and electronic data-gathering instrumentation. Its design is modular and has a plug-in feature for simplicity of operation and ease of maintenance.

Figure 32 shows the PCM central-station equipment in the fire-control building at G-1 range. Additional central-station installations are in operation at G-2, K-2, the supersonic track ranges (SNORT, B-4, and G-4), the fuze evaluation range, and SCI. Three mobile central stations are also available for temporary use as needed.

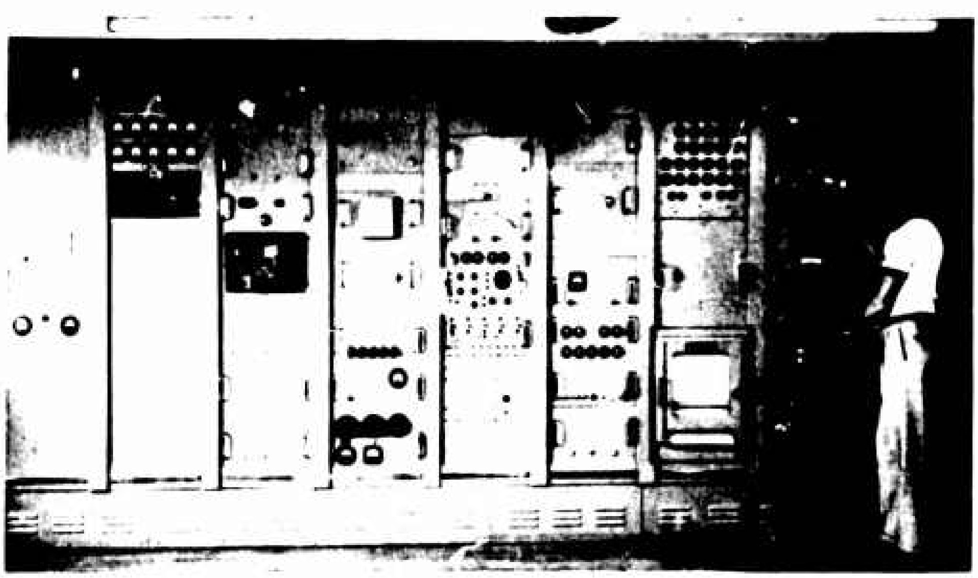


FIG. 32. PCM Central Station.

Transmitted timing and control functions are customarily synchronized at a basic 10-kc frame rate. System time-accuracy is ±2 microsec, well within the needs of existing instrumentation. The timing and control functions are derived in a central station by means of digital and pulse techniques, and are transmitted by UHF radio link. Up to nine independent functions can be transmitted simultaneously over a single RF carrier to the instrumentation sites. The block diagram in Fig. 33 summarizes a central station operation; at G-1 the 100-kc time base is generated in a crystal-controlled primary standard having a long-term stability of five parts in 10^{10}.

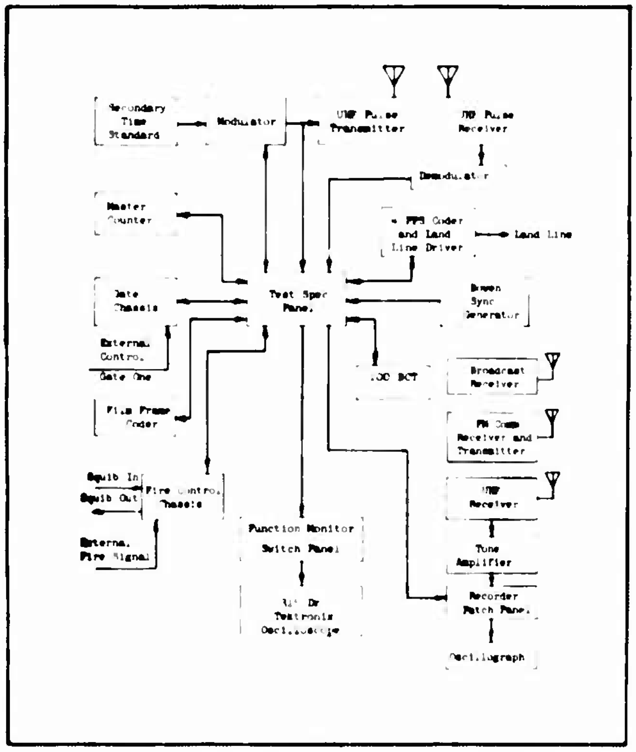


FIG. 33. Central Timing Station Operation.

At the start of daily operations, the standard in each central station is checked against a radio-transmitted primary frequency standard located in the instrumentation laboratory building. The primary standard is in turn calibrated, as needed, against standard time signals transmitted by National Bureau of Standard Stations WWV or WWVH.

The interconnection of each of the component chassis in any central station is performed at the test-specification panel. Manual manipulation of multiposition switches on this unit makes possible a quick accommodation to the requirements of each test and routing of the proper signals to the various PCM information channels.

The overall monitoring of each test is accomplished by means of a complete timing-receiving station installed in one of the central-station equipment racks. The timing monitor is produced by recording all of the outputs of a demodulator on a multichannel oscillograph during each event. The following timing and control functions are available from a central station via radio-link or short landline:

100 and 10 kc	Instrument radio-start pulses
1,000, 200*, 100, 50, 20, 10 pps	*Various mixed pulse rates
5, 4, 2, and 1 pps (delayed 50 millisec, flash lamp pulse rate)	1,000 pps, coded every 16th pulse
5, 4, 2, and 1 pps (cinetheodolite shutter pulse rate)	*PCM zero-time pulse
100 pps binary-coded time	30 pps for Bowen synchronization
Film-frame code (binary count of cinetheodolite frames)	*Instrument landline start pulse
	*Coded 4 pps
	Sequenced control function pulses

*Available at central stations only

During operations at the G-1 range, timing and control functions riginating in the central-station equipment are microwave-linked to a nearby mountaintop (B Mountain), from which they are repeated in the 500-Mc region at a level of 1 kw. This level assures reliable reception at all downrange instrument sites in line-of-sight contact with B Mountain. Additional transmitting equipment is available for relaying the initial transmission to remote impact areas and instrumentation sites where reliable reception of the B-Mountain signals cannot be maintained.

A block diagram of a typical downrange receiving station (a cinetheodolite) is shown in Fig. 34.

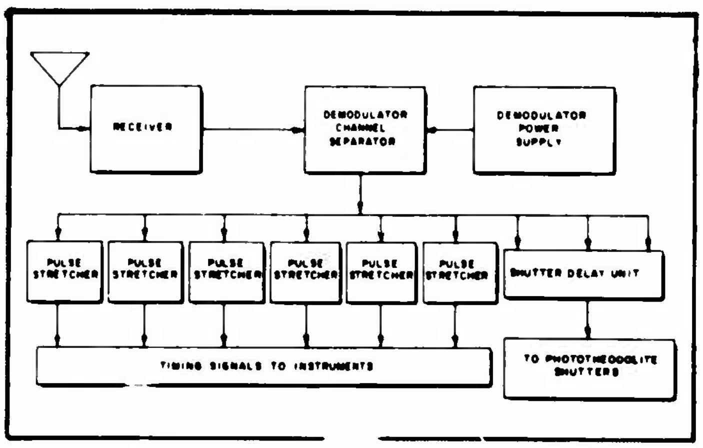


FIG. 34 Block Diagram of Cinetheodolite Receiving Station.

Each instrument site receiving station consists of a directional high-gain antenna, UHF pulse receiver, PCM demodulator, and accessory equipment such as control boxes and timers. The type of receiver and demodulator used at each particular station is determined by the station's function and location. At each station it is possible to provide the entire nine different timing and control signals, nine separate outputs of a single function or any combination of functions, or (by use of a simplified demodulator) the timing data information contained on only the first four transmitted channels. The demodulator reproduces the original modulation pulse widths and furnishes the information at 150-v peak, low impedance, which will drive long lengths of coax cable.

In all, receiving and demodulating equipment adequate to equip 190 instrument sites is available at the NOTS ranges.

In addition to the PCM timing system, limited IRIG standard format timing is being generated and distributed via a 141-Mc radio link. The primary standard--with a stability of about one part in 10^{10}--is used as the source of the standard signal. The transmitted code establishes time of year in UT_2, and is kept synchronized with transmissions of the U. S. Frequency Standard to within ±500 microseconds. Some equipment is currently available for operation of range instruments directly from the standard format. It is anticipated that the older PCM operation will be phased out completely as additional procurements of standard format equipment permit.

Target Acquisition

A target acquisition system (TAS) has been installed on the ground ranges to assist Askania camera operators in finding and tracking targets, particularly those at high altitudes or when the target is small. Digital data from the east and west MIDAS stations are transmitted by microwave to G-1 test control where they are combined with digital data from any or all of the three tracking radars via an IBM 4901 buffer. The combined data are then transferred to the UNIVAC 1218 computer at G-1. The computer edits and computes, makes parallax corrections, and generates messages containing pointing instructions for each of eight Askania camera stations. The messages are distributed to each receiving station at a rate of 10 per second.

At the instrument receiving sites, the transmitted instructions in digital form are compared with camera-pointing data. Differences are displayed in the form of right/left azimuth and up/down elevation lights mounted in the periphery of the field of the spotting telescopes. The operator's problem is thus reduced to one of moving the camera so as to extinguish the data display lights which results in the camera axis being aligned so that the target is visible in the spotting telescope.

TELEMETRY

The three main types of radio telemetry facilities at the NOTS missile ranges include FM/FM and PAM or PDM/FM. The telemetry building (see floor plan in Fig. 35) is headquarters for these facilities. This building contains the terminal equipment for six FM/FM stations, two PAM or PDM/FM stations, and a dual telemetry playback facility. A permanent wirelink recording facility is installed in the G-1 radar building and two mobile wirelink telemetry systems are on hand for use at other locations. Facilities for communicating with and monitoring launcher control, range, and other critical areas are available to the test conductor in the flight-observer area of the telemetry building. Monitoring equipment includes six 8-channel direct-writing oscillographs, two 18-inch bargraph oscilloscopes, various frequency counters, and auxiliary equipment.

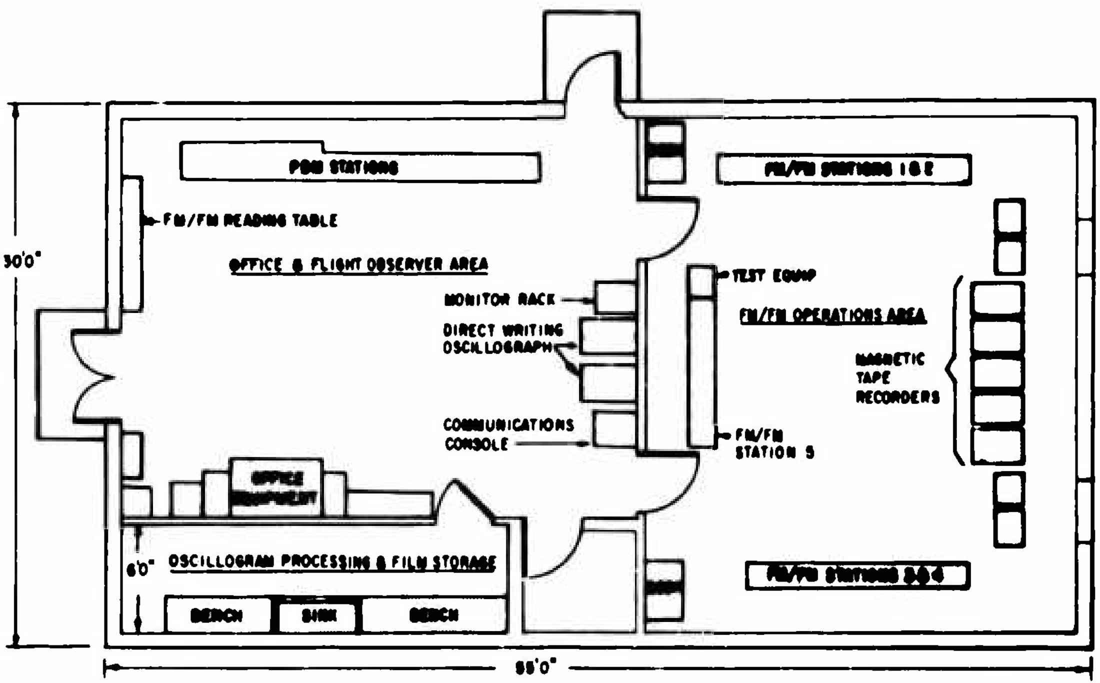


FIG. 35. Interior Plan of Telemetry Building.

In addition to the fixed stations in the telemetry building, a mobile station consisting of antenna, preamplifier, receivers, and two tape recorders is available for downrange operation or for backup of the fixed stations. The magnetic-tape record can be played back in the telemetry building for presentation of the data on oscillographic film or paper.

FM/FM Stations

The telemetry building houses five 12-band FM/FM stations (Fig. 36). Each station consists of two phase-lock crystal-controlled telemetry receivers, one 7-track magnetic tape recorder, one 12-inch recording oscillograph, and any 12 of the 23 IRIG standard subcarrier discriminators, all of which are equipped with wow-and-flutter compensation. Calibration and monitoring equipment is available to all stations.

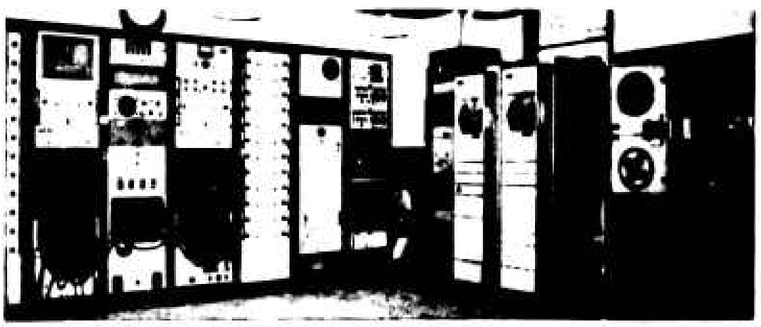


FIG. 36. FM/FM Telemetry Station.

High frequency functions can be recorded on a 35mm oscilloscope camera. There are six 8-channel and one 2-channel direct-writing recorders with patch capabilities. These recorders can be patched to either or both decommutator stations and any number of discriminators in any order to provide a total of 50 quick-look data channels. A tape playback station is available and consists of two 12-subcarrier discriminator stations with wow-and-flutter compensation, 12-inch recording oscillographs, one 45-channel decommutator unit, four 8-channel direct-writing recorders and a tape recorder capable of playing back either 7-track one-half-inch tape or 14-track one-inch tape.

The antenna system for the real-time recording station comprises one quad helix with remote control (located in the operations area), two bifilar manual-track helices and two 28-ft parabolic antennas.

Radio-relay data from areas not serviced by the present telemetry-receiving system can be provided on a limited test-to-test basis.

The missile-telemetry facility provides complete acceptance testing, calibration, and checkout of telemetry units before they are installed in test items.

PAM/PDM/FM Stations

Each of the two time-division telemetry stations (Fig. 37) comprises a helical antenna, a preamplifier, multicoupler, receiver, 7-channel 1/2-inch magnetic-tape recorder, and a decommutator system.

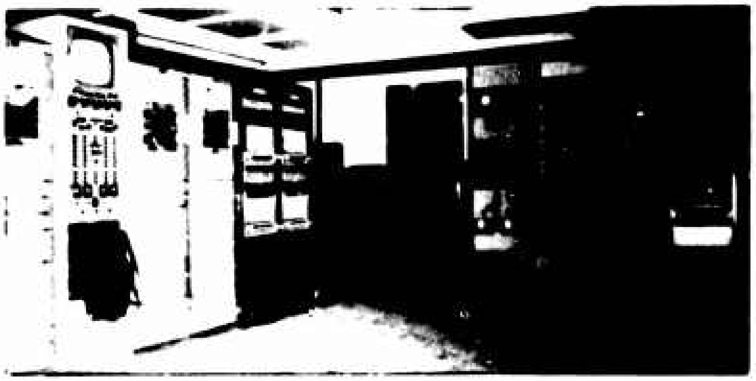


FIG. 37. PAM/PDM/FM Telemetry Station.

The decommutators are Arnoux Model TDS, 45-channel PAM/PDM units which will handle all standard IRIG commutation rates. The output of the decommutator can be presented on four 8-channel direct-writing oscillographs in real time or on playback from the flight tape. An 18-inch bargraph oscilloscope is used for monitoring.

In addition to the above, flight telemetry records recorded on magnetic tape can be processed through NODAC.

This facility can accommodate either direct-pulse transmission systems or commutation on any channel of an FM/FM telemetry system.

OTHER RADIO LINK TELEMETRY FACILITIES

In accordance with various DOD and Navy directives, UHF telemetry links are being developed, tested and evaluated. The planned evacuation of the 225-260 Mc telemetry band and transfer of operations to either the 1435-1535 or 2200-2300 Mc bands is scheduled for 1 January 1970. NOTS plans gradual acquisition of equipment and, at present, anticipates sufficient equipment to support flight operations during the 1968-1969 period. A minimum capability exists at the present time, and flight tests are currently being conducted in these bands to establish operating techniques and propagation criteria.

Manual, slaved, and autotracking antenna systems (for both frequency bands) and all-band receiving and conversion equipment will be installed during the 1965-1970 span with full operating status being achieved prior to the 1 January 1970 cut-off date.

Special-Recording Telemetry

This facility consists of four vans and a permanent installation in the basement of the radar building on the G-1 range. Three wire-link carrier systems (a Wiancko 3-kc dual system, a Hathaway 5-kc system, and a CEC 10-kc system) are available. Provision is made for recording data on CEC recording oscillographs, a visicorder, both 35mm strip and Polaroid Land cameras, and magnetic tape using both direct and wide-band FM.

The special-recording facilities are used to measure a wide variety of phenomena in guided-missile, track-range, and blast tests. Transducers are available to measure motion, high-level transient sound, horizontal and vertical accelerations, strain, air-blast pressure, and earth pressures. In addition, equipment is on hand for the precise calibration of the transducers used in these measurements.

TYPICAL RANGE OPERATION

A typical range operation might include such instrumentation as Bowens, M-45 mounts, telemetry, Midas, radars, and all nine channels of the PCM-timing system. The overall timing system is highly flexible, permitting fast rearrangement of channels as test conditions dictate.

Requests for Service

Requests for timing and control services are normally made by filling out an experiment specification form (see Appendix) published by the Project Engineering Division, Code 301. Any unusual timing requirements should be discussed in detail with the assigned Project Engineer. Additionally, consultation services are always available through the Timing and Telemetry Branch in the Instrument Operations Building, Room 115, Ext. 712339 or 712341.

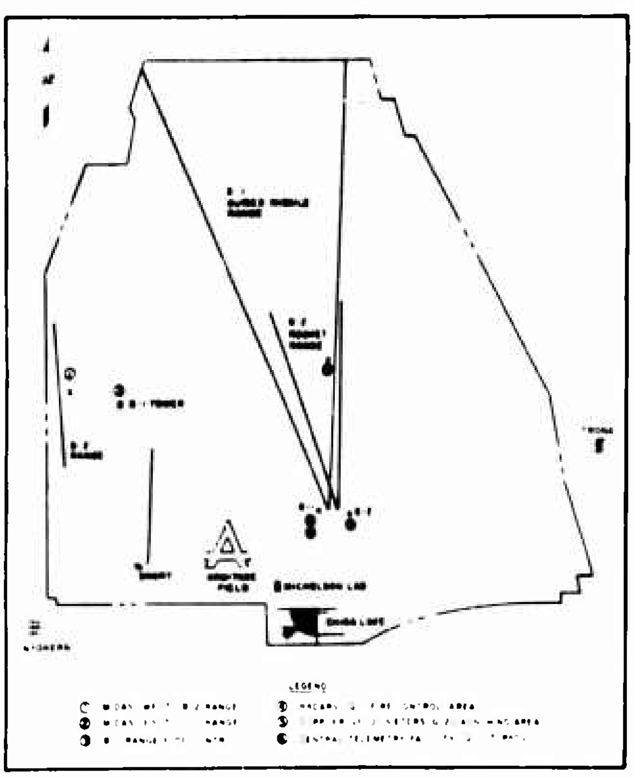
METRIC ELECTRONICS BRANCH

The Metric Electronics Branch designs, develops, maintains, and operates electronic-measurement, data-transmission, and communication systems and radar targets; evaluates electronic techniques; and provides consulting services for users of these electronic systems.

The Branch is made up of three sections. The Radar/Plotting Section operates Doppler velocimeters, tracking radars, plotting boards, and computers; the Telecommunications Section is responsible for communications and special electronic units; and the Engineering/MIDAS Section provides engineering services as required and operates MIDAS--the missile intercept data acquisition system.

Branch personnel number about 30, of whom approximately 5 are electronic engineers, 20 are electronic technicians, and 5 are electronic mechanic helpers, assemblers, and apprentices.

ELECTRONIC TRAJECTORY MEASURING SYSTEMS



The NOTS missile ranges use both MIDAS and tracking-radar electronic trajectory-measuring systems. These systems provide real-time trajectory information in the form of plotting board records. In addition, trajectory data from MIDAS and radars is recorded on tape for assessment and is available in digital form for the IBM 7094 computer, and this data is recorded for playback via the UNIVAC 1218 computer. Missile velocity information is obtained by Doppler velocimeters and is recorded both for assessment and in real-time form. Main locations of this equipment are shown in Fig. 38 (Fig. 31, repeated here for reader convenience).

FIG. 38. Main Locations of Metric Electronics Technical Equipment.

Missile Intercept Data Acquisition System

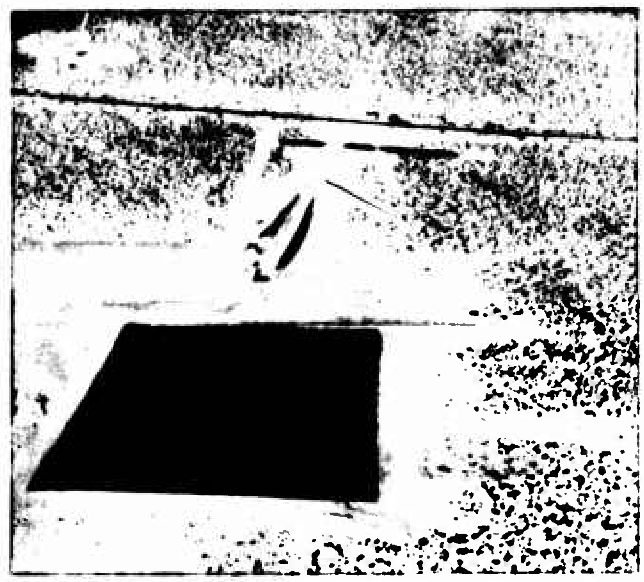


FIG. 39. East MIDAS Site.

This instrumentation facility is an electronic trajectory, miss-distance, impact-location measurement system that can track two airborne vehicles simultaneously.

The system uses electronic interferometers to measure phase differences of RF signals received at antenna pairs from airborne transmitters. Signal sources are telemeter transmitters normally installed in developmental missiles, and CW signal sources specially installed in target aircraft. The phase measurements provide angular data in the form of direction cosines referred to two antenna fields located 12.4 miles apart on the B-2 and G-2 ranges (see Figs. 38 and 39). From these angular data, instantaneous spatial coordinates of the vehicle are computed. For aircraft control and range safety, real-time information is sent to plotting boards at G-1 range test control by way of microwave and the UNIVAC 1218 computer. For later assessment or playback on plotting boards, MIDAS data is recorded on tape and processed on the UNIVAC 1218 or reduced on the IBM 7094 computer at Michelson Laboratory. MIDAS pointing information is also transmitted to theodolites via TAS (see page 28).

To maintain optimum system accuracy, each MIDAS antenna field must receive tracking information above a minimum (and below a maximum) elevation angle as specified in the table of performance characteristics on page 36. A less accurate continuous track is maintained at other elevation angles and at all azimuth angles.

PERFORMANCE CHARACTERISTICS OF NOTS ELECTRONICS TRAJECTORY MEASURING SYSTEMS

DATA GATHERING UNIT	FREQUENCY		PEAK POWER (kw)	POLARI-ZATION	PRF CAPA-BILITY (pps)	PULSE DURATION (μ sec)	BEAM WIDTH (deg)	CODED BEACON CAPA-BILITY
	BAND	RANGE (Mc)						
MPS-26 tracking radar	C	5450-5825 tunable	250	hor vert. cir.	(a)	0.25 or 1.0	1.4	no
Mod 7290 tracking radar	S	2700-2900 tunable	800	hor vert	(b)	0.8	3.0	yes
M-33 radar: Track mode	X	8600-9600 tunable	250	vert	1,000	0.25	1.1	no
M-33 radar: Search mode	S	3100-3600	1,000	hor	1,000	1.3	5.0	
SCR-584 radar track mode	S	2700-2900 choice of several fixed freqs.	250	hor vert.	(c)	0.8	4.0	yes
M36-3A track mode	X	8600-9600	400	vert.	1350	0.25	1.7	no
Search mode	S	3100-	1000	hor.	500	1.3	2-14	no
Velocimeter 10A	S	2640	200w	vert	CW	CW	4.0	
MIDAS (Missile Intercept Data Acquisition System)	TM band (225 , 229.9, 231.9 and 234.0 Mc)		Receiving system has 3μv sensitivity with 88-Kc bandwidth		Antenna receiving pattern is 360 deg. in azimuth. Main lobe is between elevation angles of +1.5 to +75 deg. Range depends on power of signal being received (approx 65 mi for 2-watt transmitter)			
Plotting boards, 4 ea with 1 digital and 2 analog computers	Plots position of target or missile being tracked by radars and/or MIDAS; real-time recording system.				Scale factors normally used: 1 K yd/in. and 3 K yd/in.			

NOTES: (a) 320, 341, 388, 394, 427, 485, 512, 640, 732, 884, 1084, 1280, 1707
(b) 341, 388, 394, 427, 512, 588, 640, 732, 854, 1024, 1280, 1707
(c) 732, 884, 1084, 1280, 1707

RANGE CHARACTERISTICS					AZIMUTH CHARACTERISTICS				ELEVATION CHARACTERISTICS					
MAXIMUM CAPABILITIES			READOUTS AND THEIR PRECISION (yd)		MAXIMUM CAPABILITIES		READOUTS AND THEIR PRECISION (mil)		MAXIMUM CAPABILITIES			READOUTS AND THEIR PRECISION (mil)	
Distance (k yd)	Rate (k yd/sec)	Accuracy (yd)	Pots	Synchros	Rate (deg/sec)	Accuracy (mil)	Pots	Synchros	Limits (deg)	Rate (deg/sec)	Accuracy (mil)	Pots	Synchros
400	8 track 15 slew	±10	400k ±40 and 100k ±25	524288/rev & 4096/rev	40 track 60 slew	±0.5	360° ±0.1	1 speed ±2.4 36 speed ±0.07	-2 to +89	20 track 40 slew	±0.5	90° ±0.1	1 speed ±2.4 2 speed
400	8 track 15 slew	±15	400k ±100 and 100k ±25	160k/rev and 8k/rev	40 track 60 slew	±1.0	360° ±0.1	1 speed ±2.4 36 speed ±0.07	-2 to +89	20 track 40 slew	±1.0	90° ±0.1	1 speed ±2.4 2 speed ±0.07
100	1.2 track 6 slew	±15	100k ±25	100k/rev ±37 2k/rev ±0.74	40 track 60 slew	±1.0	360° ±0.1	16 speed ±0.15 and 1 speed	-10.125 to +84.375	29.4 trk 40 slew	±1.0	90° ±0.1	16 speed ±0.15 and 1 speed
120	6	±125	(PPI)				(PPI)		0 to +70.3				
84	2.4 track	±25	84k ±21	50k/rev ±70 2k/rev	38.4 trk	±1.0	±0.1	16 speed ±1.4	-1 to +89	20 track	±1.0	±0.1	16 speed ±1.4
100	12 track 12 slew	±15	2k/rev 100k/rev	100k/rev	40 trk. 40 slew	±1.0	360° ±0.01	16 speed ±0.15 1 speed	0-10.125 to 84.375	29.4 trk. 40 slew	±1,0	90° ±0.1	16 speed ±0.15 15 speed
250		±125	(PPI)				(PPI)		2° to 22°				
7													

Digital data recorded on Ampex FR-100A for IBM-7094 Computer assessment, or recorded on Potter 906II-1, for play-back on EAI digital plot boards, or data presented to plot boards and TAS in real-time.

Maximum tracking rate is 0.22 cosines/sec. Sampling rate is 1, 2, 5, 10, 20 or 50 samples/sec.

Precision of board and computer combination: ±0.1%

Accuracy of radar/MIDAS--plotting board system derived from comparisons with cinetheodolite data; plotted points are typically within a 50-yd radius of the Askania spatial location of the target for radars and within a 20-yd radius for MIDAS.

Tracking Radars

Three tracking radar installations are used for tests on G-1 range (Fig. 40a, b, and c), and several mobile units are available for use at other locations as needed. These radars, which are all equipped with optical trackers for target acquisition and identification, beam pulsed RF signals at airborne targets, measure the reflected signal delay time to obtain range data, and provide angular information by using directional antennas to automatically track targets.

AN/MSG-3A acquisition and tracking radars with computer/plotting systems (Fig. 40d) are used in mobile drone control exercises for tracking rockets and projectiles and in a weather modification program.

FIG. 40a. MPS-26 Tracking Radar.

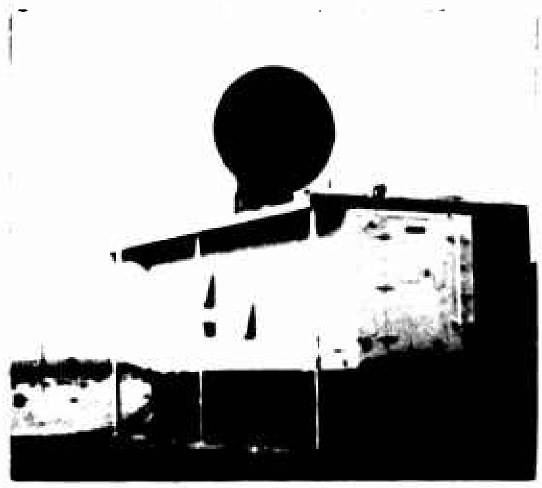


FIG. 40b. M-33 Tracking Radar.

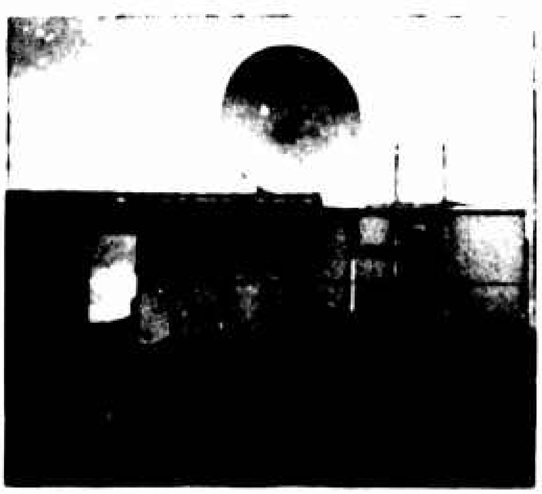


FIG. 40c. Model 729B Tracking Radar.

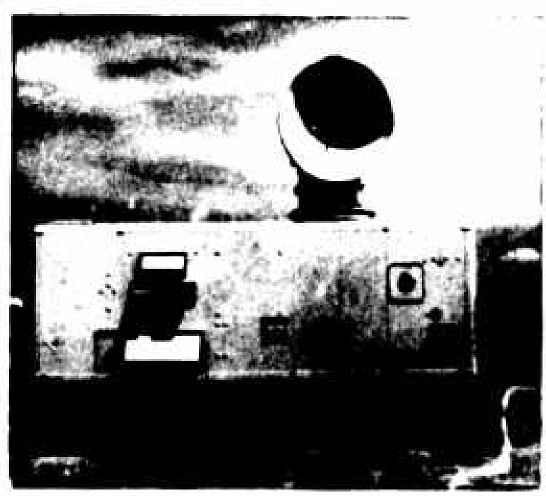


FIG. 40d. Model MSG-3A Tracking Radar.

Target Radars

Several rennovated and modified radars are in use as missile tragets on both the ground and aircraft ranges. Radar target characteristics are tabulated below.

Radar	No. of Units	Frequency (Mc)	PRF (cps)	Pulse Width (μsec)	Azimuth (deg)	Type Scan	Scan Rate (cps)	Peak Power (kw)	Antenna Polarization	Power Requirements
SCR 584	4	4900-5100	var.	0.8	360	none	none	250	vertical	3 phase delta 60 cps, 120V
SCR 584	43	2700-2900	var.	0.8	360	Conical	30	250	circular	3 phase delta 60 cps, 120V
CPS-1	1	2700-3100	350	1	360	none	none	240	vertical	3 phase delta, 4-wire, 120/208
CPS-4	1	2700-3100	294	1	±10	Nodding		450	circular	3 phase, 4-wire 60 cps, 120/208
MPG-2	1	8500-9600	var.	0.5 0.2	360	Palmer Conical	30	65	vertical	3 phase delta 60 cps, 120V
FPS-6	3	2700-2900	350	2.0	360	Nodding		4500	vertical	3 phase, 4-wire 60 cps, 120/208
CPS-6 SU	1	2700-3100	350	1	360	none	none	210	diagonal	3 phase, 4-wire 120/208
SL		2700-3100	350	1	350	none	none	235	diagonal	3 phase, 4-wire 120/208
VL		2700-3100	350	1	360	none	none	440	vertical	3 phase, 4-wire 120/208
VC		2700-3100	350	1	360	none	none	195	vertical	3 phase, 4-wire 120/208
VU		2700-3100	350	1	360	none	none	282	vertical	3 phase, 4-wire 120/208
FPS-8	1	1280-1350	360	2.7-3.3	0 to 10 RPM 360	none	none	1200	horizontal	3 phase, 4-wire 60 cps, 120/208
MPS-11	1	1280-1350	360	2.7-3.3	360	none	none	1200	horizontal	3 phase, 4-wire 60 cps, 120/208

Plotting Boards

DC analog and digital data from G-1 range tracking radars and digital data from MIDAS are sent to four computer-plotting boards at test control, where X-Y and Y-H trajectories from three targets can be displayed simultaneously on individual plotting boards. Operational plotting accuracies of approximately ±25 yd/in. and scale factors of 600 to 9,000 yd/in. are available.

Doppler Velocimeters

Doppler velocimeters are reflective CW radars that measure radial velocity of rockets and projectiles by means of the Doppler frequency-shift principle (see Fig. 41). By comparing the frequency of a transmitted wave with that of its reflected wave, a signal varying in frequency by an amount proportional to the velocity of the rocket is obtained.

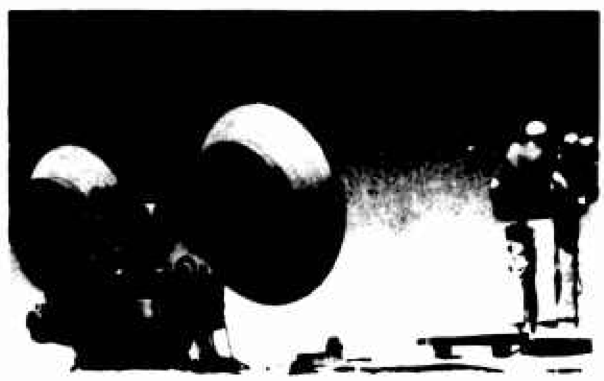


FIG. 41. Doppler Radar Antennas.

A Resdel Model 10A velocimeter is permanently installed behind the G-2 range launching area, and a second unit is trailer-mounted. These radars operate on 2,640 Mc, have a receiver bandwidth of 180 kc, and have an RF output of 200 w. The Doppler signal can be recorded on magnetic tape for assessment by NODAC, can be fed to a binary register and photographed for manual assessment, or can be applied to a frequency meter for visual observation. Real-time information can be obtained from plotting-board records.

A typical assessable signal can be obtained to a range of 7,000 yd from a 5-inch rocket having a maximum velocity of 4,000 fps. Operational accuracy of the system is 0.1%.

COMMUNICATIONS

Th· communications facility comprises both wire and radio channels which connect the test control center at each range with its instrument sites and vehicles.

Most communications are handled via an FM two-way radio network. Two independent channels are available, and most of the stations can operate on either. Both channels are relayed through a dual-frequency repeater station located on a nearby mountain, which retransmits the message on another frequency. The repeater station transmitters have higher power output than the other network stations, which effectively increases the range of the network. The G-1 and G-2 test control centers operate the repeaters by landline to ensure positive control during the critical periods of test operations.

The system presently encompasses over 350 units in fixed, portable, and mobile stations. Communications units are available for temporary installation in special instrumentation units needed for particular test programs.

Located in the test control centers are the public-address, paging, and multichannel intercom systems connecting the assembly buildings, launcher areas, and local instrumentation sites.

Ground-to-aircraft communications are provided in the test control centers and at the radar plotting boards via two UHF channels. In addition, two vehicles are equipped with UHF transmitter-receiver units and FM radios to provide range communications for special test requirements.

FLIGHT TERMINATION AND RADIO COMMAND CONTROL

During the early flight-testing stages of missile development, a command flight-termination system is usually employed. The system is designed to destroy the test vehicle if its course of action becomes a safety hazard. This command system is also used for radio command control of target aircraft (such as the QF9F, KDA, KDB, and Q2C), for flight termination of high-altitude research balloons, and for remote control of various developmental projects.

The ground station consists of two systems of two AN/FRW-2 transmitters each with related monitoring equipment. If a malfunction occurs in the operational transmitter the integrated automatic sensing-control equipment switches to the standby transmitter in approximately 100 millisec. The transmitters can be operated in the frequency range of 406 to 549 Mc, in 0.1-Mc increments, and have a maximum RF output power of one kw with a bandwidth of 350 kc. The RF signal is frequency-modulated by any one or any combination of twenty different tones available, each tone corresponding to a particular function of the test vehicle.

Monitoring of transmitted signals is accomplished by a self-contained monitor receiver feeding an audio-decoder. The output is recorded on a 30-channel brush recorder. Either a right-circularly polarized antenna having a 45 deg beam width at the half-power points, or a vertically polarized omni-directional antenna with hemispherical coverage is available; both resonate at the frequency assigned to the ground ranges for this type of operation.

One ground station system is installed in the range operations tower building and is remotely controlled from a station located at the plotting boards in the G-1 test control building. The duplicate AN/FRW-2 system is installed in a trailer for use at any test location.

MICROWAVE TELEVISION LINKS

Two portable closed-circuit television links provide remote coverage of ordnance tests. Included in this TV system are four cameras, nine monitors, and a video tape recorder. The recorder can be used to record and reproduce optical events via the television cameras.

DUAL TARGET PRESENTATION

A TV link is used in dual airborne-target operations to orient two target aircraft in close, parallel flight over the G-range. The system is comprised of a transmitter, a TV camera, and control equipment installed in a pod on one aircraft. Preflight and operational signals are received in a mobile van equipped with a receiver, directional tracking antenna, and video monitors. Conventional ground control is used to fly the second aircraft within the field-of-view of the TV camera in the first aircraft to maintain parallel flight.

MICROWAVE DATA LINKS

Four microwave links are used to transfer digital information among the east, west, and central MIDAS sites, and a fifth link relays MIDAS tracking data to the target acquisition system (TAS). A two-way link is also maintained between the test control center and the IBM-7094 computer in Michelson Laboratory.

MISCELLANEOUS MEASUREMENTS

Missile impact points are measured to an accuracy of ±10 feet relative to a predetermined ground target site by a system of geophone pickups and time-difference measurement equipment. The impact information is available as a real-time record.

Various microwave RF measurements are performed to supplement test program data or to investigate electromagnetic problems. These measurements include field-strength, precision-power, and power-density measurements to determine electromagnetic radiation hazards; alignment and calibration measurements for transmitters and receivers, as well as for closed-circuit TV video equipment; and microwave amplifier measurements (noise figure, gain, and minimum discernable signal).

TYPICAL RANGE OPERATION

A typical range operation of this Branch includes electronics measurements made before and during a test firing of a developmental missile launched from a carrier aircraft against an airborne target. A preflight operational checkout is made of the radio command control transmitters and the target aircraft control equipment. Flight termination equipment and target transmitters are tested and installed in the missile and target, respectively. During the firing, radar target-tracking information is recorded by the plotting boards for aircraft control and range safety; MIDAS missile and target trajectory data are plotted in real time and recorded for assessment; and real-time data is sent to TAS from radars and MIDAS. Flight termination is effected as required. Communications are maintained for each test exercise.

Requests for Service

Once arrangements for use of the ground ranges have been made, notify the Project Engineering Division, Code 301, of the need for communications, MIDAS, or radar support as early as possible. At this time a conference including the contractor, personnel from the Project Engineering Branch, and representatives from the Metric Electronics Branch is usually set up for a general discussion of test requirements. Code 301 will arrange for the necessary conference with the Station frequency coordinator to procure RF assignments if needed.

ATMOSPHERIC STUDIES BRANCH

The Atmospheric Studies Branch consists of the Measurements Section, responsible for gathering the data requested for tests and determining the methods by which these data are to be obtained, and the Evaluation and Development Section, which conducts meteorological research, develops methods of improving data-gathering techniques, evaluates newly-developed systems, and issues the daily forecasts.

Branch personnel number four meteorologists, four meteorological technicians, and one electronics technician.

PERMANENT WEATHER-REPORTING STATIONS

The locations of the permanent weather-reporting stations at the China Lake facilities of NOTS are shown in Fig. 42 with the following symbol: ⚑. Not shown is the NOTS fuze-testing installation at the Projectile Range, 23 miles southeast of China Lake, at which an additional weather station is located. A summary of the equipment in use at each of these locations is shown in the table on pages 48 and 49.

The rawinsonde system is the principal system for aloft measurements and is based at Tower 8, G-1 range. Release of the system airborne equipment at this point, centrally located to most of the ranges, yields data (representative of the Station as a whole) to altitudes of 100,000 ft. A similar receiving system is located at the instrumentation laboratory to provide a double network furnishing more accurate data.

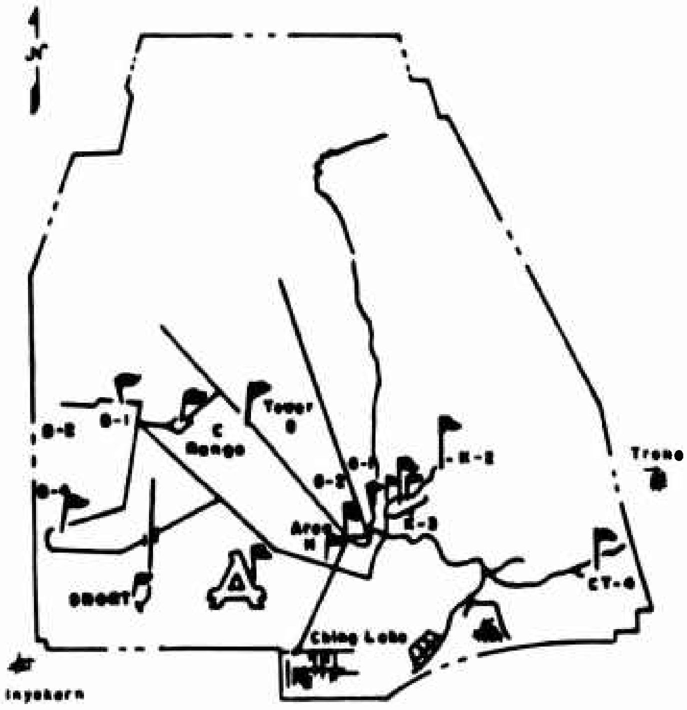


FIG. 42. Location of Weather Stations at NOTS China Lake Facilities.

METEOROLOGICAL MEASUREMENTS AT THE SURFACE

Temperature and Humidity

A shelter (Fig. 43) is used to shield temperature and humidity instruments from direct solar and nearby structural heating. The shelter allows air to pass freely over the instruments to ensure representative readings.

The most commonly used temperature-measuring instrument is the mercurial thermometer, which indicates temperatures from -20° to 120°F and is accurate to ±0.1°F. Maximum and minimum thermometers indicate the extremes in temperature reached since their last setting, the maximum thermometer measuring from -15° to 125°F, the minimum from -65° to 110°F; both are accurate to ±0.1°F.

Relative humidity is measured to within 6% at 20°F, 2.4% at 60°, and 1.6% at 90° with the psychrometer. Absolute humidity, specific humidity, and dew-point temperature can also be calculated from the psychrometer readings.

FIG. 43. Instrument Shelter: Hygrothermograph (l), Maximum and Minimum Thermometers (c), and Psychrometer (r).

If a continuous record of relative humidity is needed, the direct-reading hygrothermograph is used. This instrument is calibrated with a psychrometer and is accurate to within 3%.

The standard hygrothermograph provides a temperature and humidity record on a single, 7-day revolving chart over a 10° to 110°F range. If necessary, the temperature range can be altered for higher or lower temperatures. A smaller hygrothermograph with a range of 0° to 110°F is also available; this instrument can be set to operate for either 10 or 30 hours. Both instruments record temperature to within ±2°F.

LOCATION OF WEATHER INSTRUMENTS*

INSTRUMENTS	AIRCRAFT RANGES		AREA "R"	ARMITAGE FIELD	INST. LAB
	B-1	C			
For Surface Measurements:					
Instrument shelter	X	X	X	X	X
Mercury wet- and dry-bulb thermometers	-	-	-	X	X
Mercurial barometer	-	-	-	X	X
Aneroid barometer	-	-	-	X	X
Hygrothermograph	X	X	X	X	X
Microbarograph	-	-	-	X	X
Aerovane anemometer (AN/UMQ-5)	X	2X	X	X	X
Hot-wire anemometer (Hastings)	-	-	-	-	-
Rain gage	-	X	-	X	X
Temperature recorder (Speedomax)	-	-	-	-	X
For Aloft Measurements:					
Radiosonde Recorder (FMQ-2A)	-	-	-	-	X
Radiosonde recorder (TMQ-5A)	-	-	-	-	X
Radiosonde recorder (SMQ-5)	-	-	-	-	-
Rawin set, GMD-1B	-	-	-	-	X
Single-theodolite station	X	X	-	X	X
Double-theodolite station	X	-	-	X	X

*Portable equipment is available for use at locations not normally instrumented.

WEATHER INSTRUMENTS ON GROUND AND TRACK RANGES

INSTRUMENTS	GROUND RANGES					TRACK RANGES					
	CT-4	G-1	T8 G-1	G-2	Projectile	B-4	K-2	K-3A	K-3B	K-3C	SNORT
For Surface Measurements:											
Instrument shelter	-	X	X	X	-	X	-	-	-	-	X
Mercury wet- and dry-bulb thermometers	-	X	X	X	-	-	-	-	-	-	X
Mercurial barometer	-	-	X	-	-	-	-	-	-	-	-
Aneroid barometer	-	-	X	-	-	-	-	-	-	-	-
Hygrothermograph	-	X	X	X	X	-	-	-	-	-	X
Microbarograph	-	-	X	-	X	-	-	-	-	-	-
Aerovane anemometer (AN/UMQ-5)	X	2X	X	2X	3X	X	X	X	X	-	X
Hot-wire anemometer (Hastings)	X	-	-	-	-	-	-	-	-	-	-
Rain gage	-	-	X	-	-	-	-	-	-	-	-
Temperature recorder (Speedomax)	-	X	-	-	-	-	-	-	-	-	-
For Aloft Measurements:											
Radiosonde recorder (FMQ-2A)	-	-	-	-	-	-	-	-	-	-	-
Radiosonde recorder (TMQ-5A)	-	-	X	-	-	-	-	-	-	-	-
Radiosonde recorder (SMQ-5)	-	-	X	-	-	-	-	-	-	-	-
Rawin set, GMD-1B	-	-	X	-	-	-	-	-	-	-	-
Single-theodolite station	X	X	X	X	-	-	-	X	X	X	-
Double-theodolite station	-	-	X	X	-	-	-	X	X	-	-

Pressure

Surface atmospheric pressure is measured with a mercurial barometer that indicates pressure to within ±0.001 inch of mercury. Two portable instruments are used for measuring pressure: the aneroid barometer which indicates pressure in millibars, and the microbarograph, which continuously records pressure in millibars for a period of up to 7 days on a revolving graph, both instruments are accurate to within 0.5 millibar.

Wind Speed and Direction

Frequent gusty and high-velocity local winds call for surface-wind measuring instruments. Requirements of individual t st programs dictate the type of instrument to be used, the orientation point, and the appropriate units in which to measure wind velocity. The cross-wind component relative to the missile is computed when required.

The most commonly used surface-wind measuri - equipment is the aerovane (Fig. 44), which consists of a windpseed and direction transmitter, an indicator panel, and a 14-day varispeed recorder. The wind-speed transmitter has a starting speed of less than 3 knots. The transmitter and indicator together are accurate within $1\frac{1}{2}$ knots in a 3- to 40-knot range, and within 3 knots in the 4- to 120-knot range. The transmitter will align itself to within 3 deg in a 5-knot wind when displaced 8 deg from the wind direction. A specially designed, portable aerovane unit is available for use in remote locations.

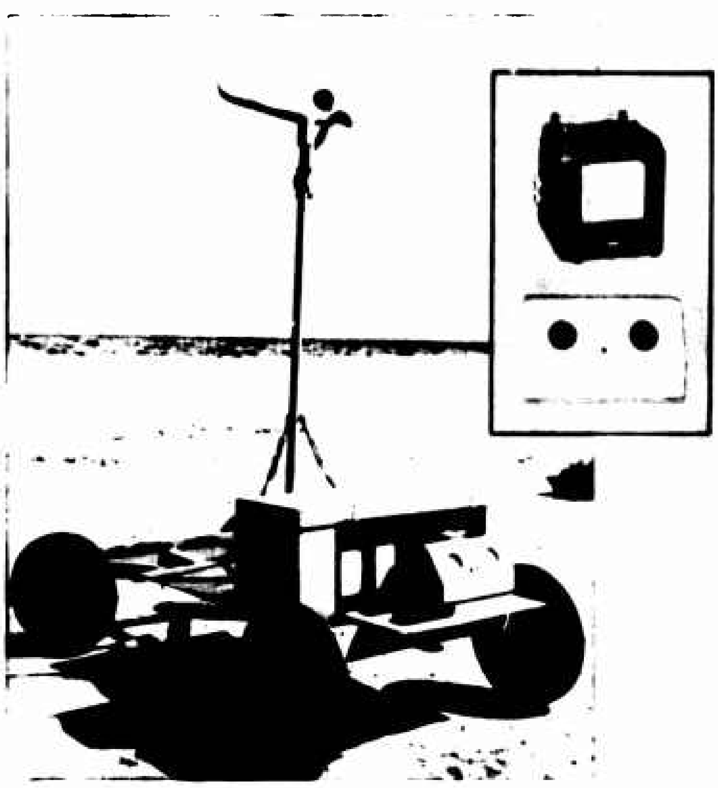


FIG. 44. Aerovane Wind-Speed and Direction Transmitter; (Inset) Recorder (T), Aerovane Indicator Panel (B).

Three types of wind indicators are in general use: (1) the wind-measuring set AN/PMQ-3, comprising a wind turbine and wind vane in a single, hand-held unit, accurate to within 1 knot in the 0- to 10-knot range, or within 2 knots at higher velocities, (2) the portable wind indicator (designed by the Atmospheric Studies Branch for local field use) consisting of a tripod-mounted wind vane and a Taylor anemometer that measures wind speeds up to 10,000 ft/min with great accuracy, and (3) the Hastings air meter, used for low-speed air or gas measurements to an accuracy of ±0.5 fps.

Miscellaneous Measurements

Daily surface observations on atmospheric density vapor pressure, sky condition, visibility, precipitation, and solar radiation, as well as the permanent records of these observations, are available on request.

Test programs at NOTS frequently call for measurements to be made at new or seldom-used sites. The Atmospheric Studies Branch makes surface and aloft meteorological measurements as needed at remote locations on the China Lake test-range complex, either through special installation of the equipment needed for surface measurements for the duration of the testing program or through use of the mobile weather unit shown in Fig. 45. This mobile unit has capabilities for obtaining data on both surface and upper-air meteorological parameters.

The Branch also provides special measurements such as determining the effects of surface covering on heat transmission, computing the speed of sound, computing the average daily mixing ratio for propellant-processing operations, and determining the effect of heat waves on the operating capabilities of range instrumentation.

FIG. 45. Mobile Weather Unit.

METEOROLOGICAL MEASUREMENTS ALOFT

Pressure, Humidity, Temperature and Density

The principal equipment used to measure meteorological conditions aloft is the rawinsonde system (Figs. 46 and 47). This system consists basically of a radio direction finder designed to automatically track a balloon-borne radiosonde transmitter-modulator, and a meteorological recorder. The transmitter-modulator, which is connected with a set of meteorological instruments, continuously transmits the free-air values of temperature, pressure, and humidity while balloon elevation and azimuth angles are recorded for measuring wind speed and direction throughout the vertical extent of the sounding. Transmitted data from the soundings can be obtained to heights exceeding 100,000 ft and horizontal distances up to 125 miles.

FIG. 46. GMD-1B Antenna and Balloon Train, With Radiosonde.

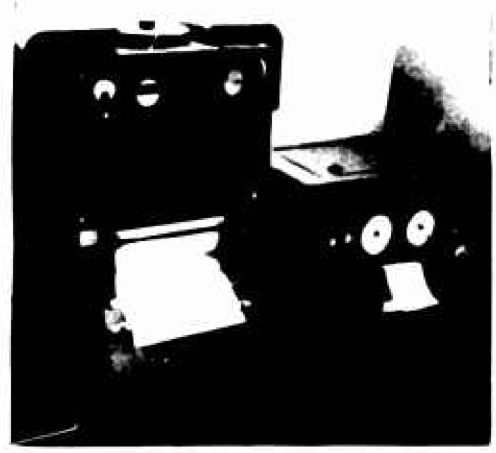


FIG. 47. TMQ-5A Radiosonde Recorder (L), and GMD-1B Control Recorder (R).

To measure pressure, the balloon-borne unit contains a sylphon cell, which is responsive to pressure changes within an average error of ±3 millibars below 50,000 ft, and ±1.5 millibars above 50,000 ft.

The humidity instrument is essentially a humidity resistor or hygrometer element consisting of a carbon-coated plastic strip with metallized edges. The resistance across the chemical film changes with variations in the amount of water vapor in the air. Under ideal conditions this instrument measures humidity within ±5%. However, at temperatures below 0°C, or at high humidities (95 to 100%) such as occur in clouds or precipitation, the error is greater. Operational limit of the humidity element is about 45,000 ft.

To determine temperatures aloft, the balloon-borne unit contains a temperature resistor made of temperature-sensitive ceramic materials. Instrument resistance increases as the temperature decreases to provide data accurate to about ±1.1°C.

Atmospheric density at any level aloft is calculated after the pressure, temperature, and water-vapor content of the air at that level are determined.

The mobile weather unit shown in Fig. 41 also has capabilities of measuring these upper-air parameters, although it is generally used for relatively lower-level soundings (up to about 25,000 ft). Because of its mobility, this unit can be used at any location which is accessible by truck.

Wind Speed and Direction

The single- and double-rawinsonde, the pibal, and the smoke-puff systems are used to determine wind speed and direction aloft. In using the single rawinsonde system, the balloon-borne transmitter-modulator is tracked from release at the surface with the radio direction finder. The elevation and azimuth angles of the transmitter are recorded at regular intervals to altitudes of 100,000 ft and higher. The altitude is determined from a pressure-height curve. Single rawinsonde accuracies range from within 1 mph in winds of 20 mph near the surface to 40 mph in winds of 100 mph at 100,000 ft.

The double rawinsonde system, also used at the Station, employs two RDF antennas to obtain the balloon's altitude by triangulation, greatly increasing the accuracy of the data at high altitudes.

The wind data can be presented in numerous forms such as tabulations of crosswind components and ballistic-wind measurements, as desired by the requester.

In the pibal system, a theodolite similar to a surveyor's transit is used to measure the elevation and azimuth angle of a small balloon in free flight. The angles are observed and recorded at regular (usually one minute) intervals throughout the sounding. A single theodolite is usually used, but greater accuracy can be obtained using two or three theodolites.

When a single theodolite is used, the balloon is inflated for a specific ascensional rate, so that its height will be known at each elevation and azimuth angle reading. Severe vertical currents, however, alter the assumed ascension rate of the balloon and create a corresponding error in windspeed and direction measurements.

With two theodolites, elevation and azimuth angles are recorded simultaneously by both theodolite operators, and the position of the balloon is determined by triangulation. Additional accuracy is obtained by using three theodolites. Accuracies over horizontal distances of 0 to 30,000 ft vary from 0.6 fps with three theodolites to 3.8 fps with a single theodolite. Over distances of 30,000 to 60,000 ft, respective accuracies are within 1.2 and 6.2 fps. Wind-speed and direction measurements to altitudes over 100,000 ft are possible during periods of favorable winds aloft and cloudless skies. Normally, however, pibal soundings are limited to about 40,000 ft.

When the wind speed and direction for a single altitude are required, an aircraft-ejected smoke puff can be tracked by theodolites on the ground, if optical tracking conditions are favorable. With a single theodolite the vector error is approximately ±2 knots; the double-theodolite accuracy is approximately ±1 knot.

Cloud Height

Cloud heights are usually measured in conjunction with other meteorological measurements aloft. The most economical of the two methods employed is the balloon technique, in which a small, free balloon rising at a fairly constant known ascensional rate, is observed (usually with a theodolite) and timed at regular intervals until it disappears into the base of the cloud. The second method involves the use of the rawinsonde system, which, although not specifically designed to measure cloud heights, usually gives excellent results by comparing the relative values of temperature and humidity that are recorded as the balloon-borne transmitter-modulator ascends.

Special Measurements

Special measurements aloft can be made by use of (1) a balloon for lifting various instruments to altitudes of 50,000 to 100,000 ft, (2) the rawinsonde system for tracking tests in which the standard radiosonde transmitter is attached to an aircraft and tracked by the ground antenna, and (3) other equipment and techniques for determining such factors as the speed of sound at various altitudes, the vapor pressure at various air levels, the approximate vertical location of turbulence aloft, and the extent of contrail formation.

WEATHER FORECASTING

Local weather forecasts are issued twice daily: at 0730 and at 1330. The forecasts include (1) the time of sunrise and sunset, (2) the previous day's maximum temperature, maximum wind, and total precipitation, (3) morning winds aloft to 30,000 ft above mean sea level, (4) the synoptic situation over western United States, (5) the 24-hour local forecast, including maximum and minimum temperatures and lighting conditions, (6) forecast levels for condensation trails, and (7) the 48-hour weather outlook.

Special forecasts are supplied on request. These include a wide range of meteorological parameters such as (1) precise surface weather expected for a particular location at NOTS, (2) expected wind speed and direction at a specific altitude or altitudes, or the altitude at which atmospheric turbulence or the lack of turbulence may be expected, and (3) long-range surface-weather forecasts.

CONSULTATION AND CLIMATOLOGY

The Branch also offers technical assistance on problems relating to meteorology, maintains a continuing weather record, dating from 1946, conducts special climatological studies relating directly to ordnance testing at NOTS, and evaluates and develops local meteorological forecasting techniques and improved methods of obtaining meteorological measurements.

TYPICAL RANGE OPERATION

A typical test on the G-1 range calls for meteorological measurements of atmospheric pressure, temperature, relative humidity, density, and wind information such as direction, speed, crosswind components, gustiness, and vectors. These are usually provided from the surface up to altitudes of 110,000 ft. Upon request, additional information such as the speed of sound, vapor pressure, turbulence levels, and contrail formation levels can be furnished. If test data requirements are known beforehand, a method by which special or unusual data can be supplied to the requester can generally be arranged.

The average SNORT test might require surface pressure, temperature, relative humidity, density, wind direction and speed, and the speed of sound. These data are generally provided with respect to the breech end of the track, but similar data can be obtained by recording instruments at any location along the track. Special winds-aloft measurements can be obtained for tests involving upper wind parameters (e.g., shear or cross-wind components) at points along the track where objects are to be ejected from test vehicles.

Some tests, however, require unusual meteorological information. One example was the request for a method by which winds aloft could be determined from a destroyer while it was under way. This problem was solved by tracking a special balloon (containing radar dipoles) with the Mk 56 radar, feeding the data into a special data panel which reduced the angular information into coded digital information, and recording this on tape for later reduction.

Requests for Service

Requests for meteorological services are made at the instrumentation laboratory in either Room 116 or Room 118, or by calling 712334 or 712335. Personnel here are available for consultation on the type of data required to adequately cover a test, the form in which the reduced data is to be provided, and the most practical and useful means of obtaining this information.

Appendix

THE EXPERIMENT SPECIFICATION

An experiment specification (ES) is a formal outline of the data desired and procedures to be followed in carrying out a request to the Station (usually addressed to Commander, NOTS) for some type of testing, evaluation, or feasibility study. The request specifies the purpose and scope of the program, time schedule, primary and secondary data requirements, and accuracies desired. It also establishes the rate of testing and number of tests, briefly describes the operating and physical characteristics of the device to be tested, and lists the items and equipment the requester will furnish and those which the Station will be asked to furnish.

When the test, or program, has been established a project engineer is assigned. The project engineer compiles all information and prepares a final draft of the requirements. The Scheduling Branch then reviews the requirements, contacts the groups whose services will be required, sets up a time schedule, and draws up the ES, copies of which are distributed to Department management and to all operating personnel involved.

Following are copies of the ES sheets 1 through 4, an Instrument Array sheet, and an Air Space Requirement sheet for a typical proposed test. An ES may include only one of the sheets, or all of them, or any combination, depending on the type of test and the amount and detail of data requested.

When these sheets are filled in with classified information, such as trajectories or combinations of components, the forms are reproduced on green paper with the classification marking. When the information is not classified the forms are reproduced on white paper.

The chart on page 65 shows the normal routing sequence of test program requests received at NOTS.

CLASSIFICATION

EXPERIMENT SPECIFICATION - PAGE 1

E-6517

RANGE: G-1 | JO: 304300-100 | E: 6517

TO: Dist. List. * | FROM: Track & Ground Ranges, U. S. Naval Ordnance Test Station, China Lake, Calif.

TITLE *(Unclassified)*

Improved TARTAR Development Flight Test

PURPOSE OF EXPERIMENT

(GENERALLY CONFIDENTIAL MATERIAL)

PROJECT REPRESENTATIVE	CODE	PHONE(S)	
D. G. Maclise	3013	71481 71407	
TA OR LP NO. AND TITLE	TYPE OF TEST ITEM		NUMBER
	Improved TARTAR		1 ROUNDS/RUNS

CLASSIFICATION:	FILM	FIRING	ROUNDS	FIELD RECORDS	ASSESSED DATA

E.S. APPROVED BY:	FOR REQUESTING OFFICE	FOR TEST SCHEDULING BRANCH.	E.S. ISSUE DATE 19 May 1961
REVISION APP. BY:			REVISION DATE

	CODES REQ.
	3061
X	3063
X	3065
X	3067
X	3069
	3072
	3073
X	3081
	3083
X	9525
X	182
	184-1
	3563

REMARKS

F9F Target
KDA with Augmentation

(Plus other information pertinent to target trajectory for quick reference)

* DISTRIBUTION			
COPIES TO	ES	DATA	TFR
ES DISTRIB. LIST NO.:			

11ND-NOTS-3900/1 (Rev. 10-60) *(Replaces 11ND-NOTS-453)*

CLASSIFICATION

CLASSIFICATION

EXPERIMENT SPECIFICATION – Page 2 — -6517

MAJOR INSTRUMENTS, EQUIPMENT AND SERVICES REQUIRED

	CODE 3061	*(1)
X	4 X 5 B&W STILLS	
X	16MM CCO TO NPC	
X	16MM COLOR	
	35MM COLOR STILLS	
X	4 X 5 COLOR STILLS	
	4 X 5 COLOR SLIDES	

*(1) NUMBER OF PRINTS REQUIRED

CODE: X 3063 / 3073

12	ASKANIA THEODOLITES	
	CZR BOWEN CAMERAS	
	RC-2 BOWEN CAMERAS	
6	M45 MOUNTS WITH:	
	6	35MM MITCHELL BCT
		16MM MITCHELL
		35MM PHOTOSONIC BCT
		70MM CAMERAS
	16MM PHOTOSONIC CAMERAS	
	16MM FASTAX CAMERAS	
	16MM FAIRCHILD CAMERAS	
	16MM MITCHELL CAMERAS	
1	35MM MITCHELL BCT or TVR Launcher Area	
	35MM PHOTOSONIC CAMERAS	
	35MM FASTAX CAMERAS	
X	DATA DIAL CAMERA	
X	BORESIGHT CAMERAS Illuminator & SPQ-5 or	
	COMPUTER DIAL CAMERAS 25/7 Radar	
	70MM CAMERA	
	TVR	
	K25	
	DYNAFAX	

CODE: X 3065 / 3073

X	DATA & TIMING MONITOR		DRONE POD
X	RECORD 1ST MOTION		DOPPLER
X	TIMING	X	PLOT. BD. (PCM)
	X — 100 PPS BCT		4 PPS LANDLINE
	2 PPS RADIO		
	4 PPS RADIO		
	X — 5 PPS RADIO		
	X — 1000/10/S		
X	RADIO-LINK TELEMETERING		
	WIRE-LINK TELEMETERING		
	COUNTERCHRONOMETERS		
	TRACK COILS		

CODE: X 3067 / 3073

	DOPPLER RADAR
2	TRACKING RADARS
2	PLOTTING BOARDS
X	UHF CHANNELS ____ ____ ____
X	FM CHANNELS ____ ____
	PORTABLE CONSOLE – FM ____ ____ PA ____
	DOWNRANGE REPEATER ____ ____
	DESTRUCTOR TRANSMITTER
	DRONE POD TRANSMITTER
X	MIDAS (MISSILE TM XMTR 227.2, 229.9, 230.9 MC)
	(TARGET TM XMTR 231.9, 234.0 MC)
X	Record First Motion

CODE 3069

X	SURFACE WEATHER
X	ALOFT WEATHER TO 40,000 FT.
	AT 500 FT. INCREMENTS
	ABOVE SURFACE — X ABOVE MSL

CODE: X 3081 / 3072

X	DIRECT TEST OPERATIONS	X	PAINTING
X	SEQUENCE TIMER	X	PHYSICAL MEASUREMENTS
X	PA SYSTEM		
X	17 MC (NAF LINK)		
	X-8 LAUNCHER		
X	X-7 LAUNCHER		
	SPOTTING		
X	First Motion Microswitch		

CODE 3083

	SURVEY IMPACTS & STATIONS

CODE 9525

	MK25 MOD 3 RADAR	X	ILLUMINATOR
X	MK25 MOD 7 RADAR		
	SPQ-5 RADAR		
	TARGET SIMULATOR		
	MK23 COMPUTER		
X	EX13 COMPUTER		
X	BECKMAN RECORDER		

	OTHERS		TARGET AUGMENTATION
X	Code 182 - Target aircraft		FLARES
		X	PODS
X	Code 182 A/G communications	X	BEACON
			BAND
			MDI
		X	SMOKE

11ND-NOTS-3900/2 (Rev. 2-61) (Replaces 11ND-NOTS-453A) CLASSIFICATION

AMMUNITION AND MATERIALS REQUIRED	SOURCE	DATE AVAILABLE	HELD FOR
DTRM - Improved	G-1		
Warhead - Telemeter	G-1		
Destructor	G-1		
Fuze	G-1		

ADDITIONAL INFORMATION PERTINENT TO PREPARING AND FIRING TEST

USUALLY INFORMATION OF A CONFIDENTIAL NATURE PERTAINING TO TEST UNITS, TRAJECTORIES, DATA REQUIREMENTS, AND SPECIAL TEST INSTRUCTIONS.

EXPECTED DYNAMIC CHARACTERISTICS

INFORMATION PERTINENT TO REDUCTION OF DATA

NOTS will not be required to assess any data.

CLASSIFICATION

EXPERIMENT SPECIFICATION - PAGE 4
EQUIPMENT AND SERVICES REQUIRED

E-6517

DATA OR SERVICE DESIRED	OPTICAL INSTRUMENTATION (P309; 3063, 3073)	TIMING & TELEMETERING (P309; 3065, 3073)	RADARS & COMMUNICATION (P309, P808; 3067, 3073)	RANGE OPER. & OTHER (P3091; 3081, 3072)
1. MISSILE TRAJECTORY a. Record zero to 40 sec	6 Askania Cameras G-1: J11, J33, J43 G-2: J20, J40, J60	Radio Timing 5 pps zero time indication	Tracking radars and autopilot with timing. Maintain radio communications Operate MIDAS.	Man BITTERROOT Coordinate instrumentation and issue countdown.
2. TARGET TRAJECTORY a. Record zero to 40 sec	4 Askania Cameras G-1: J41, J83 G-2: J50, J80			
3. MISSILE AND TARGET a. Record and entire firing run	6 M-45 Mounts G-1: M09 2BB M39 2BB M49 2DB G-2: M38 2BB M58 2DB M68 2DB	100 pps BCT with zero time indication		
4. MISSILE PERFORMANCE a. Record -15 sec to end of flight	Boresight cameras on guidance radar and Varian Illuminator	100 pps BCT with zero time indication		
5. LAUNCHER POSITION a. Record -15 sec to end of flight	Data Dials, B&W, 20 fps			
6. EX 13 COMPUTER a. Record -15 sec to +5 sec	Dials for IT (include VHR, Phase A & Hyd. Tach meters) 20 fps, B&W			
7. MISSILE LAUNCH a. Record -2 sec to +2 sec	16mm Fastax or 70mm TVR. To view missile on launcher plus 5 missile lengths. 400 [illegible]			

CLASSIFICATION

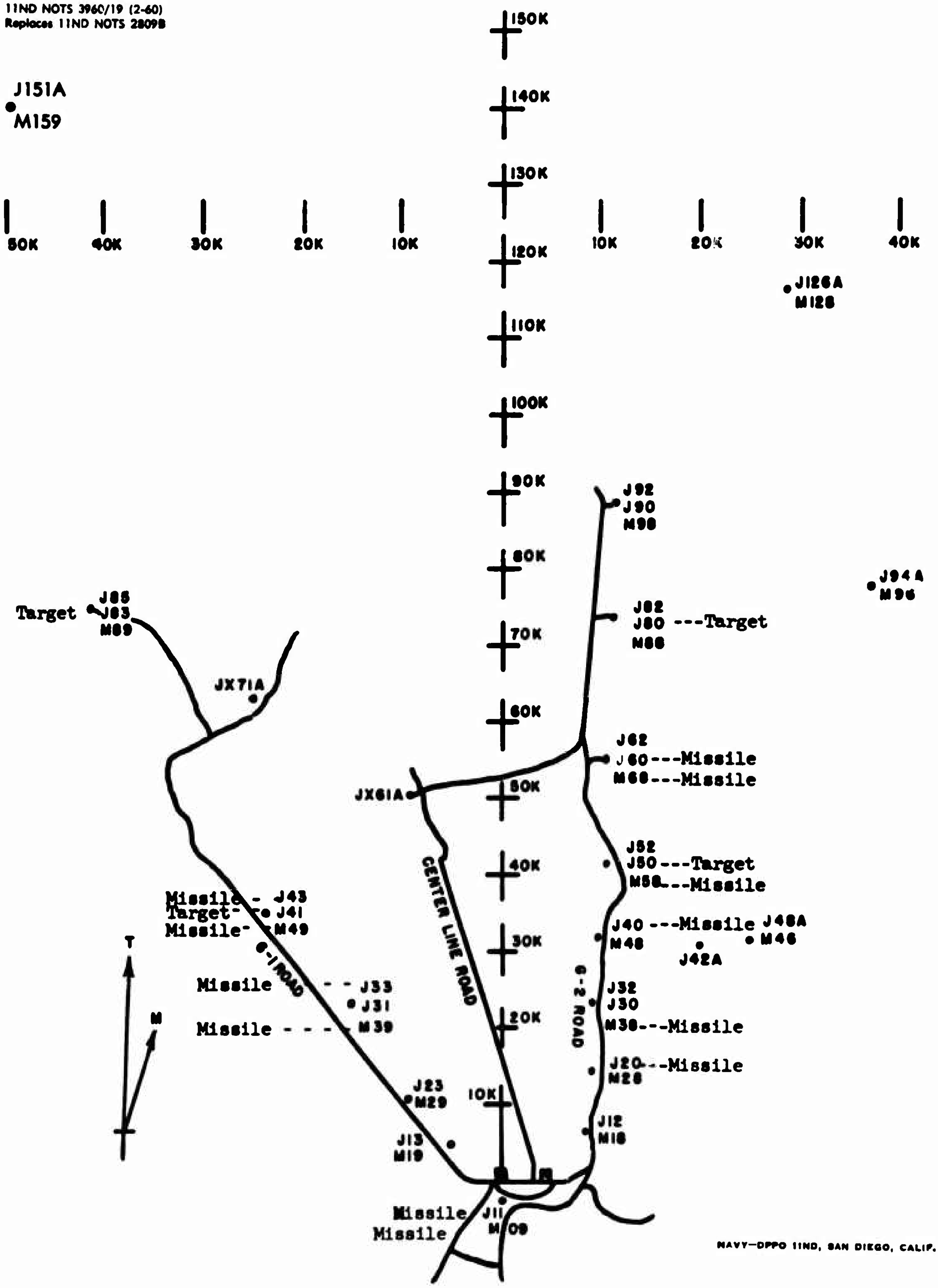
EXPERIMENT SPECIFICATION - PAGE 4 A
EQUIPMENT AND SERVICES REQUIRED

E-6517

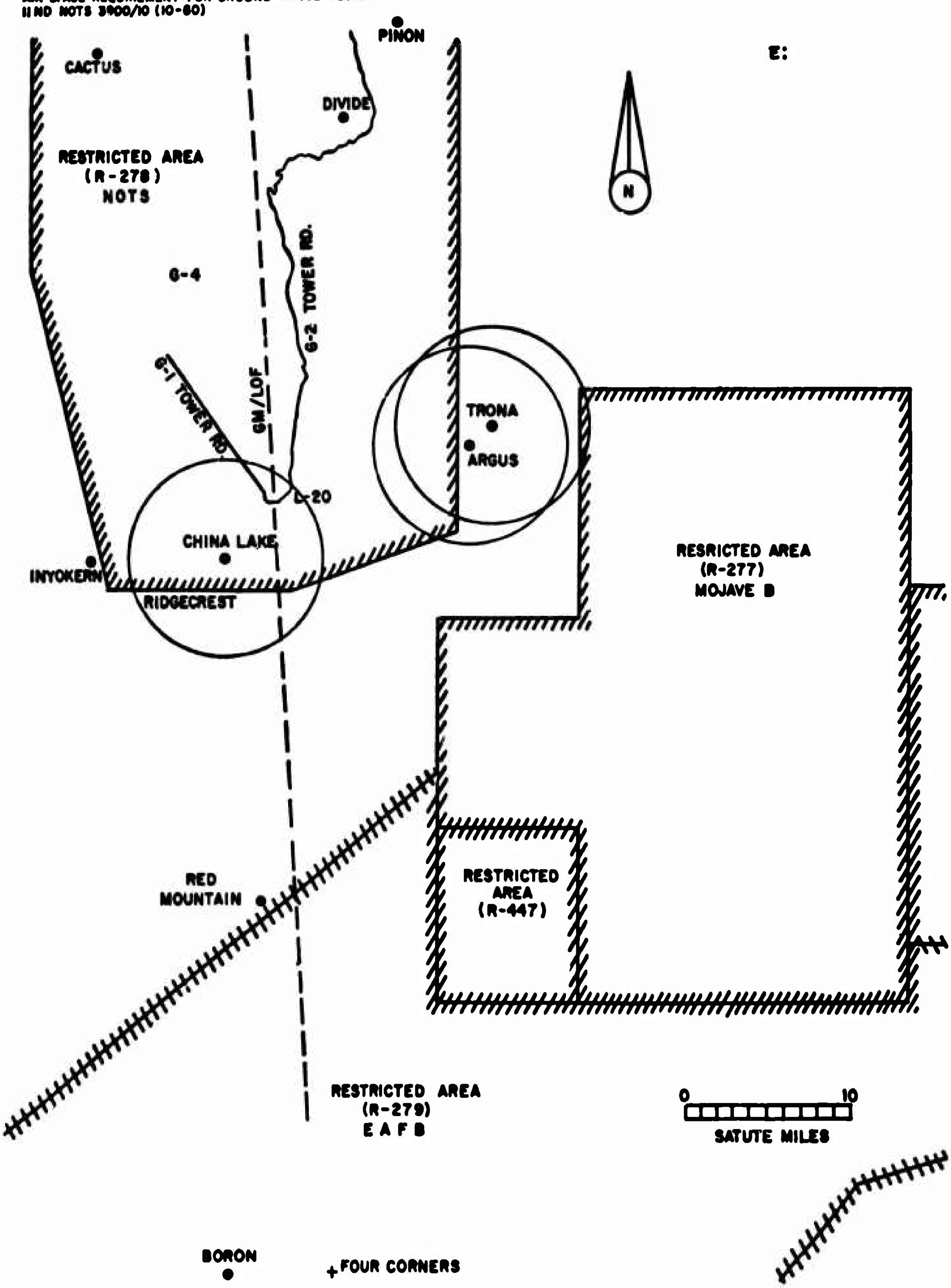
DATA OR SERVICE DESIRED	OPTICAL INSTRUMENTATION	TIMING & TELEMETERING	RADARS & COMMUNICATION	RANGE OPER. & OTHER
	P309	P309	P309 / P808	P3091
	X 3063 / 3073	X 3065 / 3073	3067 / 3073	X 3081 / 3072
8. METEOROLOGICAL DATA a. Temperature, pressure, humidity, and wind velocity and direction in 500 ft increments to 40,000 ft MSL b. Record wind velocity and direction from anemometer on barricade to +1 minute. Furnish record to PED. c. Pibal wind direction and magnitude as near firing as possible				Code 3069 Record data
9. TERRIER FIRING REPORT (Form 2772)				Provide pertinent data
10. IMPACT OF MISSILE TO ENABLE RECOVERY	Theodolite operators report readings of missile impact.		Assess MIDAS missile-impact data.	
11. TELEMETERING a. Record missile functions b. Record first motion		Operate appropriate stations. Record first motion		

G RANGE INSTRUMENT ARRAY
ASKANIA & M 45 STATIONS
11ND NOTS 3960/19 (2-60)
Replaces 11ND NOTS 2809B

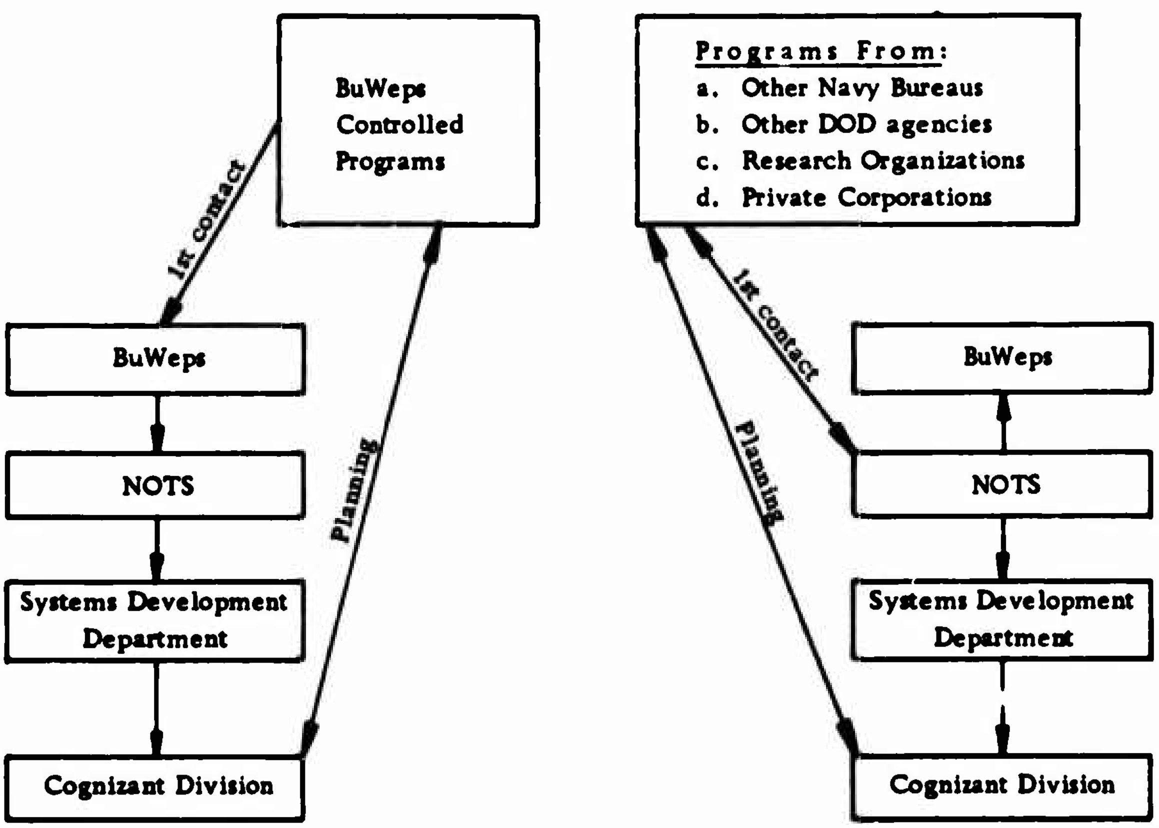
E-6517



AIR SPACE REQUIREMENT FOR GROUND RANGE TESTS
IIND NOTS 3900/10 (10-60)



PROGRAM REQUEST CHANNELS



Negative Numbers of Illustrations

Figures:

1.	LHL 101822	18.	LHL 100716	35.	none
2.	LHL 084873	19.	LHL 105505	36.	LHL 057258
3.	LHL 084870	20.	LHL 015020	37.	LHL 057256
4.	LHL 090795	21.	LHL 085893	38.	LHL 087289
5.	LHL 084871	22.	LHL 048178	39.	LHL 051539
6.	LHL 061031	23.	LHL 034446	40.	LHL 064060
7.	LHL 100357	24.	LHL 077225		LHL 050143
8.	LHL 090648	25.	LHL 015002		LHL 061510
9.	LHL 101841	26.	LHL 064234		LHL 107330
10.	LHL 101977	27.	LHL 061118	41.	NP4560020
11.	LHL 093889	28.	LHL 036040	42.	LHL 087288
12.	LHL 061034	29.	LHL 061121	43.	LHL 031187
13.	LHL 061033	30.	LHL 047901	44.	LHL 031181
14.	LHL 101821	31.	LHL 087055		LHL 031198
15.	LHL 080603	32.	NP458310	45.	LHL 085528
16.	LHL 080296	33.	none	46.	NP459274
17.	LHL 080300	34.	none	47.	LHL 031188

Initial Distribution

4 Chief, Bureau of Naval Weapons
- DLI-31 (2)
- R-36 (1)
- R-362 (1)

20 Defense Documentation Center (TISIA-1)

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Naval Ordnance Test Station China Lake, California 93557	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP --	
3. REPORT TITLE Instrument Operations on Systems Development Department Ranges		
4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)* Summary of range facilities, capabilities, and services.		
5. AUTHOR(S) *(Last name, first name, initial)* Staff, Systems Development Department		
6. REPORT DATE October 1965	7a. TOTAL NO. OF PAGES 66	7b. NO. OF REFS --
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) NOTS TP 2692, Revision 2 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* --	
10. AVAILABILITY/LIMITATION NOTICES Qualified requesters may obtain copies of this report from DDC. (Released to Clearing House for Federal and Technical Information.)		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY BuWeps, Department of the Navy	
13. ABSTRACT NONE		

DD FORM 1 JAN 64 1473 0101-807-6800

Unclassified

Security Classification

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Range Operations						
Instrumentation						
Facilities						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ____________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ____________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ____________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.